# Germany's Energy Transition Experiment:

# A Case Study about Guiding Decisions and Steering Large

# Socio-Technical Systems in Desired Directions

by

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ABSTRACT

The *Energiewende* aims to drastically reduce Germany's greenhouse gas emissions, without relying on nuclear power, while maintaining a secure and affordable energy supply. Since 2000 the country's renewable-energy share has increased exponentially, accounting in 2017 for over a third of Germany's gross electricity consumption. This unprecedented achievement is the result of policies, tools, and institutional arrangements intended to steer society to a low-carbon economy. Despite its resounding success in renewable-energy deployment, the *Energiewende* is not on track to meet its decarbonization goals. *Energiewende* rules and regulations have generated numerous undesired consequences, and have cost much more than anticipated, a burden borne primarily by energy consumers. Why has the *Energiewende* not only made energy more expensive, but also failed to bring Germany closer to its decarbonization goals? I analyzed the *Energiewende* as a complex socio-technical system, examining its legal framework and analyzing the consequences of successive regulations; identifying major political and energy players and the factors that motivated them to pursue socio-technical change; and documenting the political trends and events in which the *Energiewende* is rooted and which continue to shape it. I analyzed the dynamics and the loopholes that created barriers to transition, pushed the utility sector to the brink of dissolution, and led to such undesirable outcomes as negative wholesale prices and forced exports of electricity to Germany's European neighbors. Thirty high-level energy experts and stakeholders were interviewed to find out how the best-informed members of German society perceive the *Energiewende*. Surprisingly, although they were highly critical of the way the transition has unfolded, most were convinced that the transition would eventually succeed. But their definitions of success did not always depend on achieving carbon-mitigation targets. Indeed, Germany jeopardizes the achievement of these targets by

changing too many policy and institutional variables at too fast a pace. Good intentions and commitment are not enough to create economies based on intermittent energy sources: they will also require intensive grid expansion and breakthroughs in storage technology. The *Energiewende* demonstrates starkly that collective action driven by robust political consensus is not sufficient for steering complex socio-technical systems in desired directions.

# DEDICATION

To Maria

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Many scholars, energy experts, colleagues, fellow students, and friends helped me to structure my research, find answers to my questions, and bring this project to fruition. I am indebted to all of them.

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PREFACE

Germany's laudable and popular effort to steer its economy away from fossil fuels and build one that runs on carbon-free energy sources—the *Energiewende*—involved intensive deployment of renewable energies. In 2017, over 36% of the nation's gross power consumption was generated from renewable sources. This phenomenal share of renewables seems to be an indicator of a successful energy transition. But it is not. The expectation that replacing fossil-fuel sources of electricity with renewable ones would be sufficient to meet the nation's decarbonization goals was naïve. Power generation is, despite its importance, not the only source of greenhouse gas emissions, and the efforts to steer Germany's large and complex socio-technical energy-system to carbon neutrality cannot succeed while neglecting the emissions generated by the transport, heating, and agriculture sectors. Moreover, the most abundant renewable sources, wind and solar, are by nature intermittent, and the technology to store power at the scale necessary to level such intermittencies is not yet available. Thus, Germany's wind and solar power flood the grid when they are available, causing grid-operation costs to skyrocket, and forcing neighboring countries to accept the overflow. Grid capacity is insufficient to transport the power produced in the windy north of the country to the high-consuming south, where most industries are located. To compensate for the intermittency of renewable electricity sources, Germany's conventional power plants are forced to operate inefficiently. In fact, the German utility sector has been pushed to the brink of dissolution. The German government, as it must, has shielded the nation's principal industries from much of the economic burden of the energy transition, while less energy-intensive industries, small businesses, and households have borne the brunt of the steadily rising costs. We cannot yet know how Germany's energy experiment will end, but many lessons can be learned from what has unfolded so far.

CHAPTER 1

INTRODUCTION

**Setting the Context for Germany's Energy Transition Experiment**

Germany's energy system is changing at an incredible pace. Its renewable energy share increased exponentially over the past two decades, accounting in 2017 for more than a third of Germany's gross electricity consumption[1]. And Germany accomplished all this without having its economy collapse—in fact, it is doing well, even as renewable energies have become, with 217.9 TWh of electricity produced, the largest source of power in the German energy mix[2] (UBA, 2018, p.7). This unprecedented achievement was only possible because Germany responded to the calls to action against anthropogenic climate change, rising greenhouse gas emissions, and dependence on finite fossil resources with an integrated energy and climate policy, also known as the German Energy Turnaround, or *Energiewende*. The goal of this, the most ambitious energy and climate policy in the world, is to make a radical transition to an energy system that reduces its greenhouse gas emissions by 80-95% (from 1990 levels by 2050), without relying on nuclear power, while maintaining an affordable and equitable energy price level.

In September 2010, when the German government first presented its "Energy Concept" and described Germany's roadmap to carbon neutrality, it simultaneously passed

[1] Germany's gross final electricity consumption amounted 600.2 TWh in 2017, 36.2% of which were covered by RE sources. Being a net exporter Germany generates more power than it consumes, thus related to the gross electricity generation (654.2 TWh in 2017) the share of RE is slightly smaller (33.3%). The German gross electricity generation approximately corresponds to the cumulated power production of Florida, Pennsylvania, and California (FL+PA+CA 2016: 650.3 TWh). These three US states generated in 2016 only 49.1 TWh of power based on RE (less than a fourth of Germany's RE production 2017).

[2] Followed by lignite (148 TWh), hard coal (94.2 TWh), gas (86 TWh), nuclear (75.9 TWh), and oil (5.7 TWh).

into law[3] a series of regulations that included the decision to extend the life-span of existing German nuclear facilities by up to 14 years. But only six months later, after the accident at the Fukushima Daiichi nuclear power plant in Japan, Chancellor Angela Merkel changed course in the wake of fast-spreading anti-nuclear protests. Driven by the fear of losing her political legitimacy, Merkel decided to decommission all German nuclear power plants by 2022, while still retaining the ambitious greenhouse-gas reduction target of the German Energy Concept.

Germany's *Energiewende* did not just happen overnight, however. The vision of a carbon- and nuclear-free future can be traced back to the 1970s and 1980s, two decades of severe oil crises, intensive deployment of nuclear power plants, and increased environmental awareness. In fact, the term *Energiewende*, which means energy turnaround, was first used in 1980 as the German title for Amory Lovins's Soft Energy Paths, a book that nourished the environmental grassroots movement in Germany (Lovins, 1977; Krause et al., 1980). But it took three decades for the agenda of the Green movement to be made into a government program in Germany.

**Guiding Decisions and Governing Change: Energy Transition Challenges[4]**

In an official press release correlated to the promulgation of the Renewable Energy Act of 2004 (EEG 2004), the German Minister of Environment, Jürgen Trittin, declared that creating incentives for renewable energy would cost the average German household no more

[3] Germany's Energy Concept and the related energy and climate legislation were based on the recommendations of a long-term research project known as Prognos study (Schleisinger et al., 2010).

[4] The assertions made in this section about energy and societal costs, utility market shares and earnings, and the existential threats encountered by the solar industry will be supported in later chapters with empirical evidence.

than “one scoop of ice cream” [5] per month (i.e., 1€). “The transformation of our energy system is not only feasible, it also pays off,” [6] stated another Minister of Environment, Norbert Röttgen, based on a study of the feasibility of Germany’s plans to reduce greenhouse gas emissions without relying on nuclear power, by Nietsch et al. (2012). Despite such optimistic statements, all support schemes for Germany’s energy transition come at very high societal costs, and put an unprecedented strain on actors in the *Energiewende* arena. All 40.2 million private German households and 2.2 million German enterprises[7] are yearly confronted with a significant increase in energy costs. Germany, one of world’s most powerful economies, faces increasing energy poverty issues.[8] The rapid shift to renewables, with their emphasis on lots of small-scale, decentralized power and heat production, has fundamentally altered the traditional way of doing business for the big utilities in Germany, causing a huge drop in market share and big losses in earnings. From their past position as the backbone of the German economy, the utilities now totter on the brink of dissolution and won’t probably survive without federal subsidies. Even the newly established solar industry experiences existential threats in the wake of substantially decreasing incentives for photovoltaic and solar thermal sites.[9]

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[5] Source: BMU-press release (30 July 2004). Statement of the German Minister of Environment, Jürgen Trittin.

[6] Source: BMU-press release (5 April 2012). Statement of the German Minister of Environment, Dr. Norbert Röttgen, based on the final report “Long-term scenarios and strategies for the development of renewable energies in Germany in view of European and global developments” (Nietsch et al, 2012).

[7] Source: Statistisches Bundesamt, 2015, pp. 49 & 505.

[8] In 2014, German electricity suppliers sent according to Germany’s Federal Net Agency 6.3 million dunning letters for delayed payments and disconnected 351,802 households from the electricity grid for not being able to pay their electricity bills (Handelsblatt, 15th November, 2015).

[9] In his book *Große Hoffnungen und brüchige Koalitionen: Industrie, Politik und die schwierige Durchsetzung der Photovoltaik*, Timur Ergen analyses in detail the difficulties faced by the German solar industry (2015).

Thus, although Germany's efforts to mitigate climate change have led to incontestable achievements in the renewable energy realm, achievements which no one had even dared to imagine two and a half decades ago, Germany's *Energiewende* may be an experiment that places burdens that are too heavy for German society to sustain. And yet, even the measures of this bold transition program are insufficient for reaching the targeted decarbonization goals.

In its attempt to steer its energy system from a less desirable state towards a more desirable one, Germany's government has created an ongoing stream of new rules and regulations, all meant to "fix" their imperfect older versions. Yet energy systems are complex amalgams of technologies, institutions, markets, regulations, and social arrangements, and nations have little experience in successfully directing fundamental change in such complex socio-technological systems over specified periods of time. In fact, despite all achievements in the renewable energy realm, Germany's steadily growing regulatory labyrinth has mostly failed to achieve the desired outcomes, producing instead many examples of the unintended consequences of such interventions. And it remains an open question whether Germany's next attempts to "fix" the regulations will reduce carbon emissions and control energy prices.

**Study Aims**

I set out to critically examine the German *Energiewende* and use it to investigate the feasibility of steering large socio-technological systems in desired directions. The study objectives were:

(1) To examine the regulatory and policy framework that underpins the German *Energiewende*.

(2) To identify the social, economic, technological, environmental, geo-political, cultural, and historical factors that have motivated and continue to motivate stakeholders to take action and trigger change in the *Energiewende* arena.

(3) To document the history of change in Germany's energy policy since 1970 and to explain how Germany's large, socio-technological energy system was rebuilt based on renewable energy technologies.

(4) To analyze the intended and unintended consequences of Germany's energy transition experiment in order to enhance understanding of the potential barriers to effective governance of intentional transitions.

(5) To draw conclusions from the German case about possible ways to reduce unintended negative outcomes of intentional transitions in systems that are not only complex, but also dynamic.

**Research Contribution**

My work is addressed to academic, professional, and political readers who are interested in understanding the *Energiewende* and seeks to provide insight to help them to pursue pathways that are more likely to lead to successful transitions. The research highlights the weaknesses and critical trade-offs of the world's most radical energy policy and explores their causes.

I have had the unusual opportunity of conducting my research from a basis of applied expertise in many sectors of Germany's energy realm, rather than from theoretical frameworks and secondary knowledge alone. It has therefore been my task to take a thesis derived from decades of professional experience and examine it in the light of existing literature on large social-technical systems, institutional analysis, and innovation policy.

From this dual perspective I argue that simultaneously changing many variables in large and complex systems, with the intention of steering a system transition in a particular direction, generates destabilizing dynamics that tend to jeopardize - despite societal efforts and policy makers' best intentions - the achievement of transition goals.  Moreover, I claim that transition policies based on a broad societal consensus do not necessarily lead to desired outcomes, or to acceptable transition costs.

Fundamental changes always come with new rules of the game. But new and more sophisticated rules and regulations, even if backed by a broad societal consensus, are not enough to attain desired outcomes. They can redistribute societal wealth, but may be unable to replace missing technologies, institutional arrangements, appropriate incentives, and relevant expertise that are vital for a successful transition.

The findings of this study may help policymakers and energy managers to avoid some of the weaknesses and inconsistencies that have plagued the German energy-transition experiment. What will become apparent in the course of this analysis is that:

- there are invisible complexities that work steadily to sabotage the loftiest intentions of governing bodies that are sincerely devoted to the mission of reversing climate change,
- all legislative frameworks and economic incentives meant to do good can and will be used by market participants to maximize profit, and
- no invisible hand will somehow align that profit-seeking with the goals of reversing climate change.

Climate goals and enterprises in market economies have diverging norms (profit versus low carbon emissions) and that Adam Smith's "invisible hand"[10] is not able to align these divergent norms, because one destroys the other. In fact, the visible hand of the government that drastically intervened to steer change in desired directions was successful in deploying renewable energies and redistributing wealth in the society, but incapable of crafting a sound transition roadmap for reducing carbon emissions. Instead every effort resulted in additional degrees of complexity that made the entire endeavor incomprehensible to all participants in the *Eenrgiewende* arena including those who craft the laws, while the overarching carbon-mitigation goal was completely lost in the process.

**Study Overview**

This dissertation consists of nine chapters. The first three chapters - introduction, literature review, and methodology – are background sections that introduce the subject, narrow down the arguments I make, present the scholarly contributions that inspired my endeavor, and the methodological approaches used to structure my research. Each of the next five chapters responds to one of the study aims defined above. Together they encompass the framework that underpins Germany's energy transition, the main actors in the *Energiewende* arena, the history of this unusual experiment, my empirical findings, barriers encountered in Germany's energy transition process, and the opinions of expert actors in the *Energiewende* arena. I conclude with a chapter that suggests lessons about guiding decisions and steering change in large socio-technical systems.

Chapter 2 explains the broad theoretical context of large socio-technical systems, institutional analysis, and innovation policy to which I related my empirical findings.

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[10] Reference to *An Inquiry into the Nature and Causes of the Wealth of Nations* (Smith, 1776).

However, I neither led my research with theory, nor committed myself to a single theory. Instead, I approached my research as an ongoing dialogue among theories, empirical findings, and real-life experiences, explanations, and insights.

Chapter 3 describes the methodological approaches that I used to conduct my research and to generate new knowledge about energy transitions.

Chapter 4 explores the unique patterns of the *Energiewende* framework in comparison with elements of other regulatory frameworks for large energy systems. I describe the goals of the *Energiewende* and the laws, regulations, and directions (henceforth, "rules") that were implemented to accomplish them.

Chapter 5 provides information about the various factors that motivated and continue to motivate stakeholders to take action and trigger change in the *Energiewende* arena, and highlights similarities and differences in other large energy systems. I describe the actors, their relationships, their institutional preferences, and how their roles, values, and positions have changed over time.

Chapter 6 documents the history of change, shows how Germany's unique energy-transition experiment has arisen from the environmental movements that marked its beginning up to its current proof-of-concept.

In Chapter 7 I discuss how actors have adjusted their strategies to mitigate differences between the intended and actual results of their actions, and compare them to the actors in other case studies of large energy systems (e.g., Hughes, 1993; Laird, 2001b; Nye, 1990; Hirsh, 1989, 1999; Hirsh et al., 1996; Hirt, 2012; Hecht, 1998). I discuss how the rules are enforced and how they impact society, the economy, and the environment. I analyze the extent to which the rules produced the expected outcomes, how the rules relate one to another and to the European regulations, and which alternative rules could have been crafted. I examine the strengths and limitations of each policy alternative (i.e., taxation, funds, quota, or self-commitment models vs. feed in tariffs).

Chapter 8 comprises expert views about the *Energiewende* goals, their likelihood of being achieved, and the problems that arose during the transition process.

Finally, in Chapter 9, I identify potential transition-governance barriers and suggest ways to understand and overcome such hurdles, I synthetize the knowledge about the German *Energiewende* into lessons that can be learned from this unique transition experiment, and conclude my study with recommendations for future political decisions aimed a large-scale energy-system change.

# CHAPTER 2

# THEORETICAL SOURCES AND DEFINITIONS

I relate my own research to the broader theoretical context of large socio-technical systems, institutional analysis, and innovation policy, and to the seminal academic literature in these research fields. This literature addresses processes of governance in large and complex socio-technological systems and presents different incremental and radical transformative approaches. It describes authoritative, democratic, and participatory governance schemes, and emphasizes tensions between private and public forms of property. It analyses economic growth, problems related to common-pool resources, and Keynesian and market economic models. The literature includes many contributions about the role of science in the process of governance and about the science-technology relationship. It describes the institutional and organizational settings historically established to inform political processes, solve problems or direct change; analyzes the emergence and historical evolution of all-purpose technologies; and evaluates the more-or-less visible involvement of state and military in the emergence of new technologies. The literature encompasses a very broad range of policy theories, frameworks, and tools articulated and applied in the past decades to the challenge of directing change and enhancing innovation capacity of large socio-technological systems. It offers a diverse and valuable theoretical basis for my research. However, although many of these studies (e.g., Hughes, 1993; Nye, 1990; Hirt, 2012; Hirsh, 1989; Hirsh, 1999; Hecht, 1998; Tarr, in Coutard, ed. 1999; Graham, 1993; Nelles, 1974; Laird, 2001b; Lester et. al, 2012) directly address the historical evolution of energy systems and the statist and/or managerial efforts to direct their transformation, none explores the patterns of the German *Energiewende*.

At the same time, there is a substantial technical literature related to the *Energiewende*. A group of technical and economic studies aimed at guiding and assessing Germany's energy transition either directly addressed the *Energiewende*, by focusing on one or more of its aspects, or indirectly evaluated processes intertwined with it. These studies were conducted by several renowned research institutions[11] and were commissioned by European and German agencies[12], by cross-sector, cross-party, and cross-nation NGOs,[13] by industrial associations or initiatives,[14] and by other public or private organizations. They produced various conclusions and diverging recommendations that were strongly dependent on the assumptions made and mostly mirrored the particular views of the organizations that commissioned them, leaving many questions about how independent and unbiased such commissioned research can be.

There is furthermore a vast professional and scholarly literature published since 2012 on the subject of the German *Energiewende*. This literature consists, with few exceptions, of one-sided analyses of either the economic costs or the technical feasibility of alternative energy and energy storage technologies, of the competitiveness of German industry under the constraints imposed by the *Energiewende*, of governance levels, political instruments, or particular *Energiewende* acts. The exceptions are:

Klaus-Dieter Maubach, *Energiewende* (2013), Chapter 6 in Manfred Popp, Deutschlands Energiezukunft: Kann die *Energiewende* gelingen? (2013), and Annika Sohre, Strategien in der Energie- und Klimapolitik (2013).

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[11] Prognos, Frauenhofer Institute ISI & IWES, Ifne, DLR, rwi, booz&Co. etc.

[12] BMU, UBA, BMWi, etc.

[13] INSM, DESERTEC Foundation, etc.

[14] bdew, Desertec Industrial Initiative – Dii.

The authors of these books look at the *Energiewende* phenomenon from a variety of points of view, informed by the history of the German social movements that led to the current legislation, going back to 1980, the interconnections between and strategies behind international and national legislation (after Kyoto), or the politics of the Green party. However, none of them treat the broader question of guiding decisions and steering large socio-technological systems from a systems perspective, nor do they delve into the unexpected and multifaceted consequences of rapid and often poorly understood energy transitions. Furthermore, the aforementioned scholarly literature neither emphasizes the interplay among the general public, the German government, and the other public or private actors in the German energy arena, nor explains how these major players shaped the German and European socio-political, technological, and institutional landscapes.

My work examines the *Energiewende* as a way of approaching the question of how to steer large and complex socio-technological systems in desired directions in novel ways. My study is informed not only by my research, but also by several decades of experience with Germany's energy systems, as an employee of both large utility corporations and energy-intensive manufacturing industries. I headed different departments inside the renewable energy arm of RWE, one of Germany's largest utility groups, as well as the Energy Management Departments of three multinational (Swedish, German, and Finnish) paper manufacturers (Stora Feldmühle, Haindl Paier, and UPM). I was responsible for energy procurement and sales, all emission-trading activities, risk- and knowledge management, the development of new energy concepts, and lobbying activities. I also led the negotiations for the deregulation of the German gas markets, acting on behalf of the Federal Association of

Germany's Industry (BDI), and the Association of Large Industrial Energy Consumers (VIK).

**Large socio-technological systems**

The debates in the field of "society and technology studies" pertinent to my study of the *Energiewende* are dominated by three different theoretical approaches: (1) "social constructivism," (2) "technological systems," and (3) the "actor-network-theory."

(1) The "social constructivist" theory, with its concepts of "interpretative flexibility," "relevant social groups," and "closure," emerged, developed, and became established in studies of the sociology of science (Berger and Luckmann, 1966; Pinch and Bijker 1984; Bijker et al. 1987). The theory views technological artifacts as both socially constructed and "open to sociological analysis" (Bijker et al., 1987, p.4). Actors who attribute the same meaning to an artifact belong to the same relevant social group. Yet different social groups "produce different descriptions" of an artifact, as if they were speaking about multiple artifacts. For example, in 1870 women typically described the bicycle as "a machine in which your skirt got entangled and from which you frequently made a steep fall" while the same artifact was "a machine to impress lady-friends" from the perspective of "young men of means and nerve" who dared to ride it (2010, p. 68). Artifacts allow thus "interpretative flexibility". Social constructivists explain the structure of technological systems as a result of negotiations between relevant social groups. During these negotiations some of the competing meanings about the direction in which a technology should be developed gain dominance over the others, and the interpretative flexibility diminishes. Diverging visions about the kind of technological artifacts that would best align with

group members' interests and those of society at large eventually lead to "closure" decisions imposed on weaker groups by more powerful ones.

(2) The "technological system" approach originates in the seminal work of Thomas P. Hughes, a historian of technology (Hughes, 1986; Hughes, 1987; Hughes, 1993; Hughes, 2004). Hughes argues that large technological systems are both "socially constructed" and "society shaping." His approach employs key concepts such as "technological style," "technological momentum," and "reverse salients" to explain how "system builders" have conceived, designed, and constructed technological systems, and how those systems have changed over time. To emphasize the importance of non-technical factors for understanding technologies Hughes shows how the components of large technological systems (physical artifacts, organizations, political elements, natural resources) build a "seamless web of society and technology" (Hughes 1986; Hughes 1987, p.51; Bijker, 2010, p. 67; Bijker et al., 1987, pp.1, 3, & 6).

(3) The "actor-network theory" can be traced back to the scholarly contributions of Bruno Latour (1992, 1996), Michael Callon (1986, 1987, 1995), and John Law (1986,1987), all of whom have tried to integrate "non-human masses" into "the fabric" of a "new social theory" (Latour, 1992, reprinted in Wetmore and Johnson eds., 2008, p.152). In contrast to the social-constructivist approach, which assumes that technological change is directed by humans and not by technologies, "actor-network" scientists argue that animate actors should not have in comparison to inanimate ones a privileged position in the social-technological relationship (Law in Bijker et al., 1987, p.113).

Sarewitz and Nelson (2008) and Allenby and Sarewitz (2011) complement these theories with a functionalist approach to technology. To identify technological "fixes" relevant to future innovation policy and assess the "techno-human condition," these scholars distinguish three levels of technological function. The first level encompasses "cause-and-effect machines" that are often very successful in "increasing human control and power in the world" (Allenby and Sarewitz, 2011, pp. 36 & 32; Sarewitz and Nelson, 2008). However, the "sophisticated yet physically discrete, tangible, and recognizable" Level I technologies "do not act in isolation; they are connected to other technologies, and to social and cultural patterns, institutions, activities, and phenomena that may interact in ways that no one is able to predict or control." (Allenby and Sarewitz, 2011, pp. 37-39). Level I technologies are, together with humans who create and adopt them, components of "larger," "less predictable," and "more complicated" socio-technological systems, or Level II technologies (Allenby and Sarewitz, 2011, pp. 37-38). An energy system encompasses, for example, not only Level I technologies that effectively convert one form of energy into another,[15] or reliably transport and distribute energies from where they are produced to where they are needed,[16] but also several subsystems,[17] and an impressive number of humans. These humans invent, adopt, build, and operate Level I technologies; conceive, operate, manage, and improve subsystems; make operational and political decisions about how these systems should be used, enlarged, or developed; associate values to technologies and systems;

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[15] Such as lignite, coal, natural gas, waste or biomass boilers, nuclear reactors, steam and gas turbines, solar panels, wind mills.

[16] Such as high-, medium-, and low-pressure gas and steam pipelines, or very high-, high-, medium-, and low-tension power lines.

[17] Such as hydro, fossil, nuclear power stations, solar facilities, and wind farms, or transport and distribution grids, companies that generate, distribute and/or consume energy, governmental bodies and granting permits, setting emission limits, etc.

advocate for or demonstrate against them; build and rebuild their societies; and organize their lives around these embodiments of human genius. Given the tremendous number of heterogeneous elements embedded in Level II technologies and the multitude of possible interactions among them, complex socio-technological systems seem rather symbols of "irrationality and dysfunction" than of "effectiveness" or "reliability"(Allenby and Sarewitz, 2011, p. 37).  However, technologies are far more than reliable "volition enhancers" (Level I technologies) or parts of "complex socio-technical systems of Kafkaesque incomprehensibility and capriciousness" (Level II technologies) (Allenby and Sarewitz, 2011, pp. 37 &41).  They have "co-evolved with significant changes in environmental and resource systems"; with the increasing levels of greenhouse gases in the atmosphere and the related effect of global warming; with the collapse of entire political systems, the rise of new economies and new areas of influence for established ones; with globalization and the incredible levels of economic entanglements among the world's nations; with demographical, energy, and economic crises; with massive East-West, and South-North migration patterns; "with mass-market consumer capitalism; … with behavioral and aesthetic subcultures and stereotypes; … with opportunities for, and a sense of, extraordinary human freedom," reaching degrees of complexity that are similar to those of natural systems (Level III technologies) (Allenby and Sarewitz, 2011, p. 39). At Level I we clearly recognize technologies as machines designed to fulfill specific social goals.[18] Although these technologies function at Level II in a broader social and cultural context, in which "cause-and-effect" chains are difficult to understand, predict, or manage, we still are somewhat

[18] I.e. to transport people and goods from A to B, to generate steam, or power, to provide access to information, to manufacture products, etc.

"familiar with this second level."[19] In contrast, at Level III technologies become similar to Earth systems, being not only complex and difficult to predict, but also "constantly changing and adapting." Transformative processes that emerge at this level from interactions with natural, social, and technological elements might become too complex to be even perceived, let alone be understood, managed, or redirected to more desirable directions (Allenby and Sarewitz, 2011, p.64).

Drawing on these theoretical approaches, I define social-technological systems broadly, as follows:

Socio-technological systems are cultural artifacts that embody heterogeneous social and technological elements, connected through a web of complex relationships. Their technological elements, meant to enhance individual abilities in carrying out certain human activities and mostly succeeding to do so, became inseparable from those who not only conceived them, but also steadily adjust to accommodate the technologies they have crafted, organizing their societies, their actions, and their very existence around the functionality the technologies provide. Socio-technological systems are caused by, and major drivers of, social and technological change.

Although I agree with Pinch and Bijker (1987, p.11) that socio-technological systems are social constructions, I am convinced that social elements do not always have the predominant role in shaping technological and societal change. In this context, I share Sarewitz's point of view, that "theoretical frames that do not acknowledge technology qua technology [] are missing a huge part of the story".[20] In addition, I subscribe to the

[19] At least, we talk about energy, food, transportation, or communication systems, and recognize these systems' capabilities and limits.

[20] Quote from a private e-mail exchange.

“taxonomy of levels of technological function” introduced by Allenby and Sarewitz to reduce the “confusion about … differences between toasters and nuclear weapons” (2011, pp. 36-37).

I fully agree with Hughes’s “technological momentum” concept, meant to resolve the dichotomy between technological and social determinism,[21] and with the actor-network theory developed by Callon, Law, and Latour (Bijker et al., 1987, p. 4). However, I am more inclined to use Hughes’s system metaphor than the egalitarian approach for animate and inanimate actors employed by actor-network-theorists, because Hughes’s metaphor distinguishes social systems “without technical cores” from “technological systems” with both technical and social components. I also prefer Hughes’s systemic approach because it allows us to see how social and technical elements alternate in playing the predominant role in different development stages of a socio-technological system.[22]

Despite my preference for the systemic view, my approach to large systems is still consistent with the actor-network theory and with Michael Callon’s prominent example of the Électricité de France (EDF) - Renault controversy in the 1970s. In that case, EDF technocrats envisioned a post-industrial France in which there would be only electric vehicles (VEL). To attain this vision, they appointed roles to animate and inanimate French actors,[23] just as the German government does in the *Energiewende* arena. For example, Renault, the largest French car manufacturer, was supposed to build only the car bodies for the electric vehicles, while other companies were responsible for developing and

[21] Hughes, 1994, reprinted in Johnson and Wetmore eds., 2008.

[22] While technically minded engineers, entrepreneurs, managers, and scientists have for example the predominant role during the creation-phase of a new socio-technological system, its social components (administrative bureaucracies and “white collar” managers) gradually overtake the predominant role, as the system matures. (Hughes, 1994, reprinted in Wetmore and Johnson eds., 2008, p.144).

[23] Citizens, government actors, technology developers and manufactures, batteries, manufacturing lines, etc.

manufacturing batteries and other VEL components. However, some of the components (e.g., toxic batteries) caused environmental or health problems, and the efforts to fix these unexpected outcomes significantly increased the costs for EDF's electric vehicle. Meanwhile, the first oil crisis (October 1973) led to economic stress in western economies (1973-1974) and created much more pressing tasks for the government than promoting EDF's electric-vehicle scheme. While these activities were unfolding, Renault continued perfecting its own conventional vehicles, so that they became less polluting and more attractive, and citizens completely lost interest in buying electric cars because they were too expensive. Thus, what once started as a bold plan, meant to propel the nation into a post-industrial age by unifying societal needs for mobility with the public's calls for environmental protection and the governmental desire to make decisions that resonated with a broad constituency, derailed and disappeared from public discourse.

EDF's vision of the post-industrial society, as presented in Callon's case-study about the launch of the electric vehicle VEL, is particularly interesting to me because of its striking similarity to Germany's vision of a carbon-free future. Paraphrasing Callon (Callon, in Bijker et al., 1987, p. 90), I would ask: Who could resist a movement that unified the citizens' desire to live in a better world with the political will to become carbon free, and the scientific promise of affordable green and nuclear-free energy? Furthermore, if I weren't convinced that there ought to be a reality behind every vision, to make it viable, I wouldn't hesitate to answer this question with Callon's words: "Nothing could stay in the way of this tidal wave" (Callon, in Bijker et al., 1987, p.90).

**Institutional Analysis**

The neo-institutional approach combines theories from economics and sociology to capture both rational and non-rational behavioral patterns. It emerged in the early 20st century with Max Weber's prominent contributions *Die protestantische Ethik und der Geist des Kapitalismus* (1904) and *Wirtschaft und Gesellschaft* (1921). Weber analyzed the historical factors that perturbed the equilibrium between different religious and secular organizations and was convinced that capitalism is rooted in Protestantism. Addressing markets and bureaucracies as major secular organizations, Weber argues furthermore that bureaucracies represent the most efficient institutional arrangements (Douglas, 1986, p. 91-94)). New institutionalism views on organized human activity consider that institutional arrangements emerge and evolve in an open environment. To survive in this environment organizations have not only to succeed from an economic perspective, but also to gain legitimacy. Many scholarly works addressed the influence of norms, rules, and organizations on human behavior influencing the neo-institutional thought. Along with particular research interests of individual scholars, and varying disciplinary approaches that influenced scholarly views on institutions, distinct sub-fields of neo-institutionalism (e.g. normative, rational choice, historical institutionalism) and new concepts (e.g. "logic of appropriateness," "bounded rationality," "path dependency") emerged.

The term "institution" has different meanings and competing interpretations. These include formal institutions, institutions as "ways of thinking" that impact human behavior, and institutions as sets of formal rules that prescribe economic behavior patterns.[24]

[24] This approach emerged in the early 20st century and is rooted in the works of Vilfredo Pareto ("Pareto-optimal" behavior, for example, is a term often used in game theoretical approaches, as for instance in more recent scholarly contributions of Elinor Ostrom in the realm of new institutionalism).

Several disciplines, like public policy, governance studies, medical science, and education have used the formal institution approach to analyze the implementation of policies in governmental and non-governmental organizations, administrative bodies, school boards, health agencies, etc.

The concept of institutions as "ways of thinking" emerged in the early 20st century in the realm of sociology studies, being associated with the works of Émile Durkheim (1915) and Ludwig Fleck (1935), who identified similar behavioral patterns in individuals bound to particular institutions, and "talked about institutions or social groups as if they were individuals" (Douglas, 1986). Mary Douglas, a social anthropologist, continued the functionalist tradition of Durkheim and Fleck. In her book *How Institutions Think* Douglas argues that different institutions promote different kinds of values and allow different kinds of thoughts, making our process of "thinking" significantly dependent on the institutions we create and/or identify with (1986). Douglas, Thompson and Rayner considered culture as "locus of all entanglements" between politics, technology, and social choice, and thus essential for analyzing the inchoate nature of these realms (Schwarz & Thompson, 1990, pp. 6). They developed a cultural theory by mapping the "myths of nature" identified by ecologists onto their "typology of social relationships" (Schwarz & Thompson, 1990, pp. 1-13; Douglas, 1978; Rayner, 2012).

A third approach to institutions – the rational choice one - emerged from evidence indicating that one society's economic output significantly depends on the institutions implemented by its members (Greif & Kingston, 2011, p. 13). Like the rational choice theory[25] that inspired it, this perspective on institutional analysis draws upon the idea that

[25] The theory of rational choice draws upon Adam Smith's idea that individuals who pursue their own interests optimizing their gains, are guided by an "invisible hand" to benefit the society (1776, p.26). It assumes that

social and economic behavior results from aggregated individual behavior. This does not necessarily mean that individuals always behave or choose their institutional arrangements rationally, but offers instead various theories, frameworks, and models for analyzing the kind of institutions actors select in given situations (Greif & Kingston, 2011, p.13). The rational choice approach to institutional analysis encompasses two complementary views: one defining institutions as "rules of the game in a society" (North, 1990, p. 3; Ostrom 2005) and one defining institutions as equilibria and claiming that the "expected behavior of others … induce people to behave (or not to behave) in a particular way" (Calvert, 1995; Greif & Kingston, 2011, p. 25).

While Douglas's cultural approach uses the term "institution" to mean organizations (e.g. companies, governmental bodies), the rational choice approaches of Douglass North and Elinor Ostrom view institutions as rules that constrain individuals to behave in a certain way. In contrast to Douglas, North defines organizations as "groups of individuals bound by some common purpose to achieve objectives" and to "take advantage of opportunities" in a society (1990, pp. 3-10). In his book *Institutions, Institutional Change and Economic Performance,* North emphasizes the importance of organizations as agents of institutional change as well as the symbiotic relationship between institutions and organizations (North, 1990).

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individuals who compete for scarce resources would make rational choices to optimize their economic output and implicitly contribute to the society's wealth. Smith's "invisible hand" metaphor set the foundations for free market economics, inspiring different schools of thought and successive generations of classical and neoclassical economists (e.g. "laissez-faire" economists like Ludwig von Mises and Friedrich von Hayek, as representatives of the Austrian School of Economics, or Frank Knight, Milton Friedman, and Ronald Coase from the Chicago School of Economics, but also proponents of Keynesian economics and market equilibrium theories, like Paul Samuelson, or ordoliberal economists, like Walter Eucken, or Franz Böhm from the Freiburg School of Economics). However, modern economists distanced themselves from the absolute rationality, because competition is far from being perfect, organizations tend to be large and complex, and there is always too little time to identify and evaluate all alternative outcomes, in order to select the best possible one. Decision makers have thus a "bounded rationality" acting rationally only within the boundaries of their incomplete knowledge (Simon, 1972; March 1978) or making biased judgments based on heuristics (Tversky & Kahneman 1974; Kahneman & Tversky 1979).

At the beginning of her seminal work on "governing the commons" Elinor Ostrom claims that to date neither states, nor markets, were successful over long periods of time in motivating humans to sustainably use common pool resources. She argues that several case studies offer empirical evidence about communities that seem to be more successful in governing scarce resources, without relying on state or market rules and regulations.

To uncover the limitations of state and market policy prescriptions in regulating resource systems Ostrom uses game-theoretical approaches to conceptualize three models often used to justify such prescriptions: (1) Hardin's "tragedy of the commons"(1968), (2) Tucker's "prisoner's dilemma" (Dawes, 1973), and (3) Olson's "logic of collective action"(1965). To maximize their short-term benefits, individuals tend to overuse the resource system and this behavior is eventually detrimental for all users.[26]

Several examples from the *Energiewende* arena indicate similar behavioral patterns. For example, in the late 1990s German wholesale electricity prices dropped under 3 Pf/kWh as a consequence of market deregulation and increased competition. In comparison Dutch wholesale power prices were at that time three to four times higher. This differential increased the demand for power exports from Germany to the Netherlands.[27] Many German utilities saw opportunities to enter new markets and increase their margins by offering Dutch consumers better energy contracts than they could have negotiated with Dutch utilities. Knowing that the technical transfer capacity between Germany and the Netherlands was

[26] The theory of maximum economics emerged in the early 20st century being rooted in the work of the Italian economist Vilfredo Pareto, the founder of modern microeconomics. This scholar considered that rational actors would behave in ways that allow the maximization of their economic benefits. Along with many other economists, Ostrom uses in her game theoretical approaches concepts like "Pareto-efficiency" or "Pareto-optimal behavior" that are rooted in the work of Vilfredo Pareto.

[27] Dutch consumers were interested in reducing their energy costs by importing cheap power from Germany, and German utilities saw opportunities to enter new markets and increase their margins.

finite and that the demand for German power is likely to exceed this capacity, German utilities applied for a much higher transfer capacity than they actually needed to fulfill their Dutch commitments. The rationale behind this behavior was that even if their request were proportionally reduced,[28] they would be allocated enough transfer capacity to fulfill their contracts. This non-cooperative behavior finally led to the situation that German utilities could deliver only a very small share of their Dutch contracts by transferring power from their own facilities, being instead obliged to buy locally expensive power at the Dutch power exchange (APX) to fulfill their commitments. At that time I worked for a large paper manufacturer with a production site in the Netherlands. We negotiated with a German utility a framework contract for the 100% delivery of all our European facilities (including the Dutch site). In the end, the German utility could deliver only 6% of our Dutch demand from Germany. Additional examples of non-cooperative behavior in the *Energiewende* arena are presented in Chapter 7.

Aiming to develop more appropriate tools for managing resource systems, Ostrom complemented her collective action models with "rules of the game" derived from empirical evidence about successful resource governance examples (1990). However, these alternative examples to state and market regulations all occur in isolated rural areas[29] in which people who have to share limited resources[30] not only know each other well, but also have a strong sense of community. In such "shame-and-blame" societies the defector, who does not comply with the unwritten rules of the group and overuses the scarce resource, would be excluded from the community. Whether such "shame-and-blame" constraints can be applied

[28] Because the total capacity demand was likely to exceed the technical available one.

[29] I.e. small irrigation systems, small fisheries, etc.

[30] I.e. water, fish, etc.

to guiding collective behavior toward desired ends in large, open, and anonymous urban areas, or for regulating large socio-technical energy systems remains undemonstrated; James Scott's systematic treatment in *Seeing Like A State* (1998) is not encouraging in this regard.

In her book *Understanding Institutional Diversity* Ostrom developed frameworks that illustrate the institution–as-rules approach and establish hierarchical levels of institutional analysis (2005). Ostrom's Institutional Analysis and Development Framework (IAD) and her Multi Level Analysis Framework were both very useful for structuring my research, analyzing the process of crafting rules, and understanding institutional change in the *Energiewende* arena.

I use the term "institution" to mean "prescriptions that humans use to organize all forms of repetitive and structured interactions" (Ostrom, 2005, p.3). I adapted Ostrom's IAD framework to fit Germany's integrated climate and energy policy, and applied multi-level analysis to capture relevant institutional settings and to provide a useful structure or taxonomy for analysis (i.e., to define the "participants," the "action situations" they face, the decisions they make, the rules and technologies they craft, and their interactions at different levels of analysis, which all together form a "system" in Hughes's sense).

Yet, given the complexity of large socio-technological systems and the "inchoate nature of politics, technology, and social choice" rational choice explanations sometimes reach their limits in accounting for "what is going on" in particular action situations (Schwarz & Thompson, 1990, p. 2.). Although the inclination of major *Energiewende* actors to "game the system" seem to directly descend from the theoretical works of Ostrom, North, and Anderies on governing common pool resources, these scholarly contributions are less well suited to grasp the dual nature of large German utilities,[31] or inherent contradictions embedded in expert answers to my interview questions. That is why, I also use culture-theoretical approaches to "analyze the inchoate," to explain why outcomes matter sometimes less than the blind compliance with outdated rules, or to understand how actors in the *Energiewende* arena deal with "wicked problems," and "unconfortable knowledge."[32]

These approaches consider culture as "the essence […] through which politics, technology, and social choice are all dissolved into one another" and unify concepts from social and natural sciences (Schwarz & Thompson, 1990, p. 2). The ecologist C. S. Holling noted that actors who manage ecosystems (i.e. fisheries, forests, and other natural resource systems) adopt their strategies according to their interpretation of ecosystem (1979, 1986, 1995). To explain the diversity of these views, Holling advanced a framework based on four "myths of nature" (nature benign; nature ephemeral; nature perverse/tolerant; and nature capricious) and represented them using a ball in the landscape (see Figure 1).

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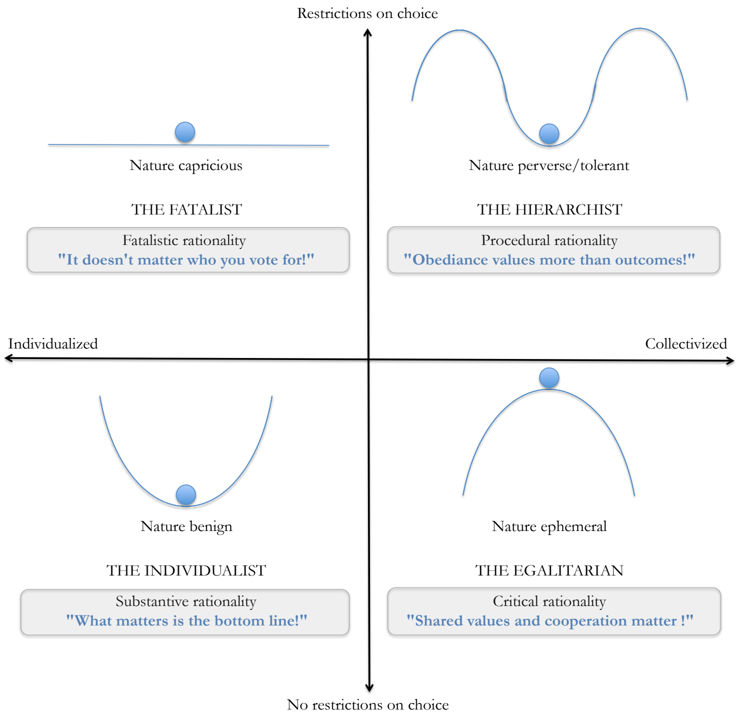
[31] As Schwarz and Thompson note in "Recognizing and Analyzing the Inchoate" large corporations, and as such large German utilities, "face outwardly towards markets" but "tend to be strongly hierarchical" within themselves (1990, p.11).

[32] In his article "Uncomfortable knowledge: The social construction of ignorance in science and environmental policy discourses," Rayner notes that individuals and organizations try to make sense of the complex world in which they act by using simplified models. To make sure that these models remain self-consistent individual and collective actors develop strategies to expunge "undesirable knowledge" – i.e., knowledge that contradicts their simplified versions of reality (2012). Despite evidence indicating that Germany's efforts are insufficient for meeting the nation's decarbonization goals and despite their very critical views about Energiewende processes, most experts I interviewed support Germany's energy transition and are confident that this bold experiment will succeed. In Chapter 8, I use Rayner's strategic categories to understand apparently irrational behavior of Energiewende actors, and to analyze how these actors "keep uncomfortable knowledge at bay"(Rayner, 2012).




Schwarz and Thompson mapped the four "myths of nature "proposed by Holling (1979, 1886) to study ecosystems onto the typology of social relationship, rooted in the work of the anthropologist Mary Douglas (1978, 1986).

Figure 1 - Myths of nature mapped onto cultural rationalities (own representation inspired by Schwarz & Thompson, 1990, p.9)

The typologies of social relationship that correspond to Hollig's "myths of nature" are:

- The individualist, guided by his "substantive rationality." He considers the nature "permissive" and his impact on ecosystem insignificant - a typical behavior for enterprises operating on the free market and trying to maximize their profits;
- The egalitarian, guided by his "critical rationality." He considers the nature as "ephemeral" and every impact on ecosystems as disastrous - a typical behavior for environmentalists and members of the Greens, for whom shared values and cooperation are important;
- The hierarchist, guided by his "procedural rationality". He considers the nature alternatively "perverse and tolerant" and values the compliance to rules more than

the economic benefits – a typical behavior for governmental actors and strongly hierarchical organizations; and

- The fatalist, guided by his "fatalistic rationality". He considers the nature as "capricious" and his behavior irrelevant for the system– a typical behavior for people who refuse to vote.

I use these cultural categories as means for understanding conflicting perceptions, diverging rationalities, and apparently irrational choices in complex socio-technical systems.

### Innovation Policy

My research project examines and questions the efforts to guide, manage, or direct change in large and complex socio-technological systems. The heterogeneous literature on this subject encompasses various theoretical concepts from academic contributions in economics, political science, sociology, history, and other social sciences. These concepts reach from (1) the linear and unidirectional conversion of findings from basic research to practical ends and societal welfare, also known as the "postwar paradigm,"[33] to (2) theories of induced technical change,[34] which consider demand and other economic factors as drivers for technological change, (3) evolutionary theory,[35] in which markets are responsible for technological advancement, (4) path dependence theories,[36] and (5) theories of revolutionary change[37] that imply fundamental changes in power structures, organization forms, and

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[33] Stokes, 1997; Kevles, 1995; Sarewitz, 1996; Bijker & Pinch, 1987; Ruttan, 2006; etc.

[34] Schmookler, 1966; Thritle & Ruttan 1987; Walsch 1984; Ames & Rosenberg, 1968 (as quoted in Ruttan, 2006, p. 9).

[35] Nelson and Winter, 1982 (as quoted in Ruttan, 2006, p.11).

[36] Bryan Arthur, 1983 & 1994, Paul David, 1985 (as quoted in Ruttan ,2006, p. 12).

[37] Karl Marx, 1948 & 1942; Uscher, 1929; Schumpeter, 1939 & 1942, Ruttan (as quoted in Rosenberg, 1982, pp.5-8, and Freemann & Louça, 2002, pp.143-144).

institutional settings within a short period of time. Many scholars have written about the entanglements among science, industry, and the hidden hand of the government in the aftermath of World War II, emphasizing that major technological paths were determined by the governmental support for military research and development. Prominent examples of this literature are Ruttan's book, *Is War Necessary for Economic Growth?* (2006, Chapter 4, pp.69-86) and many of the essays published in the collection *State of Innovation*, edited by Fred Block and Matthew Keller (2011). Some contributions, such as Andrew Schrank's essay, *Green Capitalists in a Purple State: Sandia National Laboratories and the Renewable Energy Industry in New Mexico*, and Fred Block's *Innovation and the Invisible Hand of Government*, both describe governmental interventions in an era of market fundamentalism. These essays, as well as Freeman and Louçã's *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, prompted me to ask questions related to the "viability" of innovations and the general dilemma of what we ought to do with our energy systems; answers to these questions are presented in more detail in Chapters 7, 8, 9.

In the essay collection, *Misunderstanding Science? The Public Reconstruction of Science and Technology*, edited by Irwin and Wynne (1996), as well as in a series of other valuable contributions (Wynne, 1998; Winner, 2010), scholars suggest that broad citizen participation would improve the outcomes of decision-making processes related to large socio-technological systems. However, as the German energy transition experiment and Callon's EDF-Renault controversy show, decisions based on a broad societal consensus do not necessarily lead to desired outcomes, nor are the social costs related to these outcomes necessarily broadly acceptable to the citizenry.

In *Seeing Like a State*, J.C. Scott uses various historical examples from around the world to describe how different utopian governance schemes meant to "improve human condition" failed. The author argues that these failures were caused by "pernicious" circumstances that linked the state's efforts to subordinate its subjects, its "highly modernist ideology," and its "authoritarian" governance mode with a "prostrate civil society" unable to oppose its plans. In its attempt to make a society "legible," the hierarchical state arranged its citizens and its territories "in ways that simplified taxation, conscription, [and] rebellion prevention," by collecting census data, mapping land properties, imposing standardized measurement units, or laying out streets to suppress riots and other forms of opposition to government control (Scott, 1998).

Although Scott was focused mostly on authoritarian governments, his conclusions apply more broadly in that all classification and standardization efforts in ancient and modern societies are tightly related to governance processes and are "means to construct realities of ordering things and people to produce desired outcomes" (Busch, 2011, p. 13). They are "invisible" entities until "they break down and become the subject of dispute." Classifications imply, furthermore, "ethical choices" between concurrent points of view, bear the risks of colliding definitions, and have many undesired consequences (Bowker and Starr, 2000, pp. 1-5). As some real-life examples from the German Renewable Energy Act (EEG) demonstrate, inaccurate definitions (i.e., different and context-dependent capacity definitions, incoherent and illogical biomass classifications for renewable bonuses, diverging cross-references, etc.) can have significant financial consequences for actors involved in the *Energiewende* arena, can result in market distortions, and can even operate against legislators' intentions.

## CHAPTER 3

## METHODOLOGICAL APPROACHES

I used mixed qualitative and quantitative research methods within a pragmatic theoretical frame to create knowledge about steering socio-technical energy systems in desired directions. The reason for mixing methodological approaches lies in the dual nature of energy systems (social and technical) and in the fact that the two components mutually influence each other, making it impossible to explore energy transitions by selecting only one approach without losing significant information. The mixed-methods approach enabled me to generate descriptive-analytical, normative, and instructional knowledge about energy transitions at different spatial scales (national, European, global) and temporal perspectives (past, present, future). I collected qualitative and quantitative data simultaneously. To synthesize qualitative and quantitative information and provide a comprehensive analysis of the *Energiewende* processes, I applied data-triangulating procedures.

Table 1
Knowledge Matrix

<table>
<tr><th>Knowledge</th><th>Descriptive -Analytic</th><th>Normative</th><th>Instructional</th><th>Germany's Energy Transition Experiment<br>A case study about guiding decisions and governing change in large socio-technical systems</th></tr>
<tr><td>Past</td><td rowspan="2">1a)<br>Analysis of Germany's energy transition Experiment in European and global context</td><td rowspan="2">1b)<br>Appraisal of Germany's energy transition Experiment in European and global context</td><td></td><td rowspan="3">1) Analysis & appraisal of Germany's energy transition in European and global context (past/ current state)<br>- anti nuclear movement/ vision CO2 free future<br>- the actors in the Energiewede arena, their relationships, & the 'legal' free ride problem<br>- key drivers of change, rules-in-use, institutional settings & the evolution of the energy system<br>2) Evaluation of the transition pathways (future)<br>- strengths/limits of alternative pathways<br>- public value mapping & policy evaluation<br>3) Lessons to learn / Recommendations<br>- how to guide change & avoid adverse effects</td></tr>
<tr><td>Present</td><td></td></tr>
<tr><td>Future</td><td></td><td>2)<br>Evaluation of the transition pathways</td><td>3)<br>Lessons to learn about governing change Recommendations</td></tr>
</table>

The knowledge matrix presented in Table 1 shows my three main research phases and correlates each phase with the form of resulting knowledge and the temporal and spatial scales. In the first phase I applied analysis (1a) and appraisal (1b) procedures to generate descriptive-analytical and normative knowledge about Germany's *Energiewende* for the past and the current state. Next, I evaluated the chances that the *Energiewende* will attain its goals in future, as well as its strengths and limitations in comparison with alternative pathways (2). In the third phase I evaluated the conclusions I drew from the first two phases to derive lessons about directing change and recommendations for further development, thus generating instructional knowledge (3) for future energy transition efforts.

I started my work by collecting qualitative and quantitative information about major action situations and relevant variables that characterize them (i.e., participants, positions, potential outcomes, action-outcome linkages, control exercised by participants, types of information generated, costs/benefits assigned to actions/outcomes (Ostrom, 2005, p. 14)). To collect this data I used a combination of document analysis, literature review, and direct observation of participants in the *Energiewende* arena. I made some of these observations while working as energy manager in various sectors of the German economy, including one of the largest European utility groups. My activities included energy trading, power-plant optimization, risk management, and CO2 cap-and-trade activities at sites in many European countries. Throughout my career I managed, represented, collaborated, or negotiated with diverse stakeholders in the German and European energy sectors.

I also conducted fieldwork as a graduate student while still working in the German energy industry. I carried out 30 unstructured and open-ended in-depth interviews with major stakeholders in the German *Energiewende* arena. I recruited interviewees with practical expertise and theoretical knowledge in the German energy sector to complement my own professional experience. The clusters of targeted participants corresponded to the major actor categories defined and described in detail in Chapter 5 (see Figure 4). A representative sample of interview questions is attached in Appendix A. I narrowed down this sample during the interviews by tailoring specific questions according to the expertise of each participant. Interviewees were invited to skip questions that they perceived as uncomfortable or delicate with respect to their positions. I audio recorded, transcribed, and translated the interviews. In some cases participants sent me the answers and/or additional comments via email. To protect the participants' identity and to ensure their anonymity, I employed codification and data separation techniques, and restricted access to collected data to myself. To ensure data diversity and representativeness, I carried out a minimum of three interviews for each sub-category of a participant cluster. The Institutional Review Board at Arizona State University approved all data-collection and -handling procedures.

After completing the data collection, I sorted data according to diversity, relevance, and consistency criteria and conducted, as needed, follow-up interviews to eliminate inaccuracies and ensure criteria compliance.

Next, I interpreted and evaluated the collected data. I sorted process causalities and related power dynamics chronologically to create a basis for historical analysis. I interpreted, analyzed, and evaluated the chronologically ordered data by successively applying process and discourse tracing techniques. Then I compared and contrasted the successive action situations that took place in the *Energiewende* arena during all its phases.[38] I applied historical analysis to describe how Germany's energy-transition experiment unfolded and evolved. Next I investigated the tensions resulting from diverging scientific recommendations, by identifying economic and technological biases in the *Energiewende* literature and analyzing

[38] I.e., from the environmental movements that marked its beginning and created a favorable terrain for envisioning a carbon-free future (Phase I - Birth of a Vision), to the institutionalization of this vision (Phase II), and its current proof-of-concept (Phase III) (see Capter 6, Figure 6).

how these biases influenced the political process. I applied institutional analysis[39] to capture the organizational settings and the power dynamics that triggered their historical evolution. To create a basis for evaluating the different innovation theories, I categorized their roles, their main concepts, their strengths, and their limits; I used the same process to analyze the various energy-related innovation policies implemented in Germany since the 1990s and to evaluate their strengths and limits in comparison with alternative policy options. I used my multi-faceted experience in the German and European energy arena to evaluate the *Energiewende* policies and their consequences. I evaluated public policies not only by examining their social and economic impacts, but also the norms and value of the people affected by the *Energiewende* policies,[40] to show how Bozeman & Sarewitz's "Diagnostic Model for Public Policy" (2011) can be adjusted to evaluate the energy policy realm through a public-value lens (see Appendix B). However, my work on the *Energiewende* shows that the simple act of mirroring public values in one particular policy might be desirable and legitimate yet does not guarantee success.

Finally, I synthetized my research findings into lessons that can be learned from this unique transition experiment and concluded my study with recommendations for future energy-political decisions.

While completing my research I often came across interesting inconsistencies in interview responses. Almost all participants addressed in a very critical manner the exponential increase in *Energiewende* costs, Germany's poor GHG mitigation results, and the still-missing technological breakthrough that might make it possible and economically feasible to store power at a large scale and to level intermittent power generation based on

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[39] Elinor Ostrom's IAD Framework (see Figure 4), and Multi-Level Analysis (see Figure 5).

[40] Public values are "instrumental for justifying the political action"(Bozeman & Sarewitz, 2011, p.1).

renewables. At the same time, many of these participants were not only ardent *Energiewende* supporters, but also convinced – against all the evidence to the contrary that has accumulated during the past three decades - that Germany will meet its decarbonization goals and maintain its economic wealth. Given that I interviewed only individuals with *Energiewende* expertise, and due to the fact that interviewees could skip all questions that either conflicted with their professional interests, or were outside their area of expertise, this intriguing and recurring behavioral pattern can neither be explained by the participants' lack of knowledge, nor ascribed to a deliberate intention to twist reality. I tried to make sense of this strange and unexpected phenomenon using cultural theoretical approaches developed by Schwarz and Thompson (1990), and Rayner (2012). I suggest different possible explanations for the described behavior. These explanations are hypothetical and further research is needed to confirm or reject my suggestions.

# CHAPTER 4

# THE ENERGIEWENDE FRAMEWORK

This chapter explores the unique patterns of the *Energiewende* framework in comparison with elements of other governance frameworks for large energy systems. I describe in it the goals of the *Energiewende* and the laws, regulations, and directives (henceforth, "rules") that were implemented to accomplish them. I discuss how the rules are enforced and how they interact with society, the economy, and the environment. I analyze the outcomes that these rules were intended to achieve, how the rules relate one to another and to the European rules, and which alternative rules could have been crafted. I examine the strengths and limitations of each policy alternative (i.e., taxation, funds, quotas, or self-commitment models vs. feed in tariffs). Finally, I identify potential transition-governance barriers and suggest ways to understand and overcome such hurdles.

Liberalization and deregulation of the electricity industry in Germany and Europe was similar in many ways to deregulation of energy access and breaking the natural monopolies formed by electricity grids in the US (as described by Hirsh, 1998, 1999). And the EU Emission Trading System (ETS) has much in common with the US acid-rain program described by Ellermann (2000). However, Germany's policies to rapidly phase out its nuclear facilities in the wake of the Fukushima accident while simultaneously aiming for a zero-carbon economy remain unique worldwide.

## The *Energiewende* Framework: Goals, Rules, Enforcement

A complex regulatory and policy framework underpins the German Energiewende. The framework, and all the political decisions that inform and/or change it, provide the long-term goals, rules, opportunities, constraints, and pathways that govern how Germany's energy and climate experiment unfolds. An overview of the quantitative *Energiewende* targets for 2020-2050 and the current status quo[41] can be seen in Table 2 (BMWi, 2016c, p.4; BMWi, 2016d, p.7). Beyond quantitative targets, Germany pursues a series of qualitative objectives, policies, and regulatory measures that impact the *Energiewende* outcomes, such as: securing the nation's energy supply and the affordability of the entire transition process; phasing-out all nuclear power plants; maintaining the competitiveness of domestic industries, economic growth, wealth and prosperity; expanding the transmission and distribution grids required to meet demand; unlocking sector coupling, digitalization, and innovation potentials; and harmonizing European energy and climate policies (BMWi, 2016c, p.5; BMWi, 2016d, pp.5 and 8).

The formal goal of the *Energiewende* is to reduce Germany's greenhouse gas (GHG) emissions by 80 to 95 percent by 2050, without relying on nuclear power, while maintaining secure and affordable energy access (see Figure 2, line 1 – Political level, and Table 2). This ambitious goal is to be achieved with two strategies (see Figure 2, line 2 – Strategic level): (1) promoting the deployment of renewable energy so that it makes up at least 60 percent of the nation's gross final energy consumption by 2050, and (2) increasing energy efficiency to cut gross final primary energy consumption in half by 2050 compared to 2008 levels. These targets are in turn divided into quantitative sub-targets for the electricity, heating, and transport sectors (see Figure 2, line 4 – Steering level). A plethora of laws, ordinances, incentive programs, and institutional arrangements have been or will be implemented to achieve the intended results for each sector (see Figure 2, line 5 – Tool Matrix, and Figure 3).

[41] The most recent official figures refer to the reporting year 2015.

Table 2
Quantiatative *Energiewende* Targets

| Greenhouse Gas Emissions | Reference Year | Status quo 2015 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| All economy sectors | 1990 | -27.2% | -40.0% | -55.0% | -70.0% | -80 to -95% |
| **Renewable Energy** | **Reference Year** | **Status quo 2015** | **2020** | **2030** | **2040** | **2050** |
| Share of gross final energy consumption | - | 14.9% | 18.0% | 30.0% | 45.0% | 60.0% |
| Share of gross electricity consumption | - | 31.6% | 35.0% | 50.0% | 65.0% | 80.0% |
| Share of heat consumption | - | 13.2% | 14.0% | | | |
| Share in transport sector | - | 5.2% | 10.0%* | | | |
| **Efficiency** | **Reference Year** | **Status quo 2015** | **2020** | **2030** | **2040** | **2050** |
| Primary energy consumption | 2008 | -7.6% | -20.0% | → | → | -50.0% |
| Final energy productivity | 2008 | 1.3%/year average 2008-2015 | 2.1% / year | | | |
| Gross electricity consumption | 2008 | -4.0% | -10.0% | → | → | -25.0% |
| Heat consumption in buildings | 2008 | -11.1% | -20.0% | → | → | -80.0% |
| Final energy consumption in transport | 2005 | 1.3% | -10.0% | → | → | -40.0% |

*Data source: Fifth 'Energy Transition' Monitoring Report: The Energy of the Future (BMWi, 2016c, p.4; BMWi, 2016d, p. 7). The most recent official figures refer to the reporting year 2015 (status quo).*
** Target of the European Directive EC/28/2009.*

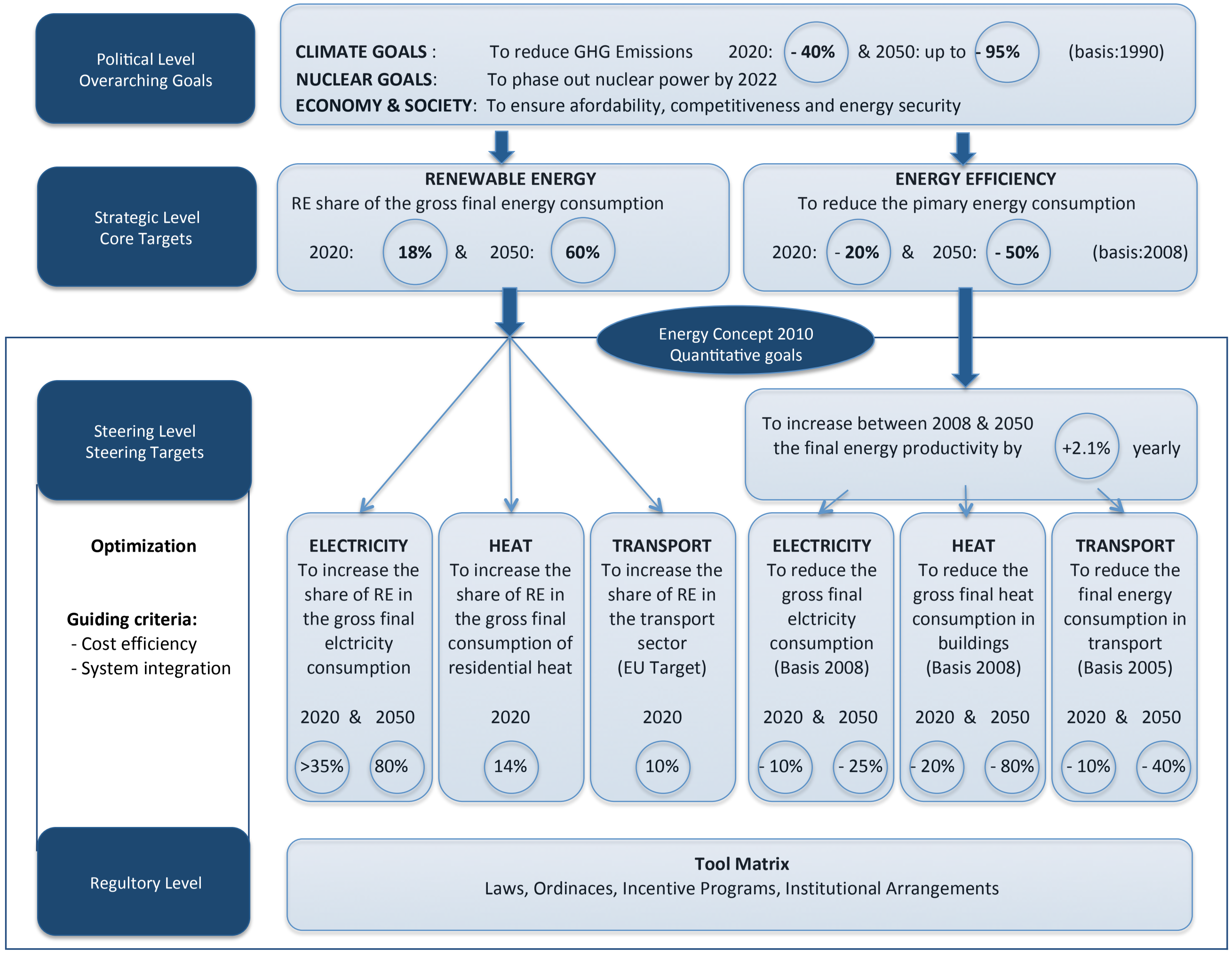


Figure 2. *Energiewende* goals on the political, strategic, steering, and regulatory level

*Data Sources: Germany's Energy Concept (Schleisinger et al., 2010), Vierter Monitoring-Bericht zur Energiewende, (BMWi, 2015) Own representation with qualitative and quantitative Energiewende Targets for 2020 and 2050, inspired by Figure 2.1, p.9 (BMWi, 2015)*

## The Convoluted *Energiewende* Tool Box

At the core of the *Energiewende* is a succession of interrelated laws and regulations that aim to: deregulate energy markets, promote REs, support combined heat and power production for local utilities and industrial sites, establish a carbon-emission trading system, and decommission the nation's nuclear power plants (see Figure 2, lines 1- 5). Other policy instruments include measures to increase energy efficiency in buildings; stimulate deployment of electric vehicles; import RE from European, Middle-Eastern, and North-African countries; and begin to explore and implement visions of a future hydrogen economy. Most of the costs of the *Energiewende* are paid directly by energy consumers. This is a significant policy change from previous German energy programs (for hydroelectric, nuclear, and fossil-fuel power projects), which were typically financed from general government funds[42].

The raft of intertwined and interdependent legislation and policies has appropriately been termed an "integrated energy and climate program." But it is so complex that individual policies do not act, and cannot be understood, in isolation and often have consequences that go far beyond what was intended, as we will see below.

## Deregulating Germany's Energy Markets

The Energy Economy Act (*Energiewirtschaftsgesetz* or EnWG) and its related ordinances are the backbone of all *Energiewende* instruments, because almost all other energy regulations refer to specific EnWG stipulations. The EnWG was enacted in 1935 to create the basis for an affordable and secure energy supply for the German people. Hitler wanted

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[42] However, a program that preceded the *Energiewende* - the so-called "Kohlepfennig" - was also directly financed by consumers. According to this program each electricity consumer had to pay between 1974 and 1995 a surcharge of 1 Pfennig (about 0.5 € cent) for each kilowatt-hour of electricity consumed for subsidizing electricity generation based on domestic hard coal.

energy supply disaggregated for security reasons. Therefore, local or regional authorities enabled, in their zones of influence,[43] a particular utility to carry out all energy-related activities,[44] thereby protecting utilities from destructive competition. The law remained in force with only minor changes for more than six decades (Kehrberg, 1997).

The Energy Economy Act was adjusted in 1998, 2003, 2005, 2008, 2011, 2012, 2014, 2016, and 2017 to allow competition in grid-bounded energy markets[45] and to comply with European Union directives for deregulation of these markets (Figure 2, Line 1). Grids always create natural monopolies because only utilities are allowed to build new lines to connect with grids, and consumers must be connected to these grids.

The EnWG 1998[46] abolished the demarcation contracts that defined the regional monopolies of electric utilities, unbundled energy trading and supply activities from grid-related ones,[47] and defined the rules for third-party access to the electricity grids. This means that vertically integrated electric utilities had to move their grid operation activities into new legal entities that allow non-discriminatory[48] access to their grids to other market participants (third parties) (EnWG 1998; Maubach, 2014, pp. 51-78; Baur et al. 2015). The EnWG 2003

[43] Mostly areas delimitated by the borders of a city, but also larger regional and trans-regional areas.

[44] Mostly distribution, and supply of energy, but some cases also energy generation, and even fuel extraction.

[45] Electricity and natural gas are transported and distributed through grids (i.e., they are grid-bounded). Energy transport and distribution grids build natural monopolies. To establish energy markets starting from a monopoly structure requires repealing contracts that protect utilities from destructive competition and establishing rules that enable third parties (consumers, independent traders, and independent power producers) to access the natural monopolies that still remain (grids).

[46] Also known as EnWG 1. – the first structural change of the EnWG since 1935 (i.e., from demarcated to deregulated markets).

[47] Electricity transmission and distribution.

[48] The newly established electricity transmission and distribution firms were not allowed to grand privileged grid access to trading companies that were previously part of the same integrated utility. They had to treat all market players, including their former colleagues, equally.

extended the rules of EnWG 1998 by defining rules for access to the natural-gas grids. (EnWG 2003; Maubach, 2014, pp. 101-118; Baur et al. 2015)

In early phases of deregulation[49], Germany opted for a negotiated third-party access (NTPA) to the energy grids. Instead of being enacted by the legislature, as in the case of regulated third party access (TPA), grid access rules were negotiated between associations representing the interests of different market players (utilities, energy consumers, as well as new energy traders and suppliers).[50] The results of these negotiations – the association agreements, or *Verbändevereinbarungen* (VV) - defined all rules for accessing electricity and natural gas grids.[51] In 2004, negotiating parties suspended their proceedings,[52] as they were unable to agree about the further development of the access rules for natural-gas grids. The government responded to this failure by enacting the EnWG 2005, which stipulated the regulated third party access (TPA)[53] to energy grids. The EnWG adjustments in 2008 and 2011 translated new European regulations, such as the deregulation of the metering business

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[49] Between 1998 and 2005. Deregulation started in 1998 for electricity markets and in 2000 for natural-gas markets. As consequence of the failed negotiations for the third natural-gas-association agreement (VVGas III), Germany decided for a regulated third-party access (TPA).

[50] Including VIK (*Verband der Industriellen Energie- und Kraftwirtschaft e.V.* – Association of the Industrial Power Generation and BDI (*Bundesverband Deutscher Industrie* e.V.– Federal Association of German Industry) as representatives of energy (power and gas) consumers, and VDEW (*Verband der Elektrizitätswirtschaft e. V.* – The Association of Electric Utilities) and VKU(*Verband kommunaler Unternehmen e.V.* – Assiociation of Communal Enterprises) as utility representatives for the deregulation of the power market, and BGW (*Bundesverband der Gas- und Wasserwirtschaft* e.V.– Federal Association of Water and Natural Gas) and VKU for the deregulation of the natural gas markets. Throughout the successive negotiations additional associations representing traders, small consumers, and grid owners adhered to these parties (see also Chapter 6).

[51] These rules were binding for market players. They defined responsibilities of the parties, the number of balancing areas, technical requirements for the grid access (grid codes), mechanisms for calculating the grid access fees and distributing the costs, allocation rules for limited capacities, etc. Because it delegated the process of crafting rules to market players, the legislator considered all grid owners that complied with VV rules as acting in "best practice." However, the legislator had no means to correct rules negotiated between the parties, even if they discriminated some categories of market participants against others.

[52] For the third association agreement for the deregulation of natural-gas markets (VV Gas III).

[53] By withdrawing NTPA ad opting for TPA the government finally aligned with the access rules selected by the other member states of the European Union.

and the access rules to gas storage facilities, into national law. More recent EnWG amendments in 2012, 2014, 2016, and 2017 aimed to increase the transparency of energy markets, to digitalize the *Energiewende*, to design the electricity market, to establish an energy auction system, and to redefine the EEG-feed-in tariffs based on renewable energy auctions. As we will see in Chapter 7, the deregulation of the energy markets and the non-discriminatory and transparent rules for accessing energy grids, fundamentally altered the structure of the German utility industry and the way of doing business in the energy sector.

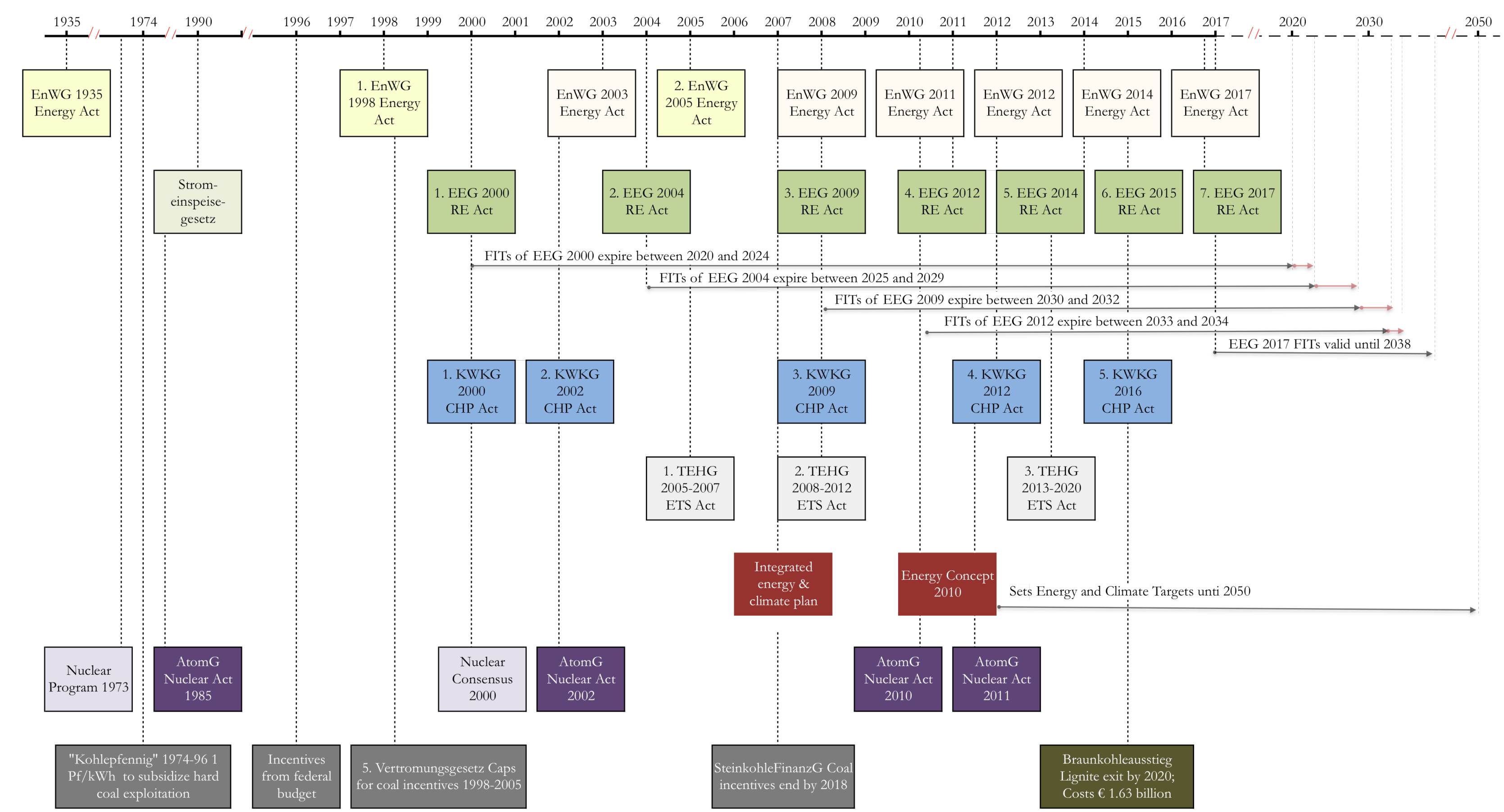


Figure 3 - Germany's integrated energy and climate legislation

**Ramping up Renewable Energy Technologies and Reinventing the Energy System**

No other instrument from the convoluted policies in the *Energiewende* toolbox has contributed more to Germany's impressive results in ramping up RE production than the successive RE acts, known as the EEGs (*Erneuerbare Energien Gesetz*), of 2000, 2004, 2009, 2012, and 2014, and 2016 (effective in January 2017). Each EEG defines the conditions for incentivizing and connecting RE facilities to the grid, as well as the level of feed-in-tariff (FIT) for each RE source—wind (on- and off-shore), solar (rooftop and large-scale), biomass (liquid, solid, and gas), geothermal, hydropower, and waste gases (landfill, sewage, and pit gas) (Salje, 2015). In contrast to all prior EEG versions, the EEG 2017 is not based on fixed and predefined FITs. These are instead established in an auction process, implemented to solve some undesired consequences[54] of the prior renewable energy acts that I will discuss below. (When I refer to EEGs in this study without specifying the year in which the act became effective, I am referring generally to the renewable energy acts of 2000, 2004, 2009, 2012, and 2014.[55])

The EEGs require grid operators (the electric utilities) to connect, on demand, any RE facility to their grid, and to do so in a way that minimizes the connection cost for the facility owner.[56] RE facility owners then receive from the grid operators generous payments based on the feed-in tariff for each kilowatt-hour of electricity fed into the grid. The relevant

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[54] For example, too-long adjustment cycles of tariffs to the learning curve of RE (i.e., too-generous FITs), or extreme burdens on the power grid.

[55] The new auction mechanism and the stipulations of the EEG 2017 are fundamentally different from prior versions. Since my work addresses Germany's efforts to steer its energy systems in desired directions, I do not completely exclude the EEG 2017 from this work. However, my primary focus is not on this particular act.

[56] This means that the connection criteria do not depend on the optimal connection point for the grid owner, but for the RE operator (i.e. the point leading to the lowest possible direct connection costs for the RE site). Additional investment costs (for example for stabilizing the grid) are not paid by the RE operator, but socialized and eventually recovered from all power consumers connected to the grid.

FIT[57] for any given RE site is fixed over 20 years and corresponds to the payment level valid at the moment of the facility's initial operation.[58] Because the FITs enacted by each EEG are reduced over time, the sooner RE owners can bring a facility online, the higher the FIT will be over the fixed 20-year period—which incentivizes rapid RE deployment. The EEGs also reduce the risks of RE ownership to almost nothing, because even if the grid operator shuts down a renewable facility due to grid instability problems, the FIT has to be paid as if feed-in from the facility were ongoing. Therefore interruptions induced by grid operators usually lead to a higher financial EEG burden than continued production.

As a consequence of generous subsidies and nearly nonexistent entrepreneurial risks the EEGs attracted many investors, the renewable energy business boomed, and fundamentally changed Germany's energy systems. However, as we will see in Chapter 7 the intensive deployment of renewable energies led to price distortions, exploding costs, grid bottlenecks and stability problems, forced exports, and negative electricity prices. While trying to fix imperfect stipulations of previous versions, each new EEG became increasingly complicated, offering some actors many opportunities to make short-term[59] profits on the back of other, less privileged ones.

In addition, successive Bio-Fuel[60] and Renewable Heat Acts (EEWärmeG)[61] were enacted, amended, and enforced to encourage the use of RE sources in the transport and heat sectors. These regulations had a rather modest contribution to climate mitigation goals.

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57 See some examples of how FITs are calculated in Appendix C.

58 Very simplified, this means that each RE site has its own FIT, but this FIT remains fixed for 20 years.

59 Such windows of opportunities regularly last until the law amendment, i.e. as long as loopholes in the legislation were not yet closed.

60 The Bio-Fuel Quota Act (BioKraftQuG) entered in force in 2007, obliging oil companies to mix an increasing share of bio-fuels in the regular fuels used in the transport sector. In 2009, a new incentive

**Germany's Nuclear Twist**

The rules for the peaceful use of nuclear power in Germany are anchored in the Nuclear Act (Atom Gesetz, or AtomG).[62] To reduce Germany's dependence on oil imports in the wake of the first oil crisis, the Willy Brandt's government presented in 1973, during Chancellor Willy Brandt's regime, an extensive nuclear deployment program (see Chapter 6; Deutscher Bundestag, 1973, p.10; Schiffer, 2017, p. 3; Schaaf, 2000; Appendix D). Continued and adjusted during the Schmidt and Kohl administrations this program and the subsequent nuclear acts led to today's existing nuclear power-plant infrastructure. But, as we will see in Chapter 6, major nuclear accidents (Three Mile Island, 1979 and Chernobyl, 1986) increased the nation's anti-nuclear mood and resulted in a cessation of further deployment of nuclear power during Kohl's administration.

If, as will be discussed further in chapter 7, the EEGs have introduced significant price distortions onto the German energy scene, a second major policy change—the phasing out of nuclear power—makes the role of REs even more complex. In 2000, shortly after enacting the first regulations for promoting RE and combined heat and power generation,[63] former German Chancellor Gerhard Schröder signed a nuclear phase-out agreement with the German utility industry (BMWi, 2000-2.). The political motivation for the phase-out was not climate change, but the anti-nuclear position of the Green party, which was part of

mechanism, that considers the differences in the GHG mitigation potential of different bio-fuels, was enacted. The goal of this law is to meet a reduction of carbon emissions in the transport sector of 10% (basis 1990).

61 EEWärmeG was enacted in response to the German Integrated Energy-and Climate Program of 2007. It entered into force in 2009 and had the purpose to increase the use of RE in the heat sector to 14 % by 2020 (basis year 2008). About 50% of the nation's gross energy demand is used in the heat sector, but only 12.9% of it is currently based on RE sources (UBA, 2018).

62 In 1960, Germany's first AtomG entered into force. The act had the goal of developing different nuclear technologies suitable for the peaceful use of nuclear power.

63 EEG 2000, KWKG 2000.

Schröder's ruling coalition at that time.[64] The nuclear phase-out was accompanied by policies to protect the decidedly not-green use of cheap domestic lignite and subsidized domestic hard coal—the most carbon-intensive fossil fuels—to protect jobs, reduce energy imports, and help preserve energy security as Germany moved away from nuclear energy (BMWi, 2000-1).

This political and policy calculus changed as climate change became an increasingly important policy priority. In 2007, German Chancellor Angela Merkel's first administration[65] decided to merge Germany's energy and climate policies into an integrated action plan to reduce GHG emissions by 36.6% from 1990 levels by 2020 (UBA, 2007). Three years later, Merkel's second government[66] upped the decarbonization goal to at least 80% emissions reductions by 2050, and presented the first integrated roadmap to carbon neutrality. To make it possible to achieve this ambitious target, the roadmap included a postponement of Schröder's nuclear phase-out, extending the life-span of existing German nuclear facilities by up to 14 years[67] (Schleisinger et al., 2010; Nuclear Act, 2010). The rationale was that nuclear technologies are nearly carbon-free, have a high energy intensity, cover about 60% of Germany's base-load power, and can not only help meet higher decarbonization rates, but

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[64] This process started before the European Union ratified in 2002 the Kyoto Protocol and Germany committed itself within the EU15 – Burden-Sharing-Agreement to reduce its carbon emissions until 2012 by 21% (UNFCCC, 2002).

[65] A black-red coalition government under joint Christian-Democratic and Social-Democratic leadership.

[66] A black-yellow coalition government under joint Christian-Democratic and Liberal leadership.

[67] This decision was based on the recommendations of a long-term research project developed by Schleisinger et al. in 2010, also known as Germany's *Energy Concept* or *Prognos* study.

also make up for the lack of affordable electricity storage facilities needed as backup for intermittent power generation from renewable sources.[68]

But just six months later, Chancellor Merkel changed Germany's policy course yet again, in the wake of the fast-spreading, anti-nuclear protests[69] that followed the March 11, 2011 nuclear accident in Fukushima, Japan. Fearful of losing her political legitimacy, she decided to decommission all German nuclear power plants by 2022, but without renouncing Germany's ambitious 2050 GHG reduction targets[70] (Maubach, 2014, pp. 21-22).

**Carbon Mitigation Efforts and their Consequences**

According to the Emission Allocation Act, ZuG 2007, facilities that were under the jurisdiction of the EU ETS had to apply for, and were entitled to receive for each of the three years of the period 2005-2007, free allowances (EUAs) corresponding to 97.09% of their average historical emissions. (UBA, 2004; UBA 2015; Gerner, 2012; Elspas et al., 2006; Maubach, 2014, pp.79-100). This requirement applied to a total of 1849 installations, including energy generation facilities with a thermal capacity over 20 MW and manufacturing facilities from selected sectors (cement, glass, chemical products, pulp and paper) (UBA,2015).

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[68] Nuclear power is not able to level out intermittencies, but if one generated more base-load power that is carbon free (i.e., nuclear power), less intermittent power (RE) would be necessary to achieve Germany's decarbonization goals. For the system this would be less disruptive, because nuclear power would bridge the lack of storage technologies until a solution (breakthrough) was found. In other words, the nation would have more time to develop appropriate storage solutions, if it used its nuclear power plants.

[69] These protests resulted, on 27th March 2011, in the election of a Green governor in Baden Württemberg (a traditionally conservative state).

[70] More details about the historical evolution of Germany's *Energiewende*, from the birth of a carbon-free future vision, over the institutionalization of this vision, up to the current proof-of-concept, and about the major geo-, energy-, and socio-political events that interfered with the political process, marking turning-points in this unique energy transition experiment, are presented in Chapter 6.

Manufacturing and other facilities that took early action to mitigate their carbon emissions, for instance by using fuels with lower carbon content, or by improving their fuel efficiency, received a number of allowances that corresponded to 100% of their average historical emissions. They had no obligation and no legal incentive to reduce their carbon emissions.

Very efficient CHP facilities could apply for additional allowances by using the so-called "special allowances rule" (ZuG 2007). This mechanism allowed CHP facility owners to receive more allowances than their average emissions.

The allocation for new facilities[71] was based on production[72] estimates (installed capacity multiplied by the estimated hours of operation) and specific emission benchmarks measured in metric tons of carbon dioxide ($t_{CO2}$) per unit of industrial product (electricity and heat, for power plants; cement, glass, paper, etc. for manufacturing processes). Overgenerous allocations for new facilities had to be adjusted to the real need in practice, and partially returned (i.e., ex-post correction of allocated allowances). However, ZuG 2007 did not encompass mechanisms to adjust the allocation in cases where the initial estimate led to insufficient allowances. This element of the law incentivized actors to apply using high and unrealistic estimates for production data. In addition, under ZuG 2007 existing facilities that were originally meant to apply for allowances using historical emission data (grandfathering method) could opt to apply for allowances using the rule for new facilities (i.e., estimated figures instead of average historical ones). In comparison with the grandfathering method, this alternative had the advantage that facilities could receive higher

[71] I.e., facilities planned to start operation during the first ET period.

[72] While production means the generation of power or heat in the case of energy facilities, for manufacturing processes this term refers to the estimated production of chemicals, paper, cement, glass, etc.

allocations, by applying based on optimistic estimates of production data, and thus be able to cover planned increases in production. That is why most of the managers responsible for the 1849 facilities that fell under the jurisdiction of TEHG and ZuG applied for allowances using the new facility rule. Without any legal means to correct the allocation in cases of underestimated production figures, all applications were based on unrealistic and very high production estimates.

Before applying for allowances, facility owners did have to have their application validated by accredited external firms. Although it was obvious that the presented figures could not be realistic, the validation process did not help to reduce the amount of allowances, because the applications perfectly complied with the ZuG rules. The total amount of allowances that had to be allocated according to ZuG was suddenly much higher than the government's initial estimate. The imperfect ZuG 2007 regulations forced the DEHSt to over-allocate allowances. This created artificially the impression that the distance to the mitigation target was greater than initially estimated, and that Germany needed to lower its initial emissions cap by another 4.5% to meet its decarbonization commitments (UBA, 2004; UBA 2015; Gerner, 2012; Elspas et al., 2006; Maubach, 2014, pp.79-100).

To prepare for the emission trading process, utilities increased their power prices even before 2005[73] (i.e., before the emission trading system became active). The free allocation of allowances for the first emission trading period (ETPI: 2005-2007) led to windfall profits in the utility industry and to significant increase in electricity prices at the beginning of this period (Gerner, 2012; BMU 2007a). As we will see in Chapter 6, the

[73] Adding to the regular power price estimated burdens for CO2 mitigation.

surplus of allowances on the market, regulatory uncertainties,[74] and the impossibility of transferring allowances from the first to the second emission-trading period rendered the allowances worthless by the end of 2007.

In the next emission-trading period (ETPII: 2008-2012), the government steadily tried to improve its allocation rules. The allocation act for ETPII, ZuG2012, was one of the few German laws that changed almost completely all principles of its preceding version (ZuG 2007). Only facilities that were granted in the ETPI 100% of their emission requirements for taking early climate actions, benefited from unchanged rules during ETPII. In contrast to ZuG2007, ZuG 2012 defined activity-specific mitigation targets and allocated allowances based on best available technology (BAT) benchmarks. For example, manufacturing processes had to reduce their overall carbon emissions only by 1.25%, while the carbon-mitigation target was set at 15% for the generation of electricity (ZuG 2012, 2007). In an official press release from August 2007 BMU[75] justified these unequal objectives with branch-specific differences in competition intensity and mitigation potentials (BMU, 2007a). In contrast to the "grandfathering" approach[76] used during ETPI, the new BAT-allocation rules were meant to promote efficient facilities, sanction inefficient ones, and accelerate the modernization process in the energy sector (BMU, 2007a, Zug 2012, 2007). Another change introduced by ZuG 2012 was that the German Emission Trading Authority (DEHSt) auctioned[77] a part of allowances (about 10% - 40 million $t_{CO2\ equiv}$) instead of

[74] The European Commission claimed that the ex-post adjustments stipulated by the ZuG 2007 do not comply with European law.
[75] The Federal Ministry for the Environment, Nature Conserevation and Nuclear Safety.

[76] Allocation of allowances based on historical emission data.

[77] The additional income from the auctioning process was used to support domestic and international climate mitigation projects and the deployment of renewable energies in the heat sector.

distributing them for free. This measure was meant to initiate the transition towards an allocation system without free allocation of allowances and to avoid windfall profits in the utility industry (BMU, 2007a). In addition, ZuG 2012 allowed CHP facilities owners to apply for allowances using a "double-benchmark mechanism,"[78] as if they had distinct power and heat generation units. They received more allowances than their average emissions, because combined heat-and-power generation is much more efficient than the generation of heat and power in distinct units. To reduce the bureaucratic effort ZuG 2012 also introduced a "small facility" clause for facilities with little mitigation potential. According to this rule facilities with yearly emissions under 25,000 $t_{CO2\ equiv}$ received a number of allowanced corresponding to their average emission during ETPI without needing to reduce their emissions.

The emission trading act for the ETPII (TEHG, 2007) allowed German facility operators to invest in international projects and to use so-called "flexible Kyoto mechanisms" to partially fulfill their return[79]obligations (BMU 2007a; Gerner, 2012; TEHG, 2007). The rules for investing in carbon mitigation projects in developing countries (clean-development-mechanism, or CDM) and other developed countries (joint implementation, or JI) as well as the mechanisms for calculating, transferring, validating the emission credits (CERs[80] and ERUs[81]) from such projects are stipulated in the European Directive

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[78] Using fuel-dependent benchmarks for power and heat generation.

[79] As previously described facility owners have to return each year a number of emission allowances that correspond to their GHG-emission in the previous year.

[80] I.e, emission allowances from CDM-projects.

[81] I.e., emission allowances from JI-projects.

2004/101/EC and the German Project Mechanism Act[82] (ProMechG) of 2005. They were implemented because the climate-mitigation effect per Euro invested is likely to be lower for domestic projects than for projects in less developed countries. Allowances from international projects, CERs and ERUs, were considered equivalent to allocated allowances, EUAs. As previously described, facility owners have to return after each year of operation a number of emission-allowances that correspond to their GHG-emission in the previous year. They could fulfill this obligation by returning up to 22% CERs and ERUs instead of EUAs. At the beginning of ETPII facility operators intensively used this option and the significant[83] price spread between EUAs and CERs to optimize their returns.

Despite its promising start in ETPII and the reduced allocation of free allowances,[84] carbon prices (EUA) dropped since mid-2008 from 30 €/$t_{CO2\ equiv}$ to about 6 €/$t_{CO2\ equiv}$ by the end of ETPII, failing to incentivize low carbon technologies.

In 2013, the third emission-trading period (ETPIII: 2013-2020) started. The European Directive 2009/29/EC[85] forms the legal basis for ETPIII. This directive centralized the allocation system, defining emission limits for all European member states, and eliminating national allocation plans. Compared to ETPI and ETPII more activities[86] are subjected during ETPIII to the emission-trading jurisdiction and more GHG emissions are

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[82] Projekt-Mechanismen-Gesetz - ProMechG
[83] The spread between EUAs and CERs was 8 Euro/$t_{CO2\ equiv.}$ in the second Quarter of 2008. At the beginning of ETPII the prices for EUAs and CERs increased until mid-2008, when EUAs were traded at 30 €/$t_{CO2\ equiv.}$ and CERs were valued 24 €/$t_{CO2\ equiv.}$. Since then prices for CO2 allowances significantly dropped and the EUAs-CERs spread narrowed. At the end of 2008 this spread dropped to 1Euro/ $t_{CO2\ equiv.}$ (Windram, 2009).

[84] BMU estimated at the beginning of ETPII that German facilities were allocated about 37 million t less than required, and 57 million less than during ETPI (BMU, 2007a).

[85] That amended the emission-trading Directive 2003/87/EC.

[86] E.g. transport.

included, alongside with carbon-dioxide emissions, in the EU ETS. With the decision 2011/278/EU the European Commission established the transitional rules for the free allocation of emission allowances in the European Union. The German Bundestag adopted in September 2011 an Allocation Ordinance (ZuV2020)[87] that transposed this EU decision in into national law. However, as we will see in Chapters 6 and 7, the EU ETS mechanisms have up to now failed to set market signals[88] that favor the investments in new, low-carbon technologies.

**Incentivizing Energy Efficiency (KWKG)**

Since 2000 several laws, ordinances, and programs have been implemented (and successively renewed and amended) to increase energy efficiency by using combined heat-and-power processes (KWKG – the CHP Act). Other measures were adopted to improve energy efficiency through a variety of means, such as incentivizing the use of better building insulation and more energy-efficient appliances. The KWKG foresees additional bonuses for electricity generation in CHP plants. As in the case of the EEG, the costs for incentivizing CHP facilities are redistributed to power consumers, large consumers are exempted from paying a large part of the KWKG contribution, and consumers do not have to pay KWKG contributions for the amount of power they generate for own consumption.  In contrast to the EEG, the KWKG contribution applies to the grid-access fees, not directly to the energy price. Large, energy-intensive industrial consumers traditionally built CHP plants at their manufacturing sites, because these plants are very efficient. The initial KWKG (2000) was primarily meant to incentivize small and less efficient local-utility CHP plants that lacked a

[87] Zuteilungsverordnung ZuV 2020.

[88] I.e., there still are too many allowances on the market, and the prices per metric ton of CO2 equivalent are too low to incentivize actors to invest in low carbon solutions.

continuous heat sink. Later amendments in 2002, 2009, and 2012 enlarged this purpose and incentivized, in addition, new industrial CHP plants, as well as the modernization of existing industrial CHP facilities.

CHAPTER 5

# THE ENERGIEWENDE ARENA

This Chapter provides information about the various factors that motivated and continue to motivate stakeholders to take action and trigger change in the *Energiewende* arena, and highlights similarities to and differences from other large energy systems. I describe in it the actors, their relationships, their institutional preferences, and how their roles, values, and positions have changed over time. I discuss how these actors have adjusted their strategies to mitigate differences between the intended and actual results of their actions, and compare them to the actors in other case studies of large energy systems (i.e., Hughes, 1987; Laird, 2001; Nye, 1990; Hirsh,1996; Hirt, 2012; Hecht,1998; Hausman et al., 2008; etc.).

This section relies strongly on first-hand knowledge from years of working in the paper and utility industries, as well as from direct involvement in the negotiations for the deregulation of the energy markets. I use two distinct and partially diverging theoretical approaches to formalize and make sense of this long experience in the energy realm. The first approach is based on the contributions of Ostrom (1990, 2005, 2007, 2009, 2011) and Anderies (1998, 2004, 2006) to new institutionalism, the second on the cultural theory approach and the works of Douglas (1978, 1985), Schwarz & Thompson (1990), and Rayner (2012). To capture relevant institutional settings and provide a useful structure for analysis,[89] I adapted Ostrom's Institutional Analysis and Development (IAD) framework to fit Germany's integrated climate and energy policy (2005; 2011). I also applied multi-level analysis to evaluate how the roles of actors, their values, and their behavioral patterns change throughout the different levels of the process of crafting rules. (Ostrom, 2005). However,

[89] I.e., to define the "participants," the "action situations" they face, the decisions they make, the rules and technologies they craft, and their interactions, which all together form a "system" in Hughes's sense.

each time that rational-choice explanations reached their limits in accounting for "what is going on" in particular action situations, I used culture-theoretical approaches to "analyze the inchoate" and to explain why outcomes matter sometimes less than the unquestioning compliance with outdated rules.

**Actors, Relationships, Preferences, Drivers of Change**

The *Energiewende* action arena is populated by numerous and heterogeneous participants. Since the 1990s, these participants have been pushed into successive action situations, such as: the ratification of the Kyoto protocol, the implementation of a complex *European Emission Trading System* (EU-ETS)[90], the deregulation of electricity markets,[91] the complex mechanisms for renewable energy deployment developed at the national and European levels, as well as various situations related to promoting energy efficiency and enforcing clean air regulations. While trying to make the best of these successive action situations, the participants face soaring energy costs, an increasing dependence on intermittent power sources, severe energy transmission and storage problems, planned imports of electricity from unstable economies[92] through nonexistent power lines, forced power exports to adjacent countries, high penalty issues related to these exports, negative electricity prices, and competitive disadvantages for domestic industries in global markets. Furthermore, many of these action situations have led to rules-in-use at different levels of analysis that constrain some participants in the German *Energiewende* arena in a manner that

[90] To comply with the successive European Emission Trading Directives and participate in this European Cap-and-Trade system Germany passed several Emission Trading Acts and Ordinances, TEHG, ZuG, ZuVo 2005, 2007, 2012.

[91] Based on the stipulations of the successive German Energy Economy Acts EnWG 1998, 2003, 2005, 2008, 2011, the successive Association Agreements for electricity and gas (VV I, VVII, VVII+ for electricity /VVI& VVII Gas) and related ordinances (NZVo and NEVo for electricity and gas).

[92] North-African and Middle-Eastern Countries –DESERTEC Project.

can lead, in extreme cases, to existential threats, bankruptcies, unemployment, business migration into countries with less strict regulations, and export of greenhouse gas emissions.

## Actors

The most important participant clusters in the *Energiewende* Arena are: (1) Chancellor Merkel and the German Government; (2) Public and Private Science; (3) Utility Companies; (4) Large Energy Consumers (5) Small Energy Consumers/ Households (Figure 4). Representatives of these clusters participate in action situations across several levels of analysis and are differently involved in constitutional, collective choice and operational situations (Figure 5).

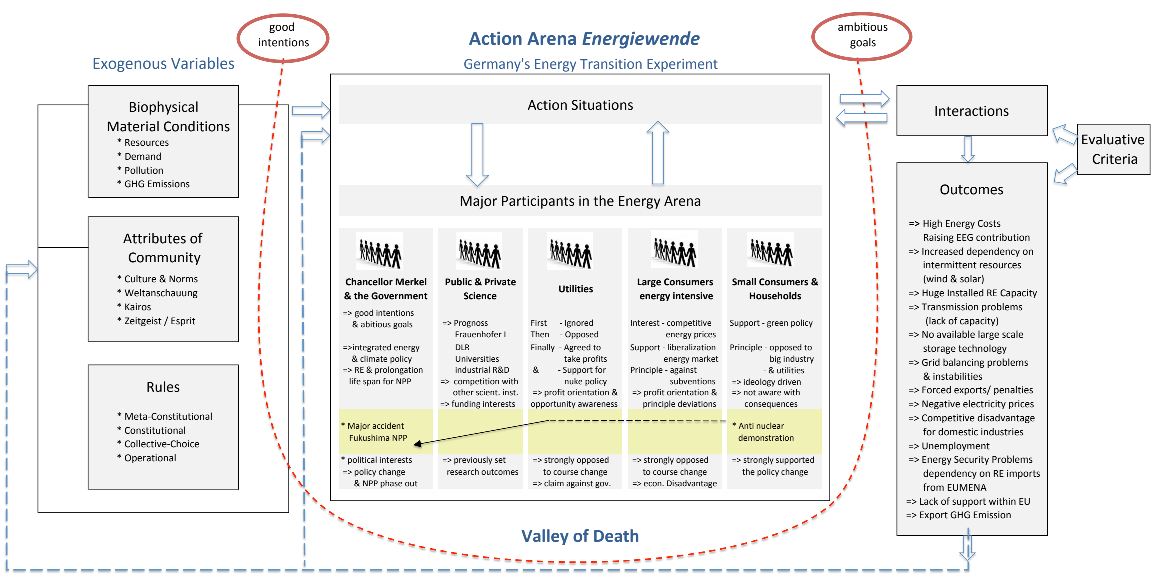


Figure 4– Ostrom's Institutional Analysis and Development Framework adjusted for Germany's *Energiewende*

**Government actors.** The Chancellor and the government (agencies, regulatory bodies) represent the nation's interests at the meta-constitutional level. They negotiate global agreements with representatives of other Parties of the United Nations (at meta-constitutional level I) and European directives with member states of the European Union (at meta-constitutional level II) with the overarching goal of finding solutions for the transboundary problems such as climate change and air pollution that influence the social, economic, and environmental wellbeing of German citizens and German enterprises. As soon as Germany's representatives reach an agreement with other parties of the global community and/or other member states of the European Union, the negotiated rules at meta-constitutional levels become rules-in-use at the constitutional level. At this level of analysis the Chancellor and the governmental bodies are responsible for crafting energy regulations and for devising policies. The government relies on studies made by public and private science,[93] as a basis for decision-making. For example, *Fischedick et al.'s Long Term Scenarios for a Sustainable Energy Usage* (2002), and *Nietsch et al.'s Guiding Studies and Long Term Scenarios for the Deployment of Renewable Energies* (2005; 2007; 2008; 2009; 2010; 2011) were used for assessing and amending Germany's energy policy and the relevant energy legislation (EnWG, EEG, KWKG, etc.); Trieb et al.'s studies on *Concentrating Solar Power for the Mediterranean* and *Trans-Mediterranean Interconnection* (2005, 2006) were used for developing renewable energy import concepts (DESERTEC); Schelisinger et al.'s *Energieszenarien für ein Energiekonzept der Bundesregierung* (2010) was used for Germany's *Energy Concept* and the life-time expansion of nuclear power plants; while *Nietsch et al.'s Long Term Scenarios for the Deployment of Renewable Energies* (2012) was used for justifying the shift away from nuclear power after the nuclear accident in Fukushima. Another instrument often used as basis for decision-making processes is the so-called *Enquête-Commission*, a committee of interdisciplinary non-partisan experts convened by the German Bundestag[94] that come

[93] i.e. Prognos, Fraunhofer Gesellschaft, DLR, Fraunhofer ISE, Fraunhfer ISI, etc.

[94] *Enquête-Commissions* can also be convened at State level (by the Landstag). The federal or state government request their advice on all types of problems (European and national or state energy policy, trans-boundary pollution, carbon mitigation, fiscal and monetary policy, migration policy, etc.)

together to advise the government and find solutions that are likely to be accepted by a large number of German citizens.

According to Germany's basic law (Grundgesetz) and to the parliamentary rules of procedure, the German government, the Bundesrat[95], or the Bundestag[96] can initiate new legislation. The Bundestag has the authority to adopt laws in a deliberative process, structured in three readings (Lesungen). During this process the Bundestag delegates the work to expert commissions, organizes hearings of experts representing the parties with seats in the Bundestag, discusses the recommendation report, and votes the adoption of the bill. After passing the Bundestag some legislation requires the approval of the Bundesrat. In this case the Bundestag sends the bill to the government and the Bundesrat. If the Bundesrat has amendments, the Bundestag deliberates about the proposed changes in a fourth reading and vote on the new draft. After finally adopting the legislation the Bundestag sends the new law to the government and to Germany's president to be signed, executed and announced. If the Bundesrat rejects a proposed piece of legislation, the bill cannot become law. In such dissent cases, the government, the Bundestag, or the Bundesrat can call a Conference Committee (Vermittlungsausschuss)[97] to find a solution (BMJV, 1949).[98]

**Public and private science.** The role of public and private science in the *Energiewende* context is to design energy transition pathways, to produce knowledge that informs and supports the political process, enabling governmental actors to make sound

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95 The Bundesrat (Federal Council) is the upper house of the German parliament, equivalent to the US Senate. It represents the interests of the 16 German States (Laender) at national level.

96 The lower house of the German parliament, equivalent to the House of Representatives. The Bundestag can propose a bill only if it is supported by at least 5% of its members.

97 With members the Bundesrat and Bundestag.

98 The process of crafting legislations is described on the web-side of the German Bundestag: https://www.bundestag.de/parlament/aufgaben/gesetzgebung_neu/gesetzgebung/weg/255468

decisions, and to promote technological advance. As of early 2018, the federal government has adopted six successive energy research programs aimed at advancing energy technologies and steering change in Germany's energy systems, the first of which was launched in 1977. Over the last 40 years it funded more than 17,300 non-nuclear energy projects, spending about €12 billion for energy related research (BMWi, 2017 c, p. 4). Four federal government bodies - the Ministry of Economic Affairs and Energy (BMWi), the Environmental Protection Agency (UBA), the Ministry of Education and Research (BMBF), and Ministry of Food and Agriculture (BMEL) - are responsible for making public funding announcements, calls for proposals in the 6th Energy Research Program, and granting the research awards (BMWi, 2011). The federal states launch in addition their own research programs. Given the ambitious *Energiewende* goals, and the importance of energy research for successful transitions towards low carbon technologies, governmental funds for strategic energy research and development at national or federal state levels have significantly increased over this 40-year period. However, almost 70% of gross domestic expenditure on research and development is financed by industry and not by governmental bodies (BMWi, 2011, p.11).

Renowned German and European research institutions like the Fraunhofer Gesellschaft and its affiliated Instituts,[99] the German Aerospace Center (DLR),[100] Prognos AG,[101] the Institute of Energy Economics at the University of Cologne (ewi),[102] the Institute

[99] Fraunhofer ISE (Solar Energy Systems), Fraunhofer IWES (Wind Energy and Energy System Technology), Fraunhofer ISI (Systems and Innovation Research), etc.

[100] Deutsches Zentrum für Luft- und Raumfahrt e.V.

[101] One of the oldest European research institutions for economic research, located in Basel, Switzerland.

[102] Energiewirtschaftliches Institut an der Universität zu Köln.

of Economic Structures Research (GWS),[103] the Engineering Office for New Energies (Ifne),[104] and many others were involved in the *Energiewende* processes, consulting with governmental bodies and actively shaping Germany's energy-political decisions. They were commissioned to conceive concepts for renewable energy, carbon mitigation, CHP, grid development plans, sector coupling, efficiency increase, market design, etc.; to produce monitoring reports and manage energy and emission data; to develop dynamic models and simulation programs (e.g. for economic development, grid management, etc.); to assess the impacts of various policies on employment; and to evaluate the success of Germany's *Energiewende*.[105] However, when unexpected or disruptive events ("contingencies," Hughes, 19987, 1993) occur, such as the nuclear accident from March 2011 in Fukushima, Japan and the anti-nuclear protests against nuclear power, the government has to react rapidly without having time to base its decision on newly commissioned scientific studies. As the example of Germany's nuclear turn-around shows, the government can even reverse decisions that were previously justified with extensive scientific studies, made by some of the research institutions listed above. In such situations the role of research institutions changes. They are asked to deliver post-hoc justifications for governmental decisions. If they want to maintain their power, their funding, and their influence, research institutions have no other choice but to accept the governmental mandate, even if research results are predetermined and might

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[103] Gesellschaft für Wirtschaftliche Strukturforschung, a private, independent economic research and business and policy consultancy organization, specialized in empirical economic research.

[104] Ingenieurbüro für neue Energien (IfnE).

[105] Research organizations deliver accurate, often very critical, evaluations of the *Energiewende* results and propose measures to reduce the distance to the targets. Beyond governmental research, these organizations also conduct independent research projects.

even contradict previous findings and policy recommendations.[106] To preserve their scientific credibility, researchers make accurate lists of conditions that have to simultaneously occur to justify their commissioned findings. However, so long as such studies conclude that a political decision is economically viable and technically feasible, they seem not to be subjected to critical scrutiny by other actors.  For example, Nietsch et al.'s *Long-term Scenarios and Strategies for the Deployment of Renewable Energies in Germany in View of European and Global Developments* confirmed the feasibility and affordability of Germany's political turnaround after the nuclear accident in Fukushima (2012). Although this study's results were sound from a mathematical perspective, they were based on unrealistic assumptions, for example: a much higher increase in energy efficiency than the long-term historical average; much higher prices for fossil fuels, conventional power, and CO2 emissions; a 25% reduction of electricity demand by 2050 coupled with a steadily growing economy, etc. It was striking that all assumptions favored the desired outcomes, and that not even the values for the year 2010, which were all known when the study was commissioned in 2011, were correct. It is also interesting that the government has chosen, after Fukushima, different research institutions to confirm the new energy program[107] than those that developed a half-year earlier Germany's *Energy Concept,*[108] which recommended extending the life-span of nuclear power plants (Schleisinger et al., 2010; Nietsch et al., 2012). I discussed this subject with different stakeholders in the *Energiewende* arena. One of these experts wrote me in an email:

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106 Compare, for example, the divergences between Schleisinger et al's *Energy Concept*, 2010, and Nietsch et al.'s *Long-term Scenarios*, 2012.

107 DLR, Fraunhofer IWES, & IfnE.

108 Prognos, ewi, & GWS.

> In principle, there is nothing to object to if the Federal Government changes the research institutions commissioned with a particular topic. Such changes can occur based on dissatisfaction with the results of previous studies, diverging opinions, or better offers from alternative institutions that applied for a particular grant. Yet it can, of course, happen that the government expects from particular experts results that are more likely to fit into its desired political line.
>
> On nuclear energy: Of course, Chancellor Merkel knows exactly that the existing German nuclear power plants are safe in operation, contribute to low electricity prices, increased security of supply, and avoided CO2 emissions. These were the reasons for the decision to extend their life span… And she is also aware that a tsunami that caused the disaster in Japan cannot happen in Germany. Nevertheless, she used the new situation for a political U-turn. The mood in the population and tactical power considerations both certainly played a role in her decision. This decision eliminated, for example, a very important argument of the Greens for being elected.

Public research funds for applied *Energiewende* projects are primarily allocated to smart grids, smart homes, smart country, smart technologies, smart cities, and smart sector coupling. This explains why research departments of major utility companies and other industries direct their research interests according to the amount of governmental funds allocated for such *Energiewende*- related research. These R&D departments compete with one with another for short-term funds and simply ignore major research topics that are critical for the success of Germany's energy transition experiment, as for example industrial-scale storage facilities. For example, I asked several researchers in utility R&D departments what cumulative capacity is needed to level RE intermittencies, and no one could give me an answer to this question, although many *Energiewende* problems[109] are related to the intermittent nature of RE. Moreover, I didn't notice any interest in new breakthrough technologies able to store electricity at the large scale, because the hard work in this direction entails a significant risk of failure and is neither rewarded with generous funds, nor characterized by short pay-back periods. The standard response to my question was that as long as there is enough fossil capacity to compensate periods of high demand and low RE output, there is no need for research in this area. Such responses show also how major participants in the *Energiewende* arena distance themselves from long-term strategic thinking.

Interviews with representatives in new technology departments of major industrial players indicate that there is no favorable environment in Germany for investing in larger electricity storage facilities.[110] That is why these companies aim to cooperate with American firms in order to place their first industrial-scale storage facilities on the US market and not in the German one. Yet there is less need in the US[111] to level grid intermittencies, and German electricity prices[112] are higher and should positively impact the bottom line of such projects. The only explanations I can imagine for such behavior are that: there are more chances for external funding for innovative projects in the US; that American companies are perceived as being less risk averse and as having longer-term strategies[113] than German ones;

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[109] As, for example, the need to expand the transmission grid, forced export, negative power prices.

[110] Based for example on redox-flow batteries, or electrolysis processes.

[111] Because the amount of RE fed into power grids is significantly lower the US than in Germany.

[112] The higher electricity prices are, the easier it becomes that storage facilities have a positive return on investment.

[113] I.e., less driven by quarterly figures.

and that there is more room for entrepreneurial opportunities in the less regulated US environment.

**Utility actors.** Utility managers, engineers, technicians, controllers, lawyers, balance circle managers, traders, key account managers, lobbyists, power plant and grid operators are probably the most important and most heterogeneous category of participants in the *Energiewende* arena. The roles of these actors differ depending on their position and the particular business area in which they work. For example, managers in trading units are responsible for the wholesale and over-the-counter commodity trading business, while those working in power generation units are in charge of optimally running their facilities, and key account managers are responsible for contracts with the different categories of clients. Employees in grid units have to operate their transmission and distribution grids, to connect new facilities, to level imbalances, and avoid grid bottlenecks, while those working in dispatching units decide on the order in which power plants are connected or disconnected from the grid to meet changes in supply and demand. Finally, managing directors are responsible for the economic results and the strategic orientations of their companies.

As we will see in Chapter 7, no other economic sector has undergone more organizational changes, been confronted with harder-to-solve managerial problems, or been harder hit by the successive waves of *Energiewende* rules and regulations than utilities, and especially large ones. The Energy Economy Act (EnWG) of 1998 introduced a paradigm change in organizing Germany's energy sector and marked the beginning of the transition towards new energy systems based on deregulated energy markets. While the most visible political and organizational changes imposed by the *Energiewende,* were focused on unbundling energy related activities,[114] deregulating the energy markets, decentralizing the energy generation, deploying renewable energies, and transforming the way energy was regulated, the tasks assigned to utility actors, as well as their roles and their importance in German society, also changed. For example, key account managers in large utility companies represented a very influential and powerful category of actors in the early 1990s.[115] They had tremendous decision-making power and financial responsibilities. Prices, rules, conditions, and even gain margins for smaller utilities were more or less dictated in the hierarchically organized supply chain by these actors. However, in the wake of deregulation,[116] key account managers steadily lost their influence in utility companies, while previously insignificant utility actors like energy traders gained more influence. In the new deregulated context, large, energy-intensive manufacturing industries and middle-sized utilities buy their commodities directly in the wholesale markets and sign their own access contracts with the responsible grid owners. They do not need key-account managers anymore. With their major clients, key account managers also lost their negotiating power and their financial responsibility. They remained responsible for energy contracts with smaller clients, but these contracts became increasingly standardized. In addition, key account managers were not allowed to make offers without involving their colleagues from the trading departments. The once powerful key account positions were reduced a kind of appendage to the energy traders, in charge of administrating contract archives and client contact data.

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[114] Generation and trading from transport and distribution (i.e., grid-related activities).

[115] I.e., before deregulation.

[116] After 1998.

Managers of conventional assets[117] represent another category of utility actors who steadily lost influence and importance during the successive *Energiewende* action situations. For more than a century, power plants were considered to be symbols of technological advancement and a guarantee of the wealth of utilities. Because asset managers were responsible for managing such capital-intensive assets and deciding on strategic investments, they were thus guardians and multipliers of wealth. However, since nuclear power has no future in Germany, and fossil power jeopardizes the nation's climate goals, these assets have become major risk factors for large utility companies and for the asset managers. The entire power-plant infrastructure that once symbolized wealth, power, knowledge, and success has become a graveyard of stranded investments and derailed subsidy schemes, a Moloch absorbing national technological knowledge, a threat to the utilities' balance sheets, an obstacle in the way of success, the remains of a once powerful sector. In the new energy political context, asset managers are charged with the thankless task of reducing losses by successively phasing out their assets and laying-off their employees.[118]

The continuous need to adjust to new action situations, to reorganize the legal entities of utility groups, and to lay off employees, put tremendous pressure on utility managers. As observers from outside these companies, industrial consumers had often the impression that managers of large utility groups have no idea what they are aiming for, have no coherent action plan, are inflexible and unable to adjust at the required pace, and are completely disoriented, being more concerned with saving their own positions in steadily

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[117] Mainly power plants.

[118] In a study made for Greenpeace, Bontrup and Marquardt describe in detail the personnel and assets policies of the "Big 4" – the four largest German utilities: Eon, RWE, Vattenfall, and EnbW (2015, pp.221- 256). They note that the Big 4 began to rationalize personnel in the 1990s in a "socially responsible way," but had to revise their generous lay-off policy, because they "overslept the *Energiewende*," their margins became negative, and they could not afford "golden handshake[s]" anymore.

changing organizations than with fulfilling their tasks.[119] From 1992 - 2004 I worked in the energy-intensive paper industry. As a major client of the utility sector, every time I requested non-standard offers for power supply,[120] from utilities, I perceived myself as someone who was disturbing the utilities. "The customer disturbs only," or "the customer is threatening (us) again with orders,"[121] we consumers used to say in such situations. Later, while working in the utility industry, I perceived from inside the chaos, the helplessness, the lack of orientation, and the fear of losing desirable positions throughout all successive organizations and at all management levels, that was triggered by the constant change required under the *Energiewende*. It is difficult to grasp from outside how much friction among top- and mid-level managers may occur in large, hierarchical, and extremely regulated utility organizations, if they have to function under continuous stress. The fear that decisions that do not prove to be the right ones for the company might jeopardize positions in the higher levels of hierarchy often gridlocked the entire decision-making process, transforming utility managers from creative entrepreneurs into strict followers of internal rules (in Ostrom's terms, rules established at the collective-choice level that become rules in use at the operational level; see Figure 2).

**Large consumers.** Most of the large and middle-sized end-uses, such as manufacturing, are connected to one of the local or regional distribution grids for electricity

[119] I.e., to satisfy their clients, to operate the grids, to run power plants, to develop projects, to respect contracts.

[120] For example the procurement of a low cost "nuclear power plant slice." or a power price mechanism that is equally attractive as the investment in a modern cogeneration plant at the manufacturing site.

[121] "Der Kunde stört nur" or "wieder droht der Kunde mit Auftrag".

and gas.[122] Very large energy consumers are sometimes even directly connected to transport grids.[123] Often cities and their local utilities (*Stadtwerke*) developed around large, energy-intensive manufacturing facilities. Such local utilities sometimes had less negotiating power than their industrial clients, but trans-regional and regional utility managers were reluctant to break the traditional supply chain and to directly negotiate contracts with end-users in the local service area.

Some industrial processes like aluminum, chemicals, cement, glass, or paper manufacturing are energy intensive. For example, in the 1990s, the share of energy costs (electricity, natural gas and other fuels, etc.) in finished paper products was on the same order of magnitude as the share of employment costs, and even greater than that of costs for any of the raw materials (wood, pulp, chemicals) used in manufacturing these products.

Given their huge energy demand and their significance for the supplying utilities, large, energy-intensive consumers had, in comparison with smaller ones, better chances to optimize their energy costs in the period that preceded the market deregulation. Moreover, different large end-users had different negotiation skills, and the most skillful ones used their negotiation power to obtain better conditions than those stipulated in standardized contracts. In cases of prohibitively high energy-prices, large end-uses could appeal to the Federal Antitrust Agency (Bundeskartellamt) about abuse of utilities' monopoly position.

Despite the importance of energy costs for their final product, most large international paper groups with manufacturing sites in Gemany[124] followed, in the early

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[122] Mostly to middle voltage (10, 20 or 30 kV), sometimes to high voltage (110 kV) power grids, and to natural gas pipelines operated under 16 bar.

[123] To very high voltage transmission lines and transformer stations, or to gas pipelines operated above 16 bar.

[124] Stora Feldmühle, SCA, etc.

1990s, the "lean management" recommendations of large consultant firms, decentralized their organizational structures,[125] and out-sourced their energy activities.[126] As result of such organizational changes, the decision-making power was delegated to the manufacturing units that became distinct decision-making entities. The once-powerful central technical business units, in turn, having lost their decision-making authority, became less important within large manufacturing groups, being degraded to consultancy units. I started to work in the Central Technology Department of Stora Feldmühle AG, Düsseldorf, [127] shortly after the first decentralization wave.[128] Our department employed experts for different pulp and paper technologies, as well as experts in energy technologies and energy contracts. These highly specialized managers were involved in project teams each time that new paper machines were built, and had vast national and international expertise.[129] They were used to making strategic decisions in their particular area of competence, not to working on request as advisors for the manufacturing sites. Ten days after I started my new job, my boss informed me that the department would be reduced from 35 to 10 employees, and that we both would be among the 10 privileged employees allowed to keep their jobs. Stora's once strong Technology Department became a sort of "elephant cemetery" without satisfactory tasks for

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[125] Delegating the decision making power to the manufacturing units, which became distinct juridical entities.

[126] The idea behind the "lean management" approach was that other companies are better specialized in energy generation or other services, and companies would be better of by using all their financial means for investment in their "core business"- the paper manufacturing process. Out sourcing was mostly related to investment requirements in small industrial coal power plants such as desulfurization, and flue gas recirculation (SNCR) or catalytic processes (SCR) for reducing NOx emissions.

[127] Stora (today Stora Enso) was a large multinational Swedish paper group. Its business unit, Stora Feldmühle, manufactured high-quality magazine paper. Other business units manufactured carton board (Stora Billerud), and fine papers (Stora Papyrus).

[128] During this period, about a half of the employees in this department lost their jobs.

[129] A centralized center of technical competence made more sense in the paper industry than decentralized knowledge at the manufacturing sites, because the sector was capital intensive, large investments for new paper machines or new power plants were too rare to build up this kind of technical competence in manufacturing units.

its overqualified employees. Within few years, only my boss and I remained in this central unit, because we had been able to significantly reduce the energy costs in different business units of the Stora group.[130] One of the first projects I was involved in was the outsourcing of the energy activities of the Stora Billerud carton-board site in Baienfurt, Germany. Due to stricter clean-air regulations and limited permits for using heavy fuel oil,[131] massive investments in the power-plant infrastructure were required at this site, but the Stora group embraced the "lean management" approach and decided to invest only in the "core" paper manufacturing business. Under these circumstances we negotiated a contracting model with VEW.[132] Together with VEW we developed a new energy concept that integrated the main components (steam turbine and backup boiler) of the existing power plant with new components (a modern 25 MW high-efficiency gas turbine, a heat-recovery boiler, a circulating fluidized bed boiler that used as fuel paper sludge and rejects[133] from the manufacturing process). Instead of Stora Billerud, VEW invested, built, and operated the power plant according to the needs of the carton board manufacturing process. Contracting models are always more expensive in the long run for the manufacturing process, because another party (in our case VEW) tries to benefit from the same business.

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130 We developed, for example, alternative power-plant concepts for Stora Feldmühle, Stora Billerud, and Stora Papyrus sites located in central Europe, and used these concepts to reduce energy costs. We were successful in reducing gas prices for sites of Stora Feldmühle and Stora Papyrus, using opportunities opened by the decision of BASF to enter the natural-gas business, to found Wingas (a joint venture between Wintershall, a 100% subsidiary of BASF, and Gazprom, a large Russian natural gas enterprise), and to build parallel gas pipelines to the existing Ruhrgas grid.

131 As fuel for steam and power generation.

132 At that time, one of the largest German utilities (ranked third after RWE and PreussenElektra). Today the former VEW business is part of the RWE group.

133 Rejects are residues from the pulping process with high plastic content.

Similar "lean management" approaches were adopted in many other large corporations, including those manufacturing chemicals, aluminum, cement, glass, and other energy-intensive processes. Sometimes very large groups transferred their energy business in distinct, site-service units[134] responsible for energy generation, trading and supply of electricity, process steam, compressed air, waste management and recycling, custom-made energy solutions, etc. In contrast, the directors and owners of Haindl Papier GmbH,[135] the company I worked for between 1996 and 2004, did not succumb to the prevailing *Zeitgeist* and considered energy activities - given their importance for their final product - as "core business" similar to the procurement of round wood, wood chips, or chemical pulp (cellulose fiber) and the paper manufacturing process itself. As a result, Haindl Papier[136] was one of the few manufacturers who invested not only in processes directly related to the manufacturing of paper, but also in modern energy concepts, granting its energy managers the power to make strategic decisions in their sphere of expertise.

**Small consumers.** This category of actors comprises households, small businesses, services, crafts, and trades that are mostly connected to the low-tension and low-pressure distribution grids of local power and natural gas utilities (*Stadtwerke*). Their consumption patterns are strongly dependent on outside temperature, and they have about a fivefold higher energy demand during the winter than during the summer.

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134 These units were operated like industrial utilities. They offered their services not only to manufacturing sites of the same group, but also to other manufacturing sites on the same industrial platform. This way of organizing the energy business was typical in the chemical industry. For example, large manufacturers of chemicals like BASF, Evonik (former Degussa-Huels), Höchst, Bayer, etc., created the service units Verbund (BASF), Infracor (Evonik), Infraserv (Höchst), Currenta (Bayer), etc.

135 Although it was an international company with corporate structure, Haindl Papier was, between 1850 and the end of 2001 a family-owned business.

136 A company in which the managing directors operated with their own money.

Before deregulation, small consumers were bound to their local utilities without having any possibility of reducing their energy bills. These actors' interests were underrepresented[137] in the negotiation process for the deregulation of the energy markets, but the negotiating parties had to define rules that would allow small consumers to switch their energy suppliers. Given that power and gas meters located at small consumer sites mostly indicate only the cumulative consumption and not load fluctuations, utilities and large consumer associations had to agree on standardized load profiles for these consumers. Each time that small consumers switch their suppliers, the new supplier has to deliver energy according to the standardized load profiles. In 1999 EnBW, one of the four large German utilities, founded a new subsidiary, Yellow Strom GmbH, to supply small consumers. The company launched *Yellow Strom*, a product meant to encourage small consumers to change their supplier. In the meantime, many other similar enterprises offering power and natural gas for small consumers emerged, and small consumers learned to use the new opportunities in the energy market. In addition, many of the small consumers who were wealthy enough to afford investments in rooftop solar facilities or windmills also benefited from the incentive mechanisms of the EEG.

Small consumers had, most of the time, a passive role in the *Energiewende* arena, and their role among *Energiewende* actors can be viewed in terms of the "fatalist" quadrant in Schwarz & Thompson's cultural approach (Figure 1 in Chapter 2). Yet, despite their inability to influence the policy landscape, these consumers consistently supported the decentralized generation of power, the transition towards low-carbon technologies, and they did not hesitate to organize protest movements against nuclear power. As we will see in Chapter 6,

[137] I.e., large consumers committed to representing their interest in the deregulation process.

in the wake of the nuclear accident in Chernobyl, the "power rebels of Schönau" succeeded in opposing established utilities, to raise funds for buying their power grid, and to establish their own utility. In addition, the grassroots movements that emerged after the nuclear accident in Fukushima in March 2011 eventually forced Germany's nuclear phase-out decision. Thus, although they were most of the time passive, small consumers played, as collective actors with egalitarian approaches, a significant role in Germany's energy turnaround. According to Schwarz and Thompson's culture theoretical approach, contingencies, like major nuclear accidents, triggered these actors' "critical rationality" and motivated them to leave their passive "fatalist" institutional rationality to adopt a more "egalitarian" one (Figure 1 in Chapter 2).

**Exogenous Variables**

Along with the rules-in-use at different levels of analysis, the biophysical and material conditions, the attributes of large socio-technical energy systems, of the community, and the demographic and economic factors also count as exogenous variables with significant impacts on action situations in the *Energiewende* arena (Figures 1 and 2).

**Rules.** Drawing on Elinor Ostrom's work on governing the commons, I use the term "institution" to mean "prescriptions that humans use to organize all forms of repetitive and structured interactions" (i.e., rules) (Ostrom, 2005, p.3). Rules are usually crafted in intense negotiation and deliberation processes among representatives of the government, utility companies[138], large energy consumers[139], small energy consumers, and/or collective actors representing the interests of these groups.[140]

[138] Four large integrated corporations, Eon, RWE, Vattenfall, EnBW, and about 900 electricity and 740 regional and municipal natural-gas utilities

The levels of analyzing *Energiewende* rules (meta-constitutional I and II, constitutional, collective choice, and operational) can be seen in Figure 5. They are derived from and consistent with Ostrom's work (2005).

Actors' roles change over time, depending on the particular action situation, the historical moment, the level of analysis, or, in Hughes' terminology, the system's phases[141]. For example, during the deliberation process in which rules are crafted at the constitutional level, utility managers, large/small consumer representatives, and associations spend much effort and resources to influence the outcome (by lobbying experts in governmental bodies, and members of the government). Once constitutional rules become effective, the actors refocus their effort towards devising strategies to comply with these regulations in ways that maximize benefit and minimize loss. Furthermore, the effective laws (i.e., all Energy Acts) become exogenous variables (rules-in-use) at the collective-choice level. The role and the tasks of governmental bodies/agencies also change at the collective-choice level, evolving from negotiating and crafting rules towards enforcing, monitoring, and controlling their implementation, and sanctioning non-compliant behavior. Within groups-of-interest, associations recommend to their members strategies to comply with constitutional rules that become nonbinding exogenous variables for these participants. Within corporations, most of the rules at the collective-choice-level are designed to optimize the existing business and encourage new ones.

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[139] Chemical industry: BASF, DOW, Evonic, etc.; aluminum industry: Norsk Hydro; paper industry: SCA, Stora-Enso, UPM, Zanders, etc.; automotive industry: Mercedes, BMW, VW, Audi; etc.

[140] Associations: VIK, BDI, BDEW, VKU, VDP, VCI, etc.

[141] Hughes defines the following phases of a system: 1) Invention & development; 2) Technology transfer; 3) System growth; 4) Momentum; 5) Redirecting phase under external forces (economic crisis, war, or in the current case of the German *Energiewende*, the earthquake in Japan, followed by the tsunami wave, and the Fukushima nuclear disaster).

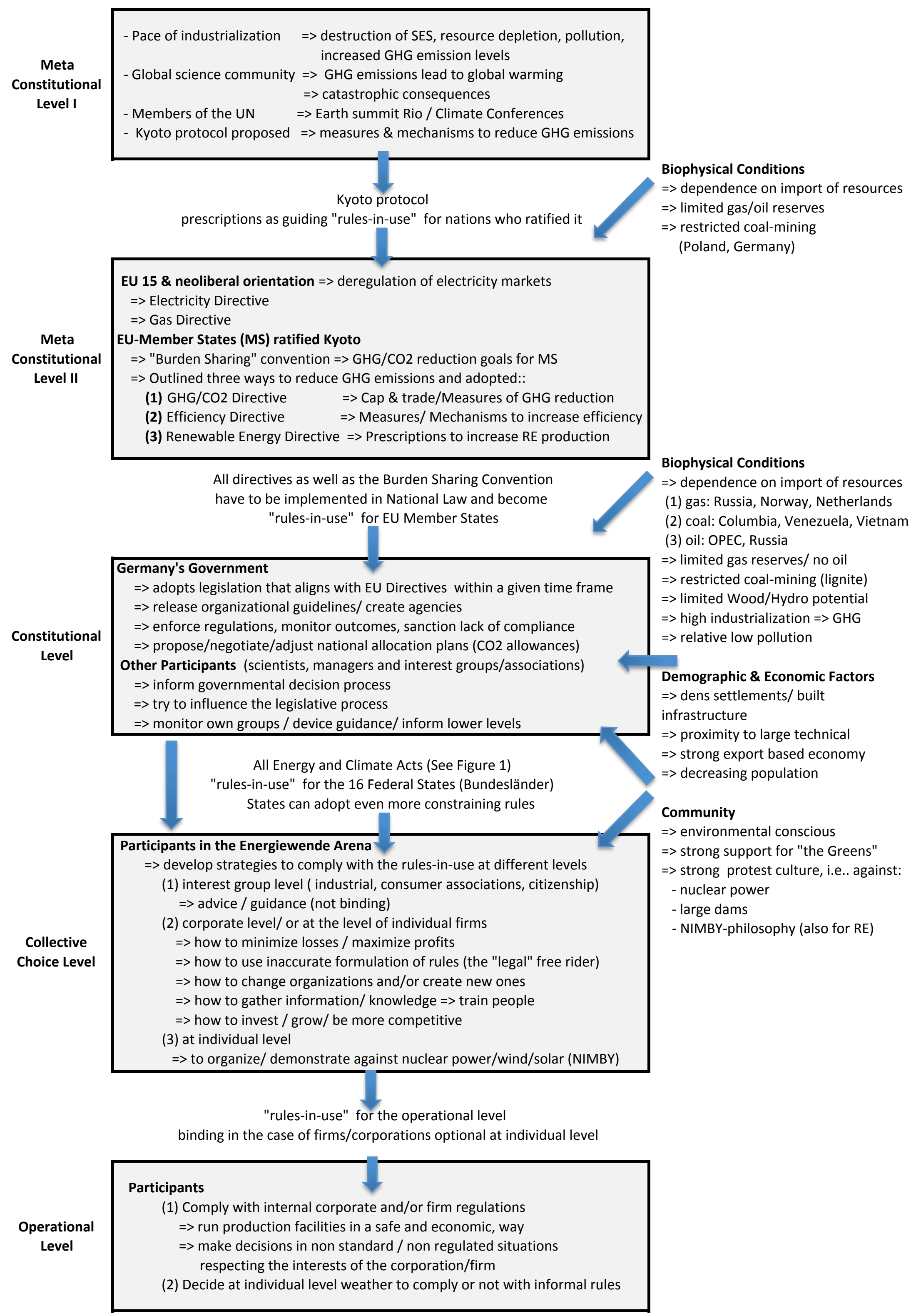


Figure 5 Elinor Ostrom's Multi-Level Analysis Framework adapted for the *Energiewende*

As we will see in Chapter 7, managing directors and other participants with managerial tasks in manufacturing industries and utility groups, who are responsible for the economic results of their companies, start searching for “legal free-ride” opportunities in the newly enacted constitutional rules, after which they develop strategies and make choices about how to maximize the profits of their companies. They have to act fast, because governmental actors will modify the meta-constitutional rules (energy acts) and close these opportunities as soon the legislators become aware of the new loopholes.

However, sometimes participants crafted rules at the collective-choice level that were inappropriate to encourage their own business at the operational level. For example, the internal rules implemented in large utility groups for their new decentralized power facilities hindered instead of encouraged this business. Many of these rules had been conceived for, and implemented as part of, traditional power generation, but they turned out to be totally inappropriate for decision making for generating power in small and middle-sized cogeneration plants and renewable power units, and for delivering their power and heat to clients. The conventional utility business was characterized by tremendous investments in large and mostly standardized power-plant units, primarily meant to generate electricity in condensation processes.[142] Power-plant managers had to be concerned only with safely running their facilities. Other business units were responsible for developing power plant concepts, getting construction approvals, procuring fuels, trading the power output on the wholesale market, hedging commodity risks, as well as for all required contracts, from those for the purchase of technical components to those for emission allowances and grid-access.

142 Condensation processes are designed to generate power as final usable energy. These processes have average efficiencies between 30-40 %. Very modern power plants reach efficiencies around 50%. Condensation processes are less efficient than CHP plants that generate heat and power as final usable energies and reach overall fuel usage efficiencies between 60 and 90%.

The extremely high level of investment and the long periods of return required strict hierarchical rules and several internal-approval sessions at the highest levels of management[143] for each investment step. Given the relatively small number of large power plant projects that were simultaneously pursued, and the high level of standardization (i.e., nearly identical units), the CEO and the board of directors could manage the information and work effectively.

In contrast to such conventional power generation, the new decentralized business was characterized by relatively small investments per installed unit. New energy departments and business units, which emerged in large utility companies for developing and implementing decentralized energy generation concepts for small and middle-sized consumers,[144] could not afford the degree of specialization of the large utility businesses. Managers in these new, smaller units had to think creatively, understand the legislation and the energy markets, purchase fuels, sell electricity and heat, buy and sell carbon emissions, understand complex power-plant concepts, design, plan, construct, and operate power-generation units, and most importantly, have very good negotiation skills. In addition, they had to be extremely flexible in the market, to understand the consumers' positions, and to rapidly respond to their wishes and preferences in order to be successful in this special market niche. It should have been obvious that the prevailing conventional rules that required so many high-level approvals before going to the client and making him an offer couldn't be appropriate for the new decentralized businesses. Yet this simple insight was missing, because, having initially ignored and lobbied against decentralized power, the utilities never took seriously the need to revisit the rules until it was too late. Indeed, before

143 Mostly involving the CEO and the entire board of directors.

144 Mostly based on renewable energies and combined heat and power generation.

2008, the decentralized power activities in large utilities served as political cover rather than as serious business units. They were not significant enough to merit a distinct set of rules that would stimulate this kind of business. Not even as the momentum behind decentralized power continued to gather, did the utilities revisit and revise the rules that governed their internal behavior. In their study about the future of the large German utility companies (Big 4),[145] Bontrup and Marquardt (2015) claimed that "management [of these companies] did not see any need to change the strategies and focus more on renewable energies" because the market power of the companies allowed them to make high profits until the end of the 2000s (2015, Summary p.1). The Big 4 thus missed the opportunity to prepare for the envisioned energy transition in the period of high returns and weak energy-market regulation,[146] and this has since proven to be a major strategic mistake (Bontrup & Marquardt 2015, pp. 120-154). From the perspective of Hughes' large system theory, the radical change induced by Germany's *Energiewende* regulations altered the competitiveness of large German utilities. Despite changed regulatory frames, lasting momentum and systemic inertia prevented managers from devising more appropriate rules for changed situations. Cultural theory offers a third explanation for the persistence of outdated rules in large organizations. According to Schwarz and Thompson, "large corporations face outwardly towards markets but, within themselves, tend to be strongly hierarchical" (1990, p. 11). Being "biased towards large-scale, high technology approaches that demand specialized knowledge and centralized direction," modern hierarchical organizations value obedience and compliance with internal rules more than they value satisfying their customers or maximizing their profits (Schwarz & Thompson, 1990).

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145 Eon, RWE, EnBW, and Vattenfall.

146 I.e., until 2005, the period in which Germany opted for negotiated third-party access to the energy grids.

Another example of rules blindly transferred from a realm in which they made sense to one in which they cause harm is that of hedging rules for commodity risks related to fuel contracts. For example, in most natural-gas contracts, prices are calculated based on formulas that involve the prices of other commodities[147]. This kind of gas price formula was created in a time when facilities primarily used other fuels for generating energy (i.e., coal, heavy fuel oil, or gasoil) instead of gas. To encourage clients to change to natural gas, these formulas were designed to ensure that gas prices couldn't exceed those of the alternative fuels. Even if this kind of pricing doesn't make much sense in a decentralized market,[148] in which coal or heavy fuel-oil are no longer real alternatives to natural gas, they are still customary practice.[149] Such a pricing mechanism makes sense from an economic perspective, because coal and fuel-oil prices fluctuate less and are typically lower than gas prices at the wholesale market, and thus tend to have a stabilizing effect on gas prices. To avoid commodity risks in large power plants that use natural gas, large utilities bought the commodities (coal, oil), at the price embedded[150] in the gas-price formula, on the market. The rationale was simple: when coal prices rose, gas prices would also rise due to the pricing mechanism, but at the same time, the value of the acquired coal would increase, and compensate for the loss caused by the gas price increase. Hedging thus has the effect of freezing gas prices and gain margins at an initial value. However, this happens only if the prices for embedded commodities are the same as those one can buy these commodities for

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[147] Natural-gas contracts are not the only commodity contracts that have price mechanisms with another commodity embedded. Similar formulas are used, for example, as pricing mechanisms for process and district heat.

[148] In which commodities are available and can directly compete (i.e., one gas offer against another).

[149] This can be explained by the fact that natural gas utilities have long-term import contracts with exporting nations that have similar price mechanisms.

[150] I.e., the oil or coal prices that are used in the price formula for establishing the gas price.

on the market. Yet commodity prices from gas-price formulas usually differ in practice from those on the market. For example, coal prices from gas-price formulas (coal notations) are mostly average quarterly border prices for all German coal imports,[151] and can differ substantially from daily prices on the coal market. When the purchase quantities of embedded commodities (coal, oil) are very large and the economic outcomes depend primarily on the gas-price formula,[152] as in the case of large power plants, the differences between the average oil and coal notations and the values of these commodities on the market represent an insignificant risk, because the hedging quantities are big enough to allow for continuous trading. In such situations, one can use this method to save generous gain margins. However, the relative risk of differences between embedded commodity prices and their market price at the moment of the hedge can became high, in the case of decentralized power, where the hedge quantities are too small to allow for continuous trading and the economic output also depend on other parties.[153] While gas contracts with embedded coal and oil notations bear chances of gain improvements, hedges applied to such small contracts may sometimes even freeze negative gain margins, jeopardizing the results. Most of the managing directors I worked with in decentralized subsidiaries of large utilities simply preferred to follow the hedging rules and account for anticipated losses rather than having to explain to the next higher hierarchical level of management that a rule that makes sense for centralized power can be disadvantageous at the decentralized level. The main reason for such behavior is fear. While losses can simply be attributed to market behavior, proposals

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[151] These prices are calculated based on reports from all German coal importers, and published with a delay of three month after the end of the quarter.

[152] And not also on other clauses in power, heat, or cold sales contracts with end-users, as in the case of decentralized plants.

[153] Customers who buy steam or power from decentralized facilities.

from managers to change rules—or actual deviation from those rules—might lead to punishment, demotion, or even loss of jobs.

**Biophysical conditions.** Germany is a country poor in natural resources.[154] It imports most of its natural gas from Russia, Norway, and Netherlands; its hard coal from Columbia, Venezuela, Vietnam, and Poland; and oil from OPEC countries and Russia. The Ruhr Basin and the state of Saarland have long traditions of hard-coal exploitation. However, since labor costs are high and domestic hard-coal reserves are difficult to access,[155] domestic coal is more expensive than imported coal. To maintain its coal industry and avoid social problems, Germany has, for the past 50 years, implemented different incentive schemes for the coal-mining industry. These subsidies have steadily decreased since 1996 and will end in 2018, when the last mines will close. Germany has limited gas reserves and no domestic oil sources. Lignite, Germany's only abundant and cheap fossil resource, is extracted from open-pit mines at very low operation costs. Lignite, however, is also the fossil fuel with the highest carbon content and thus the worst choice for pursuing Germany's GHG emission-reduction goals. With respect to renewable energy sources, Germany has already used almost all of its hydropower potential (i.e., the construction of new dams is not possible), as well as its biomass-potential, and lacks abundant and consistent sunshine. This means that to increase renewable-energy production, Germany must grow mainly in wind and solar, both sources that are intermittently available. Germany is an industrialized nation that is, in contrast to other developed countries, highly dependent on technology exports. Along with its energy acts (see Figure 3 in Chapter 4, Chapter 6, and Chapter 7), Germany

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[154] In his book *Energiemarkt Bundesrepublik Deutschland*, H.W. Schiffer offers a succinct analysys of Germany's resource situation (1997).

[155] They are located more than 1000 meters under the ground.

has very strict "Clean Air Laws," and consequently relatively low specific pollution levels (i.e., emission level per unit of product). However, being highly industrialized, and relying on heavy and energy-intensive industries, Germany also contributes substantially to the absolute emissions of CO2, NOx, SO2, PM, and VOCs.

**Germany's energy systems before and after deregulation.** In the early 1990s, demarcation contracts[156] defined the zones of influence of utility companies, and each of these zones built a local, regional, or trans-regional monopoly. Within the limits of their monopolies, utilities had the obligation to supply consumers with energy. Power and natural-gas prices for small consumers (so-called tariff-consumers) were cost-oriented and had to be approved by governmental bodies at state level (Aufsichtsbehörden). In contrast, manufacturing industries and larger consumers had privileged conditions, which were stipulated in bi-lateral contracts. The contracts offered to large end-users with similar consumption patterns had to be non-discriminatory. To comply with the non-discrimination principle, utilities defined categories of end-users, and developed different types of standardized contracts[157] for each category of client. However, even if they fell into a certain category, large end-users were not identical, had different negotiation skills, and used their negotiation power to obtain better conditions[158] than those stipulated in standardized contracts.

The power supply-chain was hierarchically organized. Nine large, vertically integrated electric utilities focused their activities mainly on large-scale power generation, trans-regional

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[156] Bi-lateral contracts in which utilities committed to deliver electricity only to clients directly connected to their grids.

[157] Clients had to pay for energy consumption (kWh) and their maximal used capacity (kW). This kind of pricing favored clients with relatively constant consumption patterns.

[158] Not only better prices, but also lower take-or-pay penalties, exemptions from minimal payments if they were cause by unfavorable market situations, etc.

power transmission[159], and supplying middle-sized regional utilities and a few very large clients.[160] The core business of middle-sized electric utilities was in turn to distribute the power purchased from the nine large utilities to smaller, public utilities (*Stadtwerke*) and large end-users connected to their grids.[161] The *Stadtwerke* bought most of their power from regional and trans-regional utilities, operated middle- and low-voltage distribution grids, and supplied most of the nation's end-users with electricity. Some middle-sized *Stadtwerke* and regional utilities also operated relatively small, decentralized power-generation units.

The natural-gas system was similarly organized, but with the difference that Germany had relatively little domestic natural-gas production.[162] Five large gas utilities imported natural gas[163] and transported it through their long-distance transport grids to about twenty regional gas utilities and a few large clients directly connected to their grids. Regional gas companies distributed the commodity to more than 700 local[164] utilities. Local gas utilities (mostly Stadtwerke) were responsible for supplying end-users connected to their grids with natural-gas and for operating their distribution grids.

**Attributes of the community.** Germany has dense settlements dominated by built infrastructure (highways, streets, railroads, canals, industrial sites, buildings, etc.), and a

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159 They operated very high (380kV, and 220kV) and high (110kV) voltage transmission grids and offered balancing services for all other utilities.

160 Mostly regional and local utilities, but also some large end-users directly connected to their transmission grids.

161 Mostly high (110kV) voltage grids.

162 Domestic extraction activities are mainly localized in the state of Lower Saxony, being pursued by BEB Erdgas und Erdöl GmbH & Co. KG, a joint venture between German subsidiaries of ESSO and Shell.

163 Mostly from Norway, Russia, and the Netherlands.

164 Mostly Stadtwerke.

"scientifically managed" natural environment[165]. Consequently, its citizens' lives are woven into large technological systems. The German population is decreasing (low birth rate, high longevity). German citizens are environmentally conscious and have a long tradition of environmental and anti-nuclear grassroots movements. They overwhelmingly support the *Energiewende*. However, when dams, high-voltage electricity lines, large- and small-scale wind, solar, or biomass plants are planned in close proximity to their homes, the *Energiewende* projects typically encounter resistance due to concerns about local environmental impacts[166] (Althaus, 2012; Zikow et al., 2015; Gobert, 2015; Jarass, & Obermair, 2005; Bosch & Peyke, 2011; Haberstroh & Schwarz, 2017; Arnold et al., 2017). For example, massive protests against new overland power lines forced policy makers to decide on a much more expensive solution using underground power lines. The new lines are urgently needed to transport electricity from the windy North to the high-consuming South, and the protests delayed Germany's grid-expansion plans, with negative consequences for the *Energiewende* (Jarass, & Obermair, 2005; Borggrefe & Nüßler, 2009; Zikow et al., 2015, pp. 32-35). The Atdorf [167] pump storage project is another example of citizens mobilizing against energy-transition infrastructure critical for the success of the *Energiewende* (Zikow et al., 2015, pp.36-37; Gobert, 2015; EnBW, 2017). The high costs, the unfavorable regulatory framework, and the uncertain outcome of citizens' protests finally made EnBW stop the project (EnBW, 2017).

165 As in J.C. Scott's example about scientific forestry (Scott, 1998, pp. 11-53)

166 In a study commissioned by the Ministry of Environment, Zikow et al. analyze the public participation in large projects and the conflict dialog between citizens, project developers, and local policy makers (2015). The authors briefly describe selected projects, their state, and the conflicts and public involvement in the permit process. The study entails examples of very high and high voltage power line-projects of Tennet and Eon Netz (p.32-35); two pump-storage projects, Blautal and Atdorf (pp.35-37); geothermal facilities (pp.37-38); three CCS pilot-projects (p. 38-39); the Eon coal power-plant project in Staudingen (p.43-44), as well as projects unrelated to the *Energiewende* processes.

167 The largest European pump storage project, with a capacity of 1.4 GW, a storage volume of 13 GWh, and an estimated investment of € 1.6 billion.

In his book *Wiederstand gegen Grossprojekte* (Opposition against Large Projects), Gobert notes:

> Wind turbines pose a threat to bats or rare species of birds, and woods have to be deforested for building power lines. This leads to the paradox that environmental protection and nature conservation associations can be found in some projects, such as the pumped-storage plant Atdorf, on the side of both project advocates and opponents. … In this context project opponents are often accused of having a not-in-my-backyard mentality (NIMBY). I.e., [they] believe in the social necessity of the project, but do not want it to be realized in their own environment (2015, p.16).

In *Rapid energy transition threatened by angered citizens and environmental organizations?*[168] Althaus (2012) analyses the conflict potential that emerges from large *Energiewende* projects, how citizens organize in interest groups, and what strategies they use to hinder large *Energiewende* projects. He concludes:

> Neither citizens' initiatives nor environmental associations fundamentally threaten the *Energiewende*. Their claims are difficult to circumvent, probably expensive, and time-consuming. Yet in most cases [these claims] request adjustments and not a complete project stop. Being depicted as 'climate killers,' coal-fired power plants represent an exception. In this case, ideological indoctrination leaves no room for negotiated solutions (Althaus, 2012, p. 113).

**Values and Norms in the Process of Crafting Rules**. The behavior of various actors in the *Energiewende* arena is guided by distinctive interests, values and norms. The following example describes an action situation that was typical for negotiations of grid access rules for deregulating the energy markets (electricity and natural gas) until 2004 and is based on

[168] Original title: "Schnelle Energiewende bedroht durch Wutbürger und Umweltverbände?"

first-hand information.[169] In this example, energy experts from utility associations[170] and associations of industrial consumers[171] came together to craft grid-access rules at meta-constitutional level. The result of negotiations, *Verbändevereinbrungen,* were private agreements, between the associations of the main actors in the *Energiewende* arena, about the grid-access rules. In contrast to laws, *Verbändevereinbrungen* were voluntary agreements and had no rigid enforcement mechanisms. Each association had to convince its members to comply with the negotiated rules. The Energy Economy Act, EnWG, stipulated that as far as utilities complied with the *Verbändevereinbarungen* rules, they were considered to act in "best practice" and thus also to be compliant with German law. As owners and operators of electricity and gas transport and distribution grids, established energy utility companies were interested in running their grid infrastructure as a profitable business. As a consequence, they were proponents of rules that allow high returns on investments,[172] and enable them to safely operate their grids much as they did prior to the deregulation process. Despite these common interests, utility representatives formed a heterogeneous group with diverging approaches to the way the access

[169] Between 1998 and 2001 I was the named speaker for the associations VIK (Verband der Industriellen Energie- und Kraftwirtschaft) and BDI (the federal association of German industry) and led the negotiation for the deregulation of the natural gas market as representative of Germany's energy consumers. My former boss, with whom I was in a continuous exchange, led between 1996 and the early 2000s the negotiations for the deregulation of the power market, as named speaker for VIK an BDI.

[170] For the deregulation of: (1) the electricity market--the association of German electric utilities VDEW (Vereinigung Deutscher Elektrizitätswerke), the association of communal energy companies VKU (Verband kommunaler Unternehmen), and in later deregulation phases also the working group of regional electric utilities ARE (Arbeitsgemeinschaft regionaler Energieversorgungs-unternehmen), the German transmission society – DVG (Deutsche Verbundgesellschaft), and the association of German grid owners VDN (Verband deutscher Netzbetreiber); and (2) the natural gas market--the federal association of gas and water utilities, BGW (Bundesveband Deutscher Gas- und Wasserwirtschaft), and VKU.

[171] For the deregulation of: (1) the electricity market--the association of industrial energy-and power plant operators – VIK (Verband der Industriellen Energie- und Kraftwirtschaft) and the federal association of German industry BDI (Bundesverband der deuschen Industrie); and (2) the natural gas market--VIK, BDI, and in later deregulation phases also the federal association of new energy suppliers BNE (Bundesverband neuer Energieanbieter) and the European Federation of Energy Traders – EFET.

[172] I.e., generous access fees.

to their grids should be organized. For example, representatives of the powerful natural-gas utilities[173] that owned the large long-distance transport grids, were strongly against a cost orientation of grid access fees, because it would have forced them to open their books and would have limited their gain margins. They argued that competition between the different grid owners should be the only criterion for accessing transportation grids, because direct pipeline competition is possible in the gas sector,[174] and all grid owners want to transport as much natural gas as possible through their grids. In contrast, representatives of smaller, local, public natural-gas utilities (*Stadtwerke*) preferred cost-related access fees to their grids.[175] Although large and small utilities were on the same side of the negotiation table, the dissent was too deep for a unitary utility position and utilities eventually offered different access models for transport and distribution grids.

At the other end of the negotiating table, energy consumers[176] were primarily interested in rules that enable easy, flexible, and non-discriminatory access to the transport

[173] Ruhrgas (today Eon), BEB (today Shell), VNG, etc.

[174] To support their position they claimed that, in contrast to the power sector, the north-south and east-west natural-gas transportation pipelines were built in joint ownership (i.e., different large utilities have capacity shares in the same pipelines, and that these utilities can compete with one another to optimally use their capacity shares), and that the construction of parallel gas pipelines is allowed in Germany. (Not agreeing with its gas supplier (Ruhrgas) about the terms and conditions for the gas supply of their site in Ludwigshafen, a large energy consumer, BASF, founded in the early 1990s, directly imported natural gas from the Russian Gazprom, establishing a new large natural-gas utility (Wingas,) which built parallel gas pipelines to the existing ones. This example is unique in Germany's energy sector and it is not likely that other companies would act as BASF did, because the construction of large gas pipelines is extremely capital intensive, and only an extremely powerful group such as BASF could afford investments on this order of magnitude.)

[175] On one hand, they were used to opening their books, because they were public utilities; on the other they were afraid of direct pipeline competition. Their fear was justified, because investments in short pipelines that would have connected large consumers from their area of distribution to the grids of larger utilities were affordable, and thus likely to be built. Moreover, large utilities could have supported such behavior, forcing *Stadtwerke* to operate their pipeline infrastructure inefficiently.

[176] Associations representing the interest of large energy consumers led the negotiation (VIK, BDI). Given the common deregulation goal, representatives of small energy consumers allied with and accepted the lead of the stronger and more knowledgeable representatives of large consumers.

and distribution grids, at low cost[177]. New energy traders and suppliers[178] formed a third interest group. Their negotiation goal was to establish non-discriminatory, transparent, and easy-to-use grid-access rules, which would enable them to enter the market without having competitive disadvantages in comparison with already-established utilities. Given their strong common interests, associations of energy consumers and new energy traders joined forces under the leadership of the associations of large energy consumers. However, since grid-access costs ultimately had to be paid by consumers, new energy traders and suppliers had no particular interest in reducing the level of grid-access fees, which made the intern negotiation on the consumer side also very difficult.[179]

As described in Chapters 4 and 6, the gridlocked negotiations for the third association agreement for the deregulation of gas markets (VVGas III) and new rules at European level motivated Germany's government to renounce the negotiated third-party access to energy grids (NTPA) and implement a regulated access to these grids, directly anchored in German law (EnWG 2005 and its related ordinances for grid access terms, rules, and fees).

Since 2005 the main actors in the *Energiewende* arena have continued to influence the regular legislation process, as described at the beginning of this section. Their interests and their values in 2018 are no less divergent than they were before 2005. Yet these divergences are not so obvious as in the described case, because each association or interest group tries

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[177] I.e., cost-oriented access fees with pre-defined (small) gain margins.

[178] I.e., electric utilities not yet present in the German market.

[179] The negotiation strategies were prepared in advance in joint committees and ad-hoc working groups with representatives of gas traders (EFET) and large consumers (VIK). Despite having the lead in the negotiation process, consumer representatives had less knowledge about the gas business than gas traders. To avoid unfavorable turns in the negotiation line, consumer representatives had to prevent traders from gathering too much influence in the meetings of the ad-hoc working groups.

to influence the legislature only by making sound arguments for or against particular stipulations of energy bills. Consumer, utility, and trader associations do not have to find a common denominator among their diverging positions, because the third-party-access is now regulated by law.

### Brief Summary

As stated in the beginning of Chapter 5, "The *Energiewende* Arena,[180]" I adjusted Ostrom's IAD and Multi-Level Analysis frameworks (2005) for my particular case study (Figures 4 and 5), and used her "institutions as rules" approach to:

- structure my research findings;
- identify the main actors who influenced Germany's energy transition and analyze their behavior at various levels;
- describe the prevailing biophysical conditions, major changes in Germany's energy systems, the attributes of the community, the process of crafting rules, the values and the norms of different interest groups, and a part of the *Energiewende* outcomes.

The main *Energiewende* rules (EnWG, EEG, KWKG, AtomG) were described in detail in Chapter 4. The chronology of the institutional preferences, the drivers that triggered institutional change, and a more detailed analysis of the governance outcomes and barriers will be part of the next sections.

Although cultural theory uses a completely different approach to institutions,[181] I complemented Ostrom's theoretical frameworks with Schwarz and Thomson "rationalities"

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[180] The term "*Energiewende* arena" is directly derived from Ostrom's "action arena" (2005).

[181] Using the institutions-as-organizations approach, instead of institutions-as-rules one.

mapped onto Holling's "myths of nature" to explain apparently contradictory behavior patterns within the same actor cluster (i.e., large utilities that have simultaneously "individualist" and "hierarchical" rationalities, or small consumers who develop in extreme situations "critical" rationalities, leaving their "fatalist" corner and becoming powerful collective actors in the *Energiewende* arena ( Figure 1, Chapter 2)). As previously noted, many of the examples presented in this chapter are based on first-hand knowledge, from observations during my professional experience and discussions with energy experts in the *Energiewende* arena.

# CHAPTER 6

## HOW THE ENERGIEWENDE CAME TO BE

In this chapter I document how Germany's energy systems have changed during the past four decades and identify the turning points in Germany's energy policy and the "contingencies"[182] that have led to significant changes in its socio-technological energy system. The *Energiewende* developed in the context of an economic system peculiar to Western Germany: the *Social Market Economy*[183]. This system is based on *ordoliberal theories*,[184] according to which the role of the state in modern democracies is to design, establish, and enforce coherent rules that not only encourage a free-market economy, but also promote citizens' social and economic well-being. Germany's social-market economy was instituted after World War II, during Chancellor Adenauer's conservative government, and pursued, with some variations depending on the party in power, by all German chancellors thereafter. The social-market system, Germany's post-war economic reforms,[185] and the US decision to extend the European Recovery Program (Marshall Plan) to Western Germany all catalyzed economic growth and led to the German *Wirtschaftswunder*.[186] Less than two decades after World War II, Germany had completely recovered from the devastations of the war, reestablished itself as an economic power, and implemented a welfare system that eradicated extreme poverty by redistributing wealth (van Hook, 2004; Oppelland, 1996; Abelshauser,

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182 Sensu Hughes (1987) – i.e. recessions, hot and cold wars, oil crises, accidents, etc. that can redirect and fundamentally change one system's development path.

183 The concept is also known as *Rhine Capitalism.*

184 Developed in the 1930s in the Freiburg School (*Freiburger Schule*).

185 In 1948, to stabilize inflation, Germany reformed its currency system, replacing the *Reichsmark* with the *Deutsche Mark*. At the same time, drastic cuts in income taxes significantly increased both the buying power of low-income households and the circulating capital stock.

186 *Wirtschaftswunder* means "economic miracle."

1983; Klump 1985). Yet the rapid pace of industrialization that increased social well-being and alleviated poverty also triggered air, water, and soil pollution, causing severe health problems and damaging the environment. In response to these undesired effects of economic growth, Germany's citizenry developed a strong protest culture that was able to significantly influence political outcomes. This protest culture made it possible for the energy policy of a fringe environmental movement to take center stage, and major points of the "green" agenda were appropriated by all traditional political parties (Maubach, 2013, pp. 29-78; Siekmeier and Larres, 1996; Oppelland 1996).

**Phases of Change: The Evolution towards a Renewable Energy System**

I distinguish three phases of change that are relevant for documenting how Germany's unique energy transition experiment has unfolded, from the environmental movements that marked its beginning up to its current proof-of-concept. These are: Phase I - *The birth of a vision about a carbon-free future*; Phase II – *Institutionalization of the vision about a carbon free future*; and Phase III - *The proof of concept*.

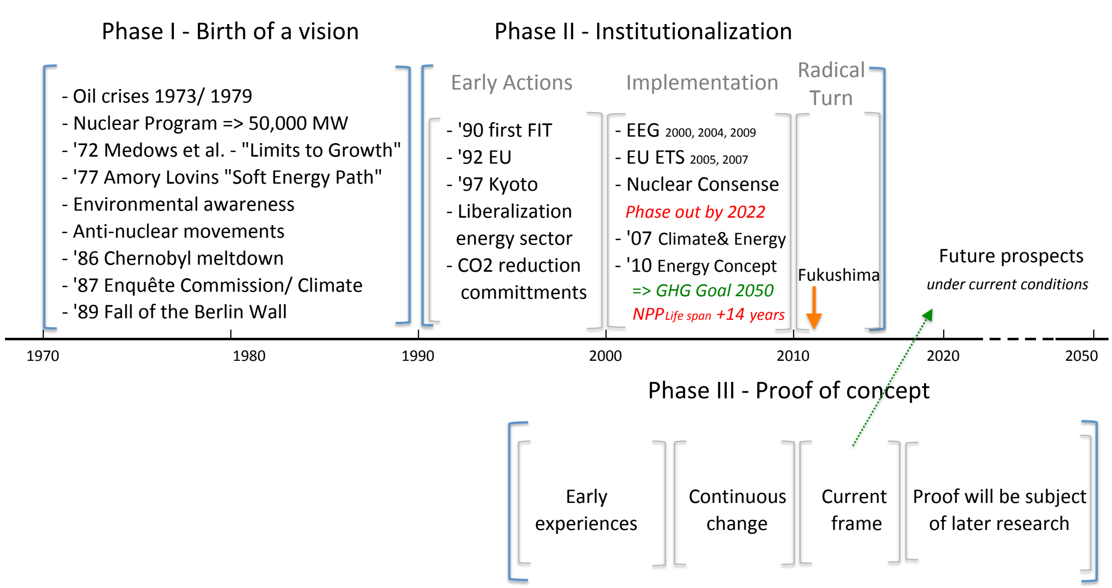


Figure 6. Phases of Change

Figure 6 outlines the timeframe and the major geo-, energy-, and socio-political events that impacted Germany's energy and climate policy along all phases of change. Given that the complex regulatory and policy framework that underpins the *Energiewende* was periodically adjusted in response to the feedback from monitoring its success, the institutionalization (Phase II) and the proof-of-concept (Phase III) are partially overlapping.

**Phase I: Birth of a Vision**

"The sky above the Ruhr region has to become blue again,"[187] claimed Willy Brandt in 1961, long before environmental issues gathered international attention. In the late 18th century the Ruhr basin, with its abundance of hard coal and lignite, attracted many industries. Entrepreneurs like Friedrich Krupp, August Thyssen, and Leopold Hoesch built their steel, iron, and coal-mining empires in the region. Many other industries (e.g., chemistry, glass, paper, utilities) also located their production facilities in the region. Yet the wealth of the Ruhr region came at the price of extreme pollution. Smog darkened the area, awakening the nation's environmental consciousness.

The 1970s and 1980s, two decades of severe oil crises, large nuclear deployment programs, and increased environmental awareness created a favorable terrain for envisioning a carbon-free future and marked the beginning of Germany's energy experiment.

The fear that humans might lose their means of livelihood due to reckless resource exploitation and obvious "Limits to Growth"[188] made environmental protection a central topic in the political discourse in the early 1970s (Genscher, in Forstner et al., 2014, p. IV).

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[187] Brandt used this slogan (in German "Der Himmel über dem Ruhrgebiet muss wieder blau warden") in the 1961 elections, when he first ran for chancellor.

[188] Meadows et al, 1972.

After a long and difficult deliberation process, Willy Brandt's first government[189] released, on September 29th, 1971 Germany's first environmental program.[190] This program allocated governmental funds for 54 distinct environmental protection measures and stipulated that those responsible for environmental damage[191] would have to pay the costs of restoring and protecting the environment (Deutscher Bundestag, 1971). In an official letter from August 23, 1971, Germany's Minister of Interior, Hans-Dietrich Genscher, proposed Brandt to establish a German environmental protection agency (Bundesamt für Umweltschutz) analogous to that of the US Environmental Protection Agency. On May 29, 1972 the Cabinet Committee on Environmental Questions[192] agreed to support Genscher's proposal. However, the intention to locate this agency in West Berlin (outside of the zone if influence of the West German government)[193] encountered skepticism on the part of the western allies and was interpreted by Moscow and Eastern Germany as a West German effort to extend its administrative reach into Berlin, and thus was seen as an unfriendly act. This conflict couldn't be settled during Brandt's two administrations and delayed the establishment of Germany's environmental protection agency.[194]

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189 A social-democrat (SPD)– liberal (FDP) coalition government.

190 Hans-Dietrich Genscher, Minister of Interior during Brandt's first administration, succeeded to implement this program, against the strong opposition from industrial associations.

191 Primarily manufacturing industries, as major pollutants.

192 Germany's government can set up cabinet committees on specific questions. Such committees include a part of the members of the government and have the task to assess these questions and prepare governmental decisions related to them. Cabinet committees do not have own decision power, they only can issue recommendations. With the Ministerial Decree of December 28, 1971, Genscher set up the Cabinet Committee on Environmental Questions.

193 According to the Berlin Agreement, in which the four allied wartime powers reconfirmed their responsibilities for the future of Berlin and the whole of Germany, West-Berlin remained outside the constitutive part of western Germany and outside its administrative reach.

194 Germany's Umweltbundesamt (UBA) was finally established by federal law on July 22, 1974, during Chancellor Helmut Schmidt's first administration (Forstner et al., 2014, p. 27).

Several scientific studies published in the 1960s and 1970s came to the conclusion that pollutants were having an impact on the environment beyond local or national borders. For example, the Swedish scientist Svante Odén demonstrated that the acidification of Scandinavian lakes had been caused by sulfur-dioxide emissions in continental Europe (Odén, 1968; Semb in EEA, 2001, p.102; UNECE, 2004, p.2). In 1968 at the United Nations Economic and Social Council (ECOSOC), Sweden's government proposed to the other members of the United Nations (UN) to institute a conference on human-environment interactions. The UN General Assembly agreed to the proposal on the basis of scientific evidence that national environmental protection initiatives would have to be complemented by international cooperation programs to effectively combat environmental problems with transnational occurrence patterns. The UN convened, in 1972, its first Conference on the Human Environment in Stockholm. The conference triggered debates about acidification all over the globe and marked the beginning of intense international cooperation on environmental issues (UNECE, 2004, p. 2; Semb in EEA, 2001, p.102). After the conference, the General Assembly decided to establish a new agency, the United Nations Environment Program, to coordinate the UN's environmental activities and to advise and support environmental programs in developing countries (UN, 1972).

On October 3rd, 1973[195] Chancellor Brandt's second government[196] informed the German Bundestag[197] about Germany's first energy plan (Deutscher Bundestag, 1973; Schiffer, 2017). The government estimated that 90 GW of additional power-plant capacity

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[195] Two weeks before the OPEC oil embargo and the subsequent oil price shock.

[196] A social-democrat – liberal coalition government.

[197] Germany's federal parliament.

would have to be installed by 1985[198] to meet Germany's steadily growing electricity demand (Deutscher Bundestag, 1973; Schiffer, 2017, pp.2-3). On October 16th 1973, in response to the US intervention in the Yom Kippur War, the Organization of Petroleum Exporting Countries (OPEC) proclaimed an oil embargo against the US and other developed economies, and decided to reduce its oil export rates (Smith, 2006, p.329). The supply deficit, generated by the reduced oil production in the OPEC states, led to a fourfold oil price increase on the global market,[199] inducing the most severe economic crisis since the Great Depression (Yergin, 2008, pp. 587-590). In the wake of the unfolding crisis, dependence on oil imports and finite energy sources dominated the political discourse in all major economies. In December 1973, Germany's government complemented its energy plan with an ambitious nuclear program[200] meant to reduce Germany's dependence on oil imports. The program aimed to move Germany from 1766 MW of installed nuclear power to 40-50,000 MW by 1985[201] using the "competitive" and "largely environmentally friendly" nuclear technology (Deutscher Bundestag, 1973, p.10; Schiffer, 2017, p. 3; Schaaf, 2000; Appendix D).

By the end of Brandt's second administration, the government had passed the Federal Pollution Control Act[202] (BImSchG, 1974), Germany's most important

[198] Considering the 60 GW installed in 1973, this corresponds to a capacity increase of 150% between 1973 and 1985. The total capacity demand for 1985 was estimated at 140 GW (10 GW were planned to be decommissioned during this period of time).

[199] From $3/ barrel before the boycott, to $12/barrel at the end of the oil embargo, in April, 1974 (Frum, 2000, p. 318; Schiffer, 2017, p.3)

[200] The fourth nuclear program since 1957.

[201] About 50% of the previously defined capacity gap of 90 GW (Deutscher Bundestag, 1973).

[202] Bundes Immissionschutzgesetz.

environmental law. After entering into force in March 1974[203], the act was complemented by 42 ordinances (BImSchV 1-42). It defines, together with the related ordinances, which manufacturing sites require environmental permits,[204] and sets limits for air[205], water and soil pollution.

Brandt resigned in 1974 in the wake of an espionage scandal.[206] Germany's next chancellor, the social-democratic chancellor Helmut Schmidt - a convinced proponent of nuclear power - continued Brandt's energy policy. However, local anti-nuclear protests[207] successfully delayed and finally totally blocked the nuclear power plant project in Whyl,[208] in

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203 Before 1974 environmental protection rules were anchored in the Trade Law (Gewerbeordnung) of 1869. The Federal Pollution Control Act, BImschG, extended previous rules and decoupled environmental issues from the Trade Law.

204 For example, Ordinance 4. BImSchV lists all industrial facilities that need an environmental permit.

205 The first rules for airborne emissions were passed in 1964 and included in the Technical Guidance on Air Quality Control (Technische Anleitung zur Reinhaltung der Luft – TALuft). An amended version of TALuft was integrated into the Federal Pollution Control Act. This regulation sets emission limits for sulfur-dioxide (SO2), nitrogen-oxides (NOx), particulate matter (PM), organic and inorganic compounds of fluorine, arsenic, cadmium, lead, mercury, thalium, and nitrogen. The emission limits are periodically revised. After each TALuft amendment, owners of existing facilities have to adjust their emissions to the new rules within a predefined time limit.

206 The "Guillame affair," in which Brandt's secretary, Günter Guillaume, was exposed as a spy for the Eastern German intelligence service (Die Zeit, 2003).

207 Whyl marks the beginning of anti-nuclear German protest culture. Yet protesters (farmers from the area and later citizen advocacy groups located on both sides of the Rhine river – i.e., in Germany and in France) were initially not concerned about nuclear contamination. Instead they thought that condensed vapors from the cooling towers might change their microclimate by reduced sun incidence, more fog formation, that the cooling water might heat the Rhine river, and above all that the sleepy Rhine area might become a "second Ruhr area" (Wüstenhagen, 1975, p.13).

208 In 1973, immediately after the public announcement of the location for a large nuclear project (2 x 1,300 MW) in Wyhl, 27 citizens from Wyhl initiated an anti-nuclear protest (Wüstenhagen, 1975, p.13). At the beginning of 1975, shortly before the Ministry of Economic Affairs of Baden-Württenberg granted a construction permit for the first power-plant bloc in Wyhl, 55% of Wyhl's citizens voted against this nuclear project. Despite this fact, construction work started in February 1975, based on the permit. In response, citizens from Wyhl and surrounding communities occupied the construction site, and some of them filed claims against the project at the Administrative Court in Freiburg. In March the court decided to temporarily stop the construction pending further investigation. The dispute continued until December 1985, when the court came to the verdict that construction could be continued. In an ironic twist, the state Baden-Württenberg reviewed its previous decision regarding the necessity to build a new nuclear facility in Wyhl, and came to the conclusion that new capacity was not needed until 2000. Given that Chancellor Schröder's administration

the state of Baden-Württenberg, dividing the Social-Democratic Party. Anti-nuclear protests, rising uranium prices, and a more moderate increase in electricity demand than had earlier been estimated motivated Chancellor Schmidt to successively adjust Germany's nuclear program, reducing the capacity to be installed by 1985 to about 22,000 MW. To reconcile the tensions between the pro- and anti-nuclear factions of the Social-Democratic Party, and to respond to the growing anti-nuclear mood in Germany, the government decided to assess not only the future deployment of nuclear power, but also a nuclear phase-out alternative, and to keep both options open.

Considering domestic hard coal (*Steinkohle*) essential for Germany's electricity mix, Helmut Schmidt's government passed, at the end of 1974, the Third Electrification Act (Drittes Verstormungsgesetz - VerstrG3). According to the stipulations of this act, all power consumers had to pay an additional Pfennig for each kilowatt-hour of electricity consumed, to subsidize the use of domestic hard coal in German power plants (VerstrG3, 1974).

Driven by the fear that Germany and the other European nations could not protect themselves against potential nuclear attacks initiated by the Soviet Union, Chancellor Schmidt issued proposals to place middle-range ballistic missiles on Western European territory if the Warsaw Pact did not agree to limit these controversial weapons. In December 1979 these proposals were incorporated into the NATO Double-Track Decision. Schmidt's very controversial defense policy[209] triggered a wave of German protests against the proliferation of nuclear weapons. The protesters joined with the increasing number of

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decided in 2002 that Germany wouldn't build new nuclear facilities anymore, the project Wyhl was never realized. (Engels, 2003, pp. 111-124; Maubach, 2014, p. 29)

[209] That was not only rejected by a large number of German citizens, but also criticized inside Schmidt's own political party.

environmental activists who opposed the deployment of nuclear power plants, and formed, in January 1980, the Green Party.

Meanwhile, the Islamic Revolution in Iran in 1979 and the Gulf War in 1980 both led to supply discontinuities in the global oil supply, causing the second oil crisis. The raising oil price level pushed Germany and other industrialized Western economies into a severe recession. As a consequence of the deteriorating economic situation, Chancellor Schmidt curtailed state expenditures for social welfare, despite growing opposition from his own political party (SPD).

In the face of ongoing political debates about social welfare and the proliferation of nuclear weapons, Chancellor Schmidt's second coalition government was unable to agree upon Germany's economic, social, and security policies and broke apart on September 17, 1982.[210] Within less than two weeks the Federal Democratic Party (FDP), the former governmental coalition partner, switched sides and forged an alliance with the conservative Christian-Democratic (CDU) and Christian-Social (CSU) Parties. On October 1, 1982, parliament withdrew confidence from Chancellor Schmidt[211] and named Helmut Kohl (CDU) as his successor.

Chancellor Kohl continued Schmidt's energy and defense policies and decided in 1983[212] - contrary to the strong movement against the proliferation of nuclear weapons - to place midrange NATO missiles on German territory (von Weizsäcker, 2006). Major accidents at the nuclear facilities of Three Mile Island (March 28, 1979) and Chernobyl (April

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210 When the four ministers, named by the minority coalition partner, FDP, stepped down and left the cabinet.

211 The "constructive vote of no confidence" (konstruktives Misstrauensvotum) is a political tool that allows the parliament (Bundestag) to remove the chancellor from office by majority vote, if it also agrees with a positive majority upon a prospective successor.

212 Kohl's second Christian (CDU/CSU)- Liberal (FDP) administration.

26, 1986) intensified the anti-nuclear movements around the world and showed how a succession of minor, relatively insignificant incidents in large and complex socio-technological systems –"normal accidents" in Charles Perrow's terms[213]– can lead to catastrophic outcomes, severely impacting human wellbeing.

Seminal publications such as Meadows et al.'s "Limits to Growth" (1972) and Amory Lovins's "Soft Energy Path" (1977) had inspired the anti-nuclear grassroots movements. The term *EnergieWende,* meaning *Energy Turnaround,* was first used by the Öko-Institut in 1980 as the title for the German translation of Lovins's book, and became in the following decades the brand name for energy transition processes (Maubach, 2014, pp. 29-30).

During the first *Energiewende* phase, Germany's political leaders aspired to regain international recognition, acceptance, and territorial integrity, to increase the nation's security, to ensure economic growth and prosperity, and to provide a minimum level of well-being for all German citizens. Although they tried to fortify Germany's "social market economy,"[214] they had to change, in the wake of successive oil crises and economic recessions, the level of state interventions in economic processes. Assuming a linear relationship between economic growth, energy generation, and societal well-being, Germany's leading politicians implemented energy programs meant to reduce dependence on oil and diversify the power mix by complementing the existing power-plant pool with new, modern nuclear facilities. During this time all political parties involved in the succeeding government coalitions (SPD, CDU, CSU, FDP) considered nuclear power as a

[213] In his "normal accident" theory, Perrow demonstrates that large and complex high-risk systems are prone to failure even if managed well (1984).

[214] The "social market economy" concept, also known as "Rhine capitalism," was implemented by Chancellor Ludwig Erhard in the 1960s. It combines the concepts of "social state" and "free market economy" and presumes that state interventions in economic processes can eliminate market failure, increase societal wealth, and eliminate poverty.

means to societal wealth. Utilities built the new power-plant infrastructure based on public money and became even more powerful. Germany's energy policy not only reduced dependence on imported oil, but also triggered environmental grassroots movements. More and more citizens became active in environmental groups, opposing both utilities and federal energy programs. The government plans to place nuclear missiles on German territory triggered a powerful wave of protests against the proliferation of nuclear weapons. In 1983 the relatively young Green Party surpassed the 5% hurdle and entered parliament.

In November 1979, the European Community, USA, Canada, and the Soviet Union adopted in Geneva the *UN Convention on Long-Range Transboundary Air Pollution* (Geneva Convention).[215] The contracting parties aimed to "gradually reduce and prevent air pollution" (UNECE, 2004, Article 2, p.9). They agreed in Article 9 (UNECE, 2004, p.11) to implement a *European Monitoring and Evaluation Programme* (EMEP), and in Article 10 designated the *United Nations Economic Commission for Europe* (UNECE) as the executive body of the Geneva Convention (UNECE, 2004, article 10, p.12). The Geneva Convention was the first instrument to set legally binding pollution-reduction targets for combating damages caused by air pollution at the transnational level. Since 1983, when it became effective, the convention has been extended by eight protocols encompassing specific measures for mitigating emissions of sulfur-dioxide, nitrogen-oxides, volatile organic compounds, heavy metals, and other pollutants. The common efforts to mitigate air pollution are periodically monitored and evaluated by the United Nations Economic Commission for Europe (UNECE, 2004, p.12; Appendix E).

[215] After being adopted the Convention had to be ratified, accepted and approved by the UN nations.

By the end of 1983, Pérez de Cuéllar, the former Secretary General of the United Nations, asked the Prime Minister of Norway, Gro Harlem Brundtland, to create and chair the World Commission on Environment and Development (WCED). In April 1987, Brundtland's Commission published the report "Our Common Future," and introduced the new political concept of "sustainable development."[216] Brundtland's concept asserts that humans should meet their current needs without jeopardizing the ability of natural systems to provide resources and ecosystem services for future generations (Brundland et al., 1987).

In March 1985, the UN parties agreed on another multilateral environmental program: the *Vienna Convention for the Protection of the Ozone Layer*[217] (UNEP, 1985). This convention was extended in September 1987 by the *Montreal Protocol on Substances that Deplete the Ozone Layer* (UNEP, 2016), the first environmental protocol ratified by all UN parties. Besides depleting the ozone layer, many of the substances listed in the Montreal Protocol also contribute to the greenhouse-gas effect and have significant global warming potential.[218]

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216 A concept that seeks to unify the principle of nature conservation, expressed by the term "sustainable," with what is often viewed as incommensurable goals of economic progress and change, embedded in the term "development."

217 The Vienna Convention was initiated by the United Nations Environment Program and based on scientific evidence that showed that some gases resulting from human activities deplete the stratospheric ozone layer that protects the Earth from ultraviolet B (UV-B) radiation. Ozone depletion is a major threat to life on Earth. UV—B radiation increases rates of skin cancer, compromises crops, and damages marine phytoplankton. The Dutch scientist Paul Jozef Crutzen and his American colleague Harold S. Johnston independently found that high concentrations of nitric oxide (NO) in the stratosphere catalyze the depletion of the ozone layer. After Crutzen's work, two scientists from the University of California, Frank Sherwood Rowland and Mario Molina, demonstrated that chlorofluorocarbons (CFCs) also destroy the stratospheric ozone layer.

218 The global warming implications were not explicitly recognized at the time the Protocol was ratified, but its later amendments in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997), and Kigali (2016) broadened the scope of the Montreal Protocol, transforming a treaty designed to protect the ozone layer into an "effective instrument for combating climate change" said the Minister of Environment, Barbara Hendricks, (BMUB, 2016, October)

That is why the Montreal Protocol reaches far beyond its purpose, to restore the stratospheric ozone layer, playing a significant role in mitigating climate change.[219]

Just months after the Brundtland Commission' s report and shortly after the Montreal Protocol, the German parliament convened, in October of 1987,[220] an interdisciplinary Commission (Enquete Kommission) to compile recommendations for protecting the earth's atmosphere, because it considered climate change to be one of the most severe environmental threats of our times (Deutscher Bundestag, 1987 a, p. 3; Deutscher Bundestag, 1987 b). Intermediate findings of this investigation were published in November of 1988 (Deutscher Bundestag, 1988). In March of 1989, the final report of the Enquete Commission was published (Deutscher Bundestag, 1989). The Commission recommended that chlorofluorocarbons in the atmosphere be reduced by at least 95% by 1997, to avoid further damage to the ozone layer; the report included recommended mechanisms for doing so. The Commission also claimed that by 2005, GHG emissions needed to be reduced worldwide by 20-30% (from the 1987 level), and by 80% by 2050.

In the 1980s, the government also passed amendments to the Federal Pollution Control Act (BImSchG), introducing its 13$^{th}$ Ordinance (13. BImSchV, 1983) with more strict emission rules for sulfur-dioxide ($SO_2$), nitrogen-oxides ($NO_x$), and particulate matter (PM) in large combustion plants, and modified the Technical Guidance on Air Quality Control (TALuft, 1986).

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[219] The protocol even lists substances like hydrofluorocarbons (HFCs), which do not harm the ozone layer, have significant global warming potential.

[220] During Helmut Kohl's third administration.

In the late 1980s, Mikhail Gorbachev's political reforms,[221] his "common European home" concept, and his sustained disarmament efforts,[222] substantially contributed to reduce East-West tensions. His political decisions weakened the member states of the Warsaw Pact and triggered a wave of anti-communist protests in all Eastern European countries. This revolutionary wave culminated with the fall of the Berlin Wall and the collapse of the communist bloc. Gorbachev and George H.W. Bush declared an end to the Cold War at the Malta Summit on December, 3, 1989 (BBC News, 1989).

By the end of Phase I, Germany's economy had completely recovered from the two oil crises and was booming.  The nation's strong economy was backed up by a modern and reliable energy system based on fossil, nuclear, and hydro-power.  Yet this period of time was also characterized by steadily increasing antagonism between pro- and anti-nuclear groups.

**Phase II – Institutionalization of the Vision of a Carbon-Free Future, 1990-2010**

The second energy-transition phase institutionalized and continues to institutionalize the vision of an energy system free of fossil and nuclear fuels. It encompasses almost three decades of major changes in Germany's energy system, as well as an ever-growing pool of innovation policies[223] and institutional arrangements[224] implemented to guide the transition,

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[221] Perestroika and Glasnost legalized private ownership, allowed freedom of press, and increased the transparency of state institutions.

[222] During the 1980s USSR's president Gorbachev negotiated with the US administrations of Ronald Reagan and George H.W.Bush the arms control treaty Start I, which was finally signed in 1991.

[223] Such as the successive Energy Economy Acts (EnWG), Renewable Energy Acts (EEG, EEWärmeG), Nuclear Acts (AtomG), GHG Emission Acts (TEHG), as well as all related Ordinances.

[224] BNA – Federal Grid Agency,  DEHSt –The German Emission Trading Institution, etc.

to mitigate adverse climate effects, to monitor the results, and to correct undesired developments.

At the beginning of Phase II, two major geo-political events significantly impacted the *Energiewende* arena: the reunification of East and West Germany in 1990, and the founding of the European Union in 1993[225]. After two successful terms as Chancellor of West Germany, Helmut Kohl was elected Chancellor of the reunified Germany in 1990, with an overwhelming majority of votes.

**Early actions - institutionalization in the first decade.** The first decade of the institutionalization of the *Energiewende* vision was one of early environmental and climate actions.

***(1) Voluntary commitments for achieving environmental and climate goals.*** In the early 1990s, voluntary commitments made by industries and agreements between policy makers and industrial associations became popular instruments for achieving environmental and climate goals. For example, in 1990, the German automotive industry committed itself to reduce its carbon-dioxide emissions in transportation by 25% by 2005.[226] In the following years, the same industrial branch committed to banning chlorofluorocarbons (CFC) in air-conditioning systems and to reducing station-wagon fuel consumption by 25% by 2005 relative to 1990 (BDI, 2004; BMU, 2011).

***(2) The Energy-Feed-in-Act.*** At the end of 1990, Germany's government passed its first act for the support of renewable energies and decentralized power generation, the

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[225] The Union of European Nations (EU) was formally established on 1 November 1993, when the Maastricht Treaty (ratified in February 1992 by 15 European states) entered into force. It is a supranational intergovernmental organization with common security, justice, and home affairs policies. The EU establishes regulations (i.e., directives, guidelines, etc.) that have to be implemented within a given time frame in national law in all of its member states, with the overarching goal of ensuring the free movement of products, people, services, and capital within its borders.

[226] Reduction basis: year 1990.

Energy-Feed-in-Act or *Stromeinspeisungsgesetz* (StromEinspG, 1990). The Act became effective in January 1991, and stipulated that electric utilities had to purchase renewable electricity produced in their area of supply by paying feed-in-tariffs (FITs). At that time, FITs were calculated as percentage of the average electricity sales prices.[227] This first scheme for subsidizing renewable energies triggered investments in wind parks in the wind-intensive coastal regions of Northern Germany. However, the FIT-level of the Energy-Feed-in-Act was insufficient to cover the costs for solar power, so investments in photovoltaic facilities remained rare exceptions in the early 1990s.

***(3) Actions for protecting the earth's atmosphere at national and global level.*** In April 1991, Germany's Parliament[228] convened a second Climate Enquete Commission to establish a coherent action plan for protecting the earth's atmosphere (Deutscher Bundestag, 1991). The second Enquete Commission had to work under changed socio-economic conditions. In the wake of reunification, the public's interest moved away from environmental and climate issues toward economic issues, because of the disparity in economic conditions between the two halves of the country. Some members of the Commission lost their political independence because of pressure from various political parties. The changed conditions not only made it difficult for the newly convened body to work efficiently, but also considerably weakened its political influence (Drechsler, 2001). Despite these problems, and against strong opposition from the agriculture and transport sectors, the members of the second Enquete Commission finally agreed that Germany should reduce its CO2 emissions by 25-30% from 1987 levels by 2005.[229] The commission

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[227] 90% for wind and solar, 75% for hydro-power, biogas, landfill- and sludge-gases, and 65% for all other RE.

[228] Helmut Kohl's third CDU/CSU-FDP coalition government.

[229] These climate mitigation goals were identical with those set by the previous Enquete Commission.

identified pathways for meeting these targets[230] and urged the government to take immediate action to mitigate climate change (Drechsler, 2001). Its first report was published by the end of March, 1992 (Deutscher Bundestag, 1992,) to provide political advice and consolidate Germany's position for the Earth Summit in Rio de Janeiro (June, 1992). A second report followed in July of 1994 (Deutscher Bundestag - a, 1994). The third and final report was published in October, 1994 (Deutscher Bundestag - b, 1994). Because Germany succeeded in reducing CO2 emissions by 15% between 1987 and 1993, the Enquete Commission concluded that Germany would not have problems meeting its national reduction targets for 2005 (Deutscher Bundestag - b, 1994, p.4). The Commission emphasized that beyond national commitments, climate actions were imperative at the global level.

Since 1995, the United Nations Framework Convention on Climate Change (UNFCCC) has organized annual Conferences of the Parties (COP) to assess progress in mitigating climate change and establish binding GHG reduction targets for developed countries. The first United Nations Climate Change Conference (COP-1) took place in April 1995 in Berlin, Germany. UN Parties agreed at COP-1 to establish the Ad hoc Group on the Berlin Mandate*,* a working group in charge of framing protocols (or other instruments) that define binding GHG emission targets for developed countries. Germany committed itself at COP-1 to high GHG reduction rates. Although most of the UN Parties were skeptical about the appropriateness of legally binding decarbonization targets in an international context, Germany's early commitment to reduce its carbon emissions contributed to convincing some of these parties to ratify the Kyoto Protocol (COP-3) of 1997.

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[230] These decarbonization pathways were: (1) federal support schemes meant to steer transition towards low carbon technologies, (2) energy and carbon dioxide tax, (3) emission cap-and-trade system, (4) instruments for transnational cooperation, and (5) self-commitments of economic sectors to reduce carbon emissions.

The successive reports of the Enquete Commission and the Conference of the Parties in Berlin increased the public's awareness about threats related to GHG emissions and brought climate change to the attention of Germany's citizens. Driven by the fear that Germany's government might introduce rigid rules for mitigating GHG emissions,[231] several industrial associations signaled, in 1995, shortly before COP1, their readiness to reduce GHG emissions by up to 20% by 2005, if the government, in return, renounced plans to tax carbon-dioxide emissions and to increase heat-efficiency requirements[232] (Kohlhaas & Praetorius, 1995). After intense negotiations and several amendments, this industrial initiative materialized in an agreement signed in 2000 by Germany's government and the representatives of 16 industrial associations representing energy-intensive industries. These industries committed to reducing carbon-dioxide emissions by 28% by 2005 (basis 1990) and emissions of other GHGs by 35% until 2012 (basis 1990). This was much more than the industries had originally wanted but less than the government had planned (BDI, 2004, p.2).

***(4) Circular economy.*** In 1990s, the government again passed adjustments to the Federal Pollution Control Act (BImSchG), and modified its 17th Ordinance about the Combustion of Waste (Verordnung über die Verbrennung und die Mitverbrennung von Abfällen – 17. BImSchV, 1990) to comply with the European Directives 89/369/EEC and 89/429/EEG. It also adopted the Packaging Ordinance[233] (Verpackungsverordung – VerpackV, 1991), implemented a dual system for collecting municipal and packaging waste

[231] I.e., rules that are too general to take into account particularities of specific manufacturing processes and too difficult to change once established.

[232] The government planned to amend the Heat Protection Ordinance (*Wärmeschutzverordnung*) and to increase the heat-efficiency in buildings.

[233] The ordinance required manufacturers to support the costs of disposing or recycling all of the packaging for their products.

(Duales System Deutschland –DSD, 1991), and introduced the Green-Dot Symbol[234] (der Grüne Punkt, 1990) on packages that can be collected in special recycling containers. In addition, Germany enacted legislation that restricted allowances to dispose of waste in landfill (the Technical Guidance for the Treatment of Municipal Waste, TA Siedlungsabfall – TASi, 1993), and passed the Circular Economy Act (Kreislaufwirtschaftsgesetz –KrWG, 1994).

*(5) Parents for a nuclear free future. The electricity rebels from Schönau.*

Approximately four years after the nuclear accident in Chernobyl, the German press ran a story that said the major accident had increased radioactivity levels in the southern part of Baden Württenberg. In response, a group of concerned citizens from Schönau, a small German town[235] located in the Black Forest, initiated a movement, "Parents for a Nuclear Free Future." Deciding not to wait until politicians and utilities took action against the nuclear threat, the group's members organized meetings, raised funds for a medical clinic in Kiev that treated children diagnosed with cancer, learned about electricity generation and consumption, distributed information about measures that could be easily implemented to reduce household energy consumption, and even established a cabaret-group called "Watt-Killer" that went on tour to make their energy-saving ideas popular. The first idea behind this initiative was to "just save the nuclear power away." More and more people joined the group and it became larger. However, its members soon come to realize that their energy-saving initiatives were not sufficient to displace nuclear power. Citizens from Schönau invested in small but highly efficient combined-heat-and-power facilities and renewable

[234] The Green Dot informed the consumer that the manufacturer had paid in advance the cost of recycling the package.

[235] With about 420 inhabitants in 1990.

energies (they reactivated small hydro-power plants and installed photovoltaic panels on their roof-tops) (Janzig, 2008; Dietsche & Kiefer, 2008; EWS, 2017). In addition, the "electricity rebels from Schönau" asked the local utility,[236] Kraftübertragungswerken Rheinfelden (KWR), to design special tariffs to honor their energy-saving efforts and support their renewable initiatives. At that time, KWR had the exclusive right to carry out all electricity-related activities (i.e., it had a concession agreement with the authorities of Schönau). From this position of power, it not only ignored the citizens' request, but also offered to pay the town of Schönau €100,000, if local authorities agreed in return to extend the concession by 20 years. Given the lack of reaction from KWR, the citizens concluded that they would have to become independent from KWR; they decided to buy the distribution grid in order to produce and distribute ecologically friendly electricity. To hinder the local authorities from extending the concession agreement with KWR, the concerned citizens also offered the town €100,000 to not extend it. However, the community council decided, by a slight majority, to extend KWR's concession. At the same meeting the rebels petitioned for a referendum to allow all citizens to vote for or against their project. Finally, in 1991, the voters reversed the town council's decision to extend KWR's concession; this gave the rebels time to prepare for next steps before KWR's existing concession expired. In 1994, the activists founded a new utility, the Elektrizitätswerke Schönau GmbH (EWS). The new company had as its single shareholder the Netzkauf Schönau GbR (The Grid Purchase Society Schönau), a society owned by 650 citizens. In November 1995, the town council decided to grant EWS the concession to be the town's future electric utility. However, at that

[236] These actions took place in the early 1990s, before the electricity markets had been deregulated. At that time, communities usually granted concessions for electricity-related activities (generating power, operating the distribution grid, and handling purchase and supply contracts) to a selected electric utility. By doing this they avoided destructive competition and ensured a stable, socialized, and affordable electricity supply. However, such concession agreements led to locally demarcated monopolies that excluded competition.

time the grid was still owned by KWR, which petitioned for a second referendum in hopes of reversing the council's decision. Meanwhile, the citizens' movement gathered attention and sympathy at the national level, becoming a symbol for the anti-nuclear movement. EWS won the second referendum with a clear majority (85%). But even though it became the most democratically legitimized utility in the world, it remained unable to function properly because the town's electricity grid was still owned by KWR. And KWR asked prohibitive prices for their grid: €8.7 million, about twice as much as its value as estimated by an independent evaluator. Although EWS established the "Schönauer Energiefonds" and succeeded in collecting about €4.0 million, the funds were insufficient to buy KWR's grid. The rebels took their problem to professional advertising agencies and convinced them to start a pro bono fund-raising campaign in support of the cause, using all available media. The agencies cooperated, and Schönau's energy initiatives reached every German household via TV, movie theaters, newspaper, and radio.[237] The campaign was successful; EWS bought KWR's grid and became a functional utility. (Janzig, 2008; Dietsche & Kiefer, 2008; EWS, 2017).

***(6) New basis for subsidizing Germany's energy mix.*** Domestic hard coal (*Steinkohle*) was considered indispensable for Germany's electricity mix. But the exploitation costs of German hard coal exceeded by far the cost for coal imports. To encourage the use of domestic coal, Helmut Schmidt's government introduced, at the end of 1974, a subsidy scheme known as *Kohlepfennig* (see Phase I: Birth of a Vision, p. 8 ; VerstrG3, 1974). As a consequence of a legal claim initiated in 1985 by an electric-utility (RWE) that charged the

[237] One very suggestive advertising spot filmed different individuals from Schönau against the background of a large nuclear facility, saying: "I am a disturbance. I buy my town's electricity grid, because I do not want to live with nuclear power. Help me!"(EWS, 2017).

*Kohlepfennig* against a private person who refused to pay this contribution, Germany's Federal Constitutional Court (Bundesverfassungsgericht) decided in 1994 that the *Kohlepfennig* was unconstitutional (BVerfGE, 1994). Acting in the general interest, the constitutional court did not revoke the coal contribution, but urged the legislature to find other ways to subsidize domestic coal. In response to this decision, Chancellor Kohl's fifth administration abrogated the *Kohlepfennig* at the end of 1995. The government decided to bridge the price differences between domestic and import coal exploitation between 1996 and 2005 from the federal budget[238] (VerstrG5, 1995).

*(7) Deregulation of the energy markets.* Following the founding principles of the European Union and the spirit of the economic union established in the 1957 Treaty of Rome,[239] the European Parliament passed, in December 1996 and after intense negotiations, the European Directive 96/92/EC, which established common rules for a deregulated (liberalized) European electricity market. According to its stipulations, member states had to deregulate their electricity markets by successively allowing different categories of consumers to access the grids and switch their suppliers. Member states could opt for one of two alternative grid-access models: regulated third-party access (TPA) or negotiated third-party access (NTPA). They had to ensure the legal unbundling of electric utilities.[240] Following the

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238 According to the new coal subsidy laws, the Federal Ministry for Economic Affairs (Bundesministerium für Wirtschaft) had to annually approve the total amount of direct coal subsidy, based on an economic plan made by The Federal Agency for Economy (Bundesamt für Wirtschaft). In contrast to the previous (indirect) incentive scheme, the new subsidy directly financed mining activities (VerstrG5, 1996).

239 France, Italy, Germany and the BeNeLux countries ratified in March 1957 the Treaty of Rome. The named nations aimed to establish an economic union that allows the free movement of products, people, services, and capital within its borders. The economic union envisioned in Rome in 1957 was complemented in 1992 in Maastricht by the vision of a supranational organization with common security, justice, and home affairs policies - the European Union (Deutscher Bundestag, 2007).

240 I.e., to make sure that vertically integrated utilities unbundle their trading and transportation (transmission and distribution) activities into distinct legal entities.

subsidiarity principle, member states had to transpose the stipulations of the electricity directive into national law within two years. To comply with the directive, Germany modified its 1935 Energy Economy Act (EnWG) by abrogating all agreements that granted exclusive electricity supply rights in a certain area to one utility company (Demarkationsverträge), and amended the Act Against Limitation of Competition (Gesetz gegen Wettbewerbsbeschränkungen - GWB). In contrast to the majority of other European states, Germany decided that rules for accessing electricity grids had to be negotiated between third parties and grid owners (NTPA). The detailed rules for access to the grids were defined in the First Association Agreement for the Deregulation of Electricity Markets (Verbändevereinbarung Strom – VVI Strom)[241] of May 1998.

In August 1998, the European Parliament passed Directive 98/30/EC, which established common rules for the internal natural-gas market and for non-discriminatory access for third parties to the natural-gas grids. Member states had to transpose the natural gas directive into national law within two years, and to open their natural-gas grids for competition. To ensure an increased level of competition, integrated natural-gas utilities had to keep accounts for their trading and transportation activities separate.[242] Germany's government opted for a negotiated-access model (NTPA) for the gas grid. Because the new Energy Economy Act (EnWG, 1998) was adopted prior to the natural-gas directive, it couldn't encompass specific rules for deregulation of the natural-gas grids. That is why the government amended the Act against Limitation of Competition (Gesetz gegen

[241] The association agreement VVI Strom was negotiated between the Vereinigung Deutscher Elektrizitätswerke (VDEW), an association representing the interest of utility companies, and two associations representing the interest of large energy consumers (Verband der Industriellen Energie- und Kraftwirtschaft (VIK) and Bundesverband Deutscher Industrie (BDI)).

[242] Account unbundling and not legal unbundling as stipulated in the electricity directive.

Wettbewerbsbeschränkungen – GWB, 1998), implementing stricter anti-trust rules that prohibited players with a dominant position in the market from generating competitive disadvantages for smaller players by hindering access to the grid. Thus, the amended GWB together with the remodeled EnWG 1998, and the negotiated access to the natural gas grids, provided the legal framework for complying with the European natural-gas directive (Klag, 2003, pp.247-261 & 272).

*(8) The end of the Kohl era.* Chancellor Helmut Kohl made tremendous efforts to unify Eastern and Western Germany. He supported the East German peaceful revolution, convinced the Hungarian government to renounce repatriating East German citizens[243]who had tried to escape the socialist regime by crossing the Hungary-Austria border, and welcomed all East German refugees. In the wake of Eastern German protests against the socialist regime, Kohl recognized the opportunity to unify East and West Germany and pushed his ambitious reunification plan forward despite West German worries about exploding costs and strong opposition from East German intellectuals. He negotiated Germany's reunification with the four winning nations of World War II, ensured that the reunified Germany became a member of the NATO pact[244], introduced a solidarity fund to rebuild Eastern Germany, and equalized currencies, salaries, and pensions of Eastern and Western Germany at the monetary exchange rate of 1:1. Finally, he steered the reunified nation through the difficult and costly reunification process. Together with his French counterpart, Francoise Mitterrand, Kohl designed the modern European Union as a supranational organization with common security, justice, and home affairs policies, and was

[243] Warsaw Pact countries had an agreement to arrest and send back (repatriate) citizens of allied countries that tried to escape the system over their borders.

[244] Against the request from the Soviet Union that Germany remain political neutral.

the architect of European monetary reform, with the Euro[245] as the common European currency (DailyNK, 2014; Die Welt, 2004; Deutscher Bundestag, 2007). In 1997 Kohl identified GHG emissions as major threat for humans. With voluntary commitments to substantially reduce GHG emissions and deregulate the energy markets, the successive Kohl administrations created a basis for energy transitions and climate mitigation.

Yet Kohl's bold political decisions had very high social costs. The German monetary reform, which obliged Eastern German industry to pay, practically overnight, wages and benefits in West German Marks (DM), pushed most Eastern manufacturers into bankruptcy, significantly increased the unemployment rate, and triggered tensions between East and West Germans. The Solidarity Fund established to rebuild the economic infrastructure of East Germany was financed by all West German employees, diminishing their own incomes. With these problems came decreased support for Kohl's reforms. In 1994 Kohl was reelected Chancellor with only a slight majority of votes. The reconstruction boom at the beginning of the 1990s was followed by a time of economic stagnation and soaring unemployment rates[246] at the end of the decade, resulting in even less support for Kohl's policy. Indeed, in September 1998, after 16 years in office, Kohl lost the federal elections to the representative of the Social-Democratic Party (SPD,) Gerhard Schröder. Chancellor Schröder formed a coalition government with the Green Party. After decades of grassroots movements and parliamentary work, the Greens, headed by Joschka Fischer, entered into a governmental coalition for the first time in the party's history. The new "red-green" coalition

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[245] Many citizens were reluctant to renounce the Deutsche Mark (DM,) the symbol of Germany's *Wirtschafts-wunder*. In an interview with Jens Peter Paul in March 2002, Kohl confessed that he imposed the Euro on Germans like a "dictator." He pushed the European monetary union forward against internal opposition knowing that a referendum would have turned in favor of the Deutsche Mark and being aware that his decision for the Euro would cost him votes (Paul, 2010, p. 293).

[246] The number of unemployed German citizens increased from 2.6 Million in 1990 (7.3%) to 4.4 Million in 1997 (12.7%).

took office in a troublesome time of economic difficulties during which Germany was considered the "sick man of Europe" (*The Economist*, 1999).

**Implementation - institutionalization in the second decade.** The second decade of the institutionalization of the *Energiewende* vision continued the rapid pace of intensive change.

*(1) Extensive economic and social reforms – the Agenda 2010.* To spur economic growth, reduce unemployment, and steer Germany away from the structural crisis it entered after reunification, Chancellor Schröder's administration passed extensive economic and social reforms. Yet Schröder's pro-business policies led to severe tensions within the Social Democratic Party (SPD). The traditional labor-wing of the SPD grouped around party chairman Oskar Lafontaine and strongly opposed Schröder's reforms. The conflict split the party and led in 1999 to a succession of election losses for the SPD in six German States. In March 1999, Oskar Lafontaine resigned from his office and Schröder took his rival's position as Chairman of the SPD. Despite all of its pro-business reforms, Schröder's first government was unable to reduce unemployment rates and to keep the promises it made in the 1998 elections[247]. At the beginning of the election campaign of 2002, the odds seemed to be against the Chancellor retaining his office[248] until Schröder managed to revive his poll ratings, first by monopolizing media during the catastrophic spring flood of 2002, and then by strictly opposing the Iraq war during the summer of 2002. In the end, the Social Democrats and Greens won the 2002 elections with a slight majority of votes and

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[247] Schröder ran his 1998 election campaign against Kohl with the slogan, "If we do not manage to significantly reduce the unemployment rates, we do not deserve to be reelected" ("Wenn wir es nicht schaffen, die Arbeitslosigkeit spürbar zu senken, dann haben wir es nicht verdient wiedergewählt zu warden" (Spiegel, 2005)). The rising unemployment rates in the wake of the elections 2002 thus put Schröder in a very difficult position.

[248] And to favor Edmund Stoiber, the center-right candidate from the Christian Social Union (CSU).

established the second German red-green coalition government. In his second term, Schröder continued his reforms against increasing opposition from his own party. From March 2003, under Agenda 2010, Schröder's reform policy, the government significantly reduced the taxation burden for employers[249] and employees,[250] and put the entire labor and social-insurance market on a new basis by reducing pension and unemployment payments,[251] encouraging private pension opportunities,[252] and introducing "one Euro jobs" to force people to go to work instead of receiving social payments.  Instead of spurring the economy, Schröder's reform package resulted in an economic crisis. Unemployment figures soared from 3.8 million people (10.2%) in 1998 to 5.2 million in 2005 (12.6%), the highest point since the founding of Germany's Federal Republic[253] (Spiegel, 2005).

*(2) Red-green energy policy:  coal based energy mix and nuclear phase-out.*

Werner Müller, the Federal Minister of Economic Affairs during Chancellor Schröder's first administration, initiated in 1999 an energy dialog among decision makers from policy,

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[249] The corporate tax was stepwise reduced from 45% to 25%. Further tax advantages entered into force to support small and middle-sized companies.

[250] The highest income tax rate was stepwise reduced from 53% to 42% while the lowest income tax rate dropped from 25.9% to 15%.

[251] The labor market reform, also known as "Hartz" reform, limited the period of unemployment assistance to one year and eliminated previous redundancies between social welfare and long-term unemployment assistance, by unifying the two systems. According to the Hartz reform citizens who are unemployed for more than one year can apply for social welfare. They receive a fixed monthly payment (known as Harz IV) but have to accept in turn low qualification jobs. In addition the government significantly reduced the health insurance benefits in the statutory health insurance system and encouraged citizens to privately contract additional health insurances.

[252] The pension system reform raised the minimum retirement age to 67 years and significantly reduced the obligation of employers to contribute to the employees' pensions. In the meantime, citizens were encouraged to invest during their active time in pension funds (Riester pension) to compensate the curtailed contribution of their employers.

[253] During Schröder's two terms the unemployment figures rose from 3.8 million people (10.2%) in 1998 to 5.2 million in 2005 (12.6%). (Spiegel, 2005)

economy, and environmental associations,[254] to jointly define goals for development of the energy sector. Nuclear energy was explicitly excluded from the deliberation process because the invited parties had strongly contrary positions on it. The final report of the Energy Dialog 2000 was published on 5th June 2000 under the title *Guidelines for the Energy Policy,*[255] and encompassed policy recommendations for: (1) competition and deregulation, (2) energy consumption, renewable energies, and CO2 mitigation, and (3) the energy site Germany - energy security and employment (BMWi, 2000 a, pp. 19-20). The report concluded that it was vital for a resource poor country like Germany to develop new technologies based on renewable energy sources, and to become more sustainable[256] by integrating these technologies in its existing energy systems (BMWi, 2000a, p. 24). However, Dialog participants also agreed that the transition to low-carbon technologies required time and would have to occur gradually, without forcing rapid changes in Germany's energy mix (BMWi, 2000a, p. 32, (I.42)). They emphasized the importance of hard coal and lignite–the most abundant domestic fuels–for Germany's energy mix (BMWi, 2000a, p. 32, (I.43-44)), and that renewable technologies should primarily increase Germany's energy independence primarily by reducing imports of fossil fuels (BMWi, 2000a, pp. 6 &12). Despite the fact that the future of nuclear power was not a topic on the Dialog agenda, the final report

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[254] The environmental groups: Deutscher Naturschutzring (DNR), Greenpeace, Umweltstiftung WWF-Deutschland (WWF), NABU Naturschutzbund Deutschland (NABU) und Bund für Umwelt und Naturschutz BUND (BUND) left the Energy Dialogue 2000 in Mai 2000, because they disagree with the achieved results.

[255] The policy recommendations were presented in the German Parliament by the End of June 2000. Given that the environmental associations (Deutscher Naturschutzring (DNR), Greenpeace, Umweltstiftung WWF-Deutschland (WWF), NABU Naturschutzbund Deutsch- land (NABU) und Bund für Umwelt und Naturschutz BUND (BUND)) involved in the Energy Dialog 2000 did not agree in all points with the consensus achieved by the other participants, they left the discussion on May 10th without signing the final report. However, many of their positions were integrated in the final report. (BMWi, 2000a, p.20)

[256] More sustainable means in this context that political decisions related to energy generation and energy use have to equally consider economic, social and ecologic aspects of (BMWi, 2000a, p.21 (I.1)).

emphasized the government's clear position against nuclear power (which was stipulated in the red-green coalition agreement of October 1998), as well as its intention to start negotiations with utility companies about phasing out nuclear power plants (BMWi, 2000a, p.20, (2)). Less than two weeks after publishing the final report of the Energy Dialog 2000, on June 14th the German government came to a nuclear phase-out agreement with the utility industry (BMWi, 2000b)[257].

Decisions to phase-out nuclear power plants tend to result in increased carbon-dioxide emissions, because the nuclear share of the power mix has to be replaced by energy generated in power plants using carbon-intensive fuels.[258] However, Germany's decarbonization goal at the time of Schröder's *Nuclear Consensus* was the rather modest (14% by 2005; basis year 1990) indicating that the government's primary concern was to preserve Germany's coal-based energy mix and not to achieve ambitious climate goals (BMWi, 2000a, p.19; Semrau & Hufschmied, 2000 ).

***(3) The ecological tax reform: mixing elements for energy, labor, and social taxation.*** In March 1999, Schröder's red-green government passed the Act for the Introduction of an Ecological Tax Reform (eco-tax reform).[259] In addition to implementing a new tax on electricity[260] (Deutscher Bundestag, 1999 a, Article 1, pp. 378-380), this act

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[257] The *Nuclear Consensus* was officially signed one year later, on June 11, 2001, by Chancellor Gerhard Schröder, the Minister of Economic Affairs Werner Müller, the Minister of Environment, Jüergen Trittin, and the representatives of the utility industry Hartmann, U. (Eon), Kuhnt, D. (RWE), Goll, G. (EnBW), and Timm, N. (HEW).

[258] As long as there is no technology in place able to store electricity at a large scale, it is not possible to replace base-load nuclear power with intermittent and carbon-neutral renewable power.

[259] Gesetz zum Einstieg in die ökologische Steuerreform (Ökosteuergesetz).

[260] Stromsteuergesetz.

modified existing energy-taxation rules for petroleum, petroleum products, and natural gas[261] (Deutscher Bundestag, 1999 a, Article 2, pp. 380-384). It aimed to stimulate environmentally conscious behavior, reduce energy consumption, encourage the deployment of more efficient technologies, and consider external energy-consumption costs[262] by introducing additional taxes on primary and secondary energy.[263] The act also aimed to stimulate the economy by using additional income from the eco-tax to reduce the amount companies had to pay for social benefits for their employees[264]. To stimulate the deployment of low-carbon technologies, renewable-energy facilities were completely exempted from paying eco-taxes. To avoid creating competitive disadvantages for manufacturing industries, the act stipulated that the companies would pay eco-taxes at a reduced rate.

In December 1999, parliament passed the Act for the Continuation of the Ecological Tax Reform,[265] which stipulated a stepwise increase in taxes on electricity and petroleum products[266] between 2000 and 2003. It allowed companies that used natural gas in highly efficient combined heat-and-power (CHP) sites to recover, for a limited period of time, the taxes on oil products (Deutscher Bundestag 1999 b; Deutscher Bundestag, 2006, p.4). This rule enabled companies with CHP facilities to recover not only the ecological part of their energy taxation, but also the taxes on mineral-oil products that preceded the eco-tax reform,

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[261] Mineralölsteuergesetz.

[262] Such as costs for health issues that emerge from burning and/or exploiting fossil fuels, or costs for combating storms, floods, and/or other consequences of global warming.

[263] Electricity, natural gas, petroleum, and petroleum products.

[264] For example in 2003 the additional income from ecological taxes was Euro 18.7 Billion. From this amount Euro16.1 Billion were used to reduce the contribution companies had to pay for the retirement benefits for their employees by 1.7%.

[265] Gesetz zur Fortführung der ökologischen Steuerreform (Deutscher Bundestag, 1999b).

[266] Including natural gas.

and thus to substantially improve their balance sheets.[267] In November 2000, a climate protection agreement[268] was signed, between Germany's federal government and representatives of Germany's industries (compare Early Actions - Institutionalization, Decade I, (3), p. 14). The industries committed to voluntarily reducing their GHG emission levels by 35%[269] by 2012 (BMWi, 2000c; BDI, 2004). In return, the government ensured that ecological taxes for electricity and petroleum products wouldn't affect the competitiveness of German industrial sites. To protect companies from soaring taxation costs, the government introduced a peak-compensation mechanism (Spitzenausgleich) that allowed manufacturing industries to recover up to 95% of their eco-taxes, if these taxes exceeded the economies they realized by paying less for retirement benefits for their employees (Häder, 2010, p.63).

In December 2002, at the beginning of Schröder's second term, the government again amended the eco-tax system by passing the Act for the Further Development of the Ecological Tax Reform,[270] and increasing taxes for natural gas and different petroleum products independent of their ecological impacts.

***(4) Energy markets: from negotiated to regulated access to electricity and natural gas grids.*** Schröder's red-green coalition government continued the deregulation of energy markets based on two laws passed by the end of Helmut Kohl's last term: the Energy Economy Act (EnWG 1998) and the Act Against Limitation of Competition (GWB). In

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[267] This measure temporarily created competitive advantages for German manufacturing industries on the European and global markets, and from the perspective of other Member States of the European Union, it constituted "unauthorized state aid." (Ekardt, 2013; Ekardt, 2015)

[268] Vereinbarung zwischen der Regierung der Bundesrepublik Deutschland und der deutschen Wirtschaft zur Klimavorsorge, 9. November, 2000.

[269] Compared to the GHG emission level from 1990.

[270] Gesetz zur Fortentwicklung der ökologischen Steuerreform vom 23. Dezember 2002 (BGBl. I S. 4602).

December 1999 the Second Association Agreement for the access to the Electricity Markets (Verbändevereinbarung Strom II – VVStrom II) entered into force. It encompassed improved rules for access to the electricity grid[271] for small electricity consumers. Two years later, industrial associations[272] amended the Second Association Agreement (VVStromII+), establishing new concepts for comparative markets.

In July 2000, Germany fulfilled its obligation as a member state of the European Union to transpose the Directive 98/30/EC into national law, by adopting the First Association Agreement for the Deregulation of Natural Gas Markets (Verbändevereinbarung Gas – VVGasI).[273] The VVGasI included detailed rules for accessing to the natural-gas grids and, together with the remodeled EnWG 1998 and the amended GWB, created the legal framework for complying with the European natural-gas directive. According to the stipulations of VVGas I, customers had to pay a distance-dependent fee[274] to access the natural-gas grids. One of the controversial points on the negotiation agenda that remained unsolved by this agreement was about access priorities in cases of grid

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[271] VVStrom II introduced the concept of Balancing Circles to determine the grid-access and balancing fees, established rules for small consumers to access the grid based on standardized consumer profiles, and eliminated the transaction fees between different balancing areas.

[272] The Union of German Electricity Plants (Vereinigung Deutscher Elektrizitätswerke (VDEW)), the Association of communal enterprises (Verband Kommunaler Unternehmen (VKU)), the association of electricity grid owners (Verband der Netzbetreiber (VDN)), and the Working Group of Regional Utilities (Arbeitsgemeinschaft Regionaler Energieversorgungunternehmen (ARE) – all representing the interests of the utility companies; the Association for Industrial Energy-and Power Economy (Verband der Industriellen Energie- und Kraftwirtschaft (VIK) ) and the Federal Association of German Industries (Bundesverband Deutscher Industrie (BDI)) - representing the interests of electricity consumers.

[273] The association agreement VVI Gas was negotiated between two associations representing the interests of gas utilities (Bundesverband der deutschen Gas und Wasserwirtschaft (BGW) and Verband Kommunaler Unternehmen (VKU)) and two associations representing the interests of consumers of natural gas (Verband der Industriellen Energie- und Kraftwirtschaft (VIK) and Bundesverband Deutscher Industrie (BDI)).

[274] According to VVGas I, grid-access fees were calculated and negotiated individually for each possible transaction, making the entire system slow and the costs unpredictable. It was, for instance, extremely difficult to properly compare offers made for a particular site by different suppliers if the transportation distances were not identical. This kind of access did not consider the fact that the gas grids were interconnected, and that the theoretical transport distance did not correspond to the paths the gas molecules actually took.

bottlenecks. Another unsolved issue was access to storage facilities. Despite apparently open access for all customers to the natural-gas grids, grid owners could hinder fair competition by creating artificial bottlenecks.[275] In addition, non-discriminatory access to natural gas grids could be hindered if grid owners did not offer a virtual or physical access to connected storage facilities. That is why in 2001, the associations passed two addenda to the VVGas. In May 2002, they adopted the Second Association Agreement for the Deregulation of Natural Gas Markets (Verbändevereinbarung Gas II -VVGas II). In contrast to the previous agreement, VVGas II established an entry-exit fee system[276] and eliminated the transport distance as component for the grid-access fees. The industrial associations involved in the deregulation of the natural-gas grids agreed to limit the validity of VVGas II to September 2003 and intended to solve by that date the points on the negotiation agenda that were still open.

To equalize the rules for accessing electricity and natural-gas grids, in May 2003 the government amended the Energy Economy Act (EnWG, 2003). The amended EnWG included a provision that partially legalized the association agreements for electricity and natural gas, by assuming that each grid owner who complied with the relevant association agreement acted in "best professional practice."[277]

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[275] For example, by adding contracted capacities and not taking into account that peaks did not occur simultaneously.

[276] The grid-access fees, according to VVGasII, had an entry and an exit component that functioned similarly to a postage-stamp system. If a consumer intended to change the supplier of natural gas, he usually paid the exit fee. Depending on the point where the new supplier accessed the grid, he had to balance the valid entry fees In addition to the transportation costs that were covered by the entry and exit fees, the consumer had to pay for the delivered energy (kWh or $Nm^3$ of gas) and for system services (including grid dispatching and balancing, quality switch, etc.)

[277] This EnWG stipulation made it more difficult for regional and federal Anti-Trust Agencies to intervene in cases of hindered grid access, because it reversed the burden of proof (i.e. given the supposition of "best practice" it became the responsibility of the Anti-Trust Agency to proof that grid owners hinder the non-discriminatory access to their grids).

The deregulation of the electricity markets (which preceded the deregulation of the gas markets) led, at least in the beginning, to extreme competition in the electricity sector and to a significant drop in electricity prices for consumers. Natural-gas utilities and the associations that represented their interests tried to avoid similar developments in the gas sector. That is why the negotiation process for the deregulation of the natural-gas markets became increasingly difficult. After a long period of stagnation, in 2003 the involved associations withdrew from the negotiation process for the Third Association Agreement Gas. The government thus had to replace, at least for the deregulation of gas markets, the negotiated-access model (NTPA) with regulated third-party access (TPA). In June 2003 the European Parliament passed new directives for the complete deregulation of electricity (2003/54/EC) and natural-gas (2003/55/EC) markets. In contrast to their previous versions, the new directives eliminated the NTPA as a deregulation option, obliging the member states of the European Union to establish regulatory bodies to deregulate energy markets. To comply with the revised European directives, Germany's government decided to drop the negotiated grid-access model and to opt, as did all other European countries, for regulated third-party access (TPA).

In 2005, by the end of Chancellor Schröder's second term, the government tasked the Regulatory Authority for the Deregulation of the Telecommunication Sector with deregulation of the energy sector and renamed it the Federal Network Agency (Bundesnetzagentur -BNetzA). In June 2005 the red-green coalition passed a new Energy Economy Act (EnWG, 2005).

***(5) Deploying renewable energies: the Renewable Energy Act – EEG.*** To incentivize the deployment of decentralized rooftop solar facilities Schröder's red-green government implemented in 1999 its 100,000 Solar-Rooftop program. The program granted low interest credits to households and small solar companies as long as their total installed solar capacity did not exceed 300 MW (BMU& KfW, 2003).

In April 2000 Schröder's first administration replaced the 1991 Energy-Feed-in-Act with the Renewable Energy Act - EEG. The new law introduced a grid feed-in priority for electricity from renewable energy sources and defined different, source-dependent, digressive[278] feed-in-tariffs (FITs) for each renewable source. The EEG 2000 stipulated that electric utilities had to purchase renewable electricity produced in their area of supply by paying fixed FITs for each kilowatt-hour of power fed into the grid, for 20 years. According to the EEG, the costs for the deployment of renewable energies are aggregated at the national level and redistributed to electricity consumers. For each kilowatt-hour they consume, power consumers have to pay a renewable-energy contribution (EEG–Umlage). In comparison to the Energy-Feed-in-Act, the FITs of the EEG 2000 were much more generous (Appendix C). The EEG 2000 limited the total solar capacity in Germany to 350 MW (50 MW implemented prior to the EEG 2000 and 300 MW additional capacity from the 100,000 Rooftop program). In 2003 this limit was exceeded. Although the funds and EGG FITs for rooftop-solar were capped at 350 MW installed solar capacity, the government intended to further incentivize solar generation.  Therefore, an adjusted Renewable Energy Act was passed in December 2003. To comply with the European Renewable Energy Directive 2001/77/EG, the government revised again its Renewable Energy Act in August 2004. The incentive principle remained unchanged, but the tariff level was adjusted. (Appendix C)  (Salje, 2012; Salje 2015; Baur et al., 2015; Maubach, 2014, pp. 51-78)

[278] Meaning that tariffs decrease each year after the EEG becomes effective by a predefined percentage.

*(6) The Combined Heat and Power Act – KWKG.* In the late 1990s and early 2000s, large and powerful utility companies tried to position themselves anew in the electricity market, seeking influence in areas where other electric utilities had previously been protected by clear demarcation contracts.[279] As a consequence of market deregulation, competition in the electricity sector reached unimaginable levels,[280] and power prices plummeted (Guss & Zipp, 2015, p.3). These unexpected dynamics put at risk publicly owned electric companies (Stadtwerke) that had an important role in distributing electricity and other utilities (heat, water, natural gas) and providing diverse services (public transportation, harbor services, etc.) to smaller and middle-sized consumers located in their area of influence. Traditionally, many of these municipality-owned Stadtwerke installed, prior to the deregulation of the energy markets, combined heat and power (CHP) facilities to deliver electricity, process steam, and provide district heating to clients located in their distribution area. Under the new conditions, these public utilities couldn't function economically. To protect the Stadtwerke and avoid "stranded" investments, the government passed in May 2000 the first CHP Act[281] – a law exclusively protecting existing public CHP facilities. The central feature of this act was direct aid for public CHP, which it provided by obliging electric utilities to accept and remunerate CHP electricity fed in to their grids (Guss & Zipp, 2015, p.3; Deutscher Bundestag, 2000; KWKG, 2000).

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[279] Contracts between utilities that defined the areas in which a particular utility alone is responsible for the energy supply.

[280] It was a period of unhealthy competition in which large utilities literally chased larger consumers by offering power prices that could barely cover the variable costs for large lignite power plants. German lignite is exploited in open-pit mines at very low costs and is the least expensive fuel. Energy experts responsible for purchasing electricity for manufacturing sites couldn't believe their luck—the cost of electricity was almost as low as the cost of primary energy.

[281] The Act for the protection of electricity generation in CHP facilities (Gesetz zum Schutz der Stromerzeugung aus Kraft-Wärme-Kopplung).

In April 2002, by the end of Schröder's first term, the parliament passed the KWKG, an act that created, in addition to the protection of public power plants, incentives to implement new CHP facilities[282] and to modernize existing ones. Beyond incentivizing combined heat and power generation, the new CHP act set the goal of significantly reducing annual carbon emissions[283] through simultaneous generation of power and heat (Guss & Zipp, 2015, p.3; Deutscher Bundestag, 2001, p. 9, KWKG, 2002). The aggregated costs from incentivizing CHP facilities were redistributed to electricity consumers. In contrast to the EEG redistribution mechanism that increased the energy component of the power price, the CHP contribution (KWK-Umlage) increased its transport and distribution component. To diminish the burden for manufacturing industries, commerce, and trade, these enterprises had to pay only reduced CHP contributions.

***(7) Mitigating carbon emissions - the first European Emission Trading Period –ETPI (2005-2007).*** In 1997 the United Nations Framework Convention on Climate Change hosted in Kyoto the third Conference of the Parties (COP-3). To limit the global-warming effect resulting from human activity, UN Parties agreed to define binding reduction targets for GHG emissions in developed countries (Annex B States) for the period 2008-2012. They aimed to reduce the cumulated GHG emissions of Annex B states by 5% with respect to 1990 levels. UN Parties also agreed that the final document of COP-3, the Kyoto Protocol, would enter into force as soon as ratified by 55 Annex B states.

The European Union committed itself at COP-3 to reduce the average GHG emissions of its member states by 8% (basis 1990) until 2012. In order to develop and implement appropriate measures that enable the European Member States to achieve their

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282 With a capacity smaller or equal to 2 MWel (KWKG, 2002).

283 By 10 million $t_{CO2\ equiv.}$ until 2005 and by 20 to 23 million $t_{CO2\ equiv.}$ until 2010 (KWKG, 2002).

mitigation commitments, the European Commission launched in June 2000 the European Climate Change Program (ECCP). Under the framework of the ECCP, European Member States came to the conclusion that a European GHG Emission Trading System that complied with market principles and used a cap to limit emissions would be the most suitable instrument for meeting their mitigation commitments.

On May 31, 2002 all member states of the European Union simultaneously ratified the Kyoto Protocol. Within the European Union, Germany committed to a GHG reduction goal of 21%[284], while Great Britain set its reduction target at 12.5%, and France decided to stabilize its GHG emissions at the 1990 level (UNFCCC, 2002). Given that Germany's 1990 emissions level was bloated by the addition of East German emissions, and that the United Kingdom was in the process of switching away from coal to natural gas, the choice of 1990 as a reference year was a particularly convenient political decision (Benedick, 2001).

In October 2003 the European Council passed the Emission Trading Directive 003/87/EC, which set the legal framework for the EU ETS and for the National Allocation Plans (NAPs). The directive defined two emission-trading periods: 2005-2007 (ETPI) and 2008-2012 (ETPII). EU member states had to transpose the directive 003/87/EC into national law and to establish criteria for the allocation of emission allowances prior to the beginning of ETPI. To estimate Germany's CO2 reduction target, complete the national allocation plan, and define the allocation rules for allowances, each CO2-emitting facility had to report extensive historical energy and production data, as well as the amount of carbon emissions resulted from burning fossil fuels. The collected emissions data were complemented with estimates for new facilities that were expected to begin operation

[284] Germany's ambitious GHG-mitigation commitment within the European burden-sharing significantly contributed to convincing other UN Parties to ratify the Kyoto Protocol (compare Early Actions - Institutionalization, Decade I, (3), p. 14).

between 2005 and 2007, and aggregated at national level. According to the aggregated data Germany had to reduce carbon emission by about 3% during ETPI in order to meet its climate-mitigation goals (Elspas et al., 2006; Gerner, 2012; ZuG 2007, 2004).

Based on these estimates, Germany's government submitted in March 2004 its national allocation plan for approval to the European Commission. In July the Commission rejected the German NAP, considering the ex-post adjustment of the allocation of emission allowances incompatible with criteria 5 and 10 of Annex III to Directive 2003/87 (EC, 2004). Yet given the tight time schedule[285] the Commission allowed Germany to allocate allowances in before complying with the requested NAP amendments (EC, 2004). Indeed the decision of the European Commission came too late for implementing the requested changes in Germany's legislation. On July 8, 2004 Germany's parliament passed the GHG Emission Trading Act (TEHG)[286] to comply with the Directive 003/87/EC. Subsequently the government agreed on the Allocation Act (ZuG 2007),[287] an act that defined the criteria for allocating CO2 emission allowances.

ETPI focused on mitigating only carbon-dioxide emissions from the energy and manufacturing sectors. Other economic sectors (transport, agriculture) were not subjected to the EU-ETS. All manufacturing plants that needed pollution allowances,[288] as well as all facilities with a thermal capacity above 20 MWth, had to apply for CO2 allowances. Smaller facilities were not under the jurisdiction of the EU-ETS but could opt-in on a voluntary

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285 Member States had to enact national laws, create rules and organizations for allocating allowances; facility owners had to understand the legislation, apply for allowances before 2005.

286 Treibhausgas-Emissionshandelsgesetz was enacted only one day after the decision of the European Commission to reject Germany's NAP (TEHG, 2004).

287 Zuteilungsgesetz, (ZuG 2007, 2004).

288 That need an approval based on the Federal Emission Protection Act (BImSchG, 4. BImSchV).

basis. Germany's government designed the German Emission Trading Authority (DEHSt)[289] at the Federal Environmental Protection Agency (UBA)[290] to allocate emission allowances and coordinate the national emission trading activities. Before applying for allowances, facility owners had to have their applications validated by accredited external experts. After each year of the ETPI, facility owners had to return a number of allowances that corresponded to their real emission figures (Elspas et al, 2006; Gerner, 2012).

As described in Chaprer 4, the "new facility," "option," "special allocation," and "early action" clauses of the ZuG2007[291] led to an extreme over-allocation of emission allowances. Since it mirrored Germany's NAP, this act also encompassed a clause meant to correct over-allocations, which, according to the European Commission, did not comply with European law. This dissent ended at the European Court of Justice, in favor of the German government. However, it took the Court nearly the entire period of the three-year ETPI to deliver a judgment.[292] While the case was being decided, DEHSt did not reduce allocations. The unclear legal situation also kept facility owners from trading allowances. In addition, the German and European rules did not foresee the possibility of transferring allowances from the first into the second ETP.  All these factors maintained surplus of allowances, leading towards the end of 2007 to a drastic price decline.

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[289] Deutsche Emissionshandelsstelle.

[290] Umweltbundesamt.

[291] The "new-facility-clause" motivated facility owners to apply for allowances using unrealistic production estimates; the "option-clause" offered existing facilities the possibility to bypass the allocation based on historical data, to apply for allowances using the "new-facility-clause," and to receive much more allowances than they needed to operate their facilities; the "special-allocation-clause" offered additional allowances for power generation in CHP plants also leading to over-allocation of allowances; finally, the "early-action-clause" exempted facilities from the obligation to reduce their emissions (see Chapter 4; ZuG 2007, 2004).

[292] In the Case T-374/04 of September 2004: Federal Republic of Germany against the European Commission, Germany applied at the European Court of Justice (ECJ) for partial annulment of Commission Decision C(2004) 2515/2 (EC, 2004). ECJ communicated its final judgment on November 11, 2007 (ECJ, 2007).

*(8) From Schröder's red-green coalition to Merkel's grand one.* "If we do not manage to significantly reduce the unemployment rates, we do not deserve to be reelected," declared Chancellor Schröder in 1998, while running the election campaign against Helmut Kohl (Spiegel, 2005). Yet, as I have discussed, instead of spurring the economy, Schröder's successive reforms pushed Germany into an even more severe crisis. With his policies, the "bad-luck" chancellor [293] maneuvered himself into an increasingly difficult position. Loss of popularity within his own party made Schröder decide to resign as Chairman of the SPD in February 2004. After the defeat of Social Democrats in the elections of the state North Rhine-Westphalia[294] in May 2005, Schröder announced his intention to call early federal elections. To trigger the elections, Schröder asked Germany's federal parliament for a motion of confidence, arguing that the red-green coalition might have lost voters' support. The motion was defeated with a vote of no confidence in July 2005. Subsequently, President Köhler dissolved the government, paving the way for new elections. Federal elections took place in September 2005 and resulted in a slight electoral advantage for Christian Democrats (CDU: 35.2%) over Social Democrats (SPD: 34.2%), although both parties lost support, and none of the traditional political alliances[295] were able to gather a majority in parliament. In October 2005, CDU/CSU and SPD agreed to form a grand coalition government led by Angela Merkel.

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[293] Spiegel (2005) named Schröder "the bad luck chancellor."

[294] As coal reach region and important center of labor-intensive industries North-Rhine-Westphalia was traditionally a red (social-democrat) German state.

[295] Neither the "black-yellow" alliance between Christian-Democrats and Liberals (CDU/CSU and FDP) nor Schröder's "red-green" one gathered enough votes to institute a new coalition government. The Party of Democratic Socialism (PSD), led by Gregor Gysi and Oskar Lafontaine, was the only party that gained a significantl number of votes, but no established party agreed to build a coalition government with the direct successors of the Eastern German Socialist Unity Party (SED).

***(9) Merkel, the climate chancellor and her Integrated Energy and Climate Policy.*** In August 2007 Merkel's grand coalition government agreed on 29 measures (the "Meseberg measures") meant to create a coherent climate and energy policy (BMU, 2007b, p.1). The government estimated that these measures had the potential to reduce GHG emissions by more than 220 million tons of carbon-dioxide equivalent by 2020 and achieve an overall emission reduction of 36.6% compared with the basis year of 1990 (BMU, 2007b, p. 8). To create the legal framework for implementing these measures, the government presented in December 2007 drafts for 14 laws and ordinances aimed at increasing energy efficiency, stimulating the deployment of RE in the electricity and heating sectors, and reducing GHG emissions. These regulations were complemented with another set of acts in May 2008 (BMU, 2007b, p. 8). An overview of the estimated carbon-mitigation potential for each of the Meseberg measures is presented in Appendix F.

***(10) Mitigating carbon emissions. The second emission trading period - ETPII (2008-2012). Banking EUAs and CERs.*** After the experiences with over-allocation, failed ex-post corrections, forbidden allowances transfers from the first to the second emission trading period, and worthless allowances by the end of first emission trading period, Germany's government restructured in August 2007 its emission trading and allocation acts (TEHG and ZuG). In response to the European Directive 2004/101/EC, the Bundestag adopted the ProMechG (2005) and amended the emission-trading act (TEHG, 2007). As described in chapter 4, the new TEHGs allowed facility owners to fulfill 22% of their obligation to mitigate carbon emissions by using allowances from international projects[296] and introduced a banking system[297] (BMU, 2007 a; TEHG, 2007; Gerner 2012). In addition the ZuG 2012 (2007) introduced activity dependent emission reduction targets,[298] reduced the amount of free allowances for electricity generation, allocated allowances based on best available technology benchmarks,[299] reduced the amount of free allocated allowances for power generation, and introduced a "small facility"[300] clause (BMU, 2007 a; ZuG 2012, 2007; Gerner 2012). Although the allocation system was fundamentally changed and the number of allowances allocated in ETPII was reduced in comparison to ETPI by 57 million $t_{CO2equiv.}$ (BMU, 2007a) these efforts failed to achieve their expected results. After a promising start in ETPII in January 2008, allowances peaked mid-2008 at 30 €/$t_{CO2equiv.}$, and have followed since a downward trend so that by the end of 2012 the cost of allowances bottomed out at about 6.2 €/$t_{CO2equiv.}$, a price that is too low to incentivize actors to invest in low carbon technologies (eex market platform; Windram, 2009; Munzel, 2014;).

*(11) Continuing to deploy renewable energies. The EEG 2004, and 2009.*

In June 2004 the German Bundestag adopted a new Renewable Energy Act, the EEG 2004, changing the feed-in-tariffs (FITs) for the deployment of renewable energies and bolstering the position of operators of renewable energy facilities. In contrast to the EEG 2000, the EEG 2004 allowed facility operators to feed electricity into their local grids and to

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[296] I.e., to invest in mitigation projects in developing countries (clean development mechanisms – CDM) or other developed countries (joint implementation), to transfer and use allowances from such "flexible Kyoto mechanisms" (i.e., CERs and ERUs) to fulfill an emitter's obligation to reduce carbon emissions.

[297] That allowed the transfer of allowances from the ETPII to the ETPIII.

[298] To account for differences in competition intensity and carbon mitigation potentials manufacturing processes had lower reduction targets compared to electricity generation (BMU, 2007a, Zug 2012, 2007).

[299] To incentivize high efficiency facilities.

[300] According to this clause facilities with an annual emission under 25,000 $t_{CO2\ equiv.}$/ year had no obligation to reduce their carbon emissions.

receive the FITs without having to agree on feed-in-contracts with grid operators. EEG 2004 also: 1) introduced additional bonuses for generating power in CHP plants; 2) introduced a clause that defined the rules for the redistribution of additional costs on end-uses of energy; 3) introduced reduced EEG contributions for manufacturing processes, and 4) exceptions from paying EEG contributions for energy intensive industries, as well as for electricity generated at manufacturing sites ("own generation"). These exceptions introduced market distortions for large manufacturers, who out-sourced their energy generation facilities (as described in Chapter 4), because new contracting facilities had to add the EEG contribution to their energy costs. It also generated competitive disadvantages for independent power producers who offered energy-contracting services, because their products became even more expensive than the own generation (EEG 2004, 2004).

In October 2008 the German Bundestag adopted yet another Renewable Energy Act, the EEG 2009, which maintained the structure of the EEG 2004, but modified the FITs and introduced additional bonuses,[301] reduced the capacity limits for biomass power plants from 20 to 5 MW,[302]allowed grid operators to intervene for grid stability problems and reduce the RE generation, and obliged RE facility owners to give operators access to automatically reduce their load. However, grid operators had to compensate facility owners for their losses. The EEG 2009 also introduced the so-called "green power privilege," which stipulated that energy traders that have more than 50% renewable energies in their portfolio can offer electricity to end-users without charging the EEG contribution (EEG 2009, 2008).

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301 E.g. Landscape conservation bonus, technology bonus, renewable-raw-material bonus, etc.

302 A rule that led to significant disadvantages for investors in Biomass facilities, who invested before this act entered into force.

As we will see in Chapter 7, the creative interpretation of this rule led to cases of "legal misuse."

***(12) Germany's Energy Concept: Expanding the Life-Span of Nuclear Power Plants.*** Ten years after Schröder's *Nuclear Consensus*, on 28th September 2010, during Chancellor Merkel's second term, Germany's government [303] presented its roadmap to carbon neutrality: Germany's *Energy Concept*.[304] The *Energy Concept* not only envisioned a nearly carbon-free future by 2050, but also decided to achieve its extremely ambitious decarbonization goals by extending the life-span for existing German nuclear facilities by up to 14 years[305] (i.e., to postpone Schröder's *Nuclear Consensus*) (Schleisinger et al., 2010; Nuclear Act, 2010). The rationale behind this change in the policy course was that nuclear technologies are nearly carbon free, have a high energy intensity, cover about 60% of the base-load power, and not only help to meet higher decarbonization rates, but also to bridge the lack of affordable electricity storage facilities, which are needed to level intermittent power generation based on RE.

**Implementation - institutionalization in the third decade.** The third decade of the institutionalization of the *Energiewende* vision was one of retreat on nuclear power and radical change across other elements of the energy system.

***(1) Back to Schröder's nuclear consensus.*** Only six months after launching its Energy Concept, Chancellor Merkel's black-yellow coalition government changed Germany's policy course again. The nuclear accident in Fukushima on March 11th 2011 led

[303] A "black-yellow" coalition government, under joint Christian-Democratic and Liberal leadership.

[304] Energiekonzept der Bundesregierung.

[305] This decision was based on the recommendations of a long-term research project developed by Schleisinger et al. in 2010, also known as Germany's Energy Concept or Prognos-study.

to fast-spreading anti-nuclear protests.[306] The increasing anti-nuclear mood in German society resulted in less support for Christian-Democrats and Liberals and culminated with the election of a Green governor in Baden Württemberg on 27th March, 2011. Winfried Kretschmann was the first Green governor of a German state. These results were not only a huge victory for the Greens, but also a serious warning for Merkel's government, because Baden-Württemberg was traditionally a conservative state. Driven this time by the fear of losing her political legitimacy, Merkel decided to decommission all German nuclear power plants by 2022,[307] without renouncing the ambitious greenhouse-gas-reduction target of the German *Energy Concept*. Utilities reacted to this radical turn-around in Germany's energy and climate policy with successive lawsuits against federal and local governments. In December 2016, the Federal Constitutional Court concluded that it is the government's duty to compensate utilities for their losses related to the nuclear phase-out (Handelsblatt, 2016; FAZ, 2016a; Die Welt, 2016; MM-Manager Magazin, 2016). As we will see in Chapter 7, after this verdict, utilities agreed to retract most of their lawsuits and pay € 23.55 billion into a nuclear fund. In return the government agreed to transfer any further obligation related to the long-term costs of nuclear waste[308] to future taxpayers.

***(2) Mitigating carbon emissions - the third European Emission Trading Period –ETPIII (2013-2020).*** As noted in Chapter 4, the European Directive 2009/29/EC[309]

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306 The widespread anti-nuclear mood resulted, on 27th March 2011, in the election of a Green governor in Baden Württemberg (a traditionally conservative state.)

307 For example, the Minister of Economic Affairs, Rainer Brüderle, claimed that Merkel's turnaround in the nuclear policy was motivated by tactical reasons related to the elections in the state Baden Württemberg (Süddeutsche Zeitung, 2011).

308 According to Spiegel the estimated gap between payments and the needed financial means for the final repository of nuclear waste amounts to €30 billion (SpiegelOnline, 2015).

309 That amended the emission-trading Directive 2003/87/EC.

forms the legal basis for ETPIII. In contrast to the previous two emission trading periods, emission caps for European member states and rules for free allocations[310] of emission allowances are established at European level. The Directive 2009/29/EC enlarged the scope of the EU ETS including more activity sectors (e.g., aviation) and more greenhouse gases (e.g N2O). Facility operators, who transferred allowances from flexible Kyoto mechanisms (CERs and ERUs) from the ETPII could not directly use these allowances to fulfill their emission targets. Instead, they were allowed to exchange a limited amount of CERs and ERUs against EUAs. The manufacturing sector, which benefited from free allocation of allowances during ETPI and ETPII, had to acquire an increasing number of emission allowances in auctions. After a disastrous start in ETPIII EUA with prices under 3 €/$t_{CO2equiv.}$, the EUA prices followed a steady upward trend between 2013 and 2015, peaking at about 8.5 €/$t_{CO2equiv.}$. At the beginning of 2016 they fell again to under 5 €/$t_{CO2equiv.}$, and oscillated the rest of the year between 4 €/$t_{CO2equiv.}$ and 6.8 €/$t_{CO2equiv.}$ In 2017 EUA prices dropped to 4.3 €/$t_{CO2equiv.}$ by May, and recovered to 8 €/$t_{CO2equiv.}$ at the end of the year. The upward trend continued in 2018 peaking at 10.5 €/$t_{CO2equiv}$ in February (data source: eex - intraday market platform; https://www.eex.com/en#/en). However, these allowances prices are still too low to incentivize low carbon technologies.

*(3) Successively amending the renewable energy acts: EEG 2012, 2014, 2017.*

In July 2011 the German Bundestag adopted a revised Renewable Energy Act, EEG 2012. This act modified FITs, introduced incentives for the integration of renewable power

310 The Decision 2011/278/EU of the European Commission established the transitional rules for the free allocation of emission allowances in the European Union. The German Bundestag adopted in September 2011 an Allocation Ordinance (ZuV2020) and transposed this EU decision in into national law

in the energy market (*Market-Premium-Model*),[311] and for the construction of biogas storage facilities, and designed stricter rules for the "green power privilege"[312] (EEG 2012a, 2011) An additional act adopted in July 2012 significantly reduced the tariffs for the power generation in solar facilities, limited the total amount of solar power incentivized by the EEG, and reduced the compensation rules of the *Market-Premium-Model* to 90% (EEG 2012b, 2012). This rule triggered a series of bankruptcies in the solar sector and a significant reduction of jobs in this sector.

A new review of the renewable energy act, the EEG 2014, was adopted in November 2013. This act reduced FITs for on- and offshore wind facilities, limited the construction of new biomass power plants to facilities using biological waste as fuel, and eliminated the "green-power privilege". It also stipulated that, after 2017, all facilities with a capacity over 5 MW have to market their power on the wholesale market. It further announced that after 2018 the feed-in incentives would be established in auctioning system (EEG 2014, 2013). As noted in Chapter 4, the EEG 2017 (also known as EEG 2.0) fundamentally changed the incentive mechanism for renewable energies, introducing an auctioning system and defining the capacity that has to be installed. The results of auctions drastically reduced the incentives for renewable energies. For example, in the first offshore wind auction participants made offers for 4 offshore wind parks in the North Sea with a total capacity 1,490 MW. Three of the 4 winning bids ended at the price of 0 ct/kWh, and

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311 The "Marktprämien-Modell" incentivized RE operators to sell their electricity generation on the wholesale market and compensated the differences between FITs and Market price.

312 I.e., obliged energy traders who intended to use this privilege to integrate at least 20% intermittent sorces of power in their portfolio, and to charge end-users a reduced EEG-contribution of 2 ct/kWh.

one at 6 ct/kWh.[313] In the first onshore-wind auction 256 participants offered their bids for 70 wind-projects with a total capacity of 2.1 GW. The auction was concluded with winning bids[314] between 5.21 - 5.78 ct/kWh (Handelsblatt, 2017).

**Phase III: Proof of Concept**

The proof-of-concept phase started in the mid-1990s and encompasses more than two and a half decades of experiences with: (1) deregulation of the energy markets (EnWG), (2) negotiated and regulated third-party access to the electricity and natural-gas grids, (3) the European emission trading system (ETS) and the specific allocation rules for emission allowances (TEHG, ZuG), (4) successive schemes for promoting RE (EEG), combined generation of heat and power (KWKG), or energy efficiency, and (5) a lot of unintended consequences, which resulted from efforts to steer Germany's energy systems into desired directions and the measures implemented to fix the unintended consequences.

## Theories of Change and the Phases of Germany's *Energiewende*

In his systems theory, Thomas P. Hughes (1987) explains how "contingencies" (recessions, hot and cold wars, oil crises, accidents, etc.) can redirect and fundamentally change a system's development path. Many scholars have tested and confirmed Hughes's hypothesis by exploring, for example, the causal relationships between the Great Depression and Roosevelt's 'New Deal' programs, World War II and the Manhattan project, the end of war and Eisehower's 'Atoms for Peace' program, and the race for scientific excellence and leadership induced by the Cold War (Hirt, 2012; Ruttan, 2006; Noble, 1984; Laird, 2001; Lester, 2012, Stockes, 1997). There is a similar causal relationship between the major

313 To utility groups (EnBW, and Dong Energy) won the auction. A price of 0 ct/kWh means that the companies will market the power on the wholesale market an renounce an additional market premium.

314 Most winning bids were offered by citizens' initiatives.

accident in 2011 at the Fukushima nuclear power plant, and the significant change in Germany's energy and climate policy, which reversed previous decisions about nuclear power, accelerating the transition towards low-carbon technologies, and once more confirming Hughes's theory.

# CHAPTER 7

## TRANSITION GOVERNANCE AND BARRIERS TO TRANSITION

This chapter aims to increase understanding of potential transition governance barriers. I identify the major *reverse salients*[315] the German energy system encountered. The share of renewable energy fed into the electricity grid grew and the instruments of the *Energiewende* toolbox sprawled out like mushrooms after the rain, reaching a degree of complexity impossible to process by a single human mind. Using real-life examples, I explain how non-governmental actors can and do misuse imperfect rules for their own profits. Next, I discuss problems related to the intermittent nature of wind and solar energy,[316] and explain why transitions to low-carbon societies require technologies for large-scale storage to be successful. I show how the instruments implemented to trigger Germany's energy transition primarily incentivize mature technologies, neglecting the need for new ones. Finally, I show how governmental actors have forgotten to focus during the transition process on Germany's decarbonization goals, because these goals either interfered with communitarian values and overarching economic interests, or simply got lost in the multitude of conflicting rules and regulations implemented to meet them. Despite best intentions at the top of and across government and broad citizen support from the bottom up, the *Energiewende* has not produced the intended results. While trying to remain up-to-date with the steadily changing

[315] In his book *Networks of Power* (1993) and the Chapter *The Evolution of Large Technological Systems* (Bijker et al, 1987) Hughes introduces the *reverse-salient* concept to analyze the evolution of large technological systems. Reverse salient is an insufficient developed component of a large technological-system that prevents the whole system to evolve. Hughes' concept is it valuable in the larger context of its Large System Theory because it facilitates the analyses of causes allowes to identify barriers for system transition. In the *Energiewende* context, the insufficient developed grid, and the missing technology able to store power at a large scale are major reverse salients. Alongside with these components social components of lare technological systems can also prove to hinder the system's evolution. For example people protesting against the constructuion of high voltage-power-lines, wind-mills, or power-plants are also reverse salients in Hughes' sense.

[316] The most available RE sources.

and increasingly complex regulatory framework, diverse actors in the energy arena have faced soaring energy costs, an increasing dependence on intermittent power sources, severe energy-transmission and -storage problems, forced electricity exports, negative electricity prices, and loopholes that motivate actors to take legal free rides on the backs of less favored, or less creative, players in the energy system. Such unintended consequences should not be surprising given the daunting complexities of the *Energiewende* and related efforts to steer the German energy system toward a clean energy future.

**The New System's Paradox: Falling Prices and Increasing Power Bills**

The intensive RE deployment that has been incentivized by the EEGs has put more power into the electricity market, with the result that wholesale prices over the past decade have fallen from about 60-80 €/MWh to 20-30 €/MWh.[317] Yet household and small industrial consumers experienced the opposite trend because they had to pay the rising *Energiewende* "contributions"—surcharges added to the electricity bill to subsidize RE and other *Energiewende* elements (see Figure 7).

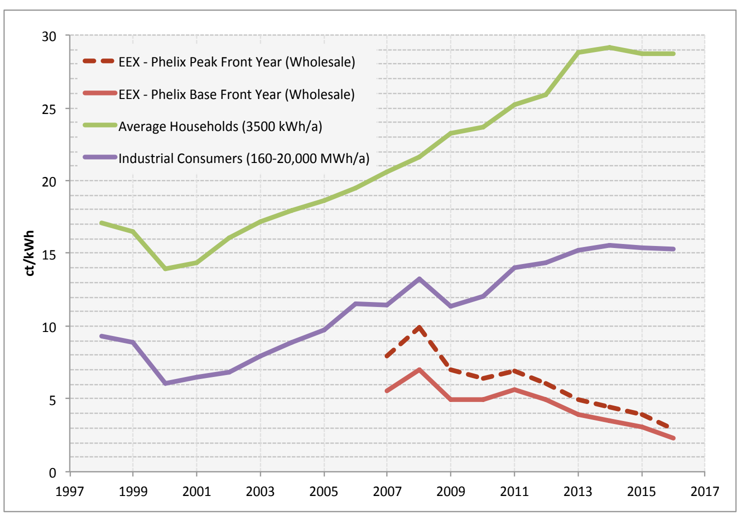


Figure 7 - The Evolution of Electricity Prices 2000 - 2016

[317] Further explanations to the mechanisms for establishing wholesale market prices and the "merit-order effect" of RE are presented in Appendix G

The EEG contribution has risen from about 0.2 ct/kWh in 2000 to 6.88 ct/kWh in 2017, an increase of more than thirty-fold (see Figure 8).

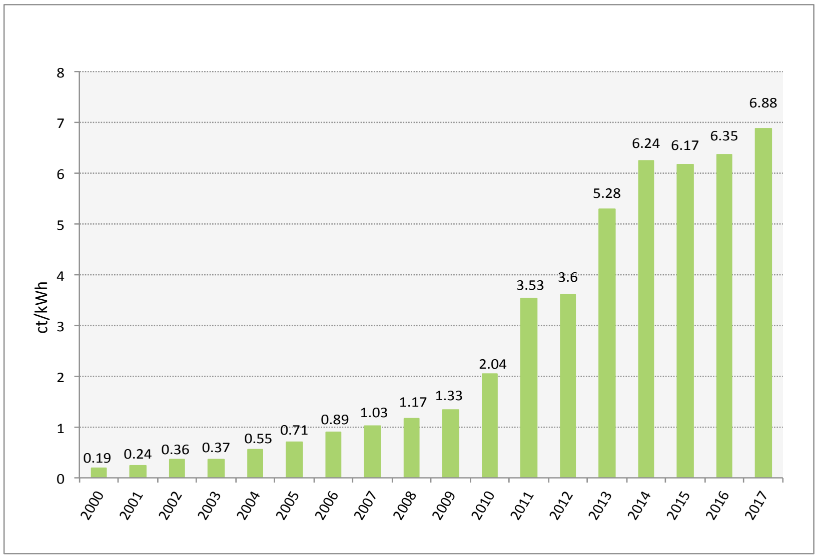


Figure 8. - The evolution of the EEG-Contribution 2000 – 2017

The total electricity-related *Energiewende* costs in 2016[318] are estimated at €34.1 billion, of which €22.9 billion[319] (67.1%) represent the EEG costs (bdew, 2016).

The costs for the transformation of Germany's electricity systems amounted to only €2.3 billion in 1998, at the beginning of the deregulation of the energy markets, and the deployment of RE contributed only about €0.3 billion (or 13%) to these costs (see Figure 9). Households and industrial consumers covered about two-thirds of the expected EEG burden in 2016, with €7.9 billion and €7.2 billion, respectively (see Figure 10).

318 Including taxes and duties and contributions.

319 The EEG costs were actualized to €23.5 billion on the (Netztransparenz, 2017). However, since the other cost elements were not yet revised, I kept all data from the same source (bdew, 2016).

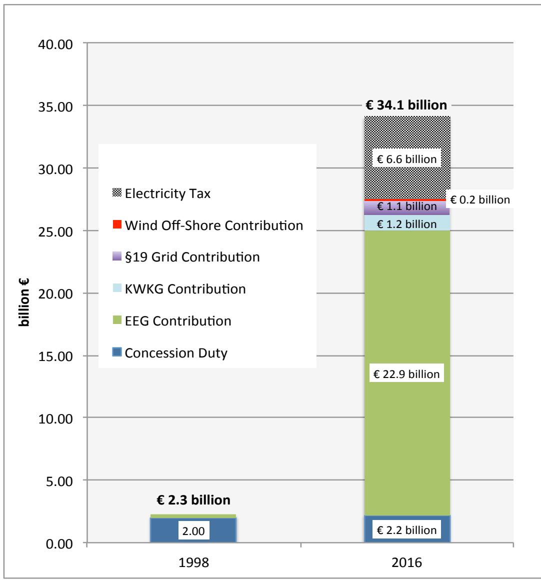


Figure 9. Taxes, duties, and contributions in the electricity Sector in 1998 and 2016

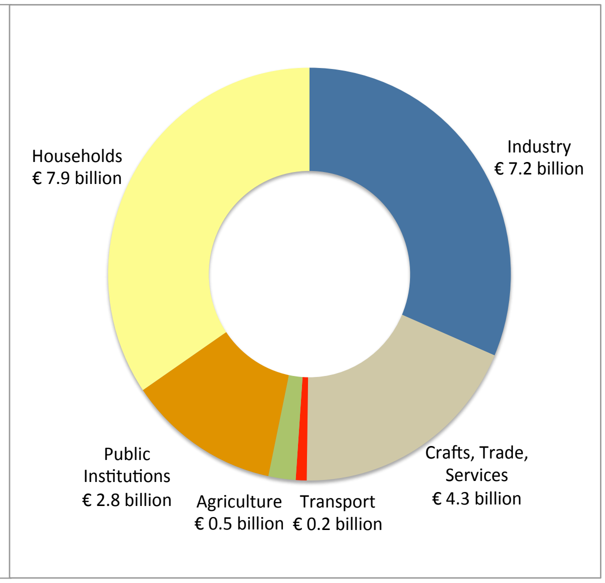


Figure 10. Distribution of the EEG burden 2016 of € 22.9 billion

A deeper look into the components that build the electricity price (see Table 3 & 4) shows that households and industries pay more for *Energiewende* contributions[320], taxes, and duties than for actual electricity supply (i.e., for procurement, balancing, sales margins, and grid access). For example, a German household with a yearly consumption of 3,500 kWh paid in 2016 on average €1,005.2 for electricity (or 28.72 ct/kWh,) which is equivalent to $1,115 (or 31.88 cents/kWh). More than the half of these costs (54%) are *Energiewende* contributions, taxes, and duties.  In comparison, the average US household[321] paid in 2016 for a more than threefold-consumption (10,764 kWh) $1,351.1 (or 12.55 cents/kWh). In Germany it would have paid for the same amount of power $3,431.5 ($1853.1 of which would have been surcharges). Arizona households, which consumed in 2016 on average 12,360 kWh, would have paid for their consumption $3,940.3 (including surcharges of $ 2,128) in Germany instead of $1,502.3 they paid in the US.

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[320] *Energiewende* contributions, taxes, and duties represent 54% of the total electricity costs paid by households respectively 57% of those paid by industrial consumers.

[321] Own calculations based on data for 2016 from the US Energy Information Administration (EIA, 2016).

Table 3

**Components of the electricity bill 2016 for an average German household (3,500 kWh/a)**

| | | | |
|---|---|---|---|
| Electricity procurement (generation, balancing & sales margin) | 6.15 ct/kWh | 21% | These components cover power procurment, balancing, sales margin and grid access |
| Grid access fee | 7.06 ct/kWh | 25% | |
| EEG Contribution | 6.35 ct/kWh | 22% | EW Contributions & related taxes |
| Other EW Contributions (KWKG, §19 NEV, Off-Shore Wind) | 0.86 ct/kWh | 3% | |
| Electricity Tax | 2.05 ct/kWh | 7% | |
| Concession levy | 1.66 ct/kWh | 6% | EW independent taxes & duties |
| + VAT (19%) | 4.59 ct/kWh | 16% | |
| **= Electricity price incl. VAT** | **28.72 ct/kWh** | **100%** | |

54% of all electricity costs of an household are EW Contributions,Taxes, & Duties
EW Contributions reprsent 32% of the electricity bill of an average German household

Table 4

**Electricity bill 2016 for small & middle sized industries (160,000-20,000,000 kWh/a)**

| | | | |
|---|---|---|---|
| Electricity procurement & Grid access | 6.49 ct/kWh | 43% | This component covers power procurment, balancing, sales margin and grid access |
| EEG Contribution | 6.35 ct/kWh | 42% | EW Contributions & related taxes |
| Other EW Contributions (KWKG, §19 NEV, Off-Shore Wind) | 0.55 ct/kWh | 4% | |
| Electricity Tax | 1.54 ct/kWh | 10% | |
| Concession levy | 0.11 ct/kWh | 1% | EW independent taxes & duties |
| **= Electricity price** | **15.04 ct/kWh** | **100%** | |

57% of all electricity costs of small industrial consumers are EW Contributions, Taxes, & Duties

The electricity tax in an ecological tax and is related to the Energiewende process, thus EW contributions reprezent 56% from the electricity bill of small& middle-sized industries

Why have energy consumers had to foot the rising electricity costs even as the market price of electricity dropped? First, the surcharges imposed by the *Energiewende* far outweighed the falling prices on the wholesale markets (see Figure 7). Secondly, to preserve Germany's economic health, which depends largely on exports of industrial goods, the government shielded energy-intensive manufacturing processes, such as chemical, aluminum, paper, and glass production, from paying the EEG contribution and other *Energiewende*-related charges.[322] It did so to keep manufacturing companies from migrating to countries with cheaper energy, or simply to protect them from economic failure due to the high price of electricity. As a result, about 40% of the nation's electricity is used by industries that are largely protected from contributing to the *Energiewende* costs—costs which therefore must be borne by other energy users.[323] Lastly, the EEG contribution always increases with falling wholesale prices. The reason for this lies in the definition of the EEG contribution and in the mechanism for calculating it. The net EEG costs, also known as EEG difference costs, are calculated by subtracting the market value of the RE power fed into electricity grids from the cumulative EEG costs paid as FITs to RE facility owners. To obtain the EEG contribution, one needs to divide the EEG difference costs in a given period of time (year, month) by the total final power consumption (kilowatt-hours) subjected to EEG surcharges[324] in the same period of time. So, because FITs remain the same regardless of the

[322] Taxes on natural gas and electricity, surcharges for combined heat and power, grid access fees, etc.

[323] Although only 4% of the 45,253 industrial sites paid reduced EEG contributions (i.e., 0.05 to 1.27 ct/kWh instead of 6,35 ct/kWh according to §64 EEG), the power demand of the privileged industrial sites represented 39% of total industrial power consumption. In addition, about 15% from the total power consumed at industrial sites comes from in-house generation facilities and is completely exempted from paying the EEG-contribution. This means that 96% of all industrial sites, together with households and other small end-users, have to shoulder almost the entire EEG burden.

[324] I.e. only the power demand of consumers that are not exempted from paying EEG contributions.

market price for electricity, the EEG difference costs, and with them the EEG contribution, increase when earnings from selling electricity on the wholesale market fall.

**The End for Germany's Peaceful Atom**

If the EEGs have introduced significant price distortions onto the German energy scene, a second major policy change—the phasing out of nuclear power—makes the GHG reduction goals more difficult to achieve, and the role of REs even more complicated. In addition, in response to Merkel's nuclear twist (see Chapter 4), utilities initiated several lawsuits against the government (Die Zeit, 2012).

By the end of 2010, Germany's decision to extend the nuclear life-span had triggered a wave of massive investments in refurbishing older nuclear power plants[325] so that they could be operated for an additional 8 to 14 years. A case in point is Vattenfall, one of Germany's four large utilities, which invested €700 million in repairs for the nuclear facilities Krümmel and Brunsbüttel (Die Welt, 2011a and b). Yet all these investments were "stranded" within only a few months, due to the turn-around in Germany's nuclear policy.

Immediately after the nuclear accident in Fukushima, Merkel ordered the temporary shut-down[326] of seven nuclear power plants for security investigations (*Nuclear Moratoruim*). An eighth nuclear facility, Vattenfall's power plant Krümmel, was out of service for a regular maintenance and repair cycle at that time and was not allowed to restart. Merkel's *Nuclear*

[325] According to Schröder's *Nuclear Consensus,* older nuclear facilities were supposed to be decommissioned early (i.e., in 2011 or 2012). That is why owners massively reduced the maintenance and repair cost of these plants towards the end of their life.

[326] There was no technical reason for shutting-down these facilities. Nor were German nuclear plants at risk of being subjected to a tsunami. But people protested and Merkel did not want to risk her lead. Thus, she revised her previous decision only for securing her political dominance. Merkel's decision did not affect the electricity supply or the stability of German grids, but it led to an increase in CO2 emissions, because fossil facilities had to replace the nuclear generation.

*Moratoruim* hindered Vattenfall, RWE, Eon, and EnBW from operating eight of their seventeen nuclear facilities, imposing financial burdens for these utility groups.

At the end of May 2011, the expert commission instituted to assess security and ethical issues related to Germany's nuclear power facilities recommended that the government retract the operation allowances for these eight nuclear facilities and successively decommission the remaining nine nuclear power plants by 2022. The government followed this advice and passed, in June 2011, a second nuclear phase-out decision. Although it was initially planned to restart the eight nuclear power plants after three months of investigation, these facilities never operated again (SpiegelOnline 2011a).

At the beginning of 2011, the total installed nuclear capacity was 21,523 MW. After March 17, 2011 only nine nuclear power plants with a total capacity of 12,702 MW were allowed to continue operation. Between 2010 and 2012 the gross power generation in nuclear power plants dropped from 140.6 TWh to 97.1 TWh. 85.5 TWh were generated in 2016 in nuclear facilities with an installed capacity of 11.4 GW (See Figure 11).

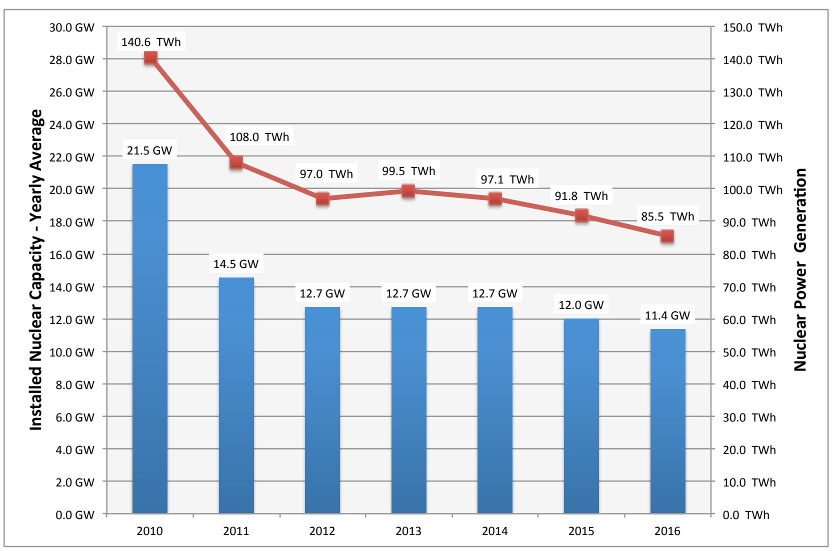


Figure 11. Nuclear power: installed capacity and gross power generation 2010 - 2016
(Data Sources: DAtF, 2011, 2012, 2013, 2014, 2015, and 2016; Statista 2017).

Arguing that the accelerated nuclear phase-out violated their constitutional property rights, Eon, RWE, and Vattenfall initiated lawsuits, claiming €18.7 billion in damages, at the Federal Constitutional Court, and the US Arbitration Court (for Vattenfall) (Die Welt 2011 a, b, and c; SpiegelOnline 2011 b; Börseonline, 2015). Utilities made clear that they did not aim to reverse the phase-out decision, but argued that the government should compensate them for their losses (Table 5, Nr. 1). In other lawsuits RWE, Eon, and EnBW claimed that there was no technical reason for Merkel's *Nuclear Moratorium.* They argued that the state of Germany's nuclear power plants was assessed before the government's decision to extend the life-span of nuclear power plants, and asked for damages of €715 million (Table 5, Nr. 2) (Börseonline, 2015). Another aspect of Germany's nuclear policy that severely impacted the returns of the four largest German utilities was a tax on nuclear fuel elements (*Brennelemente-Steuer*). In September 2010, in return for the expected gains from running their plants 8 to 14 years longer, utilities agreed and began to pay this additional tax on nuclear fuel elements. Since they had already agreed in 2000 to decommission their nuclear power plants by 2022, utilities wouldn't have had any reason to accept an additional tax on nuclear fuel elements without the prospect of an extended operation time for their facilities. Yet, although the government reversed in 2011 its decision from 2010, it further raised the nuclear-fuel-element tax, considerably reducing the profits of the owners of nuclear power plants in Germany[327] (Börseonline, 2015).

In response to the government's failure to honor its part of the bargain,[328] utilities issued additional lawsuits with claims of €4.6 billion against Germany's federal government, at the Constitutional Court and the European Court (Table 5, Nr. 3) (Börseonline, 2015).

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327 Eon, RWE, Vattenfall, and EnBW.

328 Primarily the agreement to allow nuclear plants to continue operating in exchange for a tax.

Arguing that the government had no right to impose an additional tax for nuclear fuel elements if it did not honor its part of the agreement, utilities demanded to be reimbursed for all of what they viewed as unrightfully retained taxes.

Finally, Eon and Vattenfall filled lawsuits against the states of Lower Saxony, Bavaria, and Schleswig-Holstein, and the German federal government, claiming that additional damages resulted from the decision to close the temporary nuclear-waste repository in Gorleben (Table 5, Nr. 4) (Börseonline, 2015).

An overview of these claims is presented in Table 5.

Table 5 - Overview of the Different Nuclear Lawsuits and their Litigation Values

| | Germany's Nuclear Lawsuits | Eon | RWE | Vattenfall | EnBW | Total | |
|---|---|---|---|---|---|---|---|
| 1. | **Against the accelerated nuclear phase-out**<br>=> Constitutional Court (Eon/RWE/ Vattenfall)<br>=> US Arbitration Court (Vattenfall) | x | x | x | - | € 18.7 billion | - Utilities do not aim to revert the government's phase-out decision<br>- They claim compensation for damages related to the Nuclear Act 10/2010<br>=> decision of the constitutional court on December 2016 |
| | | € 8.0 billion | € 6.0 billion | € 4.7 billion | - | | |
| 2. | **Against the Nuclear Moratorium 2011**<br>RWE => lawsuiy at the State Court in Essen against the Federal Govenment (BMU) & the Land Hessen the illegality of the Nuclear Moratorium | x | x | - | x | € 715 million | - Compensation for damages related to 3 month still stand of 7 NPP |
| | | € 380 million | € 235 million | - | € 100 million | | |
| 3. | **Against Nuclear Fuel Element Tax 2010**<br>Eon, RWE, Vattenfall<br>=> Constitutional Court<br>=> EuGH - European Court | x | x | x | - | € 4.6 billion | - Tax introduced in 2011 according to the nuclear act 2010<br>- Utility Companies have to pay this tax untill 2016 |
| | | € 2.3 billion | € 1.2 billion | - | € 1.1 billion | | |
| 4. | **Against Temporary Nuclear Waste Storage**<br>Eon => against States Niedersachsen (Lower Saxony), Bayern (Bavaria) & Federal Government<br>Vattenfall<br>=> Schleswig-Holstein & Federal Government | x | - | x | - | n.a. | Additional costs related to the decision to stop temporary storage of nuclear waste in Gorleben |
| | **Quantified damages** | | | | | € 24.0 billion | |

Data Source: Börseonline, 2015, February 3rd

The Federal Constitutional Court in Karlsruhe decided in December 2016 that the government's decision to accelerate the nuclear phase-out complied with the constitution, because it was the duty of the government to protect its citizens from catastrophic accidents. However, the court also ruled that the German State had to appropriately compensate utilities for damages (Handelsblatt, 2016; FAZ, 2016a; Die Welt, 2016c; MM-Manager Magazin, 2016).

## Electricity Storage: The Missing Technological Breakthrough

With nuclear power no longer a part of Germany's energy future, the country's aggressive decarbonization goals could only be achieved with even faster deployment of RE, and that is the course that the nation has pursued. But the rising share of intermittent solar and wind[329] creates technical, economic, and environmental problems[330].

Most importantly, as intermittent RE sources increasingly come onto the grid, the ratio of electricity generated to installed capacity goes down. Fossil and nuclear plants are able to reach about 8,000 "full load hours" per year (the amount of electricity actually generated in a year, divided by the installed capacity). The average "full load hours" in Germany are about 2,000 hours for onshore wind, and about 800 for solar energy. So the more that electricity is generated by intermittent sources, the more the full load hours decline. (see Figure 12).

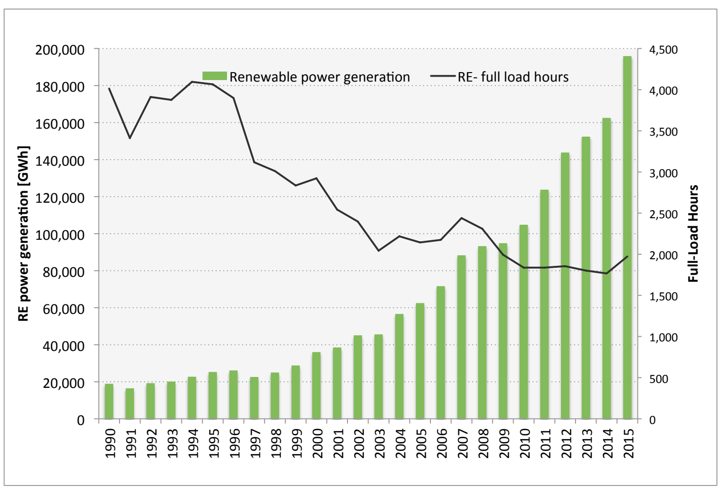



Figure 12. The evolution of RE power generation 1990 -2015 and the correlated full-load hours for RE power

329 The most available RE sources.

330 Storage, transmission, and balancing problems in the technical realm; exploding costs, unemployment and burdens for people and businesses in the economic realm; the destruction of landscapes (visual pollution), phonic pollution in the vicinity of wind-mills, loss of natural habitat for birds and small animals (biodiversity loss) in the environmental realm.

In 2016, the installed RE capacity was slightly higher than the conventional capacity (104.02 GW compared to 96.7 GW).[331] The current conventional power-plant pool is already sufficient to meet the entire energy demand without relying on RE at all. But because RE feed-in is a priority, and a "power back-up" ordinance[332] prevents conventional power-plant owners from phasing out uneconomic sites if they are necessary for grid stability, utilities are forced to run their power plants inefficiently[333] and to generate almost one-third less electricity than they technically could.[334] Despite these imposed operational inefficiencies, conventional plants still generate more than twice as much power as RE facilities can produce with slightly higher installed capacity.

One way to think about this problem is that for every megawatt (MW) of conventional base-load capacity generated by fossil or nuclear fuel, you'd need 10 MW of capacity in solar power or 4 MW in wind.[335] Yet this RE capacity would ensure only that one could generate the same amount of power as conventional sources over one year, and not that one could always match supply and demand. For example, on a sunny and windy holiday, when demand is low, the generated power would by far exceed the demand, but on cold, windless nights, with high consumption patterns, it would be very difficult to meet the demand. To grasp the order of magnitude of this problem, consider a real-life example from January 24th 2017. It was a cold and wind-still day and Germany's total power demand at

[331] Data based on BMWi (2017 a, Table 4) and the entsoe transparency platform for 2016.

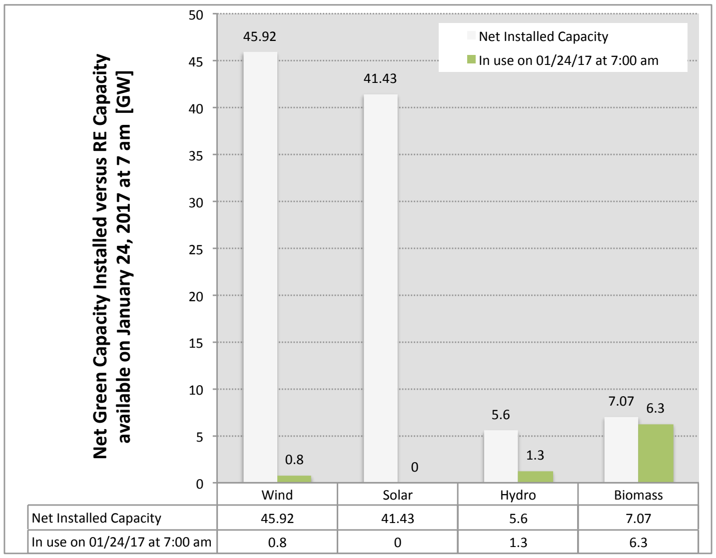
[332] NetzResV (2013).

[333] In partial load, or in stand-by mode.

[334] Although the conventional power installed is sufficient to cover the gross power generation of 650 TWh/year it generates yearly only 450 TWh; the rest of the 200 TWh are substituted by RE.

[335] I.e., one needs 700 GW of installed solar capacity or 280 GW of installed wind capacity to replace 70GW installed in coal and nuclear power.

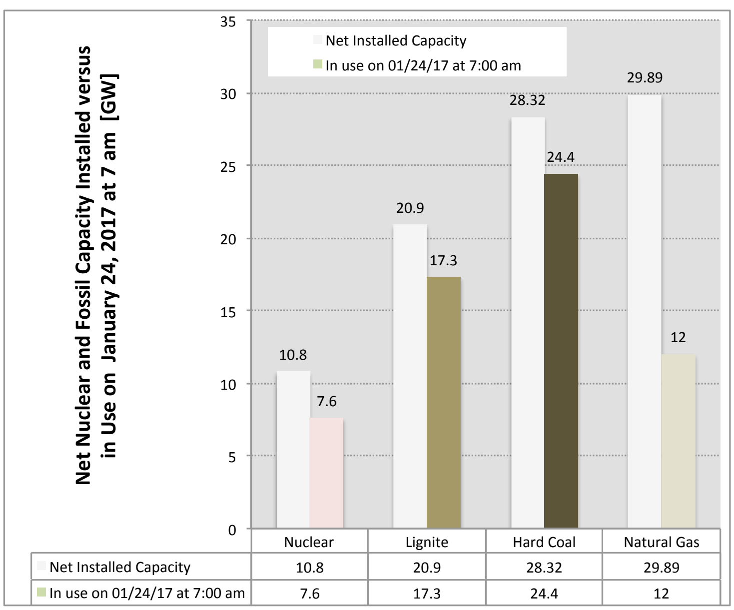
7:00 am (before sunrise) was 69.7 GW. Figure 13 shows that the installed capacity in wind (45.92 GW) and solar (41.43 GW) would have been sufficient to meet and even exceed this demand if the wind was blowing and the sun was shining, but they were not.




| | Wind | Solar | Hydro | Biomass |
|---|---|---|---|---|
| Net Installed Capacity | 45.92 | 41.43 | 5.6 | 7.07 |
| In use on 01/24/17 at 7:00 am | 0.8 | 0 | 1.3 | 6.3 |

Figure 13. Net green capacity installed and available on January 24, 2017 versus capacity in use at this date

From the 87.35 GW installed in wind and solar, only 0.8 GW were available at 7:00 am. Hydropower was working at about 25% of its capacity (1.3 GW), and biomass was operating at full load (6.3 GW from 7.07 GW installed).




| | Nuclear | Lignite | Hard Coal | Natural Gas |
|---|---|---|---|---|
| Net Installed Capacity | 10.8 | 20.9 | 28.32 | 29.89 |
| In use on 01/24/17 at 7:00 am | 7.6 | 17.3 | 24.4 | 12 |

Figure 14. Net conventional capacity installed and available on January 24, 2017 versus conventional capacity in use at this date

Thus, more than 100 GW of installed green power contributed only 8.4 GW to balance the demand. The missing 61.3 GW were generated in nuclear (7.6 GW), lignite (17.3 GW), hard coal (24.4 GW), and natural gas (12 GW) (See Figure 14.)

As this example shows, not only are fossil and nuclear energy needed to backup renewables, but they have to be operated in an uneconomical, partial load condition because REs have feed-in priority.[336] The chosen example is not a rare exception. Periods of high demand and low green-energy output ("Dunkelflaute") can persist for 10 days in a row, as Figures 15, and 16 show.

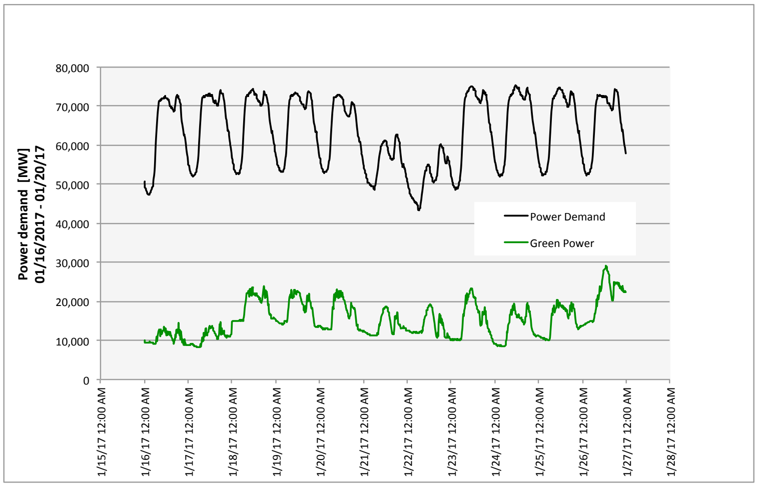



Figure 15. Dunkelflaute 2017 - Power demand and green power generation in the period 01/16/2017 12:00 am– 01/26/2017 11:45 pm

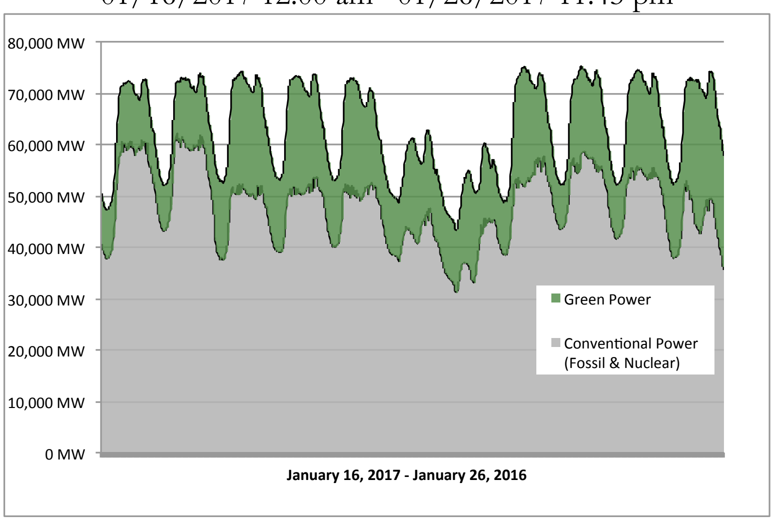



Figure 16. Dunkelflaute 2017 – Conventional (fossil & nuclear) versus green power 01/16/2017 12:00 am– 01/26/2017 11:45 pm

[336] This means that conventional energy sources, and especially the less carbon-intensive natural gas, could have generated significantly more electricity.

The more intermittent power is fed into the grid, the more difficult it becomes to ensure reliable and stable grid operation, especially because there is no affordable technology for storing electricity at a large scale. Wind and solar intermittencies are currently leveled by conventional power plants, most of which are coal-burning.

One way to balance the load is to transform excess power into potential energy by pumping water up hill into reservoirs that can provide hydroelectric power on demand. This storage technology is the least expensive of those available, but it still costs more than twice as much as the cost of the electricity itself: 7.7 cents/kWh for the storage, vs. 2-3 cents/kWh for power on the wholesale market (SVR, 2010, Table 3-1, p.28). [337]

I used Werner von Sinn's simplified method (Sinn 2013, 2016, 2017) to determine the minimum storage volume needed to level wind and solar intermittencies for the year 2015, based on real feed-in data[338] for these resources published by the four large transmission grid owners responsible for matching power supply and demand (Amprion, 2015a, b; Tennet, 2015 a,b; TransnetBW, 2015a, b; 50Hertz, 2015 ). The method assumes that:

(1) the theoretical storage volume must be large enough to store sufficient energy to meet demand whenever intermittent RE generation is below its average in the period of analysis;

(2) the volume should be large enough to receive surplus energy whenever intermittent generation exceeds its average value in the period of analysis;

(3) over the period of analysis, the energy stored and delivered should be identical;

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337 Yet cheaper than other storage technologies.

338 For the successive 15 minute periods from 01/01/2015 at 0:00 AM until 12/31/2015 at 0:00 PM (about 35,000 values each for wind, solar, and cumulative wind and solar for all four transmission grid owners)

(4) losses that would increase the minimum storage volume are not considered;

(5) the selected sources are analyzed in isolation (i.e., as if there were no available electricity sources with less intermittent patterns); and,

(6) the storage demand is calculated to completely level out intermittencies; it ignores that electricity demand also fluctuates, and doesn't consider mechanisms[339] that could reduce the storage demand by adjusting demand to supply.

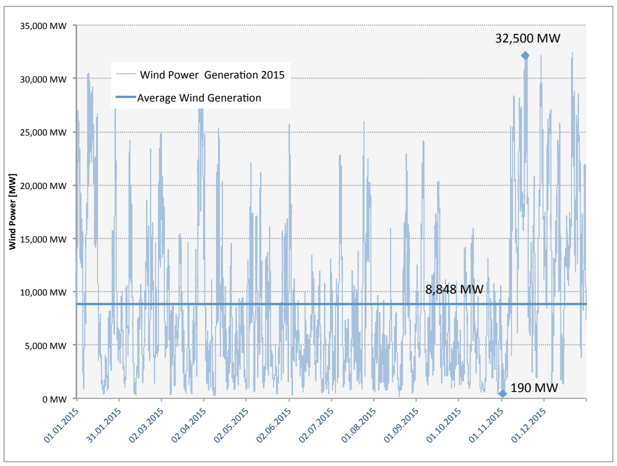


Figure 17 Wind - Power generation 2015

In 2015, 44.54 GW of installed wind capacity generated on average 8.85 GW of power. The power output fluctuated between 0.19 GW and 32.5 GW (Figure 17). The storage volume needed to level out these intermittencies amounts to about 13,700 GWh (Figure 19).

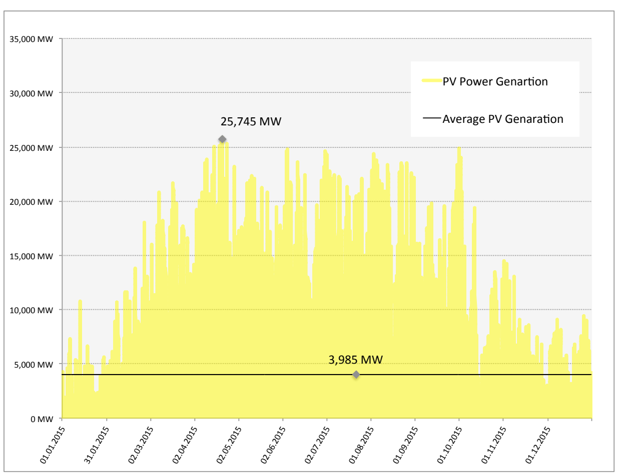


Figure 18 Photovoltaic - Power generation 2015

In the same period of time, solar panels with an installed capacity of 39.8 GW generated on average 3.985 GW. The power output fluctuated between 0 and 25.75 GW (Figure 18). Solar intermittencies in 2015 could have been leveled if a storage volume of 8,900 GWh had been available (Figure 19).

339 Such as demand-side management.

Adding the simultaneous generation data of wind and solar power, the necessary storage volume can be reduced to about 9,000 GWh (Figure 19).

Large pump-storage facilities can store approximately one GWh, so about 9,000 pump-storage facilities would be necessary to level the intermittencies generated by wind and solar energy in 2015 (see Figure 8.) Currently there are only 36 such facilities.[340]

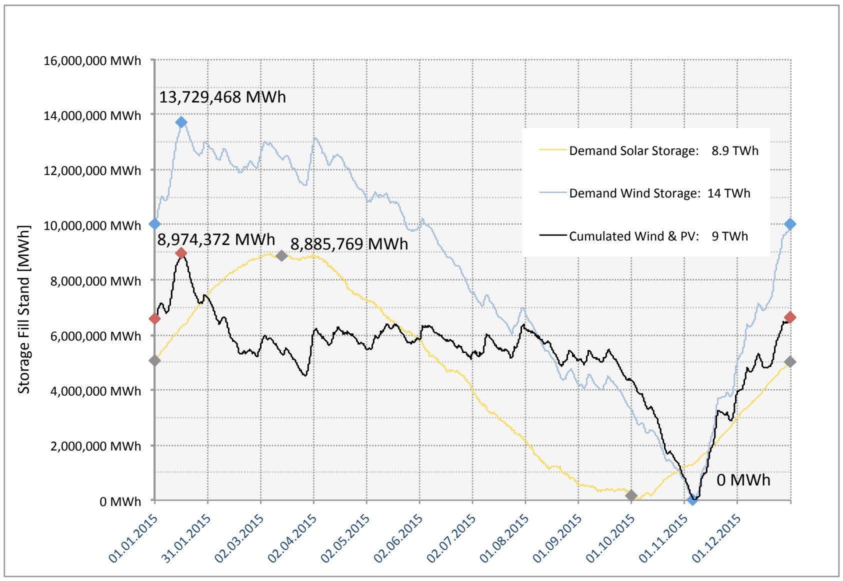


Figure 19. Storage volume needed to level solar and wind power intermittencies in 2015
*Data Source: Own calculations based on cumulated15 minutes feed-in values from Germany's transmission grid owners (Amprion, Tenet, BWNet, 50Herz)*

Even if 9,000 GWh had been sufficient to transform the intermittent wind and solar generation in 2015, it wouldn't have been enough to overcome the "Dunkelflaute" 2017, between January 16 and January 27. 12,679 GWh of power, more than three quarters of the total power demand in this period, were delivered from nuclear and fossil resources. A storage volume of nearly 13,000 GWh (or about 13,000 pump storage facilities of what

[340] German pump-storage facilities have a total storage volume of 0.04 TWh (SVR, 2010, Table 3-1, p.28).

might be expected to be a typical size) would have been needed to overcome this period without relying on nuclear and fossil fuels.

Some industrial sites with continuous heat demand installed "power-to-heat" aggregates[341] to benefit from phases of low electricity prices. This technology increases the power demand in times when RE generation is high, and reduces imbalances in the power grids, as well as the need for storage facilities. However, "power-to-heat" aggregates cannot be implemented on a large scale because they need the proximity of a heat sink[342] and have to meet an existing demand[343]. Because investments in "power-to-heat" facilities will always be subject to risks related to high electricity prices,[344] such storage solutions will probably maintain their "niche" character.

Other ways to balance RE intermittencies, such as "power-to-gas"[345] and battery storage, have been tested only in small-scale pilot experiments and remain too expensive to be implemented at a large scale.

In addition to so-called "demand-side management,"[346] measures can be implemented to adjust the electricity demand to the intermittent power generation and reduce the amount of electricity that has to be stored.

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[341] Electric boilers that transform cheap electricity into heat, and steam accumulators to store the heat produced.

[342] For example, a manufacturing process with a continuous heat demand.

[343] According to the Energy Conservation Ordinace (Energieeinsparverordnung- EnEV) it is forbidden by law to waste heat and other energies.

[344] They are economical only as long as electricity prices are very low.

[345] Power generation peaks (wind, solar) are used to produce hydrogen, which is storable, in an electrolysis process. Hydrogen can either be used directly to fuel cars or manufacturing processes, or transformed in a further process into synthetic methane.

## Negative Electricity Prices

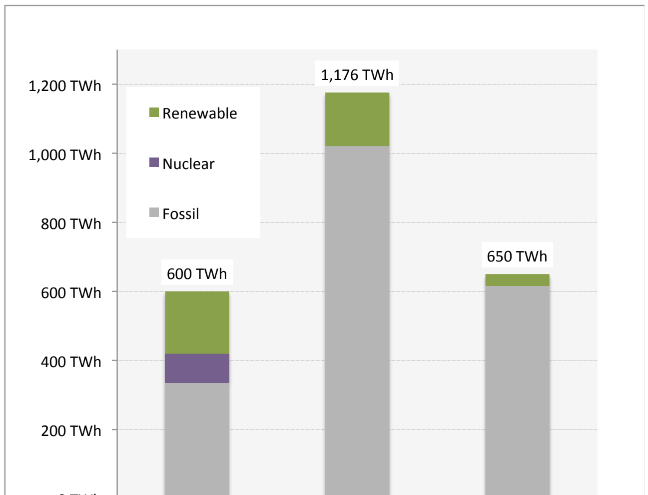
Another problem related to the intensive deployment of RE and the lack of appropriate storage facilities is that electricity prices become negative in periods when RE feed-in is high but demand is low, and utility companies have ended up having to *pay* users to consume electricity. The reason for this is that gas power is too expensive and coal power is not flexible enough to compensate for intermittencies at the quarter-hourly scale (the unit of time at which participants in the wholesale energy market have to forecast generation and consumption). It typically takes about eight hours to run a coal power plant completely down and another eight hours to bring it up to capacity generation again. Being too important for the stability of the grid to be phased out and too sluggish to rapidly adjust their generation, coal power plants continue operation during the relatively short RE peaks. If such situations occur in periods of very low power demand (e.g. during weekends, winter holidays, Eastern, etc.) prices turn negative, on the wholesale market, as a consequence of the imbalance between supply and demand.

## Energy Consumption and its Forgotten Components

Thus far, we have discussed *Energiewende* results for the electricity sector (*Stromwende*). But the incontestable success in deploying RE delivers an incomplete and distorted picture of Germany's energy-transition experiment and is by no means the only metric to be considered when evaluating its success. Heat and transportation are also major components of the transition. Germany's goal is that RE will provide 60% of gross final energy consumption, which includes energy for heat and transportation, not just electricity. Electricity represents only 25% of the gross final energy consumption (Figures 20 & 21).

[346] Instead of adjusting the power generation to meet the demand one can also adjust the consumption to the generation. Such methods are common practice at industrial sites (utility and manufacturing) and can be extended to smaller consumers.

About 85% of the 2,400 TWh of energy consumed annually in Germany are still provided by fossil and nuclear sources (Figures 20 & 21). The RE balance looks less impressive, and the targeted goals less attainable, when one includes other sectors in the monitoring process (Zeitreihen EE, 2016.)




| | Electricity | Heat | Transport |
|---|---|---|---|
| Series4 | 600 TWh | 1,176 TWh | 650 TWh |
| Renewable | 181 TWh | 155 TWh | 34 TWh |
| Nuclear | 84 TWh | | |
| Fossil | 335 TWh | 1,021 TWh | 616 TWh |

Figure 20. Gross Final Energy Consumption in the Sectors Electricity, Heat, and Transport

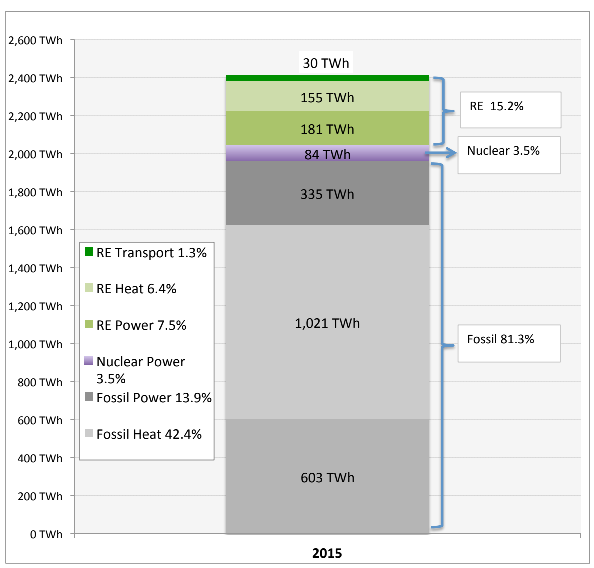



Figure 21. Renewable, nuclear, and fossil shares of the gross final energy consumption 2015

**Gaming the System: the Legal Free-Ride**

Intermittency is not the only difficulty created by the *Energiewende*. A significant and less publically known set of problems is related to the ability of actors in the energy system—especially large ones—to take advantage of loopholes and improperly specified rules, even if they know that such "grey areas" will be eliminated by policy makers as soon as they become aware of them.

For example, the way that the EEGs generate revenue to support costs for RE deployment is through the surcharge[347] on electricity consumption for all end users (apart from exempted industries). To further incentivize companies that supply end users with electricity to increase the share of RE in their portfolios, EEG2009 allowed traders with at least 50% RE power in their portfolios to deliver 100% of their electricity to end users without being obliged to charge their clients for the EEG contribution. In consequence, ingenious traders dutifully designed portfolios with exactly 50% RE and 50% conventional power, slightly reduced the electricity prices for their end-users in bilateral agreements, and kept most of the saved EEG surcharge, enriching themselves and returning only minimal savings to their customers.

The RE acts also exempt companies that produce their own power from paying EEG surcharges (EEG, 2000, 2004, 2009, 2012, 2014, 2017). The resulting loophole allowed companies to lease a power plant (usually one that burned fossil fuel), produce their own electricity, and share the savings in EEG costs with the power plant's owner.

Another example of perverse incentives created by the *Energiewende* is the booming business in small lignite boilers. To avoid disproportionate bureaucratic burdens for

[347] This surcharge functions similarly to a tax and doesn't increase one trader's gains, because traders have to transfer the EEG contribution they received from end-users to the relevant transmission grid owner.

relatively small heat-generating facilities, boilers with a thermal capacity under 20 MW are not subjected to the emissions-trading law, so operators of such boilers do not have to purchase allowances for their carbon emissions. This rule led to a flourishing business in 19.9 MW lignite boilers,[348] because lignite is the cheapest fuel, even though it is also the one with the highest carbon content.

**Cap-and-Trade: A Wonder-Tool for Carbon Mitigation?**

The European Emission Trading Directives and the acts implemented in Germany in response to these directives offered actors various opportunities to game the system in a way that added up to the awarding of an excessive amount of emissions allowances. During the first emission-trading period (ETPI) Germany's Allocation Act (ZuG2007) opened one of the most impressive legal-free-ride situations. As we will see, the self-oriented and non-communitarian behavior of facility owners undermined their own interests. ZuG 2007 required that facilities[349] under the jurisdiction of the EU ETS had to apply for, and were entitled to receive for each of the three years of the period 2005-2007, free allowances corresponding to 97.09%[350] of their average historical emissions. Manufacturing facilities and facilities that took early actions to mitigate their carbon emissions, for instance by using fuels with less carbon content, or by improving their fuel efficiency, received a number of allowances that corresponded to 100% of their average historical emissions. They had no obligation and no legal incentive to further reduce their carbon emissions. Very efficient CHP facilities could apply for allowances by using the so-called "double benchmark

[348] This information is not public. It is based on the statement of a utility representative who was responsible for commercializing lignite boilers.

[349] During ETPI 1,849 installations had to apply for allemission allowances..

[350] This corresponds to a reduction factor of 2.91% and resulted from the collection of historical data for the national allocation plan (NAP) in 2004.

mechanism" where applicants could apply for allocations for both conventional electricity and heat generation based on benchmarks for conventional performance standards. But combined heat and power generation is much more efficient than those standards, so applicants were awarded a higher number of allowances than needed to account for their average emissions. The allocation for new facilities[351] was based on production estimates (installed capacity multiplied by the estimated hours of operation). Overgenerous allocations for new facilities had to be adjusted ex-post to the real need in practice and partially returned to the DEHSt. ZuG did not, however, encompass mechanisms to adjust the allocation in cases where the initial estimate led to insufficient allowances. This rule incentivized actors to apply using high and unrealistic estimates for production data. In addition, existing facilities that were originally meant to apply for allowances using historical emission data (grandfathering method) could opt to apply for allowances using the rule for new facilities (i.e., estimated figures instead of average historical ones). In comparison with the grandfathering method, this alternative had the advantage that facilities could receive higher allocations[352], and thus be able to cover planned increases in production. That is why most of the managers responsible for the 1,849 facilities that fell under the jurisdiction of TEHG and ZuG applied for allowances using the new facility rule. Without any legal means to correct the allocation in cases of underestimated production figures, all applications were based on unrealistic and very high production estimates. Before applying for allowances, facility owners had to have their application validated by accredited external firms. Although it was obvious that the presented figures could not be realistic, the validation process did not help to reduce the amount of allowances, because the applications perfectly complied with the

351 I.e., facilities planned to start operation during the first ET period.

352 By applying based on optimistic estimates of production data.

ZuG rules. The total amount of allowances that had to be allocated according to ZuG was suddenly much higher than the government's initial estimate. The imperfect ZuG 2007 regulations forced the DEHSt to over-allocate allowances. This created the impression that the distance to the mitigation target was greater than initially estimated, and that Germany needed to lower its initial emissions cap by another 4.5% (from 2.9% to 7.4%) to meet its decarbonization commitments (UBA, 2004; UBA 2015; Gerner, 2012; Elspas et al., 2006; Maubach, 2014, pp.79-100).

In July of 2004, the European Commission claimed that ex-post corrections of emission allowances, such as those stipulated in the ZuG2007, do not comply with European Law because they intervene in the market, attract investors to Germany, and add uncertainties for companies that received an allocation without being able rely on it being correct (DEHSt, 2008, pp.1-2). To protect its allocation rules, Germany's government initiated, in September 2004, a lawsuit against the European Commission at the European Court of Justice. The suit was resolved in November 2007 in favor of Germany (DEHSt, 2008, p.2). Because the outcome of the claim was uncertain, during almost the entire duration of the ETPI, Germany did not curtail the allocations according to real emission figures at the end of each year of the ETPI. The extreme over-allocation, the delayed ex-post adjustments, and the impossibility of transferring allowances from the first emission trading period into the second led to a tremendous surplus of allowances by the end of 2007, and hence to a drastic price decline (from about €30/t of CO2 in April to €0.05/t of CO2 in December 2007).

## Minimizing Utilities: A Branch on the Brink of Dissolution

Inside the *Energiewende,* there was no economic branch harder hit by the successive waves of induced complexity and change than the utility sector. Deregulation of the electricity market in the late 1990s triggered a strong consolidation wave, reducing the number of registered utilities by about 25% from 1229 to 919, between 1997 and 2001[353] (see Figure 22).

Immediately thereafter, the successive EEGs that subsidized the decentralized generation of power incentivized the creation of small, new utilities, and between 2001 and 2013 the number of registered utilities increased by about 46%, from 919 to 1344[354] (see Figure 22).

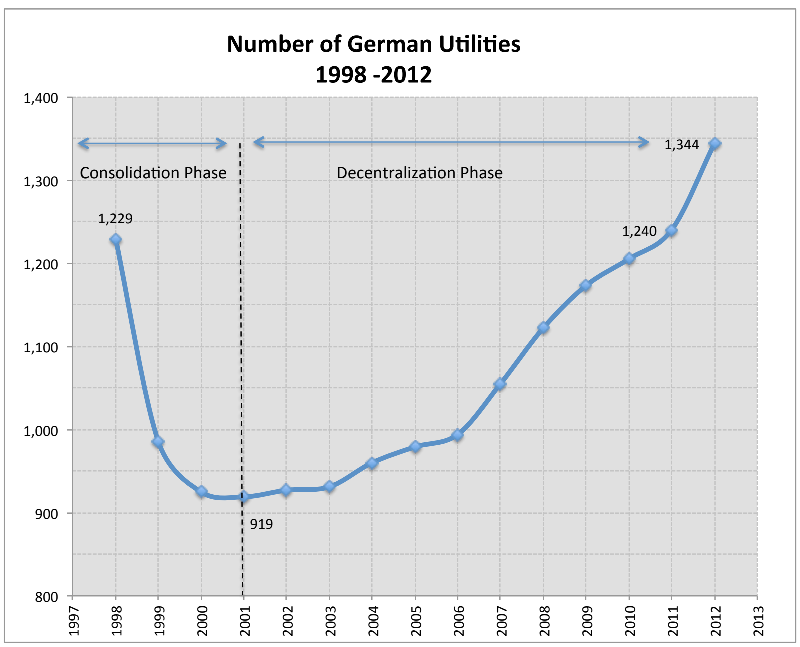



Figure 22. Evolution of thee number of German utilities between 1998 and 2002

Data source: Bontrup & Marquardt, 2015.

353 From 1,229 utilities in 1997 to 919 in 2001.

354 From 919 utilities in 2001 to 1344 in 2013.

This shows that utilities initially expected to have better chances in the deregulated market the larger they were. However, they had to learn that large organizational structures cannot react flexible enough in a continuously changing market, that the *Energiewende* regulations, with their focus on decentralized power, cannot be reversed, and that their large structures are not functional in the new regulatory context.

Mergers among the nine largest German regional utilities led to the four big energy corporations that dominate Germany's utility sector today: Eon, RWE, EnBW, and Vattenfall (see Figure 23; compare Bontrup & Marquardt, 2015).

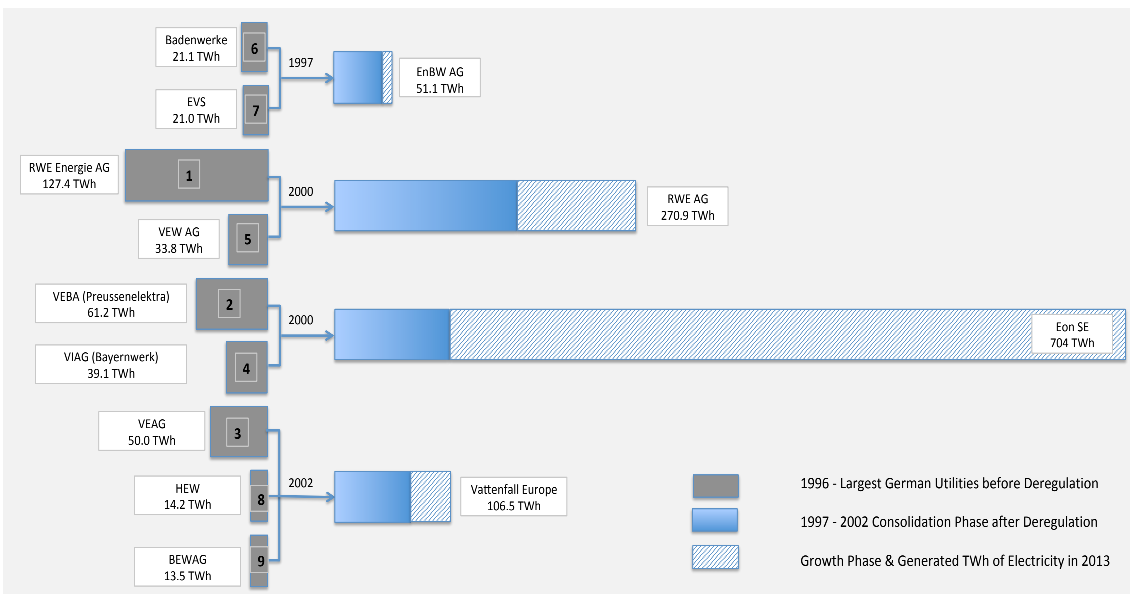



Figure 23 - The birth and expansion of the four largest German Utility Groups

In 1997, two regional utilities, Badenwerke and EVS (Energieversorgung Schwaben), the sixth and seventh largest utilities and both located in the German state of Baden-Württemberg, merged to create EnBW (*Energie Baden- Württemberg*). In 2000, two mixed chemistry-and-energy groups, VEBA (*Vereinigte Elektrizitäts und Bergwerks Aktiengesellschaft*) and VIAG (*Vereinigte Industrieunternehmungen AG*) merged to form Eon. Their energy subsidiaries, *Preusseneleektra* and *Bayernwerk*, became Eon Energie AG. Shortly after the founding of Eon, RWE (*Rheinisch-Westfälisches Elektrizitätswerk AG*), at that time the largest German electric utility, merged with its competitor VEW (*Vereinigte Elektrizitätswerke Westfalen AG*) to form RWE AG. In 2002, the Eastern German utility group VEAG (*Vereinigte Energiewerke AG*),[355] HEW (*Hamburgische Electricitäts-Werke*), and BEWAG (*Berliner Städtische Elektrizitätswerke AG*) merged to create Vattenfall Europe SE.[356]

For the newly established large German utilities, the consolidation phase was followed by a period of diversification[357] and international expansion triggered by deregulation, the EEGs, and other *Energiewende* laws. National utilities became global energy companies almost overnight, investing in new facilities and companies in Germany and other countries, and generally changing their focus from domestic to international markets.[358] By the end of this extreme expansion period, in 2013, Eon's electricity portfolio had increased to 704 TWh, roughly seven times larger than its initial portfolio in 2000.[359] Meanwhile, RWE

355 After the fall of the Iron Curtain, the nine largest German utilities acquired shares of the Eastern German VEAG. PreussenElektra (VEBA), RWE, and Bayernwerk (VIAG) together owned about 75% of VEAG shares. These companies had to sell their VEAG shares due to European respectively German anti-trust conditions for the mergers between VEBA-VIAG and RWE-VEW.

356 The Swedish utility group Vattenfall AB acquired, in 1999, 25.1% of the HEW (a large communal utility located in Hamburg) shares. In 2001, Vattenfall became majority owner of HEW by buying additional HEW shares from the local Government of Hamburg. To comply with the European anti-trust stipulations for founding of Eon, VEBA and VIAG sold, in 2001, their VEAG shares (49%), BEWAG shares (49.9%), and HEW shares (15.4%) to HEW. To get approval from the German anti-trust authority (BKA – Bundeskartellamt) for the RWE-VEW, RWE also sold its VEAG shares (26%) to HEW. With its decision to sell its remaining 25.1% HEW shares to Vattenfall, the city of Hamburg enabled the Swedish group Vattenfall AB (which already held, through HEW, a significant number of shares of VEAG and BEWAG), to squeeze out all minority shareholders, and to found Vattenfall Europe AG, the third largest electric utility in Germany.

357 The Eon-Ruhrgas merger in 2003 is the most prominent diversification example. By acquiring Ruhrgas (the largest German supplier of natural gas), Eon entered the natural gas sector and took the lead in Germany's utility ranking.

358 Because borders were open, a European market was established, utilities were wealthy and these companies tried to find their place in the new market.

359 When VEBA (Preussen Elektra) and VIAG (Bayernwerk) merged to form Eon.

increased its power portfolio only from 161 TWh to 271 TWh between 2000 and 2013 and lost its position as Germany's biggest utility.

At first, utilities ignored government efforts to encourage RE deployment. Later they began to lobby against RE sources, arguing that managing the problem of intermittency would be both expensive and technically difficult. Yet utilities soon came to recognize that the EEGs offered a comfortable pathway to making profits without taking entrepreneurial risks. By 2008, the major utilities had begun massively investing in RE and by 2014, as they realized that their conventional assets were being rendered worthless, they began to split their companies into "bad" traditional fossil- and nuclear-energy businesses that could not make a profit, and "good" entities that invested in REs, in a desperate effort to save whatever could be saved (Die Zeit, 2015; NTV, 2016; FAZ, 2016b). The "good" entities were attractive merger prospects to powerful companies; the "bad" ones had to be maintained because without them the grids would collapse.

The *Energiewende*'s focus on RE feed-in forced utilities to run their power plants inefficiently and to generate significantly less electricity than they technically could. Meanwhile, the nondiscriminatory grid-access rules implemented to deregulate the energy markets subjected utilities to increased competition and significant loss of market share as new players were enticed into the *Energiewende* arena and small, flexible entrepreneurs developed new business ideas that exploited market niches in the decentralized power-generation realm. Electricity prices for industrial consumers and households dropped significantly in early deregulation stages, reaching their lowest level in 2000, but rose again under the generous, user-subsidized EEG support schemes that became effective between 2000 and 2014 (Bontrup & Marquardt, 2015).

Despite all efforts by the big utilities to improve their position in the market, the spread between revenues and earnings steadily increased[360] and the sector shed nearly a quarter of its employees between 1998 and 2012 (see Figures 24, and 25; Data source: Bontrup & Marquardt, 2015).

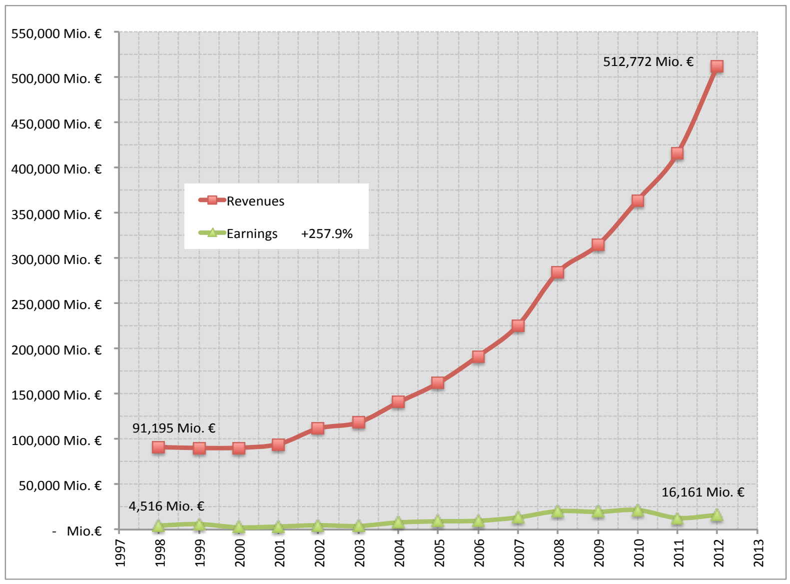



Figure 24. German utilities 1998 – 2012: Comparative evolution of revenues and earnings

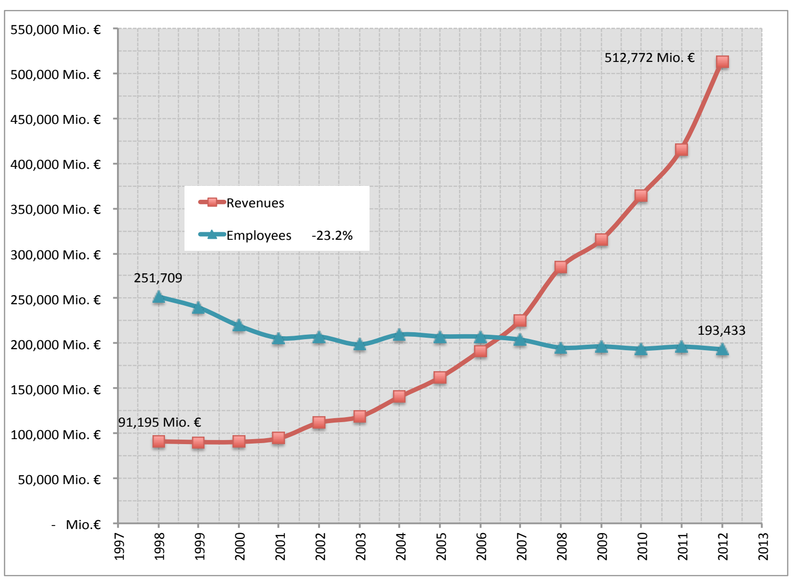



Figure 25. German utilities 1998 – 2012 : Evolution of revenues and number of employees

360 The cumulated revenues of all German utilities registered a nearly 6-fold increase between 1998 and 2012.

Shares of RWE, Germany's largest utility in 2000, rose rapidly through 2007 and have since lost about 90% of their value; Eon, currently Europe's largest utility, lost about 80% of its share value in the same period (see Figure 26).

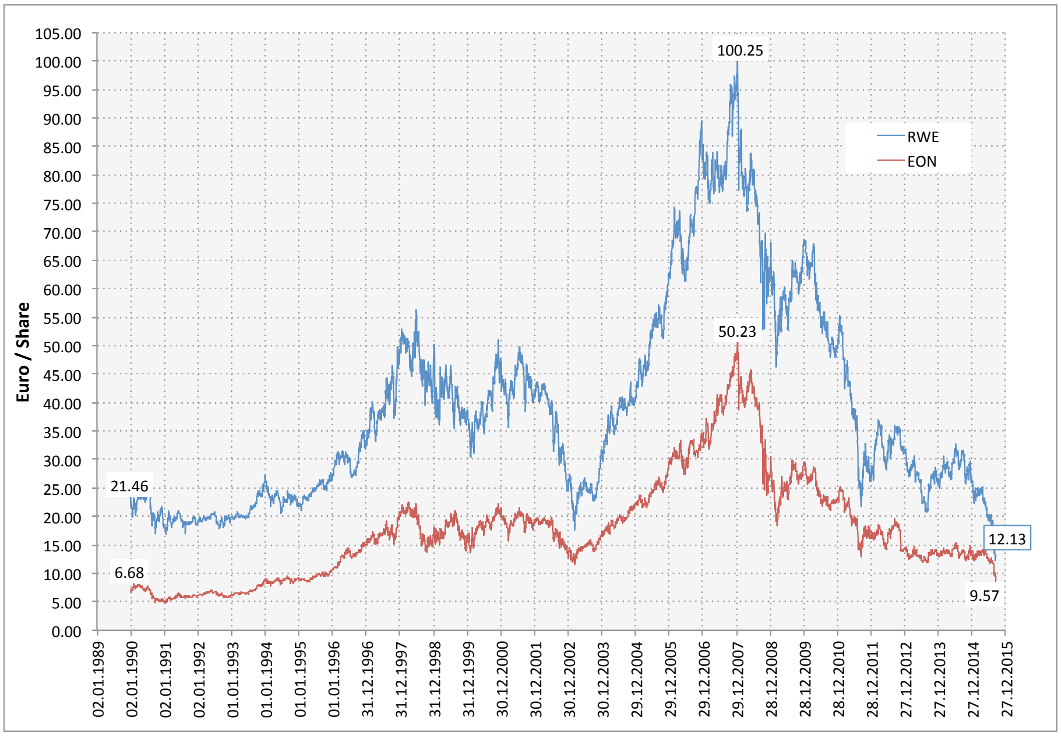



Figure 26. RWE and Eon: Share Price Evolution 1990 -2015 (Data: Börse.de 2015 a & b)

In the wake of deregulation, integrated utilities were forced to unbundle their activities in order to ensure non-discriminatory access for third parties to their grids. Given the increased dependence on intermittent wind and solar energy, electricity transmission grids became increasingly difficult to operate. The grid business is strongly regulated, allowing only small, pre-determined profit margins, so the utilities lost interest in operating transmission grids and sold significant shares of this business to compensate for losses triggered by the *Energiewende*. The tremendous decommissioning costs for nuclear power plants, coupled with the unsolved problem of nuclear waste disposal, added still more to the costs that the utilities had to bear, and this once powerful sector was pushed to the brink of dissolution. The financial agreement reached with the government in 2017, in response to the verdict of the constitutional court of justice to their lawsuits, grants them a short period of relief, but they are not yet over the hill.

In their desperate effort to survive, the big utilities defined new ways of working, organized and reorganized their activities, sold assets, changed the core of their business, and, finally, switched their focus to "intelligent" technologies, demand-side management, and energy services. But such efforts have done little to stabilize their long-term prospects. Today, the German utilities, especially those like Eon and RWE that still operate major fossil and nuclear plants, lack the financial means to develop new business models, adjust to the continually changing policy frame, satisfy their stockholders, and actively shape the *Energiewende*. Indeed, on April 25, 2015, some 15,000 utility employees working in lignite extraction, fuel manufacturing, and coal power-plant operation demonstrated in front of Chancellor Merkel's office to draw attention to their plight. But unless wholesale energy prices rise significantly, and soon, the solvency of these major companies remains uncertain.

## Is the *Energiewende* on track?

On the face of it, what amounts to an unintended sacrifice of the utility industry might seem like the necessary price to pay for creating a new clean-energy system. Indeed, on May 15, 2016, Germany met almost its entire electricity demand with RE. These impressive results in the renewable electricity realm have attracted international attention and recognition. Numerous individuals and organizations, from Al Gore and Paul Krugman to Greenpeace, share the optimistic view that Germany is now demonstrating that a totally decarbonized economy is both technically feasible and affordable (Krugman, 2014; Krugman, 2016; Gore, 2016; Romm, 2016).

But it is by no means clear that the addition of huge new RE capacity to the German electricity grid has produced the desired outcome of reduced carbon emissions. The situation in the power sector is extraordinarily complex, and the addition of RE capacity does not in any straightforward way displace fossil-based electricity; indeed, in some cases it has led to increased use of cheap fossil fuels.[361] Moreover, emissions are not produced by the power sector alone; RE deployment lags behind targeted levels in the two other major energy sectors, transport and heat, making it difficult to meet the targeted RE share of gross final energy consumption without adding more rules to induce the desired change. To visualize the *Energiewende's* progress towards its long-term and intermediate goals,[362] I used a traffic-light system (see Figure 32): green=good chances to meet or exceed targets; yellow=moderate risk to miss the targets;[363] and red=high risks to miss targets without additional measures[364].

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[361] The intensive deployment of RE, their feed-in priority, and the fact that RE are considered to have no marginal costs, pushed low carbon fossil fuels out of the "merit-order" curve (see Appendix G). This led to the more intensive use of "cheap" lignite and hard coal and not of more expensive but less carbon intensive fuels, such as natural gas, or oil.

[362] I.e. the 2050 and for 2020.

[363] Up to 10% deviation.

[364] More than 10% deviation.

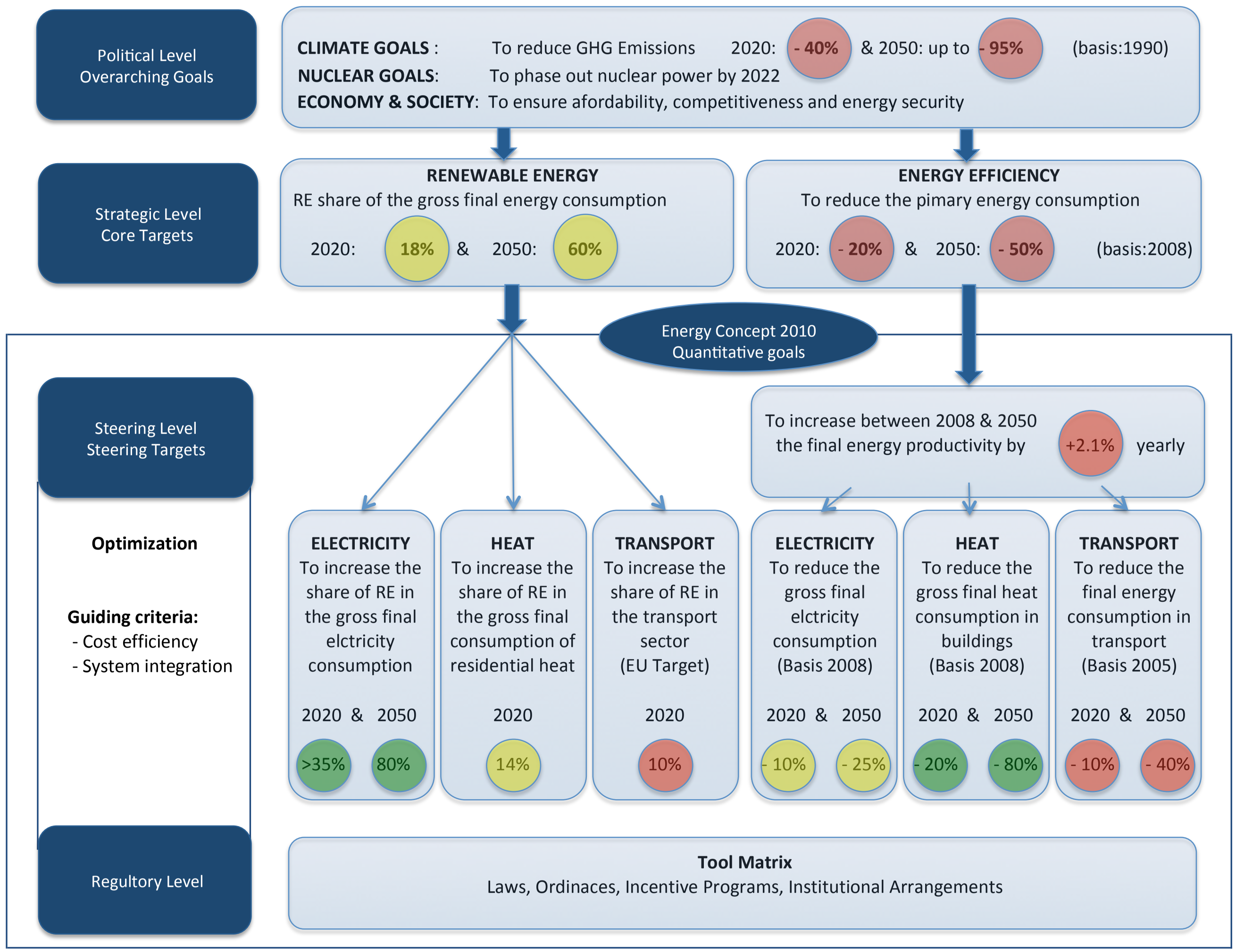


Figure 27. *Energiewende* goals on the political, strategic, steering, and regulatory level

*Data Sources: Germany's Energy Concept (Schleisinger et al., 2010), Vierter Monitoring-Bericht zur Energiewende, (BMWi, 2015) Own representation with qualitative and quantitative Energiewende Targets for 2020 and 2050, inspired by Figure 2.1, p.9 (BMWi, 2015)*

Current trends show a much slower reduction in carbon emissions than is necessary to come close to meeting the minimum target of 80% reduction by 2050 (see Figure 28). More perplexingly, the contribution of the power sector itself to reducing carbon emissions has been quite minimal so far. Indeed, it seems that emissions reductions have for the most part been driven by entirely different forces than the *Energiewende*. Germany's GHG emissions have decreased by 28% since 1990, yet more than the half of this decrease was achieved before the European Union ratified the Kyoto Protocol, before the first German regulations to mitigate climate change became effective, and before the sophisticated European cap-and-trade system was established. These pre-Kyoto achievements were primarily due to the deliberate selection of 1990 as the reference for measuring subsequent emission reductions, since that year marked the beginning of eastern Germany's economic breakdown and consequent reduction in energy use in the wake of reunification. Early voluntary commitments to climate mitigation by several industrial branches also contributed to the pre-Kyoto carbon reductions, but these were based mostly on substitution of natural gas for coal and oil. The global economic recession that started in 2008 also contributed to lower energy use and thus to reduced emissions.

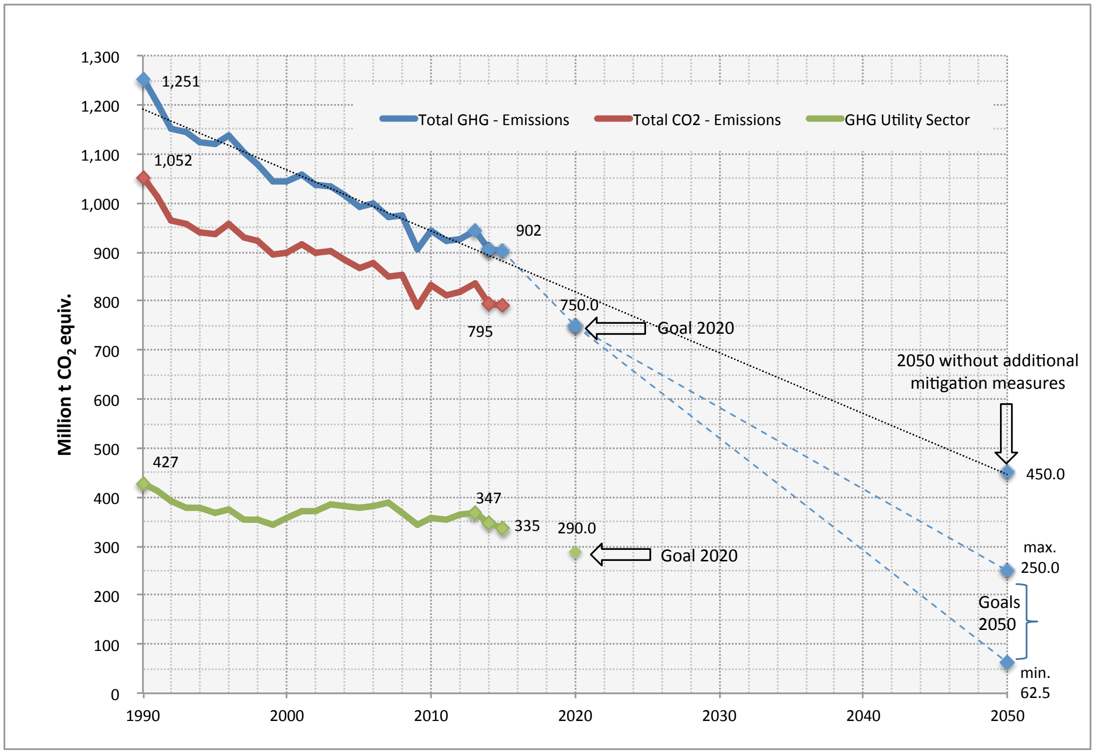


Figure 28 – Historical evolution of GHG emissions between 1990 and 2015; decarbonization goals 2020/ 2050, and linear forecast trends.
*(Data Source: BMWi, "Zahlen und Fakten; Energiedaten", Table 10 (2017))*

The post-Kyoto measures have produced relatively little mitigation in the last 14 years. In fact, between 2009 and 2014, as 44,425 MW of RE capacity was added to the German power system, GHG emissions *increased*. This occurred in part because zero-carbon nuclear facilities had to be replaced with carbon-intensive coal and gas plants. At the same time, all of the new RE capacity helped to drive down wholesale electricity prices. The European Emission Trading System, which was supposed to be a market tool for reducing GHG emissions, proved instead to be a playing field for speculators hoping to profit from boom-and-bust cycles. And bust has been much more the norm as the emission trading rules and the rapid deployment of RE led to reduced production of fossil energy and a consequent glut of carbon allowances, whose value declined from above 20 €/ton of CO2 emitted in 2008 to less than 3 €/ton in 2013, then rose slightly to just above 4 €/ton at the end of 2016 and 7 €/ton in 2017. These very low allowance prices sent the wrong signals to the market and ended up making lignite and hard coal economically attractive, thus further contributing to an absolute increase in carbon emissions.

To date, then, the *Energiewende*'s record is mixed, but very troubling. On the plus side is continued public support and a very impressive ramp-up of RE capacity. But on the deficit side of the ledger are exploding energy costs, failed policy tools such as the German and EU trading schemes that have led to incessant gaming of the regulatory regimes without emissions benefits, and hard-hit actors in the *Energiewende* arena—above all the major utilities, which increasingly look to have been consciously sacrificed to help Germany meet its ambitious GHG emission targets. Yet these targets are not being met.

The main challenge for *Energiewende* and similar programs is to integrate intermittent sources of power into existing energy systems. But despite all efforts to convert excess electrical power to hydrogen, methane, heat, or other storable commodities, and despite all progress made in battery research, storing the electricity that would be necessary to solve Germany's intermittency problem remains technologically and economically out of reach.

An optimist might declare that the very fact that Germany's electricity grid has not collapsed must mean that the intermittency problem is well on its way to being solved. In reality, collapse has been averted only through two mechanisms that run directly counter to the goals of the *Energiewende*. First, the intermittency-balancing problems on cloudy and windless days have been managed only because utilities have backed up intermittencies by running fossil power plants—and running them in ways that are uneconomical and especially bad for the environment, because partial loads require more fuel per unit of energy than full loads. Secondly, Germany's electricity generation on windy and sunny days has exceeded, often by far, the grid's balancing abilities, forcing the power surplus into adjacent grids, obliging other countries to compensate for German intermittencies, and leading to disturbances and additional costs in these countries' grids.[365] Thus, operating the energy systems as described is neither economically sound, nor beneficial for climate and environment, nor reconcilable with principles of being a good neighbor. In addition, this operation mode would not be even possible in a carbon-free economy at the European level, in which Germany's neighbors would need to balance their own RE intermittences and fossil fuels would no longer exist. In the absence of nuclear power, Germany's transition to a low-carbon energy system depends on its ability to store enough cleanly—and affordably—generated electricity to compensate for the intermittencies created by the massive introduction of REs. Until this problem is solved, the *Energiewende* will remain, above all, a testimony to the unintended consequences that result from well-meaning interventions by *Dichter und Denker*—poets and thinkers—in complex social and technological systems.

[365] Forced electricity exports are welcome as long, as they are insignificant, and do not disturb the operation of adjacent grids. However, Germany exports yearly about 50 TWh of power (approximately the amount of renewable power generated yearly in California, Pennsylvania and Florida) and its neighboring countries are all but happy to receive huge amounts of intermittent power in their grids. Despite being "acclaimed in Germany as a historic step" the *Energiewende* "increasingly arouses discontent in neighboring countries" wrote Kalina Oroschakoff in an article in Die Welt. The author claims that the Czech Republic, Poland, the Netherlands, Belgium and France try to protect their grids from forced German power exports by installing phase-shift devices that hinder such exports (Die Welt, 2015).

CHAPTER 8

# THE COLLECTIVE WISDOM OF ENERGY EXPERTS

## Participants in this Study

Thirty stakeholders in the *Energiewende* arena agreed to participate in this study. I conducted open-ended interviews of two to six hours each with 12 of the stakeholders, either in person (6) or on the telephone (6). The remaining respondents answered the questions by email. All participants received, in advance, a sample of 50 questions[366] (see Appendix A). Many respondents answered some of the questions in detail, referred to studies, or sent me their own presentations and publications that addressed different aspects of my questions. Given that energy experts and researchers travel often for business and have extremely tight schedules, it was often difficult to make time for a meeting. With one exception, all interviewees were energy experts: in different economic sectors, scientists, representatives of industrial associations, or politicians active in energy groups at the local level. The single non-expert was a private citizen who participated in several anti-nuclear demonstrations, covered his rooftop with solar panels, and is well informed on energy-related topics. In addition to formally interviewing experts, I discussed in detail many *Energiewende*-related topics with hundreds of experts, colleagues, and friends during conferences, professional association symposia[367], as well as in internal and external meetings of different RWE companies.[368]

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366 Twenty-seven main questions and eleven sub- or multi-part questions addressing different *Energiewende* aspects.

367 VIK – Verband der Industriellen Energie- und Kraftwirtschaft / Association of Industrial Energy and Power; bdew – Bundesverband der Deutschen Energie- und Wasserwirtschaft/Federal Association of Genrmany's Energy and Water Economy; BDI – Bundesverband der Deutschen Industrie / Federal Association of Germany's Industry; BAV- Bundeverband der Altholzaufbereiter und –verwerter/ Federal Association for Waste Wood Processing and Utilization.

368 Harpen AG, RWE Key Account contracting, RWE Innogy Cogen GmbH, RWE Innogy GmbH, RWE Energiedienstleistungen GmbH, RWE Vertrieb GmbH. Between January 2004 and July 2016 I headed

Because all humans have a stake in a future in which well-being will depend significantly on successful energy transitions, they are, whether consciously or not, stakeholders in *Energiewende* and similar experiments. This fact motivated me to ask many participants in my study what measures they would take, if they were Germany's Chancellor or Minister of Economic Affairs and Energy, to help Germany's energy transition succeed.

The way stakeholders perceive the *Energiewende* depends on the perspective from which they are looking at it. "How should I answer your questions?" asked one of my interviewees. "As CEO? We earn money with the *Energiewende*! As a scientist? Do you expect a neutral expert response? As a lobbyist at bdew?[369] I am concerned with avoiding the worst! As a private person? *Energiewende*: I realize that I run in the wrong direction, thus… I speed up!"[370]

I addressed my questions to a group of very educated people representing the elites of German society. About two-thirds of the respondents were familiar with different perspectives on energy- and climate-related topics, and I often had the impression that I was carrying out several interviews simultaneously. Interviewees either had energy-related expertise in different activity sectors,[371] or simultaneously occupied different positions that did not necessarily have convergent mission statements and interests regarding *Energiewende* processes. Not only were the participants in my study confronted with *Energiewende*

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different departments in these distinct juridical entities, being in charge of improving their economic output and strategic position by implementing *Energiewende* intruments, and using energy market and energy trade opportunities.

369 The German Association of Energy and Water Industries (Bundesverband der Deutaschen Energie und Wasserwirtschaft).

370 All interview responses were translated from German to English by the author.

371 For example, many respondents occupy management positions in small and/or large utility groups, as well as on the side of energy consuming manufacturing processes; some of them were active in the manufacturing or in the utility industry and also occupied political positions in parties and local governments, leading there energy commissions; other work in industrial branches and also teach in Universities.

regulations on a daily basis, but their positions were often at risk due to these regulations. About one-third of the respondents represented the utility industry and stood to lose their positions as a consequence of *Energiewende* regulations. Another third held positions in some aspect of manufacturing and feared they would lose their privileges and be forced to close their sites. Those representing decentralized RE energy generation perceived their work to be jeopardized by new EEG regulations that set FITs by auction[372], which led to a significant drop in price, a drop that restricted their opportunities to install new RE facilities. This is why I was surprised that almost all these participants support Germany's *Energiewende*, despite their profound criticism of its various rules and regulations. Interviewees understood the risks, saw the rising costs, thought that the government lacked a coherent plan for decarbonizing all economic sectors, and knew that the technology necessary to store electricity at a large scale does not yet exist, but they also saw the need for a transition to low-carbon technologies. Thus, although I did not expect these results, my study confirms all official statements that Germans support the *Energiewende*.

**Categories of Questions**

The questions fall into seven major categories: (1) Quo vadis Germany? (2) Patterns and Rules; (3) Technology; (4) Strengths and Weaknesses; (5) Outcomes; (6) Risks and Opportunities; (7) Cost Distribution; and (8) Required Changes. I sorted the responses and chose representative examples to include in the discussion below and accompanying tables.

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[372] Instead of having fixed FITs established by Law, EEG 2017 implemented RE auctions that determine the FITs. Given that the needed investment dropped, the FITs resulting from auctions are lower than FITs established in previous EEG versions. This means, that the gain margin for investors significantly dropped. Some (especially larger ones, with more administration and larger investments in the past) cannot economically function and have to reduce their investments. The auctioning procedures favor groups of citizens that unify to apply for auction tranches, because they do not have to invest prior to the auction for qualifying documents. They can make the documentation within 2 years (I have to check this) after winning the auction. I.e. groups of citizens can win an auction, but decide within this period that they are not able to realize their project.

The first category, *Quo vadis, Germany?*, comprises questions meant to capture the overall perception of the *Energiewende*, its likelihood of being successful in achieving its long-term goals, as well as prospects for this unique experiment. The second category, *Patterns and Rules* consists of questions about Germany's energy-transition pathway, the nuclear phase-out, and the instruments implemented to mitigate climate change. *Technology* questions refer to technologies needed for a successful transition and their current state of the art. As its name suggest, *Strengths and Weaknesses* questions ask about the drivers for successful transitions as well as the main barriers to them. *Outcomes* includes questions about unexpected consequences of energy transitions, imperfect rules that cause "legal free-ride" situations, and various *Energiewende* impacts (e.g., on energy costs, on different actor clusters, on transmission grids, on the society). The *Risks and Opportunities* questions aimed to identify elements that jeopardize or to stimulate wellbeing at private, company, and societal levels. Questions in the *Cost distribution* category ask about fairness in sharing the transition burden. Finally, *Required Changes* questions probe what policies should be implemented to correct undesired developments and improve the chances for a successful energy transition.

The categories of questions are presented in Table 6. Each category encompasses one or more questions. The sample questions sent to participants are shown in Appendix A. Column 3 of Table 6 indicates which questions from the sample are included in the categories.

Table 6. Categories of Questions

| | Category | Question Number | Sub-Category | Examples of questions |
|---|---|---|---|---|
| Quo vadis Germany? | 1 | 1.1 | SUCCESS/FAILURE | How would you qualify Germany's integrated climate and energy policy (success, failure)? |
| | | 1.2; 6 | GOALS | Do you believe that Germany will achieve its ambitioned climate and energy goal 2050? |
| | | 2 | EVOLUTION / PROSPECTS | What do you think about the evolution and the perspectives of the German "Energiewende"? "Quo vadis" Germany? |
| Patterns and Rules | 2 | 11;12:13 | TRANSITION PATHWAY | How do you explain that Germany has chosen a different energy transition trajectory than all other countries on the globe? |
| | | 7; 6 | NUCLEAR PHASE OUT | What do you think about the nuclear phase-out? |
| | | 22;24; 8; *25* | ENERGIEWENDE INSTRUMENT | How do you estimate the **liberalization** initiative and its result? What is your opinion about the **Emission Trading** regulation? (Is it necessary or not? Would other forms of incentives/constrains (own commitment, taxation) be more appropriate to achieve the ambitious decarbonization goals)? What do you think about the DESERTEC initiative? |
| Techno-logy | 3 | 17.1-17.4 | TECHNOLOGY | Technology State of the art/ Development - Storage, CCS, RE, Power Transmission |
| S/W | 4 | 3 | STRENGHTS / WEAKNISSES | What are the strengths and the weaknesses of Germany's radical energy policy? |
| Outcomes | 5 | 9; 16 | UNEXPECTED CONSEQUENCES | Can you enumerate some of the unexpected and/or undesired consequences of the successive energy and climate regulatory frameworks between 1990 and 2017? Is it possible to formulate a regulatory framework in a manner that avoids adverse effects? Is it possible to elaborate a regulatory frame that does not favor some actors in the energy arena at the costs of others? |
| | | 10 | FREE RIDE | I am particularly interested in regulatory and legislative stipulations (EnWG, NZVo, EEG, KWKG, BiomasseVo, TEHG, ZUG, ZUV, Atom Gesetz, ReserveVo, etc.) that were meant to encourage a certain behavior of market players and to benefit the entire society but led either to a different/adverse market behavior or even to a generalized "legal misuse" and to an additional burden for the society. Have you heard about such practices? Were you confronted with such practices? Can you name some examples? |
| | | 4.1-4.3 | IMPACTS ON COSTS | What are from your point of view the impacts of the *Energiewende* on the costs for infrastructure, transmission, energy prices, |
| | | 4.5-4.7; 23 | IMPACTS ON ACTOR CLUSTERS | What are from your point of view the impacts of the *Energiewende* on: hausholds, large utility companies, manufacturing industries? Name some important turning points in the strategic approaches used by utility companies (for instance transition from client orientation and competition philosophy to trading dominance and standardization)? |
| | | 4.8-4.10 | IMPACTS ON SOCIETY | What are from your point of view the impacts of the *Energiewende* on: employment, just energy access, society? |
| | | 20 | IMPACTS ON ENERGY GRIDS / BALANCING | What are from your point of view the impacts of the Energiewende on: transportation?grid infrastructure |
| | | 18, 19 | OTHER IMPACTS | Negative electricity prices; Merit-Order; Identical Electricity Prices? |
| R/O | 6 | 14.1-14.3 | RISKS / OPPORTUNITIES | Can you identify risks and/or opportunities related to the *Energiewende*? |
| Costs | 7 | 4.4; **5**; 27 | COST DISTRIBUTION | Do you perceive the distribution of costs/benefits as fair? |
| Chan-ges | 8 | 15 | REQUIRED CHANGES | What should be changed in Germany's energy and climate policy? |

**Category 1. Quo vadis, Germany?**

About 70% of study participants, representing all of the different parts of the arena, viewed the *Energiewende* as successful or at least partially successful. Table 7 shows a sample of their responses. Some respondents claim that success is coupled with a series of problems that could have been predicted. Others consider the ultimate measure of success to be the broad public support for the *Energiewende* rather than any quantitative indicators. Some *Energiewende* advocates emphasize that Germany's energy transition is needed not only to mitigate climate problems, but also to find appropriate energy solutions for a nation poor in fossil resources.

Table 7 – Interviewees Confident in the Success of the *Energiewende*
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Success/Failure*.

| SUCCESS/ FAILURE | | How would you qualify Germany's integrated climate and energy policy (success, failure)? (Appendix A, # 1.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Germany's *Energiewende* will be a success." |
| R16 | Manufacturing Sector | "The *Energiewende* is successful; it addresses not only climate change, but especially the depletion of existing resource-reserves." |
| R12 | Manufacturing Sector | "The question is to be answered with a clear 'successful.' The success of the energy and climate policy can indeed be quantitatively measured by the attainment of a certain quota. Yet its qualitative aspects - creating an awareness regarding climate protection, energy policy, and energy efficiency, meanwhile accepted by Germans as "normal" and 'belonging to life'- have to be ranked much higher." |
| R22 | Research Institution | "I think the *Energiewende* is, despite all its problems, a big success." |

More skeptical interviewees perceived the price of a successful *Energiewende* as too high, but assumed that goals will be adjusted in time to preserve the nation's prosperity. Some reported ambivalent perceptions, considering the high share of RE as positive, but at the same time seeing the *Energiewende* as a threat to their own wellbeing. Others said that the transition began well, but are disappointed by current developments, considering them either insufficient or too rapid, and with too many negative impacts on stability in grids.

Table 8 – Interviewees with Ambivalent Perceptions about the *Energiewende*
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Success/Failure.*

| SUCCESS/ FAILURE | | How would you qualify Germany's integrated climate and energy policy (success, failure)? (Appendix A, # 1.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R4 | Utility Sector | "I am ambivalent with respect to Germany's energy policy. Positive is in any case that RE reached a significant share of the total [power] generation. Negative is that this came at high costs and jeopardizes my workplace." |
| R15 | Manufacturing Industry | "Successful? Conceivable yes, but at what price. I assume that the preservation of 'prosperity' will gain in the long run the upper hand, and that the announced $CO_2$ reduction of 80-95% will be consequently adjusted." |
| R29 | Industrial Association | "The approach was good, but the phase-out of nuclear and coal-power is simultaneously pursued and it occurs too fast. In consequence, the power grid becomes less stable." |
| R26 | RE Projects & Research | "Compared to other countries Germany has set the right course early (EEG, RE feed-in priority, etc.), yet the energy and climate-protection policy is currently ineffective, unsuccessful, and anything but integrated." |

Slightly fewer than one third of respondents perceived the *Energiewende* as a major policy failure. They judged the *Energiewende* to be "complete nonsense," as "catastrophic with respect to energy efficiency, macro- and micro-economic implications," as a "make-or-break operation, guided by visions with no achievable mission," as a "deterrent example," and as an opportunity for others to "learn from [German] mistakes for their own energy transitions."

Table 9 – Interviewees Perceiving the *Energiewende* as Major Policy Failure.
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Success/Failure*.

| SUCCESS/ FAILURE | | How would you qualify Germany's integrated climate and energy policy (success, failure)? (Appendix A, # 1.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R7 | Utility Sector | "[…] the *Energiewende* is complete nonsense." |
| R8 | Manufacturing Sector | "For me the entire energy policy comes across like a make-or-break operation, guided by visions with no achievable mission." |
| R11 | Manufacturing Sector | "Germany's Climate Action Plan 2050 is rather a pipe dream." |
| R18 | Manufacturing Sector | "Catastrophic with respect to energy efficiency, macro- and micro-economic implications. […] A deterrent example for others. Positively speaking, the rest of the world can learn from our mistakes for their own energy turnaround." |

An interesting phenomenon was that many participants seemed to disconnect their support for Germany's *Energiewende* and their perceptions about successful transitions from Germany's declared decarbonizaton goals and the nation's ability to achieve these goals. While 21 of 30 participants (i.e.70%) support the *Energiewende* and consider it a success, only 5 respondents are confident that Germany will achieve its decarbonization goals by 2050. However, one of these 5 respondents considers that this will only happen because Germany will eventually adjust its goals to feasible ones.[373] Thus, only 4 of 30 expert interviewees thought that the current decarbonization goals would be achieved in the given timeframe (Table 10, Number I). Even some of these 4 optimists included caveats in their statements. For example, one respondent said that the goals could be met if Germany is able to initiate "the process of sector-coupling using an intelligent regulation." Another believed that a

[373] This implicitly means that this respondent considers it impossible to achieve the goals in their current form by 2050.

European policy that does not restrict more progressive German rules, and external factors that do not weaken Germany's economy, would both be necessary to meet these goals.

Table 10.
Evaluating Responses to the Question: *Will Germany achieve its goals?*

| Respondents considering that: | Number of Respondents | Subcategories of Responses / Comments |
|---|---|---|
| I. Germany will achieve its goals | **4**<br>**(5)** | In adition, one participant believes that Germany will achieve its goals, because they will be adjusted to feasible ones. This responss is counted in II. b) |
| II. Current goals won't be achieved | **18** | a) it is impossible to achieve current goals → **13**<br>b) it is impossible to achieve these goals<br>• Within the next thirty years → **1**<br>• Without adjusting them to feasible ones → **1**<br>• But, this is not relevant for the EW → **3** |
| III. It is currently not possible to predict if goals will be achieved | **8** | The degree to which goals can be achieved depends on following factors:<br>• Germany's economic strenghts<br>• Technological progress<br>• Ability to maintain public support<br>• German, European, Global development interconnected grids, nuclear & coal policy } **4**<br>• Strom regulation for sector copling<br>• Coal phase-out or CO2 tax } **2**<br>• Ability to reduce consumption → **2** |

The vast majority of participants (26 of 30 respondents) were either convinced that Germany's goals could not be reached,[374] or said that it is currently not possible to predict whether, or to what extent, the nation will meet its decarbonization targets (Table 10, Number II & III).

Table 11 displays responses from interviewees who said that Germany's climate goals cannot be achieved by 2050. Some of these respondents argue that pursuing Germany's climate goals would jeopardize the nation's wealth, lead to competitive disadvantages for German manufacturers, and cause economic collapse and social and political disturbances. Others acknowledged that RE deployment significantly increases transmission costs and

[374] At least not without being adjusted to feasible ones or in the given timeframe.

energy prices, but they simultaneously claimed that the greater good of protecting our climate justifies all transition efforts, that the members of society should shoulder additional burdens on a voluntary basis, that higher energy prices would encourage actors to lower their energy demand, and that the phase out of nuclear and fossil fuels could only succeed if people changed their behavior.

Table 11– Interviewees Considering that Goals Cannot be Achieved
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Goals 2050*.

| GOALS 2050 | | Do you believe that Germany will achieve its ambitioned climate and energy goal 2050? (Appendix A, # 1.2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R4 | Utility Sector | "No. Germany cannot achieve its goals!" |
| R8 | Manufacturing | "I do not believe in the defined energy and climate goals 2050, because I can not imagine how an industrial nation with its main focus on manufacturing processes can competitively produce its goods while pursuing these goals." |
| R13 | | "The climate goals … are not achievable, because the German economy would collapse if the operation of nuclear power plants and the use of fossil fuels were both completely negated. The German economy cannot function based only on RE and energy savings. Intransigent enforcement [of *Energiewende* regulations] would result in economic decline, massive social and political disturbances, and eventually in renouncing such targets." |
| R17 | Manufacturing | "The goals 2050 won't be achievable; it would be already a very good result if we reached 50% of them." |
| R23 | Research Institution | "I doubt that the ambitious climate goals will be reached by 2050. When one uses RE sources, energy transmission costs increase, and with them prices also [increase]. But it is worth it. … RE are, at least in principle, more expensive, but what is better is mostly more expensive and should be paid voluntarily." |
| R30 | Solar, private | "It is clear that it won't be possible to [meet goals and] renounce nuclear and fossil fuels without massively reducing energy consumption." |

Among those who share the opinion that goals cannot be achieved (at least not without being adjusted), 5 respondents thought that: (1) goals are insignificant for the transition; (2) goals will probably be adjusted to realistic values; or (3) goals could be eventually attained but not during the next thirty years (Table 10, Number II, b; Table 12).

Table 12 – Interviewees Considering Goals Irrelevant or Achievable with Adjustments
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Goals 2050*.

| GOALS 2050 | | Do you believe that Germany will achieve its ambitioned climate and energy goal 2050? (Appendix A, # 1.2; 6) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "I believe that the goals can be achieved in principle, but I doubt that this will happen within the next thirty years. The required investments in storage technologies and new power lines, which have been neglected for the past thirty years […] can hardly be bourne." |
| R14 | Manufacturing Sector | "I consider that it is not relevant whether Germany achieves its decarbonization goals or not. From my point of view, it is more important that Germany is willing to change something." |
| R15 | Manufacturing Sector | "I assume that . . . the announced CO2 reduction of 80-95% will be . . . adjusted." |
| R16 | Manufacturing Sector | "For me it is not so decisive whether the climate goals 2050 will be reached, but rather that the transition to alternative energy forms succeeds." |

Those who said that it is currently impossible to predict whether or to what extent the nation will achieve its targets (8 of 30 participants) said that Germany's ability to meet its goals depends on future economic, technological, social, and political conditions at national, European, and even global levels (Table 10, Number III; Table 13).

Table 13 – Interviewees Unable to Predict Whether Goals Can Be Met
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Goals 2050*.

| GOALS 2050 | | Do you believe that Germany will achieve its ambitioned climate and energy goal 2050? (Appendix A, # 1.2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R3 | Utility Sector | "Germany will consequently continue its pursued path. . . . To what extent the set goals can be achieved by 2050 will be highly dependent on technological progress and on how the European energy landscape will evolve (i.e., interconnected European networks, nuclear policy in neighboring countries)." |
| R9 | Manufacturing | "It is currently not possible to predict whether the set goals can be reached by 2050. This depends on future developments: will Germany be able to generate the necessary financial surpluses to develop and introduce new technologies and will it manage to maintain social acceptance across all groups." |
| R27 | Industrial Association | "To further develop RE on one hand and to wish on the other to maintain conventional, mostly coal-fired fossil power plants is a contradiction. As far as it remains unsolved, this contradiction will make Germany's goals for 2050 unreachable." |

Asked how goals and demand could be met without relying on nuclear and fossil power, most respondents said that this wouldn't be possible within the given timeframe, at least not without a technological breakthrough that allows large-scale energy storage.

One optimistic respondent, representing a renewable energy project development company, thought that "a fully renewable, integrated, and efficient energy system is not only technologically feasible at present, but it also ensures supply security, being moreover less expensive than continuing to operate nuclear and fossil power plants." Another, representing the conventional arm of a large utility, said that goals could "only be reached with a transition to a hydrogen-based energy system," and argued that upgrading the grid would be the first and most important measure to take, for Germany would have no problem achieving its goals "as long as the neighboring countries [continue] to deliver the missing capacity." If countries like Poland or the Czech Republic, for example, value their energy independence above low-carbon solutions, or nuclear-waste problems, they might keep their fossil and nuclear capacities online and use any "export opportunity," despite the fact that such solutions are neither carbon neutral nor free of risks of severe accidents. A sample of responses is presented in Table 14.

Table 14 – Meeting Climate Goals and Energy Demand without Conventional Power Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Goals 2050*.

| GOALS 2050 | | How can Germany reach its ambitioned climate goals without relying on nukes & how can Germany meet its energy demand without nukes and fossil energy? (Appendix A, # 6) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R5 | Utility Sector | "Probably it won't be possible at all, but is this so important? It would be preferable to have a 30% renewable world than a 100% renewable Germany." |
| R10 | Manufacturing Sector | "In my view, the solution can only be technological advancement, research and development (e.g., storage technology)." |
| R24 | Research Institution | "After Merkel's decision, when one has started to think about how the transition could be performed at all if one simultaneously phased-out nuclear and coal power, the illusion came up that by installing enough windmills and solar panels, they could mutualy compensate their intermittencies and deliver base-load power. However, in terms of surface, Germany is simply too small for this and we also have too extended periods of darkness during the winter. . . . Decommissioning nuclear power while aiming to reduce carbon emissions remains a cardinal policy failure." |

Respondents communicated a troubling mix of divergent *Energiewende* perceptions. Beyond dividing German society into supporters and opponents of energy transitions, the contradictions seem to also split the personality of individual actors in the *Energiewende* arena. Extreme *Energiewende* criticism and nearly religious beliefs in its success often coexist, despite all contradictions, within one and the same person. One fervent *Energiewende* supporter,[375] who is at the same time aware that Germany's transition "implies a tremendous financial

[375] Representing the manufacturing industry.

burden" and "can endanger workplaces," expressed this inherent dichotomy as follows: "The *Rheinlander*'s view on "Quo vadis": Come, follow me, and convince yourself! There is no way back and it remains uncertain if the goal will be met. But with every effort, we come a little closer to the target. The *Energiewende* shouldn't be seen as a distinct project, but rather as part of our (industrial) evolution."

Although participants in this study widely support the *Energiewende*, almost all of them are very critical of various aspects of Germany's energy transition. More than 80% of respondents (25 of 30) complained about the explosion of costs that resulted from it, and more than two-thirds of participants (21 of 30) bemoaned the lack of a coherent action-plan, and the missing "red-thread"[376] to ensure a safe way out of the labyrinth of conflicting regulations. For example, one interviewee expressed disappointment in Germany's energy and climate policy with the following words: "Citizens can't recognize a sound strategy in Chancellor Merkel's actions. Political announcements, approaches, and directions seem to be randomly mixed-up, without being backed by any recognizable 'red thread' or 'master plan.'" Despite shared values, egalitarian approaches, and strong confidence in a successful transition, interviewees complained that measures are not integrated enough; the government seems to ignore the need for large-scale storage facilities, although they are critical infrastructure for a successful transition; power grids have become more difficult to manage; grid extension plans are extremely expensive and cannot be realized on time; and after minimizing utilities with the turnaround in the power sector (*Strom-Wende*), the very existence of another major industrial branch – the German automotive industry – is

[376] The red-thread is a reference to Greek mythology. In *Odyssey* (Book 11. 320) Homer relates how Ariadne, daughter of the King Minos of Crete, gave Theseus a ball of red thread to find his way out from the Labyrinth, after fighting the Minotaur.

threatened by the envisioned transition in the transport sector (*Verkehrs-Wende*). Some of their criticisms are shown in Table 15.

Table 15 – Critical Stakeholder Views on *Energiewende* Perspectives
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Evolution/Perspectives*.

| EVOLUTION PERSPECTIVES | | What do you think about the evolution and the perspectives of the German *Energiewende*? (Appendix A, # 2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Basically, one tries to induce the turn-around by means of regulatory measures. This occurs based on contributions and taxes that represent additional burdens for low-income households and families. The desired decentralization of the energy sector takes place slowly, but the question that arises is: Who should pay for [the transition], and above all, how?" |
| R8 | Manufacturing Sector | "In my opinion, the *Energiewende* . . . will have a significant negative impact on the competitiveness of German industries. Even if energy-intensive manufacturing processes will continue to be partially exempted from paying contributions, the tremendous transformation costs have to be borne by players in Germany's economy, and I expect considerable losses of wealth." |
| R11 | Manufacturing Sector | "The share of RE in Germany's power mix will further increase until 2050 to about 80%. How this will be achieved is completely unclear. Given that there will be no noteworthy and affordable storage capacity available in the foreseeable future, the German grid concept seems to rely on current balancing methods. Therefore, about 84,000 MW of conventional backup power – the maximal grid load - have to be continuously available for dispatching calls, even after decommissioning the last nuclear power plants. . . . From my point of view, the usable power won't increase anymore by installing additional RE capacity after reaching a certain RE deployment level. At the latest then, the concept reaches its end. To date, it is not known at which RE share this point will be reached. At any rate, it is clear that more years will pass before this problem will fully emerge. I believe that we will somehow manage to balance the system up to a RE share of about 50%. This corresponds to a timeframe of about 20 years. By then, practically all currently active politicians are beyond any risk of being held responsible for the decisions they made. " |

Few of those who believed that Germany was leading the way for successful energy transitions were consistently supportive for the entire package of regulations meant to steer Germany's economy towards low-carbon technologies. Two examples are presented in Table 16.

Table 16 – Optimistic Stakeholder Views on *Energiewende* Perspectives
Responses to Question Category 1: *Quo Vadis Germany?* Sub-Category: *Evolution/Perspectives*.

| EVOLUTION PERSPECTIVES | | What do you think about the evolution and the perspectives of the German *Energiewende*? (Appendix A, # 2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R9 | Manufacturing Sector | "The transition process has not overstrained Germany's economy so far. Apart from the construction of new power lines, which is more of a 'not in my backyard' problem, and some windmills located either in the proximity of human settlements, or near breeding places for birds and bats, there is no noteworthy social opposition against the *Energiewende*." |
| R21 | Manufacturing Sector | "I believe Germany took a leading role in developing and applying new technologies required by the *Energiewende* and will later benefit from being a technology exporter." |

Critics of the *Energiewende* were not limited to those at risk. Complaints about rules and regulations were well distributed among all categories of actors. In contrast to the overwhelming majority of respondents who complained about rising costs due to grid expansion plans and expensive subsidy schemes, some participants[377] argued that existing subsidy mechanisms are hugely insufficient for a successful *Energiewende*.

**Category 2. Patterns and Rules**

The second category of questions tried to capture stakeholder perceptions about specific *Energiewende* patterns and rules. Asked, for example, why Germany has chosen a different transition pathway towards low-carbon technologies from other countries, participants gave several reasons. Nearly half explained it by citing the nation's early

[377] Mostly representing participants with stakes in new technologies and large wind projects.

romanticism and environmental awareness, and its strong anti-authoritarian and anti-nuclear positions that led first to the founding of the Green party, and later to a widespread acceptance of "green" ideas.

Some said that Germany's ambitions to "save" or "heal" the world, to take technological leadership, and to "lead the way" towards low-carbon technologies were the reasons it has taken a unique pathway. Others viewed the nation's prosperity and the fact that it can afford costly transformations as the reason behind Germany's choice of path. And some invoked Germany's lost wars, Nazi past, its penitence, and its desire to prove that Germans are able to do something "good" for other nations as possible explanations for its ambitious energy and climate policy.

However, some participants with stakes in renewable energies believed that Germany's highly praised energy and climate policy is currently anything but advanced, and that other nations have already taken the global lead in low-carbon technologies.

"When Noah built the ark, his neighbors laughed at him," said one respondent emphasizing that "Germany always sought to implement internationally binding and unitary carbon mitigation regulations, but years went by with only statements and notices of best intent," until the nation decided to go its own way. Some respondents perceived Germans as arrogant and having a "we-know-better-what-is-right-and-wrong" attitude. They claimed that Germans try to impose their rules on others, constantly refusing to acknowledge other nations' concerns, for example Poland's for its coal industry, or France's and Belgium's stake in their country's carbon-neutral nuclear power plants. Finally, some participants feared that Germany might get practical experience in "suicide" if other nations won't follow its example. A sample of responses is showed in Table 17.

Table 17 – Reasons for Selecting a Different Transition Path
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Transition Pathways.*

| TRANSITION PATHWAY | | How do you explain that Germany has chosen a different transition trajectory than all other countries on the globe? (Appendix A, # 11) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Germany has lost two world wars and feels guilty and responsible for all problems in the world. In addition, there is a fantasy […] that [it] can make everything possible. […] At the end of the day, everybody should know that Germany is only a very small part of the earth and cannot change the climate single handedly. If other countries did not support Germanys' approach, it would be a little bit like suicide… " |
| R4 | Utility Sector | "Through German mentality, anti-nuclear movements, the founding of the Greens, and Germany's wealth." |
| R9 | Manufacturing Sector | "One is always alone at the top! As an export and high-technology nation, Germany does not have significant domestic resources, but is instead far ahead with its consumption and thus strongly dependent on fuel imports." |
| R12 | Manufacturing Sector | "It certainly has many causes: early anti-nuclear movements and political orientation; official channels spreading, over decades, one-sided information among the public; idealism, after two wars, we try to do something good for the world; the arrogant idea that the German way could heal the entire world." |
| R18 | Manufacturing Sector | "German ideological extremism, this time on the green side; thoughts about rescuing the world; the desire of being "good" in the end (penance for the Nazi period); Germany is wealthy enough to afford this path, at least one believes it would be so; stubbornly following rules." |
| R26 | RE Projects & Research | "Germany has only communicated a different transition path. [..] Other countries are much further in transforming their energy systems [...]; Germany represents currently rather a negative role model." |
| R30 | Private/Solar | "I would say… anxiety, the sensibility of the '68 generation–as children of Nazi perpetrators–against authoritarian processes that lead to a strong and increasingly relevant Green Party, the broadly shared view of having responsibility for the entire world, and […Germany's] prosperity." |

Many European countries enacted similar or even more generous support schemes for RE than Germany. But in the wake of the unfolding Great Recession, some of these nations (for example Spain[378]) retracted their generous long-term commitments. And with its Energy and Climate Framework 2030, the European Union decided to loosen its decarbonization Roadmap 2050[379].

Asked how the decision to lower the carbon-mitigation targets of European member states will affect Germany's policy (Appendix A, # 12), most respondents said that Germany would continue along its path undisturbed. For example, one respondent claimed that this decision "will not significantly affect Germany's policy, because German politicians still believe that a 'fast driving train will pull the others automatically in the same direction' and [that] it is not prohibited to have stronger rules."

Asked how long Germany would continue a policy that differs from that of other nations (Appendix A, # 13), most of the interviewees said that the process would continue as long as Germany can maintain its financial strength, people are "happy with their living standards," and "no dramatic changes occur in the parliamentary landscape." One respondent thought that "the political pressure on maintaining the officially communicated goals is so high that these figures will be kept unchanged until the declaration of political

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378 Before this change, Spanish RE incentive schemes were more generous than German ones, and were guaranteed for a 25 years instead of 20. The schemes attracted many domestic and international investors, and led to a profitable business with utility-scale solar facilities and wind parks, until the incentives were drastically reduced.

379 EU member states agreed in December 2011 on the Energy Roadmap 2050, aiming to reduce GHG emissions by 80-95% by 2050 (basis 1990). To achieve long-term goals for 2050, member states have to agree on intermediate goals (2020, 2030, 2040). Due to Member States with interest in the coal industry (Poland), and many other nations that saw economic risks in the rapid deployment of RE, the European Council decided to lower its initial targts (27% RE deployment, and 27% increase in efficiency instead of 30% in each case). The Energy and Climate Framework 2030 was endorsed in October 2014.

bankruptcy is due." In addition, many interviewees consider that Germany's way will impact global change not in absolute figures, but rather as positive role model.

The question category "Patterns and Rules" also included questions about Germany's nuclear phase-out.

Of 30 respondents, 22 recognized the need to phase out nuclear power plants. However, 15 of these 22 considered that the phase-out decision was taken "too fast" and was "uncoordinated," that it destroyed "the bridge to the renewable shore," did not increase nuclear safety, and put a tremendous financial burden on German society; but 7 saw this decision as "very good" or as "a political step [taken] at the right moment to solve a sensitive topic." Eight of the thirty total respondents perceived the nuclear phase-out as a significant political failure. Some of them claimed that this failure couldn't be avoided, given the strong opposition against nuclear power in German society.

Despite their overwhelming support for the nuclear phase-out, some of the interviewees thought that there was no way out of carbon-based economies at a global scale without deploying nuclear energy or developing fusion technology. For example, a representative of the manufacturing sector said:

> One should not reverse the nuclear phase-out decision if the Fukushima accident falls into oblivion, but one should continue to carry out intensive research on controlled nuclear fusion in Karlsruhe and other centers known for their expertise in nuclear research.

A respondent from the research realm said:

> One would need surfaces on the order of magnitude of continents if one tried to supply all of humanity with renewable power. Fission and (hopefully) fusion energy

> are the only alternatives I can imagine for a carbon-free world. One should be at least allowed to dream about what would have happened if the money spent on Germany's *Energiewende* had landed in fusion research.

Another view was offered by a former co-founder of the Greens, who argued:

> By prohibiting any thought about nuclear technologies, and by treating this subject as a taboo, one bars the way to an efficient energy policy.

Addressing the security issue, this respondent claimed:

> Whoever doesn't close his eyes to reality has to realize that Germany has not become safer by shutting down its nuclear power plants, because France will continue to operate many of its nuclear power plants and new nuclear power plants are being built in in the UK, as well as in Poland, Finland, and Russia.

According to this respondent's view, opponents of nuclear power consider nuclear technologies as being:

> . . . ultimately unmanageable, because they could lead to a meltdown with incalculable consequences for people and the environment, as in the case of Chernobyl or Fukushima.

But opponents ignore that these technologies have been further developed and that the fourth generation of nuclear power plants is inherently safe, "since . . . a meltdown can not occur." The respondent also addressed the fact that this generation of nuclear power plants is able to reduce nuclear waste to an extent that makes a final repository superfluous.

Table 18 displays further responses to the question about the nuclear phase-out.

Table 18 – Stakeholder Perceptions about Germany's Nuclear Phase-Out
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Nuclear Phase Out.*

| NUCLEAR PHASE OUT | | What do you think about the nuclear phase-out? (Appendix A, # 7) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Even though I am not a real supporter of this technology, I consider the accelerated nuclear phase-out to be the wrong decision, and perceive the original exit scenario, pursued before Fukushima, as being more reasonable. […] As a consequence of the accelerated nuclear phase-out, CO2 emissions increased. We do not have in Germany conditions like those in Fukushima, and unlike the accident-prone nuclear power plants in Belgium, incidents in German facilities have never been a major topic in the news, although they have to be made public according to German law." |
| R6 | Utility Sector | "Nuclear power is, from a climate perspective, CO2 free. Without public acceptance for this technology it is right to pursue, as agreed, a controlled nuclear power phase-out by 2022. However, the arbitrary shutdown of seven nuclear power plants in 2011 was absolute nonsense, because facilities do not become safer by being disconnected from the grid. Fuel rods are still in the reactor, they can't just be pulled out, and thus the fission process continues. " |
| R14 | Manufacturing Sector | "Weighing CO2 emissions against the risk of having a nuclear accident, and against problems related to the final repository of nuclear waste, society and the government both considered that temporarily increasing carbon emissions is the lesser of two evils." |
| R18 | Manufacturing Sector | "In the long run, it avoids in principle the dangers of nuclear accidents and hazardous nuclear waste, but it should be synchronized with the development of alternatives for base-load generation and grid extension plans. The bridge to the renewable shore is demolished while we still are above the abyss." |
| R23 | Research Institution | "In Germany nuclear power is not absolutely necessary; its current contribution is rather moderate. However, I am not overly anxious about it. To make nuclear power superfluous, one needs to reduce consumption and push the development of energy storage forward." |
| R27 | Industrial Association | "Due to its inherent risks, I consider the phase-out of nuclear power as being unavoidable worldwide. Germany is a pioneer in this field. The German way should encourage all the countries that still operate nuclear power stations to follow this path." |

When asked about the deregulation of energy markets, most participants considered that this *Energiewende* instrument set, in principle, the "right market signals" and was very effective in the late 1990s and early 2000s, when it led to the break-up of monopolies, increased competition, and a significant price reduction. However, they also argued that the deregulation efforts were "killed" by *Energiewende* surcharges that "overcompensated the price reductions," eventually resulting in a steadily increasing number of rules. Some participants perceived as positive that at least natural-gas markets are less overloaded with surcharges. A sample of responses to this question is presented in Table 19.

Table 19 – Perceptions about the Deregulation of Energy Markets
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Energiewende Instruments*.

| ENERGIEWENDE INSTRUMENTS | | How do you estimate the deregulation initiative and its result? (Appendix A, # 22) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Considering competition and reduction of consumer prices as its main goals, deregulation was a successful initiative. . . . However, in the end Germany overcompensated price reductions with *Energiewende* contributions. To secure its electricity supply, Germany . . . will need a regulated capacity market." |
| R5 | Utility Sector | "Markets did not become more liberal, but there are more rules, the monopolies have broken, and everything is going to result in decentralized communal markets and new concentration of power." |
| R9 | Manufacturing | "Led to more transparency and lower energy prices." |
| R15 | Manufacturing Sector | "Significant price increase due to various taxes, levies, and EEG subsidies. Could we even speak about deregulation if the state intervenes in the market economy by imposing contributions for renewable energies and other *Energiewende* surcharges?" |
| R18 | Manufacturing Sector | "… [deregulation] has set the best efficiency signals for macro-economic optimization, but it was completely overlain and destroyed by the huge EEG subsidy regime." |

A sample of responses about another major *Energiewende* instrument, the European Emission Trading System (EU-ETS), can be seen in Table 20.

About a half of respondents considered the EU-ETS appropriate to lower carbon emissions. However, while some of these respondents claimed that there is no instrument better suited to control carbon emissions because it would lead to the least disturbances in the market economy, or that further regulatory interventions would hinder a functioning emission market, another sub-group said that the EU-ETS should be modified, because its current mechanism is "ineffective" and overloaded with governmental interventions that transform a "consistent market mechanism" into a "deterrent example" for the world. Some added that an emission trading system would make sense only if it were implemented at the global level. The other half of respondents said that the EU-ETS "completely missed its goals" and that other instruments, for instance a carbon-dioxide tax or voluntary commitments to reduce carbon emissions, would be more effective. Some claimed that the most effective way to reduce carbon emissions would be to not use carbon-intensive fuels. For example one respondent said:

> When the emissions trading system was introduced, I thought that it would be a joke. In this system, power plants with good efficiency have justified advantages in contrast to older power blocks. This approach is thus suitable to decommission less-efficient power plants. Yet the ETS mechanism is based on the idea of reducing emissions by creating a shortage of allowances and increasing $CO_2$ prices. I cannot see any success here. Emission prices remained at a low level for years. $CO_2$ prices become an integral part of the energy costs without having any regulatory effect. It is questionable if such an effect will ever establish. Whoever really wants to reduce emissions of carbon dioxide has to lower the use of carbon-intensive fuels.

Table 20 – Perceptions about the European Emission Trading System
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Energiewende Instruments.*

| ENERGIEWENDE INSTRUMENTS | | What is your opinion about the emission trading regulation? (Is it necessary or not? Would other forms of incentives/constraints (own commitment, taxation) be more appropriate to achieve the ambitious decarbonization goals)? (Appendix A, # 24) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "The emissions trading system did not lead to a significant reduction in CO2 emissions. Moreover, current CO2 prices are not high enough to make further measures economically attractive. Voluntary commitments to reduce carbon emissions, as for instance those of the chemical industry, would be more effective. I consider a CO2 tax as being more appropriate for the private realm." |
| R4 | Utility Sector | "Emission trading has completely missed its goal. A 'market price' has never been established. To manage the trade of emission allowances in Germany, a bureaucratic monster - the 'German Emissions Trading Authority' - was created. Only consulting firms are happy about many orders." |
| R9 | Manufacturing Sector | "It is the best possible control instrument; it should just be used more consistently." |
| R13 | Manufacturing Sector | "Emission-trading is … the CO2 control instrument that causes the least disruptions in our market economy." |
| R17 | Manufacturing Sector | "[EU-ETS] would be a good instrument if it were better coordinated by Brussels, i.e., without political influence from various stakeholders." |
| R18 | Manufacturing Sector | "[EU-ETS] could theoretically work as a consistent market mechanism – but it is also subjected to the arbitrariness of politics and ideology. Invented by the market-oriented Americans and implemented by the German ideologues – [EU-ETS is] a deterrent example for the world." |

The import of electricity from renewable energy projects located in North-African and Middle-Eastern countries[380] was considered to be an integral part of Germany's long-

[380] Where RE resources are abundant.

term energy and climate strategies.[381] The Desertec Industrial Initiative (DII) aimed to realize RE projects in these regions, to fully integrate the EUMENA[382] grids, and to transport renewable power to Germany to compensate for periods of low domestic RE generation.

Asked what they thought about this initiative, most participants responded that the project had already been abandoned, since most of the Desertec initiators retracted their DII memberships. While some interviewees claimed that Desertec might be politically necessary to stabilize North African and Middle Eastern economies, others argued that dependence on unstable regions makes Desertec prone to failure.

Some interviewees said that visions are always important, but should first be tested on more realistic pilot projects. One claimed that power-generation facilities built in Northern Africa will be primarily needed to supply Sub-Saharan African nations with electricity, to improve their living conditions and "reduce the number of refugees who enter Europe." He argued that power exports to Europe might be rather a solution for Middle Eastern nations that "will have to substitute revenues from oil exports" in the future. However, this respondent also pointed out that imports from both of these regions would lead to higher energy costs, making such solutions unattractive as substitutes for fossil capacities in Europe on a mid-term timescale. Other respondents claimed that Desertec projects are technically feasible but too expensive to have a realistic chance. A sample of stakeholder perceptions about the Desertec Industrial Initiative can be seen in Table 21.

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[381] Germany's Energy Concept that preceded the nuclear accident in Fukushima (Schleisinger, et. al, 2010, pp. 38-39) and Nietsch et al.'s scenarios that confirmed that the accelerated phase-out decision pays of (2012, pp 266-268, & 292) included both imports of solar power from these countries.

[382] European, Middle-Eastern, and North-African grids.

Table 21 – Perceptions about the Desertec Industrial Initiative
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Energiewende Instruments.*

| ENERGIEWENDE INSTRUMENTS | | What do you think about the DESERTEC initiative? (Appendix A, # 8) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "DESERTEC is no longer the project that it was in the beginning. In the meantime, many participants have left the project for different reasons. Therefore its realization is not very likely." |
| R4 | Utility Sector | "A nice thought, one should be free to have crazy ideas, but it is not viable in practice. Although such projects are without any doubt technically feasible, they are far too expensive and too uncertain, given the political situation in these countries." |
| R5 | Utility Sector | "From my point of view, Desertec is at the moment politically unthinkable, because the countries are politically too unstable, and nobody would invest." |
| R9 | Manufacturing Sector | "It is politically meaningful for stabilizing the region." |
| R14 | Manufacturing Sector | "I don't consider that it is a realistic approach. I believe that it is easier to build industrial facilities in those areas than to invest in all the electrical lines needed to get the power from the desert to the North of Europe and Germany. That was an idea. It is nice to have ideas, but it doesn't seem realistic." |

All who answered questions about how well different regulations complement one another to mitigate climate change seemed to agree that the efforts to harmonize the *Energiewende* instruments have failed (Table 22). They said that these efforts resulted in a "patchwork" of competing tools and a "steadily increasing bureaucracy." A representative of the utility sector complained, for example, that "no politician of sound mind would ever confuse goals with means to achieve goals," but Merkel's government managed to make this "cardinal mistake." To explain his statement he added:

> If one has the goal to mitigate carbon-dioxide emissions, then one cannot simultaneously define the instrument 'renewable energy' also as goal. The climate

goal could have been easily achieved with a $CO_2$ tax, but here goals and means got mixed-up in a weird patchwork.

While some respondents argued that the need to harmonize instruments would continue to exist as long as the process of revising existing regulations is incomplete, others suggested that each harmonization attempt resulted in a new wave of subsidies. Some respondents argued that instruments should be harmonized at the global level, because the problem at stake can't be solved only with sound national regulations.

Table 22 – Perceptions about the Harmonization Process
Responses to Question Category 2: *Patterns and Rules?* Sub-Category: *Energiewende Instruments.*

| ENERGIEWENDE INSTRUMENTS | | How do you estimate the harmonization process of energy and climate regulations and policies? (Appendix A, # 25) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R5 | Utility Sector | "I see no harmonization process. No matter how much I try, it still looks more like a patchwork." |
| R8 | Manufacturing Sector | "The harmonization process is by far not completed. Given the increasing bureaucracy, I also have doubts whether this is at all possible to achieve." |
| R10 | Manufacturing Sector | "The harmonization of energy regulations has not been completed yet. There is still no plausible concept." |
| R15 | Manufacturing Sector | "The existing legal instruments are so extensive that it is obvious that only a few people can maintain the overview here. In many cases, certain energy rules are negotiated between specialized authorities and departments after being previously discussed in specialized bodies. Is difficult to say whether the results of such negotiations really support *Energiewende* goals." |
| R18 | Manufacturing Sector | "Terrible patchwork. Each attempt to repair it leads to the next subsidy wave." |
| R29 | Industrial Association | "Legal instruments like EEG, KWKG, and ETS work partially against each other. Each time one of these laws is adjusted, the others get disturbed. Each effort to fix such disturbances results in imbalances in other *Energiewende* instruments. One should thus properly apply ETS and abolish the EEG and other tools that are meant to act in the same, or in the opposite, direction." |

**Category 3. Technology**

Responses to the questions in the "technology" category offer information about technologies needed for a successful transition, and expert perceptions about the current state of the art for these technologies.

All participants seemed to agree that the success or failure of Germany's *Energiewende* depends to a large extent on developments in power-storage technologies, because they are essential to level intermittent generation of wind and solar power.

Many respondents said that a lot of research and development work is needed in this realm. They claimed that they "cannot recognize any technological breakthrough," that the "state of the art lags behind," that besides the mature, but "geographically limited" pump-storage technology, all other storage technologies are still in their "infancy," and that the resources of lithium and cobalt needed for batteries are limited.

But other respondents claimed that storage technologies are "widely developed," "feasible," and "available." Some blamed the "stagnant *Energiewende*" and a "repressive regulatory framework" for the fact that these technologies are not yet "economically viable."

Others claimed that large-scale redox-flow batteries and power-to-X solutions are already competitive and could be implemented. However, they considered the current regulatory conditions in Germany as "hostile" for industrial-scale facilities and thus targeted other countries for building their reference sites.

Many stakeholders argued that one should distinguish between "temporary" storage solutions[383] and faciilties able to store enough power to overcome dark and wind-free periods of time, also known as *Dunkelflaute* periods. They claimed that one would need to

[383] Like for example power-to-heat, or electro mobility.

supply the power demand for about two *Dunkelflaute* weeks from previously stored energy if conventional power were not available anymore. Most of these participants also said that Germany couldn't afford to ban conventional power, because it is very unlikely that enough storage capacity can be installed to solve the *Dunkelflaute* problem in the "foreseeable future." They criticized the current focus on "temporary" solutions and considered them completely inappropriate to solve the storage problem. Although "temporary" solutions, for example "power-to heat," might bring short-term returns for those who use them to "shave" generation peaks, they are not able to deliver power when renewables are unavailable.

Some interviewees thought it was naïve and even delusional to believe that one only has to distribute RE facilities over Germany's territory to secure a low-carbon baseload supply. They claimed that policy makers were completely irresponsible to incentivize the deployment of RE while systematically neglecting the development of storage solutions. For example, one representative of a research institution said that "pushing the *Energiewende* so far, without performing the necessary development work for storage technologies" was a "cardinal policy failure."

Some stakeholder perceptions about the state of the art of storage technologies can be seen in Table 23.

Table 23 – Opinions on Power Storage Technologies
Responses to Question Category 3: *Technology*

| TECHNOLOGY | | Technology State of the Art/ Development: Electricity Storage (Appendix A, # 17.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "A lot of development is required in this realm. Small household storage facilities already exist, but such solutions are not suitable for commercial and industrial purposes." |
| R3 | Utility Sector | "I cannot recognize real breakthroughs in this realm. A distinction should be made between storage technologies and 'temporary solutions' as for example, power-to-heat, electro mobility, etc. …" |
| R16 | Manufacturing Sector | "Electro mobility has gained momentum since the 'diesel emissions affair' was uncovered. There is a great need for batteries as power-storage facilities. However, the perfect technique has not yet been found. Further efforts have to be made." |
| R24 | Research Institution | "After learning that renewable energies do not complement one another to form a base load (as one could unfortunately see this winter in January/February), one goes now for temporary storage technologies. However, one should say that there will not be enough capacity available in the foreseeable future to store about two weeks' electricity demand." |
| R26 | RE Projects & Research | "… technologically far, but not (yet) economically viable due to the stagnant *Energiewende* and its repressive regulatory framework." |
| R27 | Industrial Association | "Electricity storage is still at the beginning of its development (with the exception of pumped-storage facilities, which are geographically limited). Accumulators are available, but still too expensive, and their capacity is too limited. There is an urgent need for research into completely new types of energy storage devices with potentially novel materials, physical, chemical characteristics." |

Carbon Capture and Storage (CCS) is another technology that was intensively discussed as a possible means to achieve Germany's decarbonization goals. Germany's *Energy Concept* 2 (Schleisinger et al., 2010), which preceded the Fukushima accident, and its revised version (Nietsch et. al., 2012), published after the nuclear phase-out decision, both include CCS technologies as an integral part of Germany's long-term decarbonization scenarios. The major advantage of CCS technologies is that they are compatible with conventional power generation. The different CCS technologies capture the carbon dioxide from the exhaust of fossil-based power plants and store it in CO2 repositories. Deploying this technology would significantly reduce the intermittency problem, because a part of the energy demand could be met with energy produced in facilities able to generate baseload power. CCS would also reduce the grid-expansion and balancing problems. Yet CCS technologies are expensive, inefficient, and carry the risk of carbon-dioxide leakages. Germany's citizens seem to agree that they are against such solutions. This is why more recent developments along Germany's decaarbonization path aim to phase out fossil fuels and get along without CCS technologies.

The vast majority of interviewees who responded to questions related to the CCS debate seemed to agree that CCS had no future in Germany. Most participants said that these technologies would be inefficient and "too expensive," would gernerate "huge quantities of CO2 waste," would lead to endless debates about appropriate repositories "similar to those about nuclear waste," and would trigger social protests. One representative of the manufacturing sector emphasized that each combustion process aims to completely oxidize each carbon atom (i.e., to produce as much CO2 as possible). He claimed that it was "nonsense" to aim for complete combustion only to declare subsequently that the result is "waste" and to make tremendous efforts to capture and store each CO2 molecule. However, others argued that CCS is both available and feasible, but unfortunately "ideologically … already dead." One respondent with expertise in research and development of RE projects noted that CCS technologies might be needed in the future to achieve global decarbonization targets by generating negative $CO_2$ sinks (i.e., capturing atmospheric $CO_2$).

Some expert statements on this topic are presented in Table 24.

Table 24 – Opinions on Carbon Capture and Storage Technologies
Responses to Question Category 3: *Technology*

| TECHNOLOGY | | Technology State of the Art/ Development: Carbon Capture and Storage - CCS (Appendix A, # 17.2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The technology is well known and could be used, but it is expensive and its efficiency is low." |
| R2 | Utility Sector | "[CCS] is too expensive, in my opinion. One should instead invest in the optimization of older power plants that are still in use. Thus, one should avoid CO2 instead of storing it. And one has also the problem of finding an appropriate repository. This would generate debates quite similar to those about radioactive waste." |
| R16 | Manufacturing Sector | "Those who burn fossil fuels aim to generate as much CO2 as possible. The quantity of CO2 emitted depends only on the amount of fossil fuel one burns. The efficiency should correspond to the state of the art. To store CO2 in underground caverns, etc., is sheer nonsense. The technology bears the danger of releasing CO2 accidentally back into the atmosphere. Due to the relatively large molecular weight of CO2, one has to deal with large amounts of waste. The incorporation of CO2 into polymers is currently the subject of research and might lead in the future to recycling solutions." |
| R26 | RE Projects & Research | "At least in Germany, the further technological development [of CCS] was largely stopped due to acceptance problems. However, the technology might be required to meet climate protection goals. Climate researchers predict that one would need 'negative' emissions and this means that CO2 should be actively extracted from the atmosphere." |
| R27 | Industrial Association | "Several CCS technologies are currently known, but they are all decidedly too expensive and lead in addition to efficiency losses in power plants of about 10%. It is currently impossible to be competitive in the market by using this technology" |

Renewable energy is the realm that has experienced the most impressive transformations in recent decades. Asked about their opinions on the state of the art of RE technologies and on developments in this realm, most participants emphasized that the relevant technologies (wind, solar) are mature, have undergone impressive advancements, and will continue to play an increasingly important role in Germany's energy transition. Some participants added that there is still potential for increasing the efficiency of RE technologies.

Many respondents said that investment costs for solar and wind have dropped significantly and became almost competitive with conventional energies. Two said that the most recent auction for wind projects planned for 2023 was concluded (lowest bid) with feed-in-tarrifs of 0 ct/kWh. Referring to the decrease in price for solar energy, one respondent from a research institution, emphasized that the lowest offer for a 300 MW solar facility in Saudi Arabia was 1.5 ct/kWh, thus even lower than the current wholesale prices at Gemany's power exchange.

However, those with stakes in the RE business complained about the extreme drop in subsidies induced by the auction mechanism of the EEG 2017.

In contrast, those concerned about the increasing *Energiewende* costs thought that there was no longer a need to subsidize RE, because all relevant technologies are mature. Referring to the subsidies for RE, the CEO of a small utility said, "The *Energiewende* is good, we earn money with it." Yet this respondent claimed in the same breath that this would be only his "official statement." From his "private" (unofficial) perspective, he called Germany's energy policy "irresponsible." He argued that early solar rooftop programs and generous EEG tariffs contributed to a large extent to the broad societal support for the *Energiewende*, by incentivizing private households to become "mini" utilities, and roofing firms to expand their businesses.  As a consequence of this growing popularity for decentralized solar power, Germany—a country with long and dark winters and rather capricious and not particularly sunny summers—installed more than 40 GW[384] in solar power. Finally, he said, "solar facilities are for Germany really the most stupid and most expensive form of energy conversion … one could also decide to grow lemons."

One of the founders of the Green party and a former member of Schröder's government said:

> More and more regenerative energy sources are used worldwide to mitigate environmental burdens … Yet even renewables have to prove whether they are really efficient or environmentally friendly.

This respondent considered the accelerated deployment of RE an economic, environmental, and social "disaster." He argued that the construction of large-scale wind farms would lead to "the destruction of landscapes," to "massive losses in the population of birds," "to soil degradation," and would "damage the health of people who have to live in the neighborhood of these wind-monsters."

This respondent also claimed that "subsidies for growing energy crops for the production of biogas and biofuels" have led to unsustainable agricultural practices, resulting in an "ecological catastrophe" (e.g., "soil depletion," "significant reduction in the population of 26 species of songbirds," and the "loss of 75% in the population of insects in Germany").

Five respondents noted that renewable energies require enormous surfaces. Some even sent me articles they had published about the low energy-density of wind and solar.

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384 Despite the low sun incidence, the solar capacity installed in Germany in January 2017 was 41.5 GW, being thus higher than that installed in natural gas (29.9 GW), hard coal (28.3 GW), lignite (20.9 GW), and nuclear (10.8 GW) (ENTSO-E, 2017).

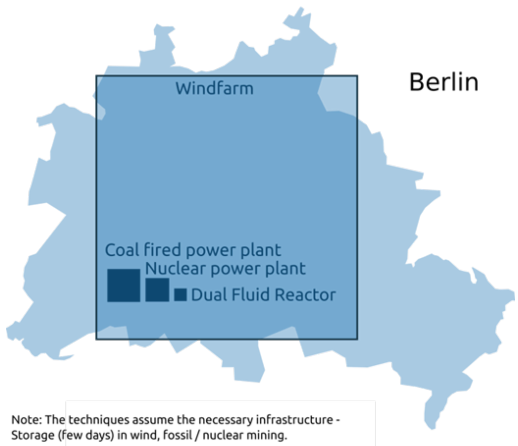


Figure 29 : Comparative surface requirements for meeting Berlin's power demand.

"One would cover almost the entire surface of Berlin with wind-mills to meet the city's electricity demand" said one respondent. He sent me the image shown in Figure X, which relates Berlin's surface area to the surface requirements for meeting Berlin's power demand by using wind, coal, or nuclear technologies.

More opinions about renewable-energy technologies can be seen in Table 25.

Table 25 – Opinions on Developments and the State of the Art of RE Technologies
Responses to Question Category 3: *Technology*

| TECHNOLOGY | | Technology State of the art/ Development: Renewable Energies - RE (Appendix A, # 17.3) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Significant progress has been made in the photovoltaic realm in terms of cell efficiency during the past years. There are certainly still potentials for increasing efficiency of wind turbines and biomass plants. With respect to biomass, the technology already exists, but is not used in practice due to economic reasons – 'too expensive.' |
| R5 | Utility Sector | "Renewables are already in use and will be even more intensively deployed in future. This development will be driven by needs of becoming independent of fossil resources and protecting the environment, rather than by climate change. " |
| R18 | Manufacturing | "Renewables are mature and should fully compete on the market." |
| R26 | RE Projects & Research | "Renewable energies are technologically advanced, but their potential is by far not exhausted." |
| R27 | Industrial Association | "Certain renewable technologies are already widely developed (wind, solar photovoltaic) and achieve almost competitive power prices. Evidence for this can be found, for example, in the most recent tender for wind projects that was concluded with a subsidy of 0 cents/kWh. … Other RE technologies are not yet economically viable." |

Power transmission and distribution grids represent a critical *Energiewende* infrastructure. Germany's grids are very reliable. System redundancies from times that preceded the *Energiewende* [385] and the "copper plate" built beneath Germany's dense settlements partially explain this high reliability. ("Copper plate" is a commonly used image for describing the high density of copper conductors in Germany's electricity grid.) However, the accelerated deployment of intermittent sources of power, coupled with lack of appropriate storage solutions, pushed existing grids to their limits. "We were often on the verge of blackout," said a respondent from the utility sector. Another, representing the manufacturing realm, claimed that "the number of interventions needed to balance the grid significantly increased with the RE deployment," making the grids more expensive and less stable.

Almost all those I interviewed agreed that the nation's "electricity highways" are no longer able to transport the huge amounts of power generated in the windy north to the high-consumption areas located in the southern part of Germany, with the consequence that excess power is pushed instead towards neighboring countries. Respondents also claimed that the mass protests against new overland power lines have significantly delayed the grid-expansion plans of Germany's Federal Network Agency. Many argued that urgent political action is needed to solve this problem. While some respondents rejected underground power lines as being too complex and expensive, others said that the problem at stake is the lack of "political will" and not the complexity of underground power lines. One respondent said that the need to expand grids wouldn't be urgent if the government encouraged more power-to-gas technologies. He noted, moreover, that the sector-coupling concepts currently

[385] When large utilities with monopoly structures aimed to autarkly secure the energy supply of all end-users in their area of influence.

being debated would more than double Germany's power consumption and require a massive extension of distribution grids. Additional statements about the operation and balancing of transmission and distribution grids are shown in Table 26.

Table 26 – Stakeholder Opinions about the Operation of Energy Grids
Responses to Question Category 5: *Outcomes?* Sub-Category: *Energy Grids & Balancing*.

| ENERGY GRIDS BALANCING | | What are from your point of view the impacts of the *Energiewende* on: transportation/grid infrastructure? (Appendix A, # 20) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The TSOs and DSOs often have trouble with overloads and need to set redispatches. … On the European level this leads to more regulation (cross-border rules and harmonization with new network codes). In Germany the solution is a forced system expansion." |
| R3 | Utility Sector | "Grids have become less reliable, redispatching interventions are more often necessary. The 'reconstruction' of the entire grid infrastructure is inevitable." |
| R6 | Utility Sector | "Grids are overloaded and therefore unstable; storage options are not sufficient and technologically still in their infancy." |
| R8 | Manufacturing Sector | "The massive deployment of RE generation, combined with the naturally occurring volatilities of these generation units, lead to stress situations in the power grids on a regular basis. … From today's perspective, these stress situations can only be mastered with a massive grid expansion." |
| R11 | Manufacturing Sector | "At the beginning of the *Energiewende*, interventions in grid operation by the grid operator were very rare. The number of interventions in the Tennet control area (formerly Eon) increased from 2 in 2003 to over 1000 in the last 3 years. The associated costs are now in the range of 1 billion Euros for all transmission system operators. In addition to these costs, passed on to consumers via increased grid-access fees, one should also consider that the risk of failure increases with the number of grid interventions." |
| R27 | Industrial Association | "Despite the considerable expansion of RE, grid operators have managed so far to keep their grid operation stable; i.e., the total generation capacity was flexible enough to offset RE volatilities. Delayed grid-expansion plans did not negatively impact the stability of German grids until now." |

A sample of opinions about Germany's grid infrastructure can be seen in Table 27.

Table 27 – Opinions about Grid Technologies and Extension Plans
Responses to Question Category 3: *Technology*

| TECHNOLOGY | | Technology State of the art/ Development: Power Transmission and Distribution (Appendix A, # 17.4) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The technology is well known and standardized. Newer developments, like superconducting power lines, will probably be part of future solutions. The main problem is the long realization time due to the need for different permissions and the public option to file a protest." |
| R4 | Utility Sector | "Small distribution networks are continuously expanded for connecting individual onshore windmills and solar panels. The North-South power connection is still in the planning phase and in delay, because citizens support the *Energiewende*, but they do not want to have power poles near their houses. Underground laying of power lines has so far been rejected by the operators of the transmission grids for reasons of cost." |
| R6 | Utility Sector | "Underground high voltage transmission lines? They should be cooled with gas. This is too complicated and too expensive." |
| R10 | Manufacturing Sector | "Considerable investments, including underground power lines, are required in this realm." |
| R15 | Manufacturing Sector | "Urgent action is needed for being able to use the electricity generated in the north of the country." |
| R26 | RE Projects & Research | "[Transmission and distribution systems are] technologically mature and uncritical; the lack of political will is the problem." |
| R27 | Industrial Association | "Grid expansion, AC, and DC power transmission are highly but not fully developed. For example, certain components for DC transmission that were previously used only in trials are still missing in practice." |
| R29 | Industrial Association | "[Grid infrastructure] should be further developed but the growing societal resistance against new transmission lines gridlocks, here too, the entire process. Grid-extension plans are already off schedule!" |

**Category 4. Strengths and Weaknesses**

Most participants seemed to agree that the "broad public acceptance" and the fact that "a highly industrialized country can generate more than 30% of its power from renewable energy sources," as one manufacturing representative stated, were major strengths of Germany's *Energiewende*. Moreover, participants representing all sectors emphasized that "the practical experience with the *Energiewende*" would open "new markets" and "new business opportunities for German industries."

Some respondents also considered as strengths the nation's "inventiveness" in finding new technical solutions, its "ingenuity" in creating new energy political instruments, and its ability to identify and eliminate undesired outcomes by adjusting policies when they miss their targets. For example, one manufacturing respondent claimed that policy makers corrected early EEG versions and their rigid support schemes based on "fixed FITs." To make the EEG more flexible, he said, politicians implemented first "direct marketing" instruments for RE,[386] then "breathing caps" for controlling the deployment pace of RE,[387] and finally an "auctioning system for establishing the level of RE payments" (FITs). This respondent also considers more-recent developments, for instance the "sector coupling" concepts,[388] as proofs of Germany's ability to correct undesired trends and adjust its policies. Along the same lines, other participants claimed that characteristics like "staying power,

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[386] Regulatory mechanisms aimed at incentivizing owners of RE facilities to market their power at the wholesale market. These instruments overcompensated the differences between FITs and market prices.

[387] These instruments reduce FITs and slow down RE deployment, when its pace is too high, and RE capacity exceeds the previously aimed deployment corridor.

[388] These concepts are meant to steer the transition in the economic sectors that are currently lagging behind their decarbonization targets (transport, or process and district heating, and building efficiency).

obstinacy, and inventiveness" would place Germany in a leading position in sustainable energy solutions.

However, while some argued that Germany would serve as a "model" and "pave the way" for other nations' transitions toward low-carbon technologies, others said that Germany's policy doesn't deserve to be called "advanced" anymore, because German politicians got "scared by their own courage" and slowed down the pace of change, allowing nations like China and the US to take the lead in solar technologies and electric mobility.

Whether they are supporters or opponents of the *Energiewende*, most respondents seemed to perceive the "lack of a coherent plan" and the "tremendous *Energiewende* costs" as major weaknesses of Germany's energy transition. For example, one representative of the manufacturing sector considered "the fact that policy makers were not able until now to present a sound concept of how they intend to bring the *Energiewende* to a successful end" as being "the greatest weakness" of Germany's energy transition. He claimed that "Dr. Sinn's words about Germany's 'turnaround into nothingness'[389]" still correctly describes Germany's lack of a sound energy political concept. Referring to the costs of transition, he said, "One cannot really say that *Energiewende* burdens for private or industrial consumers were unbearable until now," even if "the *Energiewende* burdens surpassed in reality by far the initial estimates".[390] However, he also considered these costs as being "a major weakness of the *Energiewende,*" noting that "about €150 billion were spent for this experiment for the years

[389] The respondent referred here to Dr. Werner Sinn's presentation, *Energiewende ins Nichts [Energy turnaround into nothingness]*. (2013). Dr. Sinn is a well-known German economist and a vehement critic of *Energiewende* processes.

[390] The respondent referred here to a public statement of Jurgen Trittin, Minister of the Environment during Chancellor Schroeder's administrations), claiming that the deployment of RE would cost an average German household only as much as an additional "scoop of ice cream" per month (BMU, 2004).

through 2015," and that a "serious study"[391] published in 2016 would estimate that " € 370 billion will additionally be incurred up to 2025."

Among those who consider the absence of a coherent action plan as a major *Energiewende* weakness, many interviewees also claimed that it would be politically irresponsible to timely disconnect the "aggressive deployment of RE" from the required "grid extension," and that the development of "viable power storage solutions" will not be developed any time soon.

Several respondents emphasized that Germany's political "arbitrariness" would weaken the transition towards low-carbon technologies by putting at risk entire industrial branches, the nation's wealth, and ultimately the entire society. One manufacturing representative claimed that the many "one-sided reports" and "untruths" about energy topics disseminated by public media make it impossible to approach energy and climate issues in objective, non-ideological ways. He doubted that "autocratic decisions about when coal should be phased out, how power lines should be laid, or where windmills should be built" could ever result in a successful transition.

Many participants said that the fact that energy regulations are fraught with "subsidies" is an additional *Energiewende* weakness. They claimed that subsidies would send "wrong market signals," lead to "severe economic disruptions," and finally to "control-economy tactics." One representative of the utility sector said in this context that "current developments in the RE realm" would demonstrate that "long-term subsidies always head in the wrong direction."

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[391] The participant referred to a study published in 2016 by the Düsseldorf Institute for Competition Economics (DICE) at the Heinrich Heine University in Düsseldorf (Haucap et al. 2016; Die Welt, 2016, October 10).

Table 28 shows a sample of judgments about the strengths and weaknesses of the *Energiewende*.

Table 28 – Opinions on *Energiewende* Strengths and Weaknesses
Responses to Question Category 4: *Strengths & Weaknesses*

| STRENGTHS / WEAKNESSES | | What are the strengths and the weaknesses of Germany's radical energy policy? (Appendix A, # 3) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The main strength is the broad political willingness and Germany's economic strength paired with typical German attributes like staying power, obstinacy, and inventiveness. [… At] the other extreme, guilt feelings, arrogance, blindness for consequences of too rapid changes, the lack of a coherent long-term action plan, high costs … and finally the dependence on politicians, who want to be reelected every four years, represent *Energiewende* weaknesses. … Given that energy transitions should be performed in the long run at the global level … high costs might be the biggest impediment for success " |
| R4 | Utility Sector | "Strengths: Germany serves the world as a role model in terms of energy policy, paving the way for other countries that might follow its example. Orders from abroad for RE facilities and grid-stability systems became new business fields for German industries. Weaknesses: The whole model is based on subsidies, which are paid directly by the electricity consumers via utility bills. Long-term subsidies always head in the wrong direction, as the unrestrained expansion of renewables demonstrated." |
| R14 | Manufacturing Sector | "The results in the renewable energy realm and the strong development induced by the political frame are clearly strengths of this energy policy. [Its] weaknesses … lie primarily in the very high societal costs." |
| R18 | Manufacturing Sector | [Weaknesses:] "Subsidy economy; severe economic disruptions up to the factual abolition of the 'free markets'; macroeconomic painlessness." |
| R21 | Manufacturing Sector | "Strength: wide acceptance throughout the population; Weaknesses: high costs, long decision process, and huge delays." |

Other frequently mentioned weaknesses were the accelerated phase-out of nuclear power plants and the irreparable "know-how" loss arising from this decision. Some respondents also claimed that the compromise meant to settle the lawsuits against Germany's nuclear phase-out would eventually result in increased burdens for taxpayers.

A few respondents claimed said that the general "guilt feelings" related to Germany's troublesome past, coupled with the nation's desire to demonstrate its ability "to heal the world," but also its "arrogance" and wish to "impose its solutions on others," produced unconsidered actions, rapid change, and a general "blindness" about the consequences of actions. Finally, many participants viewed the belief that a single nation's decisions could solve major global problems as both unrealistic and arrogant.

**Category 5. Outcomes**

This section encompasses expert opinions about various questions related to *Energiewende* outcomes. The questions asked about the unexpected or undesired consequences of Germany's energy and climate political decisions; capabilities to design appropriate frameworks for steering large socio-technical systems in desired directions; "free-ride" opportunities embedded in transition processes; and impacts on energy prices and transition costs, on categories of actors, and on the German society as a whole. The completely open form of questioning about *Energiewende* outcomes resulted in a very broad range of responses fraught with contradictory values, and tensions between hope and exasperation, ideology and commercial prudence, wishful thinking and stranded illusions.

Participants described several unexpected and undesired outcomes of Germany's energy policy. These outcomes included:

- the disappearance of the "affordability promise" that was omnipresent in early ideological talks, and its replacement with increasing energy prices and huge economic burdens;

- the "decline of utilities" that was neither planned nor expected;
- the undesirable "increase in complexity and bureaucracy";
- the fact that the most important *Energiewende* instruments hinder each another reciprocally "annihilating their effects" and resulting in rising emission;
- the "general uncertainty" that stems from the rapid pace of change and makes investors reluctant to invest in Germany; and
- the stability problems in grids and the increasing energy costs  caused by the feed-in priority for renewable energies and the accelerated nuclear phase-out.

Respondents from the manufacturing sector claimed that energy-intensive industries would need to close their German sites if they lost their exemptions from paying EEG and other *Energiewende* surcharges. They argued that the current "Diesel scandal"[392] and the many "stranded power-plant investments" demonstrate that the government's "unstructured way" of approaching "known problems" always pushes "facility owners out of their luck".

Table 29 shows some representative responses to the question about unexpected or undesired outcomes.

[392] This scandal started in the US because Volkswagen, a large German car manufacturer, sold "clean" diesel fueld cars, but exceeded the US emission standards. The investigations uncovered that German cars (not only VW) were illegally equiped with a software that showed better emission results during tests than in the normal use. More information available on: https://en.wikipedia.org/wiki/Diesel_emissions_scandal

Table 29 – Perceptions about Unexected *Energiewende* Consequences
Responses to Question Category 5: *Outcomes*. Sub-Category: *Unexpected Consequences*.

| UNEXPECTED CONSEQUENCES | | Can you enumerate some of the unexpected and/or undesired consequences of the successive energy and climate regulatory frameworks between 1990 and 2017? (Appendix A, # 9) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Despite all affordability promises, the electricity price increased. The market deregulation did not lead to the hoped-for reduction in prices. In addition, power became more expensive due to legal requirements (*Energiewende* contributions, levies, etc.). Since utilities' revenues shifted from energy generation and transmission to distribution, necessary investments in transmission grids have ceased. Under pressure of stock market expectations, utilities stopped their investments in order to continue to guarantee high company returns." |
| R5 | Utility Sector | "[Unexpected were:] the decline of the German utility industry, the increase in complexity and bureaucracy, the unexpected collapse of the German solar industry, and the totally confusing mixture of regulations, laws, and subsidies. Also unexpected were: that [the energy system] functions [despite changes] well, that so many renewable plants are built, and that the costs [for renewable technologies rapidely] declined." |
| R8 | Manufacturing Sector | "The nuclear phase-out, the emission trading and the EEG are certainly the most important climate political instruments of recent years. They mutually influence each other … up to reciprocally annihilating their effects …" |
| R12 | Manufacturing Sector | "The 'general uncertainty' that makes investors from abroad or from Germany insecure is such a consequence. This is particularly pronounced in the utility sector and in energy-intensive industries, where investments made only a few years ago are currently either less or not at all profitable. Investments in new power plants, grid-extension plans, or upgrades of manufacturing capacities are only a few examples of 'stranded' financial means. The successive amendments of energy laws fundamentally alter the investment conditions …" |
| R29 | Industrial Association | "More volatile power generation and increased demand for balancing energy due to the phase-out of nuclear power and coal power plants." |

Most respondents agreed that regulatory acts would always be accompanied by adverse effects and favor some actors at the expense of others, because "it never has been possible to recognize all problems *ex ante*," as one respondent from the utility sector said. Some argued that this incapacity to craft perfect regulations shouldn't hinder regulatory actions or gridlock decision-making processes. Instead, when "negative trends" occur, "regulations have to be quickly and flexibly adjusted," said one manufacturing representative of the manufacturing sector. Some respondents thought that adverse effects could be considerably reduced if regulations were restricted to defining the general frame for appropriate behavior, leaving free markets to steer actions towards desired outcomes. One of these "invisible hand" proponents from the manufacturing sector claimed that regulations would remain "compatible with the social market economy only if they were restricted to the provision of 'guard rails.'" "To avoid subsidized activities having detrimental impacts on society as a whole," he argued, "markets should direct people's actions, whenever possible." This respondent was also convinced that "start-up subsidies[393] should be carefully examined and stopped, as soon as possible." A respondent with expertise in development of large-scale renewable projects argued that a "true market economy, in which price components encompass all macroeconomic and societal externalities," would require "no, or at least less need for regulatory intervention." Although the two approaches seem similar at first glance, they are fundamentally different because market economies would require significant regulatory interventions to embed externalities and become "true" in this respondent's sense.

More opinions about the impossibility of crafting laws and other regulatory instruments in a way that avoids adverse effects are presented in Table 30.

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[393] To encourage innovations or induce transitions.

Table 30 – Views on the Ability to Craft Rules without Adverse Effects
Responses to Question Category 5: *Outcomes*. Sub-Category: *Unexpected Consequences*.

| UNEXPECTED CONSEQUENCES | | Is it possible to formulate a regulatory framework in a manner that avoids adverse effects, or does not favor some actors in the energy arena at the costs of others? (Appendix A, # 16) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "I do not think so. People are inventive and some actors will always find a way to exploit the regulatory environment for themselves." |
| R5 | Utility Sector | "No, there will be always winners and losers for each regulation, it ultimately is all about money." |
| R16 | Manufacturing Sector | "Regulatory measures always affect some groups more than others. It is a matter of political democracy and lobbying to avoid hardships, but every change will have its 'winners and losers' and this is not reason stop acting." |
| R26 | RE Projects & Research | "If there were a true market economy, in which price components encompass all macroeconomic and societal externalities, there would be no, or at least less need for regulatory actions. In other words, with a 'true' carbon price, much of the current subsidies … could be abolished." |
| R30 | Private/Solar | "No, there will always be a disadvantage for some, but this is ok. Politics means struggle for the distribution of scarce resources, and there can not be only winners in this game." |

Asked to name some examples of situations in which laws, ordinances, or other regulatory measures meant to benefit the entire society resulted instead in adverse market behavior and even "legal misuse," most respondents confirmed that they had heard about such practices, and gave several examples. For example, a representative of an industrial association said:

> Legislation always encourages certain market participants to look for gaps or gray areas in order to generate extra profits. Market players use such opportunities whenever they can, even if their behavior runs counter to the actual funding intention.

He named as examples the clever interpretation of the "plant" definition,[394] different operator, contracting, and lease models,[395] and the creative interpretation of the "date of commissioning" for RE facilities.[396] He also claimed that each time the legislator becomes aware of "abuse" situations, he tries to eliminate "grey areas" in the legislation and hinder "legal misuse situations." A participant with expertise in the manufacturing and utility sectors said that the free allocation of emission trading allowances in the first emission trading period, and the possibility to benefit from replacing older conventional plants with newer, more efficient ones,[397] led to windfall profits and finally to new coal-fired power plants, a development that is out of line with Germany's decarbonization goals.

While some participants declared that they had heard about such practices but did not use them, others argued that it is not appropriate to identify such "windows of opportunity" as "misuse cases" because companies have to use these opportunities to remain competitive on the market. For example, a manufacturing representative said:

> I heard indeed of such 'legal misuse' practices. However, my company decidedly rejected such business opportunities for compliance reasons. I hope you understand that I cannot make further comments on this topic.

A respondent from another manufacturing company said:

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[394] The definition of "plant" embedded in the emission trading, RE, and environmental protection legislation, and in the stipulations of these acts, motivated actors to build smaller plants (for example by declaring each generator located at a site as an "individual plant") in order to increase the allocation emission allowances, or the subsidy level for RE.

[395] Many of these constructs were implemented only to avoid paying *Energiewende* contributions (EEG, KWKG), taxation, or grid-access fees.

[396] Because FITs were digressive, RE facility-owners were motivated to have an early commissioning date, even if parts of the facility were not able to function properly. Often they produced only one kilowatt-hour by the end of one year, to avoid the digression, but stopped the facility immediately, because work was not completed and saving the operation wouldn't have been possible.

[397] They were allowed to transfer the higher emission allowances for their inefficient plants to their new ones, generating a surplus of allowances.

> Every energy manager will certainly try to muddle through and use the many energy laws to achieve optimal outcomes for his company. The legal frame might be interpreted now and then in different ways. However, I rather perceive it as a fallacy to talk about 'legal misuse' in such cases.

Some participants from the utility, manufacturing, and policy realms argued that the *Energiewende* rules and regulations favored richer players (not only larger manufacturers, but also richer households) at the expense of other, less-wealthy individual or collective actors. A representative of the utility sector said, for example, that large companies are exempted from contributing to the grid costs, although they use them most, while smaller players have to shoulder the entire burden. He noted that neighboring nations also profit from the *Energiewende* at the expense of Germans, because they can benefit from "cheap power imports"[398] while exporting their electricity at high prices.[399]

Another respondent from the utility sector added that richer households that have the financial means to invest in RE facilities have covered their rooftops with solar panels at the expense of poorer households, which have to shoulder higher power bills. Along these lines, a respondent representing the manufacturing sector said:

> I own a small photovoltaic system (9.3 kWp), which generates a decent return on investment. I receive EEG payments from the local utility that are three times higher than what the utility spends to generate the power in its own coal-fired power plants! Solar panels do not make sense in Germany …

[398] The respondent referred to forced exports in periods of high RE production and low energy demand. Since adjacent nations did not contract this power, they do not have to pay for it.

[399] The respondent referred in this case to the opportunity of adjacent countries to deliver back-up power when RE generation in Germany is low and demand is high. Back-up power is always expensive (i.e. above prices on the wholesale markets). However, the respondent did not mention the grid stability problems that occur in adjacent grids due to unforeseeable exports of intermittent power from Germany.

Additional opinions about "legal free ride" situations can be seen in Table 31.

Table 31 – Perceptions About Rules that Motivate Actors to "Game the System"
Responses to Question Category 5: *Outcomes*. Sub-Category: *Free Ride*.

| FREE RIDE | | Have you heard about regulatory acts meant to encourage a certain behavior of market players and to benefit the entire society, but that led instead to a different/adverse behavior or even to a generalized "legal misuse"? Were you confronted with such practices? Can you name some examples? (Appendix A, # 10) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The best example for irrational behavior is the continued operation of wind farms [… in periods of] negative power prices. Given the guaranteed [… FITs] wind-farm operators [… have] a profitable business … Opening the balancing market for renewables offers another current example. This reduces power prices, but also leads, due to volatile generation, to a less-secure balancing system … and consequently to higher risks of blackouts." |
| R4 | Utility Sector | "I always wondered whether the process of burning wood waste that is subsidized by the EEG is cleaner than that of burning coal. Above all, when one sees how fragmented the fuel supply-chain of a biomass power plant is … I mean the 'collection' of wood waste, the shredding process, and the delivery by truck … all these also create environmental burdens." |
| R5 | Utility Sector | "Landscape destruction, 'eco-tax' contracting, problems associated with insulating materials, too excessive burdens that hinder innovations in older buildings, etc." |
| R14 | Manufacturing Sector | "There are a lot of rules in use that did not lead to the desired results. For example, users with flat consumption patterns … do not have to pay grid costs. However, since power storage is not available at a large scale, and we adjust our own power generation depending on the availability of RE to help balancing the grids (demand-side management), we simultaneously destroy our flat consumption patterns and have to pay additional grid costs." |
| R15 | Manufacturing Sector | "ETS: … The instrument missed its goal and the expected steering effect because the price for CO2 allowances is too low to justify investments in low-carbon technologies." |
| R29 | Industrial Association | "To evaluate their legal options and maximize their profits companies carefully scrutinize the regulatory measures on a regular basis." |

Some questions in the "Outcomes" category referred to the impact of the implemented *Energiewende* rules and regulations on the transition costs (i.e., costs for grid infrastructure, for energy access, transmission, and distribution, as well as costs for the energy itself). Almost all participants seemed to agree that "infrastructure costs will significantly rise," and that the need to expand the grid infrastructure will be "expensive." Some explained the increase in costs with the fact that Germans are "spoiled and used to a secure energy supply," and expect that their high level of energy security will continue into the future. One interviewee from the utility sector said that this perception,[400] coupled with the increasing amount of RE fed into the grids and the missing storage technologies, resulted in "the need to upgrade grids until their capacity is sufficient to absorb all renewable and conventional power generated." To level intermittencies and limit the grid-extension costs, Germany must invest massively in new storage infrastructure, he argued. From his point of view, "hydrogen pipelines and storage facilities, based on fuel cells and other technologies," have to be built "to secure the long-term supply" in a sustainable way.

Many respondents claimed that the power corridor that has to be built to transport energy from the windy north to the energy intensive south, and the fact that Germans are against overland power-lines, would be the major cause for increased in infrastructure costs.

Other respondents were convinced that intelligent sector-coupling solutions would reduce the necessary expansions in transmission grids and contribute to shorter pay-off periods for investments in critical infrastructure. However, all of the sector-coupling concepts currently discussed imply a significant increase in power demand, because the heating and transportation sectors would use, according to these concepts, mostly electricity

[400] I.e. the right of having a secured energy supply.

to replace fossil fuels. Such changes would more than double Germany's power consumption with the result, that distribution grids would also have to be upgraded, as one respondent and the author of a sector-coupling study noted. Table 32 shows some stakeholder opinions about the *Energiewende* impacts on infrastructure costs.

Table 32 – Perceptions about *Energiewende* Impacts on Infrastructure Costs
Responses to Question Category 5: *Outcomes*. Sub-Category: *Impacts on Costs*.

| IMPACTS ON COSTS | | What are from your point of view the impacts of the *Energiewende* on the costs for infrastructure? (Appendix A, # 4.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R3 | Utility Sector | "I assume [there will be] increasing costs for high-voltage power lines and grid stability." |
| R12 | Utility Sector | "Infrastructure costs will significantly increase, but this is always the case in phases of change." |
| R16 | Manufacturing Sector | "… I expect that infrastructure costs will continue to increase due to investments in new north-south power corridors…" |
| R26 | RE Projects & Research | "From an economic point of view, infrastructure costs would pay off very quickly if grid-expansion plans were intelligently coupled to decentralized RE projects and we finally had a reasonable CO2 pricing policy." |
| R27 | Industrial Association | "On the one hand, forecasts are indicating rising costs for expanding Germany's transmission grids and building the north-south power connection. On the other hand, a well-developed natural gas infrastructure, with grids connected to underground storage facilities, already exists. One should only open this infrastructure for other uses, as for instance for the transport and the storage of wind-gas. One could make this possible by building power-to-gas plants in northern Germany and transporting synthetic methane (or wind methane) through the existing grids to customers, particularly to those located in the southern part of Germany. This means that infrastructure costs could be limited by using the existing infrastructure, and do not necessarily have to experience an exorbitant increase." |

Participants in this study seemed to agree that grid-access costs, as well as the costs for transmission and distribution, will increase on and on, due to the requirements for new infrastructure (underground transmission lines, upgraded distribution grids), the steadily increasing number of necessary interventions to balance the grids (re-dispatching), the longer electricity transport distances, and the resulting higher losses in the system. One respondent, a former governmental actor,[401] claimed that "the high share of wind and solar in the electricity mix is already causing billions in costs for so-called 're-dispatch measures,'" and that these costs will further increase, given Germany's declared goal of increasing "the share of solar, wind, and biomass power to 40-45% by 2025, and to 55-60% by 2035." Some stakeholder opinions about the impacts of Germany's energy transition on the energy access, transmission, and distribution costs can be seen in Table 33.

Table 33 – *Energiewende* Impacts on Transmission and Distribution Costs
Responses to Question Category 5: *Outcomes*. Sub-Category: *Impacts on Costs*.

| IMPACTS ON COSTS | | What are from your point of view the impacts of the *Energiewende* on the costs for energy transmission/transport/distribution? (Appendix A, # 4.2) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Energy transportation charges will rise … because German policy makers usually decide to socialize costs by creating new grid surcharges. In the final scenario, let's say around 2080, in a world of decentralized generation and power storage based only on hydrogen, transportation costs will be quite low." |
| R4 | Utility Sector | "Transmission costs will significantly rise, because the power generated in large offshore wind farms has to be transported to Germany's south." |
| R12 | Manufacturing Sector | "The 'incentive regulation' implemented to create a 'quasi' substitute for competition missed its goal. Fears of rising grid access and usage charges seem to be justified, given the fixed dividends for grid operators, and the 'dedicated collection funds' for *Energiewend*e costs." |
| R17 | Manufacturing sector | "… will increase even more due to redispaching, new underground power lines for long-distance power transmission, and the expansion of the distribution grids …" |

[401] During Chancellor Schroeder's administrations.

Questioned about the *Energiewende* impacts on energy prices and costs, almost all interviewees agreed that total energy costs would continue to increase sharply. They see the main reasons for the sharp upward trend to be the fact that the "financial expenses for the *Energiewende* add up to horrendous figures," and the clear preference of "German policy makers … to socialize costs." These "horrendous figures" will thus have to be paid back to a large extent through higher power prices, and higher energy costs.

Some respondents emphasized that the fixed costs will experience a disproportionate rate of increase, while the mechanisms for establishing prices on the wholesale markets (variable costs), will continue to relate to the marginal costs of alternative power sources available to match the demand (merit order). One representative of the manufacturing sector said that "natural gas will continue be available at relatively low cost, because producers[402] will take care not to jeopardize their market even more."

However, some respondents, representatives of RE project development companies and research institutions, perceived the focus on costs as "shortsighted." They all shared the position that "prices must tell the ecological truth."[403] One said that "a holistic view on costs" would certainly lead to "renewable energies [being] the most cost-effective form of energy, because they create neither unsolved disposal problems nor catastrophic risks, nor do they contribute to climate change and its consequential damages."

At the other end of the spectrum, one respondent and former member of the government considered the *Energiewende* and particularly the transition towards renewable

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402 The respondent refers here to the major exporting nations (Russia, Norway, Netherlands) that have an interest in delivering natural gas. RE deployment and higher generation costs tend to put at risk the exports of natural gas from these countries to Germany.

403 Original: „Preise müssen die ökologische Wahrheit sagen." According to one respondent, this quote stems from Prof. Ernst Ulrich von Weizsäcker.

energies without relying on nuclear power an economic, environmental, and social "disaster." A selection of statements about the impacts of the *Energiewende* on energy prices and costs, is shown in Table 34.

Table 34 – *Energiewende* Impacts on Energy Prices and Costs
Responses to Question Category 5: *Outcomes*. Sub-Category: *Impacts on Costs*.

| IMPACTS ON COSTS | | What are from your point of view the impacts of the *Energiewende* on energy prices and costs? (Appendix A, # 4.3) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Energy prices and costs will be high. The reasons are: the redistribution of costs to all consumers; the need to build additional grid and storage capacities; the need for additional research and development; the need to give subsidies to poor countries; the missing detailed, long-term planning, which leads to more errors than successes." |
| R9 | Manufacturing Sector | "Pricing will become more transparent. The energy management systems open opportunities for saving energy and optimize energy costs (for example, by lowering consumption and limiting the EEG contribution)." |
| R15 | Manufacturing Sector | "Away from coal means, at least in the beginning, more natural gas consumption. This will lead to a shift in the 'merit order' and thus to rising electricity costs. Natural gas prices will also increase, due to the sudden increase in demand, and will consequently lead to a further increase in electricity costs." |
| R18 | Manufacturing Sector | "I estimate that the total costs including *Energiewende* subsidies (EEG surcharges, network charges, balancing and redispatch costs, etc.), will experience a threefold increase. The so-called 'market costs' will further decrease, due to changes in the 'merit order' induced by the feed-in priority of RE (which is considered, despite subsidies, to cost 'zero' ct/kWh). This will destroy to a large extent the basis for a reliable power generation. Germany's *Energiewende* managed already to transform almost [ … all] gas-fired power plants into 'stranded investments.'" |
| R23 | Research Institutions | "In the case of RE one tends to oversee the manufacturing and the subsequent disposal costs. ... If one uses RE sources, the energy-transmission cost increases, so do the prices. … It is necessary to deliberately plan a fair distribution of the burdens." |

Some questions in the category "Outcomes" referred to the impact of the implemented *Energiewende* rules and regulations on different categories of actors – large utilities, manufacturing companies, households – as well as on the society as a whole.

As already discussed in Chapter 7, the successive *Energiewende* regulations impacted the utilities, especially large, integrated ones, more than other sectors. I asked about the *Energiewende* impacts on large utility companies. All participants agreed that the *Energiewende* led to "dramatic" changes in the utility sector, and they perceived old utility structures as "outdated." In addition, most participants emphasized the poor economic outcome for large utility companies and claimed that the sector has to adjust in order to survive under the given conditions.

Some participants considered that large utilities were so caught in old structures that they could not react flexibly to the *Energiewende* challenges. For example, one respondent from the manufacturing sector said:

> Due to their structures, large utilities will have a hard time in competing with the many small, decentralized units. In recent years, a large number of smaller competitors with a completely new cost structure have entered the market. These companies are much more flexible than the big ones can ever be. Big utilities still think and act according to their outdated structures, in terms of capital-intensive investments. But the world is now different and requires to be versed in the art of developing projects with low margins.

While some respondents considered the fact that utilities are on the brink of dissolution as an "unfair" and "undesired consequence" of the *Energiewende*, others claimed that their poor economic results are the consequence of mismanagement. A respondent from a local utility said:

> …With the *Energiewende* the share prices of the big electric utility companies significantly dropped. More financial means have been destroyed than during the bank crisis.

Some respondents from the utility sector hoped that a "capacity market," or an asset transfer in state property, would finally save utilities from bankruptcy:

> Large utilities will survive if they are able to adjust their portfolio to future needs and if the existing fossil capacities are accepted as being required for the system's stability. … Without a 'capacity market,' they won't have revenues and won't be able to invest in new technologies. This might lead in the short term… to insolvency, capacity shortages…and power blackouts. … I am confident that politicians are aware of this danger and will avoid it. However, given the shrinking capacity, utilities might be able to handle these problems easier in the long run. The remains of large utilities might be transferred in the end to a public company that supplies back-up capacities for emergency situations.

Others claimed that these utilities would lose their significance or even completely disappear in a decentralized market.

To understand how utility actors reacted to the *Energiewende* regulations, I also asked what strategic turns utilities had to take to adjust to the changing political frame. Some participants said that the deregulation of energy markets, and the increased competition in early phases of deregulation significantly altered the strategic approaches of major utilities. "The unbundling" stipulated in the deregulation act (EnWG) forced utilities to change their strategies and represented a "first important turning point" said a representative of an industrial association. To deregulate the energy market, "the separation[404] of energy generation and trading tasks from grid activities" has been imposed on vertically integrated utility companies, inducing major organizational changes. Power-lines, transforming stations, natural-gas pipelines, and dispatch units have been transferred to new legal entities (grid companies).

Transport and distribution grids build "natural monopolies" at national, regional, and local levels. Deregulation rules required grid operators to offer non-discriminatory access to all market participants (third parties). This made competition in energy markets possible, but also altered the once very tight relationships between grid operators and power traders.

The significance of consumers also changed in early deregulation years. Utilities upgraded their former "power users" (i.e., bound consumers, who have to purchase their power from their local utilities), ranking them as "customers" (i.e., consumers able to choose their power suppliers). In this phase, utilities placed their customers at the center of their trading strategies, emphasizing a strong "customer orientation."

The strong competition for larger customers led, especially in the power sector, not only to an unforeseen decrease in prices, but also to a significant loss in revenues for large electric utilities. Negative returns from existing businesses are clear signs that strategic shifts are urgently required, as a representative of a large utility explained. "This was the case in 1999/2000, when deregulation increased competition in the energy markets, and it is now again, due to other regulations meant to steer […the] energy transition," he said. To reverse the negative impacts on their balance sheets, large utilities changed their strategies in 2000,

[404] Legal separation, in the case of power businesses; commercial separation in the case of natural-gas firms.

by stringently relating their power prices to those established at the wholesale markets; that is, they shifted from "customer orientation" to "market orientation." They renounced all previous efforts to please and bind larger customers in custom-tailored contracts. The accelerated nuclear phase-out, the intense RE deployment, the discussion of a future fossil phase-out, and many other *Energiewende* regulations led to successive strategy shifts in large utilities. "They announce every two years new … turning points in their strategic approaches … but I cannot recognize in this area real success stories," said one respondent from the utility sector.

Many participants emphasized that utilities invested in the meantime in RE facilities and switched their focus from large power plants to small, custom-tailored, decentralized projects based on RE technologies and combined heat and power (CHP) plants. To attract customers, they also invented intelligent products and services ("smart homes," "smart meters," "smart grids," "smart technologies," etc.) and defined "new ways of working" – a sort of good-manners handbook that should be rather "common sense" among adults in a civilized world. To survive in the "unfavorable regulatory environment," utilities eventually separated their "healthy," renewable business ("good banks" such as Innogy and Eon) from their uneconomic, conventional business ("bad banks" such as RWE and Uniper). While trying to make profits in their renewable arms, utilities struggled to restructure their conventional arms and to offer "capacity and energy back-up services" for times of low wind and solar availability. Although they continuously adjusted their strategies, utilities have "to fight to survive," said one respondent from the utility sector, because they had "overslept [for too long] the effects of the RE deployment," said one manufacturing representative. Some stakeholder views on the impacts on large utility companies are shown in Table 35.

Table 35 – *Energiewende* Impacts on the Utility Industry
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Actor Clusters*.

| IMPACTS ON ACTORS | | What are from your point of view the impacts of the *Energiewende* on: large utility companies? (Appendix A, # 4.6) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "The *Energiewende* has and will have considerable influence on utilities. The centralized energy supply is an 'outdated' business model on the brink of dissolution and utilities have to redefine their role." |
| R12 | Manufacturing Sector | "Well, eventually they won't exist anymore ... In early transition years, utilities were among the *Energiewende* winners and made huge profits from pricing 'opportunity costs.' But due to the low energy-price level, they are currently short of money." |
| R13 | Manufacturing Sector | "Large utilities simultaneously experienced the devaluation of their assets and economic disempowerment. But the excessive spread of 'green ideas' that caused the decline of these companies is rooted, at least from my point of view, in the arrogant behavior of utility managers." |
| R17 | Manufacturing Sector | "To destroy the economic basis of these companies is terribly unfair." |
| R26 | RE Projects & Research | "Instead of investing in renewable energies, large utilities spent … millions of Euros on PR campaigns against them. Politicians are currently making enormous efforts to shape the regulatory framework for renewable energies in favor of the four large utilities, at the expense of small and medium-sized companies … From my point of view large utilities hinder a real *Energiewende*, because they will always struggle with transitions from centralized to decentralized power and 'prosumer'[405] concepts, and will thus delay the restructuring process." |
| R27 | Industrial Association | "The *Energiewende* impact on large utilities is dramatic. They defended for far too long their conventional structures based on … coal and nuclear power plants, and are now beginning to shift towards decentralized generation facilities. This led to a drastic decline in profits and triggered successive reorganization processes that are by far from complete. |

Stakeholder views on strategic turning points of utilities are shown in Table 36.

[405] 'Prosumer' is a consumer that also produces electricity. Such consumers are sometimes able to adjust their consumption and generation to compensate grid imbalances.

Table 36 – Strategic Turning Points in the Utility Industry
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Actor Clusters*.

| IMPACTS ON ACTORS | | Name some important turning points in the strategic approaches used by utility companies (Appendix A, # 23) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "If revenues from the existing business are turning negative, the time is ripe to change the strategy. For utilities, this was the case in 1999/2000 when deregulation increased competition in the energy markets, and it is now again, due to other regulations meant to steer Germany's energy transition. The new strategy is to get the needed financial means from 'healthy' activities, which were meanwhile separated from the conventional utility business … Utilities placed their 'old fashioned' power business with no sustainable earning perspectives in the market, in a way that allows consolidation, and offers new opportunities to generate revenues, by reducing the available capacity (i.e., by out-phasing facilities). The plan is to generate revenues offering capacity back-up services for emergency situations. At the end of the day the shrunken conventional portfolios of all utilities can merge to one remaining 'emergency portfolio.' This portfolio will be needed to supply energy to industrial and private consumers, when the RE are not sufficient to meet the demand, and to prevent the nation's energy systems from collapsing. The 'emergency protfolio' will thus offer a public service, comparable to the public 'fire brigade,' and should therefore be publicly owned and operated." |
| R5 | Utility Sector | "All utilities have to fight hard to survive in an unfavorable regulatory environment. They announce every two years new important turning points in their strategic approaches. I have the impression that Eon acts more coherently and sustainably in comparison to RWE, but I cannot recognize in this area real success stories." |
| R9 | Manufacturing Sector | "Division into 'good' and 'bad' banks (Innogy and RWE, Eon and Uniper). Shift to the service business (smart home, etc.)." |
| R15 | Manufacturing Sector | "Utilities have for too long misjudged or overslept the effects of the of the RE deployment. They built new modern coal and gas-fired power plants, which became 'stranded investments.' In the meantime, utilities invest in wind power. Their thinking has changed. They move away from large power plants to small, decentralized, tailor-made facilities and efficient CHP plants." |

Asked about the *Energiewende* impacts on the manufacturing sector, participants agreed that exemptions from paying *Energiewende* contributions are justified and required to ensure the nation's wealth and avoid larger manufacturers moving their sites to other countries. A respondent from the utility sector said:

> Manufacturers can only hope that politicians are able to do their job well and hinder an industrial exodus towards *Energiewende*-free regions. … Politicians have to care for a 'blooming economic situation' because the *Energiewende* is only possible if Germany raises enough taxes.

A respondent from the manufacturing sector said:

> Rising energy prices can threaten the very existence of energy-intensive industries, for example the manufacturers of aluminum, paper, or chemical products. The exemption rules make sense. Without them, Germany's economy would collapse.

A respondent representing a manufacturer-owned utility that offers custom-tailored utility services for production units located in an industrial park claimed:

> The *Energiewende* rules and regulations impact on one hand our company's costs directly (i.e., for generating power, process heat or cold, compressed air, recycling waste products, etc.), and on the other hand they impact the revenues of all manufacturing processes we are supplying with custom services. These manufacturers would get in severe financial trouble and phase out their facilities if they lost their privileges and were no longer exempted from paying *Energiewende* contributions. In this case, we would no longer be able to operate our generation units efficiently and would be forced to close our plants.

Another representative of the manufacturing sector said that "… it becomes increasingly harder to maintain the *Energiewende* exemptions necessary to preserve the nation's economic power."

While some respondents argued that manufacturers will be motivated by "rising energy prices" to make their processes more efficient and "improve their ecological footprint," others, representing mostly actors with stakes in renewable energies, claimed in addition that "prices that include external ecological costs" would push technological advancement and allow the nation to regain its technological lead.

One respondent from the manufacturing sector compared the situation in which manufacturers are pushed by the *Energiwende* regulations to a "one-way street with oncoming traffic." He considered the idea "that manufacturers of paper, steel, or other products have to subsidize another industrial sector" (i.e., power generation from sun, wind, etc.) "absurd," and the decision to put such burdens on industrial consumers "an absolute mistake."

An interviewee representing an industrial association said:

> As far as they recognized the signs of the times and acted accordingly, manufacturing companies benefited from windows of opportunity opened by the *Energiewende*. They used the increased competition in early deregulation phases to optimize their energy costs, invested in their own decentralized generation plants and modern energy supply structures. … However, compared to energy-intensive industries, small manufacturers have to shoulder unreasonably high *Energiewende* burdens (EEG, KWKG contributions, grid-acess charges, etc.).

A sample of stakeholder responses to the question about *Energiewende* impacts on the manufacturing sector is shown in Table 37.

Table 37 – *Energiewende* Impacts on the Manufacturing Sector
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Actor Clusters*.

| IMPACTS ON ACTORS | | What are from your point of view the impacts of the *Energiewende* on: manufacturing industries? (Appendix A, # 4.7) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "As energy becomes more expensive, multi-national groups are moving their energy-intensive processes to countries with lower energy costs (such as France for example). This will not be readily possible for small companies, which are rather likely to implement energy-saving measures. Energy-saving efforts are in principle positive for energy transitions, but the question arises whether these firms have sufficient financial means to make such investments." |
| R3 | Utility Sector | "German industries will reduce their energy consumption, adjust their manufacturing lines to produce new products, operate highly efficient units, and perceive the *Energiewende* as opportunity. It will strongly depend on energy political decisions of other nations, if such developments will also take place at a global scale." |
| R8 | Manufacturing Sector | "The different industries are either exempted from shouldering *Energiewende* burdens and able to manufacture competitive products, or they move their production sites to other countries. The latter case would severely impact remaining actors (crafts, trades, services, citizens) who would have to shoulder alone the transition costs, while having less financial means for operating their businesses or purchasing goods." |
| R13 | Manufacturing Sector | "The energy-intensive industry leaves Germany at large; remaining manufacturing processes have to deal with increased competition and competitive disadvantages in a globalized world." |
| R26 | RE Projects & Research | "We need (at least in Europe) energy prices that entail external ecological costs. This would massively boost innovations in energy efficiency and energy sustainability, and would enable the German industry to regain its technological lead." |

Asked about *Energiewende* impacts on households, most participants agreed that Germany's energy transition puts additional and steadily increasing burdens on households, leading to an increase in costs for living. A widely shared view was that richer households will benefit from the *Energiewende* at the expense of poorer ones. For example, one respondent from the utility sector said:

> Richer households will benefit from the *Energiewende* by operating their own solar, wind, and storage facilities … Poor households will probably need public support to be able to pay their electric bills.

Some respondents argued that one of the major tasks of policy makers would be to design the *Energiewende* regulations in a way that avoids hardship for poorer households and allows a balanced distribution of transition burdens. One respondent from the utility sector said that it wouldn't be fair for households to have to bear much higher burdens than other actors. Another, from an industrial association, added that there would be little room for further price increases, and a third, representing a developer of RE projects, argued that the current *Energiewende* burdens (mostly EEG) would be relatively small in comparison with those to be expected in future in other sectors (i.e., transportation, heating).

Critical voices, like that of a former government member, sardonically claimed that it would be:

> … only a trivial fact that 330,000 households are [yearly] disconnected from the power grid, while another 6.6 million are threatened to have their access denied, because they are not able to pay their power bills"

and that all this happens in "wealthy Germany."

On the same topic, an interviewee from the research realm estimated that when the number of disconnected households will exceed "… 1,000,000 … Chancellor Merkel will turn her neck in the other direction and claim that one cannot expect German citizens to bear such burdens." By then, continued this respondent:

> … other nations with intelligent energy transitions will probably be more successful. At least, I hope and wish this, while deeply regretting that a nation that could have

had a sound transition concept wasted its resources due to complete political mismanagement.

More stakeholder opinions about the *Energiewende* impacts on households can be seen in Table 38.

Table 38 – *Energiewende* Impacts on Households
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Actor Clusters.*

| IMPACTS ON ACTORS | | What are from your point of view the impacts of the *Energiewende* on: hausholds? (Appendix A, # 4.5) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Richer households will benefit from the *Energiewende* by operating their own solar, wind, and storage facilities … Poor households will probably need public support to be able to pay their electric bills." |
| R8 | Manufacturing Sector | "Cost of living will significantly rise, because households always bear, either directly or indirectly (i.e., by purchasing more expensive goods), the burden of increased energy prices." |
| R13 | Manufacturing Sector | "Households have to shoulder considerable additional burdens, which will lead in turn to energy savings." |
| R17 | Manufacturing Sector | "Unfair, all EEG burdens have to be shouldered by households, although the absolute costs did not significantly increase." |
| R26 | RE Projects & Research | "The electricity costs that are often mentioned in this context account for only a tiny part of one household's monthly burden. Heat and mobility costs are much higher and will dramatically increase in the long run, if one holds onto fossil fuels. Energy efficiency and savings haven't really been addressed so far." |
| R27 | Industrial Association | "The burden on households, in particular that resulting from the EEG contribution, is currently considerable. There shouldn't be much wiggle room for further increases. The government tried to stop, with limited success, the steadily upward price trend, by introducing a so-called 'power price-brake.' In the next few years, it will be necessary to work consistently to reduce energy prices for households." |

Other questions addressed the *Energiewende* impacts on employment and society as a whole. While some respondents claimed that the *Energiewende* created rather than destroyed jobs, others argued that it would be the other way around if one counts positions lost in the utility industry against the new ones in the renewable realm and takes into consideration that energy-intensive industries are likely to move their sites to counties with less strict rules. Other respondents claimed that the more recent EEG versions have negatively impacted employment in the renewable energy realm. Some respondents argued that fundamental transition processes would be always accompanied by shifts in societal wealth and employment but considered these changes as irrelevant from a macro-economic perspective. For example, one representative of the manufacturing sector claimed that:

> Unemployment is not the problem with such a broad and long-term change, because jobs lost when the old technology is phased out will be recreated in new branches of the utility industry.

In contrast, a former government member argued that Germany's *Energiewende* would be a "misconstruction from a social point of view," because it would redistribute societal wealth "from bottom to top":

> The retiree in Bochum[406] and the skilled worker in a coal-fired power plant pay the subsidy yielded by the *Energiewende* profitmakers, i.e., by the lawyer in Starnberg[407] for his solar rooftop and by the landlord who hosts on his property a wind turbine. Such imposed payments are particularly bitter for the skilled worker who finances the competition to eliminate his own job.

A sample of stakeholder statements on this topic can be seen in Table 39.

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[406] Bochum is a city in the Ruhr Basin. The abundance of coal attracted, in the past centuries, many energy-intensive industries to the region. As a consequence of globalization and *Energiewende* rules, many industries had to close their manufacturing sites, generating social problems and poverty issues in this once very wealthy area.

[407] Starnberg is considered one of the most desirable places to live. This Bavarian city attracted wealthy people who built their mansions near the Stranberg Lake, an idyllic place surrounded by the mountains.

Table 39– *Energiewende* Impacts on Employment
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Actor Clusters*.

| IMPACTS ON ACTORS | | What are from your point of view the impacts of the *Energiewende* on employment and the society as a whole? (Appendix A, # 4.8) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Renewables created jobs that are now partly destroyed by the auctioning system." |
| R8 | Manufacturing Sector | "I anticipate considerable welfare losses and expect a strong increase in unemployment in the long term." |
| R12 | Manufacturing Sector | "So far, the field of renewable energy was rather a 'job engine' than a 'job killer' and this is also to be expected for the future, since the need for innovative solutions in the realms of renewable energy generation, efficient energy use and … energy storage will create many new job opportunities." |
| R15 | Manufacturing Sector | "If manufacturers won't be able to run their production lines in an economic mode, unemployment rates will increase." |
| R17 | Manufacturing Sector | "Growth in renewable jobs would have to be offset against the loss of jobs in the established energy industry. From my observations the losses in the utility industry exeed by far the gains in the renewable realm, so that we have an overall job-loss. In addition, as long as there are other places on the globe with less costly and restrictive transition rules, energy-intensive companies will leave the country. |
| R26 | RE Projects & Research | "A 'real' *Energiewende* offers several opportunities – for example, in the field of energy and environmental technologies, but also in all classic industrial processes – for a sustainable and successful German economy and for keeping unemployment on a low level." |
| R27 | Industrial Association | "As far as the labor market situation is concerned, I believe there has been a shift in the energy transition, but rising unemployment is likely to be contained. On the one hand, although many jobs in conventional energy-supply systems have been eliminated by decommissioning (e.g., nuclear energy), on the other hand, the development of renewable energies has created numerous, completely new jobs, not only among plant manufacturers but also among service companies, consultants, planners, and larger operators." |

Some opinions about *Energiewende* impacts on society can be seen in Table 40.

Table 40 – *Energiewende* Impacts on Energy Access and Society
Responses to Question Category 5: *Outcomes?* Sub-Category: *Impacts on Society*.

| IMPACTS ON SOCIETY | | What are, from your point of view, the impacts of the *Energiewende* on energy access and on the society as a whole? (Appendix A, # 4.9-4.10) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Energy access would be fair only if it was socialized. That means that everybody gets what he needs, anytime. Society will have to accept that the world needs the *Energiewende*, that the *Energiewende* is expensive, that even fossil-based electricity is needed, that all electricity-producing facilities have a value, and that everybody has a right to get as much electricity as he needs. These points are all prerequisites for a successful *Energiewende*." |
| R13 | Manufacturing Sector | "Germany's climate goals cannot be achieved if one renounces nuclear and fossil power plants, because Germany's economy would collapse. It is not possible to maintain Germany's economic strengths relying only on renewable energies and energy savings. In the face of economic decline, rigid enforcement of such unrealistic approaches would trigger massive social and political unrest and result in political changes." |
| R17 | Manufacturing Sector | "Costs across our entire economy will rise. If policy makers continue to ignore critical *Energiewende* voices, the *Energiewende* will have negative impacts for all of us. At the moment, our living standards are high and our economy booms, producing financial means for Germany's 'special' transition path. Yet this might rapidly change, if companies lost their privileges." |

Finally, some questions in the sub-category Outcomes addressed the occurrence of negative power prices, and the impact of Germany's *Energiewende* on the order in which power plants enter into service to meet the power demand. Respondents agreed that the feed-in priority of RE power stipulated in the EEG, and the fact that renewables are considered to have no marginal costs, pushes the "merit order" curve[408] "to the right", leading to lower wholesale power prices. In consequence, more expensive generation

[408] The merit-order curve ranks available power generation capacities in ascending order of their marginal generation costs and establishes the order in which they are are called into operation.

capacities, like natural-gas power plants, are pushed outside the merit order, while coal-based power plants have to compensate generation and demand fluctuations and deliver balancing services. Because they are designed to supply baseload power and less flexible than natural-gas power plants, coal plants cannot easily adjust to load intermittencies. Especially in periods of high availability of intermittent renewable power and low demand, coal power plants are not able to properly balance the grid, because they cannot be operated under 50-60 % of their nominal load. In such periods, power prices turn negative. Stakeholder opinions on negative electricity prices and the merit order effect can be seen in Table 41 and Table 42.

Table 41 – Stakeholder Opinions on Negative Electricity Prices
Responses to Question Category 5: *Outcomes?* Sub-Category: *Other Impacts.*

| OTHER IMPACTS | | Energiewende impacts: How dou you explain negative electricity prices? (Appendix A, # 18) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "Negative electricity prices are a logical consequence of the … legal support for renewables, their ranking as 'must run' capacities, their fluctuating generation patterns, the resulting overcapacities, and the minimum load at which conventional facilities can be operated. Without legal regulation there would not be so much overcapacity and no negative prices, because the market would regulate itself." |
| R2 | Utility Sector | "The EEG triggers the generation of wind and solar power. This and the fact that the conventional power is relatively inflexible lead to massive overgeneration. Negative prices create incentives to increase power consumption in certain periods of time." |
| R8 | Manufacturing Sector | "The offer exceeds the demand. So-called 'must run' capacities generate power at very low marginal costs, and it is more expensive to run down conventional power for short periods of time than to offer power at negative prices and generate negative incomes. |
| R26 | RE Projects & Research | "Negative power prices result when the offer of energy exceeds the demand (e.g., on a windy and sunny Friday…)" |
| R29 | Industrial Association | "Oversupply in cases of high wind and solar generation and low industrial production (e.g., Christmas 2016)." |

Table 42 – Stakeholder Opinions on the Merit Order Effect
Responses to Question Category 5: *Outcomes?* Sub-Category: *Other Impacts*.

| OTHER IMPACTS | | How is the 'merit-order' impacted by the increased deployment of renewable energies? (Appendix A, # 19) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Due to the 'must-run' characteristic of regenerative energies (legal feed-in priority), gas and coal-fired power plants are no longer 'in the money.' This then leads to the closing of these power plants and the increased use of lignite in the middle load range." |
| R10 | Manufacturing Sector | "RE shift the merit order to the right. Gas-fired power plants are forced out of the merit order being no longer in use. |
| R29 | Industrial Association | "Since RE are considered 'free of charge' (power users pay for their costs), only old coal-fired power plants with low marginal costs can assert themselves in the merit order. All newer plants (e.g., modern gas-fired power plants) have higher marginal costs due to higher fuel prices … and are regularly pushed out from the merit order. The KWKG 2016 introduced special subsidies to allow *Stadtwerke*-owned CHP plants to sell their power at the power exchange." |

**Category 6. Risks/Opportunities**

Respondents who work in conventional arms of large utility groups perceive that *Energiewende* regulations jeopardize their companies' very existence. These utilities are at risk of losing their economic basis, becoming insolvent, going bankrupt, and becoming candidates for hostile take-overs. To avoid the worst results, large utilities have to reinvent themselves and reorient their focus to more lucrative business areas. The successive reorganization waves put tremendous pressure on utility employees, who are continuously at risk of losing their jobs. In view of the possibility that they would be laid off, many utility respondents gave me their private contact data so that I could reach them with further questions. Despite these serious threats, some of these respondents see an opportunity in the fact that conventional power is needed to compensate for wind and solar intermittencies, as long as economically viable solutions for large-scale power storage remain out of reach. They hope that the government will implement rules that allow large conventional utilities to market their megawatts of standby capacity (capacity market) in addition to the few megawatt-hours they can sell at very low prices on the wholesale commodity market. These respondents see additional opportunities in nationalizing the conventional energy supply, as it provides a public service.

The renewable arms of large utilities are better off than associated businesses from the conventional realm. However, they are also plagued by successive reorganization waves and thus also at risk of losing their positions (especially in higher hierarchy levels). These companies have to compete with smaller, less hierarchical, and more flexible organizations. Not only do they have to switch their focus from energy generation to energy services, but they also have to invent new products that cannot be offered by smaller companies if they want to remain competitive. For example, RE arms of larger utilities can benefit from their knowledge and practical experience with operating distribution grids, managing balancing circles, and interchanging scheduled energy, to bundle the renewable power generated in their assets into virtual power plants able to securely deliver base-load energy.[409] In this context, some of the respondents perceive the know-how that still exists in such companies as opportunity. Yet marketing marketing energy-related know-how is not enough to survive in a very competitive market. Besides using their energy related know-how, these companies have to offer their customers various non-energy-related and mostly IT-based products and services. This means not only that utility employees have to be flexible enough to acquire new skills, but also that they enter a realm in which internet companies are better qualified. In the market for new products like smart home, smart metering, smart technology, smart

[409] Therefore utilities have to internally level their assets' intermittencies.

country, and smart grids, utilities compete with Google, Yahoo, Telecom, and other big IT companies. This makes some of the interviewees skeptical about venturing into new internet-based products. Table 43 shows a sample of responses from utility managers asked to identify *Energiewende* risks and opportunities for their companies.

Table 43– Risks and Opportunities as Perceived in the Utility Industry
Responses to Question Category 2: *Risks/Opportunities?* Sub-Category: *Own Company*.

| RISKS OPPORTUNITIES | Can you identify risks and/or opportunities related to the *Energiewende* for your company? (Appendix A, # 14.1) |
|---|---|
| Respondent/Sector | Selected Answers |
| R1 Utility Sector | "The worst-case scenario is insolvency, or unfriendly takeover, followed by divestment. A chance would be to become at first part of a capacity market, and to be finally nationalized in order to provide the public service of securing the electricity supply. Conventional power is needed to back decentralized and volatile RE generation." |
| R2 Utility Sector | "The corporate landscape will dramatically change in the energy sector. "Old" utilities, which already reorganized their businesses for more than one year (e.g., splitting Eon, and RWE activities), will have to refocus on new products. Companies will increasingly reorient their energy business from energy-generation to sales of products and services. This won't be possible without coupling energy services with new non-energy-related "side products," as for example my employer's "fresh energy." I am personally very skeptical about internet-based power-meters, but it seems that the business won't work without such ideas. Markets will become more diversified, while companies that operate in these markets become smaller." |
| R3 Utility Sector | "The *Energiewende* has led and will further lead to massive reorganization waves. The still existing know-how could be seen as opportunity." |
| R4 Utility Sector | "Gas-fired power plants were once conceived to match the demand during peak hours, at noon. But meanwhile, on sunny days, photovoltaic sites feed their power into the grid at noon, and power plants can no longer be economically operated. Owners plan to decommission their uneconomic gas facilities, but they are forced by law to keep them in stand-by mode. Under these conditions, my company cannot function in an economic way. Perhaps it makes more sense to nationalize Germany's energy supply." |

Communal utilities – *Stadtwerke* – were considered winners of the decentralization process. Ninety-seven of all renewable-energy facilities are connected to their grids (VKU, 2017). They deployed decentralized RE facilities and received, over years, generous FITs for each generated kilowatt-hour. However, in the wake of Schröder's *Nuclear Consensus,* many *Stadtwerke* invested not only in small decentralized RE projects, but also in CHP projects and even in large and modern conventional power plants and RE parks, often joining capital-intensive ventures with large utilities.

GEKKO, a € 2.5 billion hard-coal project[410] of 1,530 MW located in Hamm, was such an example. The project was initiated in 2008 by RWE, one of the largest German utilities, in cooperation with 23 *Stadtwerke.* These *Stadtwerke* invested in a so-called "power plant slice," acquiring 23% of the project shares in order to have direct access to "cheap" power. Chancellor Merkel said at the project's cornerstone-laying ceremony, in August 2008:

> I am convinced that innovation and investment in the future will pay off in the next years and decades, because energy policy is a long-term-oriented policy. Here, a reliable energy supply is guaranteed over a very, very long period of time.

Despite this promising start, the project's results proved to be catastrophic for all joint-venture partners. Not only were the final investments higher than initially planned, but when the first bloc entered in operation (with a delay of about two years), power prices at the wholesale market were so low[411] that the power plant couldn't be operated in an economic way, causing millions in losses for *Stadtwerke*.[412]

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[410] The innitial investment was estimated at €1.4 billion.

[411] The *Energiewende* and the intensive deployment of renewable energies led to an extreme drop in price.

[412] *Stadtwerke* committed to buy power from the Gekko project at resulting costs that were much higher than the wholesale market prices.

The *Energiewende* similarly impacted many other investments in modern conventional-power-plant assets, including modern CHP projects and gas-fired power plants, putting not only large utility companies, but also many communal ones, in difficult financial situations. A study[413] by the Institute for the Public Sector published in 2016 found that 47 of 93 *Stadtwerke*, and 23 of the cities in which these utilities are located, were on the brink of bankruptcy, primarily due to such stranded investments (Holler et al., 2016).

The majority of my respondents from the manufacturing sector represented energy-intensive industries. To maintain Germany's economic wealth, the government shielded these industries to a large extent from paying EEG and other *Energiewende* contributions. However, these exemptions were considered by the European Commission to be disallowed state aid, because they create competitive advantages for German industries in comparison with industries located in other member states of the European Union. To date, Germany has succeeded in extending these exemptions and protecting its industries, but it becomes increasingly difficult to do this due to continued EC objections.

Respondents representing energy-intensive industries indicated that an end of the controversial exemption state for their companies would generate tremendous competition problems for these industries. They claimed that larger, multi-national groups would leave the country, while smaller manufacturers would struggle for their existence and eventually close their sites.

Table 44 shows a sample of responses from manufacturing-sector managers asked to identify *Energiewende* risks and opportunities for their companies.

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413 The study analyzed the financial situation of the 100 largest German cities and of 93 *Stadtwerke* (not each of the cities hosts its own communal utilities).

Table 44– Risks and Opportunities as Perceived in the Manufacturing Industry (1)
Responses to Question Category 2: *Risks/Opportunities?* Sub-Category: *Own Company*.

| RISKS OPPORTUNITIES | | Can you identify risks and/or opportunities related to the *Energiewende* for your company? (Appendix A, # 14.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R8 | Manufacturing Sector | "As an energy-intensive manufacturer, we depend on competitive energy prices. If we do not have them, we cannot produce in Germany. Our energy prices are currently competitive, but this is so only because we are largely exempted from paying contributions for the *Energiewende*. We are thus extremely dependent on industry-friendly regulations. The erratic behavior of German policy-makers is not encouraging us to invest in Germany." |
| R9 | Manufacturing Sector | "Risks would be the exorbitant increase in energy costs and the loss of supply security. The occurrence probability is low." |
| R12 | Manufacturing Sector | "Energy-intensive industries, and thus also our company, are literally hanging on 'a silk thread.' Without being exempted from *Energiewende* burdens, we couldn't exist. [...] There is no *Energiewende* benefit for manufacturers like us." |
| R15 | Manufacturing Sector | "Higher energy costs; energy- and carbon-intensive industries might move their sites from Germany; higher administrative costs." |
| R16 | Manufacturing Sector | "I perceive wind and sun intermittencies and delays in implementing the grid-expansion plan as risks for the stability of power grids. Other risks are the relocation decommissioning costs for nuclear and conventional power plants in the form of taxes, and our dependence on coal as the last major source of fossil energy." |
| R17 | Manufacturing Sector | "Since our manufacturing process is not highly energy-intensive, our company is less affected by the *Energiewende*. However, energy-intensive industries will disappear from Germany. This might help to reduce domestic carbon emissions, but not necessarily also to solve global climate problems." |
| R18 | Manufacturing Sector | "Risks: The loss of the disputed 'exemption status' for energy-intensive manufacturers would lead to a short-term relocation of significant production parts. Opportunities: green hydrogen and flexible consumption." |

Some participants in this study, mostly those who benefitted from the complex transition process, considered that the *Energiewende* would positively impact their companies. Two examples can be seen in Table 45.

Table 45– Risks and Opportunities as Perceived in the Manufacturing Industry (2)
Responses to Question Category 2: *Risks/Opportunities?* Sub-Category: *Own Company*.

| RISKS OPPORTUNITIES | | Can you identify risks and/or opportunities related to the *Energiewende* for your company? (Appendix A, # 14.1) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R27 | Industrial Association | "Since we represent the most efficient energy-conversion system--the combined heat and power generation (CHP)--the *Energiewende* opens opportunities for our members. CHP sees itself as a partner of RE. It uses, for the time being, mostly natural gas, but will increasingly use RE (such as biomethane and wind gas) in future." |
| R26 | RE Projects & Research | "A sound *Energiewende* primarily offers opportunities for my company, which develops renewable energy projects." |

**Category 7. Cost Distribution**

This category of questions asked about the distribution of *Energiewende* benefits and burdens among the different actors in the *Energiewende* arena. Most of the respondents perceived exemptions from paying *Energiewende* contributions as necessary, and the distribution of burdens among actors as reasonably fair. For example, one respondent from the manufacturing sector said:

> Each regulated system has advantages for some players and disadvantages for others, or … all regulations have parts of unfairness. The entire system is fair in a certain way. For example, Germany's energy-intensive industry would be destroyed if all players had to pay the same burden, and it wouldn't be fair that Germany lost its wealth and citizens lost their jobs. From my point of view, it very important that Germany protects certain industries from *Energiewende* burdens, in order to prevent

them from leaving the country. Talking of myself as a German citizen, I certainly have to pay more for *Energiewende* surcharges, but I do not have any problems with bearing these higher burdens, as long as I can work, and places such as my company exist. In contrast, my company would become bankrupt overnight if it had to pay the full EEG contribution.

Beyond perceiving the current mechanism of sharing *Energiewende* burdens as fair in principle, some respondents had doubts about the macro-economic benefits of Germany's energy transition. One utility representative said:

> Every citizen has benefits from a climate-friendly energy generation and should also contribute to its financial burden. Yet I doubt that the overall economic benefit is high. We actually had enough functioning, highly developed facilities for generating energy. Now we have new facilities and still have the previous ones, only they cannot be used as they should be. In essence, a madness and an incredible waste of resources. Abroad, people can only shake their puzzled heads.

Another utility representative argued that the cost-benefit distribution "has to be effective and viable" but not necessarily fair. "Policy makers will retouch the legislation" each time that manufacturers or citizens experience "significant disadvantages," claimed this interviewee, continuing his argument with a quote from Minister Gabriel,[414] who said, "If everybody is grumbling but nobody cries, we have a good solution."

One utility respondent perceived the cost-benefit distribution as being "neither fair nor reasonable." He claimed that it would be "stupid to define specific costs per kilowatt-hour, because prices need also a capacity component," and suggested that a broad societal

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[414] Mr. Sigmar Gabriel is currently Minister of Exterior and was at the time of the interview Minister of Ecomonic Affairs and Energy.

transition like the *Energiewende* "should be financed through taxes (maybe a CO2 tax) and not through increased power prices." Some participants from each category of respondents shared the view that a CO2 tax would probably be a more suitable instrument for achieving climate goals and avoiding inequities in the distribution of transition burdens.

Whether the sharing of burdens among the *Energiewende* actors is perceived as fair or not would be a matter of perspective, claimed a manufacturing representative. He considered the cost-benefit distribution as being:

> …unfair, from the normal citizen's view; adequate and appropriate from the point of view of the manufacturing sector; reasonably fair from a macroeconomic perspective; and bad from a microeconomic perspective, because of the distortion of competition … outside German borders.

An interviewee with stakes in wind and hydrogen technologies suggested that "old" burdens that are currently "carried along" by actors in the *Energiewende* arena should be made more transparent and more accountable, by transferring them into a "value fund" similar to that launched in 2008 for rescuing the German banks.[415] Considering the "old cost block" as a societal burden for "technological advancement, R&D, and market establishment measures," and financing these burdens from taxes, would simplify the intertwined "market design regulations" and allow a full market integration of low carbon technologies.

Finally, some respondents considered the cost-benefit distribution as "unfair" and argued that "exempting too many manufacturing branches from paying the EEG contribution" would "hamper innovation and the entire transition process."

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[415] To prevent the collapse of the entire financial system, Germany established in 2008 the Soffin fund, a bank-rescuing package financed from tax incomes. At its peak this fund distributed €29.4 billion in direct financial aid for German banks and additional €168 billion in guarantees for these institutions (Handelsblatt, 12/25/2015).

A sample of statements about this topic can be seen in Table 46.

Table 46 – Stakeholder Perceptions on the Distribution of Costs and Benefits Responses to Question Category 7: *Cost Distribution*.

| COST DISTRIBUTION | | Do you perceive the distribution of costs/benefits as fair? (Appendix A, # 4.4; 5; 27) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R2 | Utility Sector | "Not always. When this topic comes up, I always have to think of my neighbor, who cannot afford a solar PV system, because they do not have the financial means for the necessary investment. People living next to this neighbor have solar panels on their rooftop because they are wealthier and have adequate means. In other words, whoever is wealthy earns even more. This might be common practice in a market economy, but the *Energiewende* is a macroeconomic task, and everyone should benefit from it." |
| R5 | Utility Sector | "To a large extent, yes. However, in my opinion, the fairness of cost allocation is not an essential *Energiewende* problem. It just has to work and this applies to all realms." |
| R12 | Manufacturing Sector | "What is fair? The energy transition is a 'referendum.' As German citizens, we will have its full benefits. In consequence, the entire *Energiewende* project should be financed by the state, through tax payments. To put more burdens on Germany's manufacturing industry though a partial redistribution of the EEG burdens would be completely wrong and would only distort the competition." |
| R13 | Manufacturing Sector | "From my point of view, the cost-benefit distribution is purposefully determined by a democratically elected government and should therefore not be subjected to fairness considerations." |
| R27 | Industrial Association | "In my opinion, the cost-benefit distribution is broadly fair. Particular misallocations that resulted from inaccurate taxation of different energy sources should be corrected. An energy tax proportional to the specific CO2 emissions per kilowatt-hour caused by each energy source would be conceivable." |
| R28 | Policy Sector | "The *Energiewende* contradicts all principles of a market economy and leads to a systemic missallocation of financial resources. It uses command-economy tactics with a horrendous subsidy volume and an immense bureaucracy. Losers are consumers and businesses. The winners are the subsidy profitmakers, who have understood how to build up a powerful lobby using the deceitful slogan that the *Energiewende* would supposedly be a way to an environmentally friendly and sustainable energy policy." |

**Category 8. Required Changes**

The last category of questions asked about the changes to Germany's current energy and climate policy necessary to correct undesired developments and improve the chances of a successful transition to low-carbon technologies. Most interviewees shared the opinion of a respondent who said:

> A sound, holistic concept should be established. We need uniform European guidelines and regulations and no individual German policy.

Many respondents also agreed that one should "design ways of transition that use only cost-optimal techniques" and eliminate "failed developments."[416] For example, one manufacturing respondent argued:

> Renewable energies should be urgently made compliant with the principle social market economy that is valid for all other economy sectors. Above all, the subsidies for new photovoltaic facilities and … wind turbines should end. For the latter, first steps were already undertaken with the latest amendment of the EEG. Moreover, one should renounce the fight against the use of lignite and hard coal as long as the power demand cannot be covered by renewable energies and appropriate storage facilities do not exist. In addition, LNG (liquid natural gas) terminals should urgently be built to curb supply dependence on pipeline-bound natural gas.

However, some[417] considered the current "call for more market," and the idea that markets would be able to "fix" the *Energiewende* problems by stimulating actors to act in ways that lead to optimal results, as being major "political mistakes." For example, one respondent claimed that all major changes in the energy industry were induced through

[416] The "construction of underground transmission lines" was given as an example of a failed development.

[417] Mostly respondents with stakes in the renewable energy business.

"regulatory measures," that "not a single nuclear power plant or oil well" would have existed without "prior regulation," that the task of "maintaining a constant frequency" was imposed on grid operators through regulative intervention,[418] that the "strategic oil reserve is politically dictated," that all power technologies are fraught with "subsidies," and that policy makers are in charge now to design and implement appropriate rules and incentive schemes for directing energy systems towards low-carbon technologies. This participant argued that one could improve existing policies by:

> …implementing a new auctioning model that considers not only renewable technologies, but also the security of supply and the CO2 index as binding pricing-instruments for accepting a tender. This would motivate wind project developers to work together with experts in grid, storage, and power-plant technologies for making fairly priced power offers[419] that meet low emission standards, as well as energy reliability, stability, and security criteria.

Asked about the decisions he would make if he were minister of economic affairs and energy or chancellor, this respondent said:

> First, I would grant emission allowances for hydrogen technologies, according to their GHG reduction potential. Then, I would advocate in Brussels for a real sector coupling that uses the grid infrastructure to direct the excess power towards the mobility sector and would also allocate therefore emission allowances, corresponding to the realized GHG emission reduction. In addition, I would start a cross-border

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[418] Before, each power plant operator had to fulfill this task.

[419] Besides wind parks, such offers would also include balancing energy based, for example, on hydrogen, as well as modern gas turbines able to flexibly adjust their generation and deliver back-up power in periods of low wind availability.

> renewable-energy concept for Europe that allows, for example, to build wind turbines in Romania or Spain and to transfer this energy to Germany, by paying German prices for it. As previously stated, I would also adjust the auctioning system to allow a proper comparison between different sources of energy.

Another aspect addressed by many participants is that policy makers should implement measures that encourage actors to save energy and reduce their energy consumption. Therefore, all manufacturing and energy-generation processes should be optimized using efficiency criteria. One former government member said:

> Energy policy can only be effective if it succeeds in making energy extraction, generation, transmission, and consumption as efficient as possible. In other words, energy systems are then efficient when their costs and their benefits are in a reasonable rapport with one another.

While some respondents suggested that one should reduce the pace of change, one respondent from the research realm claimed that to limit the increase of global temperatures to 1.5 C,[420] one should achieve carbon neutrality by 2040 and not, as currently planned, by 2050. This respondent suggested that one could therefore implement a cross-sector climate-protection law with built-in adjustment mechanisms. The energy sources one does not intend to use in future (coal, oil, and natural gas) should be made more expensive to make RE power economically attractive.

More opinions on required changes in Germany's energy and climate policy can be seen in Table 47.

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[420] According to the climate goal of the Paris Protocol, 2015.

Table 47 –Opinions on Required Changes in the Current Energy and Climate Policy Responses to Question Category 8: *Required Changes*.

| Required Changes | | What should be changed in Germany's energy and climate policy? (Appendix A, # 15) |
|---|---|---|
| Respondent/Sector | | Selected Answers |
| R1 | Utility Sector | "The policy is continuosly in discussion and adapted to the current situation. It could be good to make more well-grounded and less election-oriented, ex-ante considerations, before changing the policy too quickly." |
| R2 | Utility Sector | "Away from regulatory actionism to a more market-oriented policy. The oil crisis in the early seventies with its peaking 'energy costs' … has led to a different view on energy consumption, without any need for political frameworks. The market has practically regulated the problems on its own." |
| R3 | Utility Sector | "One should be more honest with respect to the transition costs. Do local efforts in Germany benefit the global climate? One should put again more emphasis on saving energy. Individuals should be aware that everyone could do more than collecting paper and bottles. They could stop their cars and use their bikes instead of criticizing energy providers for burning coal." |
| R8 | Manufacturing Sector | "More realism and pragmatism instead of idealism." |
| R9 | Manufacturing Sector | "Since Germany depends on the development of external conditions, a fall-back position should be worked out." |
| R16 | Manufacturing Sector | "Further development of fuel cells, because there is no more environmentally friendly process than the combustion of hydrogen to water. Excess wind power could be used for hydrogen production in electrolysis processes." |
| R18 | Manufacturing Sector | "Strict synchronization of RE deployment, network expansion, storage, back-up power, and flexible consumption. Consistent European market mechanisms (e.g., while tenders for offshore wind were accepted at 190 €/MWh in Germany, auctions in Denmark were concluded only at 50 €/MWh)." |
| R23 | Research Institutions | "I believe that a well conceived energy tax would bring more than any detailed regulation. … It will always be difficult to completely avoid unintended consequences and uneven distribution of burdens. The influence of lobbyists should be restricted, and effectively 'democratized,' by making it transparent for the public." |

# CHAPTER 9

## LESSONS FROM GERMANY'S ENERGY EXPERIMENT

Most of the big problems modern societies are confronted with—and climate change is no exception—are "wicked," of daunting complexity, and difficult to grasp. Political leaders who are asked to find the way out of the dire situation in which humanity maneuvered itself by depleting its resources, polluting soil, water, and air, emitting greenhouse gases, and accumulating human-made artifacts on the Earth's surface rely on "clumsy solutions" that reflect and partially satisfy multiple political perspectives (Rayner, 2012). In addition, they have to deal with "uncomfortable knowledge" that reminds them that the solutions they suggest are, in fact, inappropriate to solve the problems at stake (Rayner, 2012).

Regardless of their party-affiliation, Germany's political leaders have, since the 1990s, considered anthropogenic climate change to be a major topic on their agendas. As noted at the beginning of this work, the overarching goal of the *Energiewende* is to reduce Germany's greenhouse gas emissions until 2050 by 80-95% from their 1990 levels, without relying on nuclear power, while maintaining a secure and affordable energy supply.  To achieve this goal, Germany defined three major categories of climate actions: (1) increase the share of renewable energy in gross energy consumption; (2) implement an efficient cap-and-trade system for GHG emissions; and (3) increase energy efficiency. As described in Chapter 4, Germany also defined long-term and intermediate goals for each of these categories; adopted a plethora of rules, regulations, incentive-mechanisms, and tools; and steadily amended its legislation, in part to address unintended consequences of previous actions. To comply with

European targets for the transport, agriculture, and building-heating sectors[421] Germany complemented these political instruments with short-, mid-, and long-term climate action plans. Yet this variety of institutional arrangements, as Ostrom would call them, led to mixed results. While the successive EEGs with their generous incentive schemes succeeded in ramping up renewable energies in the electricity sector to levels that no one would have dared to imagine two and a half decades ago,[422] other sectors either lagged behind or developed in undesired directions.[423] The efficiency measures did not lead to the expected reduction in energy demand and the European cap-and-trade system has, to date, failed to set the right market signals for encouraging the deployment of low-carbon technologies.

Despite these mixed results, the *Energiewende* enjoys overwhelming support across all categories of actors, and this is probably one of its major strengths. The intense discussions with *Energiewende* experts who participated in this study (Chapter 8) revealed that even categories of actors who were severely affected by the *Energiewende* rules and regulations, to the point of being at risk of losing their jobs,[424] often have an astonishing confidence in this experiment's success.

As many of the examples in Chapter 6 show, Germany's energy systems and the continuously changing and adapting *Energiewende* processes co-evolved with energy,

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[421] European climate mitigation goals are less ambitious than German ones. However, after the Climate Conference in Paris in 2015, member states of the European Union agreed on binding decarbonization objectives for the sectors not included in Germany's energy concept (i.e., transport, agriculture, building heating).

[422] About one-third (32.6%) of Germany's gross final electricity consumption (600 TWh) in 2015 was covered by RE sources. Being a net exporter, Germany generates more power than it consumes (651.8 TWh in 2015). The German gross electricity generation approximately corresponds to the cumulative power production of Texas and Florida (TX+FL2014: 668.6 TWh). These two US states generated in 2014 roughly a fifth of Germany's RE production 2015 (47.8 TWh).

[423] E.g., the carbon dioxide emissions in the transport sector exceed the 1990 levels.

[424] As, for example, managers from the conventional arms of large utility companies.

economic, and demographic crises; with the proliferation of weapons and disarmament initiatives; with the collapse of entire political systems following the end of the Cold War; with globalization and the high levels of economic entanglements among the world's nations; with the increasing levels of airborne pollutants and greenhouse gas emissions in the atmosphere; with changing perceptions, norms, values, and attributes of the community, reaching degrees of complexity similar to those of natural systems.[425] At this level of complexity, transformative processes that result from interactions with natural, social, and technological elements might become too complex to be perceived, let alone understood, managed, or redirected to more desirable outcomes.[426]

The multitude of unexpected and undesirable consequences that have emerged in the *Energiewende* arena have been exacerbated by Germany's tendency to change many variables in the large and complex energy system *at the same time*. Despite the government's best intentions and efforts to steer Germany to independence from fossil fuels, with political leaders doing exactly what the public has asked them to do, the *Energiewende* has generated system dynamics that jeopardize the achievement of transition goals.

The vision of a carbon-free future is rooted in the early 1970s and 1980s, a time in which Germany's leading politicians tried to reduce the nation's dependence on oil and diversify the power mix.  Considering nuclear power as a means to societal wealth, all political parties involved in successive government coalitions[427] implemented extensive energy programs and complemented the existing power-plant pool with new, modern, nuclear facilities. Yet a growing segment of Germany's civil society had misgivings about

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[425] Or, the state of Level III Technologies (Allenby and Sarewitz, 2011, pp. 63-85).

[426] Compare Allenby and Sarewitz, 2011, p.64.

[427] SPD, FDP, CDU, CSU.

nuclear power and protested against its implementation. Major nuclear accidents at Three Mile Island, Chernobyl, and Fukushima triggered anti-nuclear protests, eventually reversing perceptions about the benefits of nuclear power. On the political level, the ambivalence about the benefits and of nuclear power were reflected in the back and forth of the nuclear phase-out decision. For example, chancellor Merkel declared in June 2011:

> As much as I campaigned for extending the life-span of German nuclear power plants in the context of our energy concept, last fall, so unmistakably I state before this House: Fukushima has changed my attitude towards nuclear energy (Deutsche Bundesregierung, 2011).

With nuclear power no longer a part of Germany's future, the nation rushed with its entire being into the renewable promise.

Government coalitions, irrespective of their political orientations, had, since 2000, adopted one renewable-energy act after another, creating favorable terrain for the intensive deployment of renewable energies with generous incentive mechanisms and privileged grid-access rules. With 104 GW of installed capacity in 2016 (which is more than the conventional power capacity), renewable energies could alone meet Germany's demand-peak of about 84 GW if they were always available[428]. But renewable energy sources, at least the most abundant ones (wind and solar), have strongly intermittent patterns, and their availability is limited during the winter season, when demand tends to peak. Moreover, despite all progress made in battery research, there is currently no technology that can store power on a large scale and level intermittencies in systems with a large share of wind and solar power. A transition to a truly renewable economy can succeed only if there is a

[428] Data from (BMWi, 2017 b, Table 4).

breakthrough in power-storage technologies. Germany, in its willingness to shift to renewables, focused on building wind and solar facilities across and beyond its territory, but didn't develop its girds accordingly. Yet grids are vital infrastructure for energy transitions, and existing grids were not conceived for transmitting huge amounts of wind power from the nation's windy North to the consumer-intensive South. In addition, the citizens who embraced the *Energiewende* and succeeded in changing, with their protests, the future of nuclear power in Germany discovered that they did not want very-high-voltage power-lines in the proximity of their homes and hindered the grid development plans.

The successive EEGs also led to a drastic decay of power prices on the wholesale market, pushing power plants based on fuels with relatively low carbon-content (e.g., natural gas, and oil, which have lower carbon content than hard coal or lignite) out of the merit order curve. Thus new, modern, flexible, and highly efficient gas power plants[429] had to be phased-out, because their marginal power-generation costs became too high, while coal power plants had to deliver the strongly fluctuating "rest power,"[430] although they were not designed for and cannot be operated in an intermittent regime. This led to a chain of undesired consequences like price distortions, exploding costs, grid bottlenecks and stability problems, forced exports, and negative electricity prices. While trying to fix imperfect stipulations of previous versions of the EEG, each new EEG became increasingly complicated, offering some actors opportunities to make short-term profits on the back of other, less privileged or savvy ones.

Irrespective of their political divides, generations of German policy-makers stood united behind the promise that the nation's transition to renewable energies would be

[429] For example, Irsching, near Munich.

[430] I.e., the difference between the power demand and the intermittent RE generation.

affordable. Incentives for renewable energy, to be paid by power consumers, would cost the average German household no more than "one scoop of ice cream" per month, said Jürgen Trittin[431] in 2004, when the EEG contribution was at 0.58 ct/kWh. In 2011 Chancellor Merkel said:

> German businesses as well as citizens ought to continue to be supplied also in future with affordable electricity. That's why we want to speed up the market competitiveness of renewable energies and make them more efficient. The EEG contribution should not rise above its current level; today it is at about 3.5 cents per kilowatt-hour. In the long run, we want to significantly reduce the costs of incentivizing renewable power (Deutsche Bundesregierung, 2011).

To interrupt the continuous upward trend of EEG costs and contributions, the government amended the EEGs. On March 5, 2012, many prominent political leaders[432] attended a mass protest against the plans of Merkel's second coalition government to reduce the EEG feed-in tariffs for solar power. At this event, Sigmar Gabriel, chairman of SPD,[433] called Germany's renewable program a success story that "created more than 350,000 long-lasting jobs" (SPD, 2015). Yet Gabriel changed his rhetoric two years later. As Vice-Chancellor and Minister of Economy, he defended in front of the solar lobby Germany's decision to reduce the support for renewable energies, saying:

> The truth is that the *Energiewende* teeters on the brink of collapse;
>
> … we underestimated in all fields the complexity of the *Energiewende*;

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[431] The German Minister for the Environment during Schröder's red-green coalition governments, and representative of the Greens.

[432] Among them Sigmar Gabriel (SPD), Jürgen Trittin (The Greens), and Gregor Gysi (Die Linke).

[433] The largest opposition party during Merkel's CDU/CSU and FDP coalition government.

For almost all other European countries we are anyhow insane (SAT.1, 2014).

Despite political efforts and repeated affordability promises, the total incentive payments for renewable energies continued to rise, peaking at € 23.5 billion in 2016 (about two-thirds of the total *Energiewende* costs), and leading to an EEG contribution of 6.88 ct/kWh for 2017 (Netztransparenz, 2017). From 2000-2015, Germany spent roughly € 150 billion for its energy experiment.[434] A study of the Düsseldorf Institute for Competition Economics estimates that € 370 billion will additionally be incurred up to 2025 (Haucap, 2016, pp. 3-4).

However, although the *Energiewende* costs by far surpassed the initial estimates, Germany's economy is performing astonishingly well. This was only possible because the government largely protected the nation's energy-intensive industries from paying the EEG contribution[435] and other *Energiewende*-related charges.[436] Yet by shielding a portion of energy users from contributing to the nation's transition costs, the government increased the strain on less privileged actors,[437] who had to shoulder almost the entire *Energiewende* burden. As a

[434] In comparison, government expenditures ranged from Euro 244.4 billion in 2000 to 299.5 billion in 2015. This means that the additional burden for energy consumers was on the order of magnitude of about 3.4% of all government expenditures for the period 2000-2015.

[435] Although only 4% of the 45,253 industrial sites paid reduced EEG contributions, the power demand of these privileged industrial sites represented 39% of total industrial power consumption. In addition, about 15% of the total power consumed at industrial sites comes from in-house generation facilities and is completely exempted from paying the EEG contribution. This means that while 96% of all industrial sites, together with households and other small end-users, have to shoulder almost the entire EEG burden, this group together accounts for only 61% of total energy consumption.

[436] E.g., taxes on natural gas and electricity, surcharges for combined heat and power, grid access fees, etc.

[437] Households, craft, trades, services, and less privileged industries.

result, Germany, one of the world's most powerful economies, faced increasing energy-poverty issues.[438]

Moreover, the "visible" hand of the government that succeeded in saving the nation's economic power, failed to shield other players in the *Energiewende* arena from transition burdens. Inside the *Energiewende*, no other economic branch was harder hit by the successive waves of induced changes than the utility sector. Indeed, the rapid shift to renewables has fundamentally altered the traditional way of doing business in the utility sector, causing a huge drop in market share and big losses in earnings. From its past position as the backbone of the entire German economy, this sector now totters on the brink of dissolution. Although utilities have tried to reinvent themselves as providers of "smart" services, making desperate efforts to be acknowledged as players in the "big data" market, it seems rather unlikely that they will be able to survive without federal support.

While the transformative *Energiewende* wave towered above actors in the *Energiewende* arena, ready to crash down with its existential force,[439] Germany's overarching decarbonization goal got lost in the multitude of incentive mechanisms and competing subordinate goals. "We will find ways to meet our 40 percent target by 2020.[440] I promise you that," said Chancellor Merkel,[441] responding to a citizen's question in a TV debate,

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438 For example, in 2014, German utilities sent 6.3 million dunning letters for delayed payments and eventually disconnected 351,802 households from the electricity grid for not being able to pay their electricity bills (Handelsblatt, 15th November, 2015).

439 This section paraphrases notes of Allenby and Sarewitz on Level III technologies. They wrote: "… at this level technology is not just a complicated network that is bothersome in its inability to behave as we would prefer it to […]; rather, it is a transformative wave that towers above us, ready to crash down—not just an organizational or political or cultural force, but an existential force" (2011, p.64).

440 As described in Chapter 4, the 40% refer to Germany's intermediate decarbonization target for the year 2020 (basis 1990).

441 Merkel made this statement despite scientific evidence showing that Germany would be far away from achieving its decarbonization target by 2020. A study of Agora Energiewende, published prior to the TV

during the election campaign of 2017 (ZdF, 2017). Less than a month after Merkel's promise, the Minister for the Environment, Barbara Hendricks, officially announced that Germany would miss its climate goals for 2020[442] (Klimaretter.Info, 2017). Only few months later, in January 2018, the next wave of catastrophic news inundated the press. During their negotiations for the Grand Coalition, CDU and SPD not only abandoned Germany's 40% carbon mitigation objective, but also announced that the nation will not meet the European climate goals. "We will not be able to achieve the climate goals set by the EU for transport, buildings, and agriculture for 2020 …" said Nikolai Fichtner, the spokesman for the Federal Ministry for the Environment. He continued, "We are therefore preparing to buy emission rights from other Member States, which will have surpluses in the next few years".

Thus, while Germany celebrated the resounding successes of renewable deployment in the electricity realm, the goals for reducing the carbon emissions of other economic sectors (transport, heat, agriculture) fell into oblivion, and the overall GHG emissions refused to decrease, as they should have according to official projections.

Despite the best intentions at all levels of government, and broad citizen support from the bottom up, the *Energiewende* has not produced the intended results. Even Germany's decision to sacrifice a major industrial branch (i.e., utilities) for a greater good has been

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debate, indicated that Germany would miss its objectives by about 10% (i.e., would reduce its carbon emissions only by 30% instead of 40% by 2020 (basis 1990)) if it did not change its policy course (2017).

[442] On September 7, when Agora Energiewende published its study (see footnote 20), the Ministry for the Environment (BMUB) distanced itself from these results. "We do not share the extremely negative assessment of Agora Energiewende," the speaker of BMUB said (Süddeutsche Zeitung, 2017). After the elections of 2017, Hendricks revised this statement, blaming Merkel for the failed climate policy (Klimaretter.Info, 2017). Despite not being official before October 11, 2017, this information was not surprising, because the monitoring reports on the *Energiewende* progress (BMWi, 2015b; BMWi, 2016c), studies (SRU,2017a; SRU,2017b; Agora Energiewende, 2017), and several opinion pieces on this topic (Kemfert, 2018; Gawel, 2018; Fischedick, 2018; Bettzüge, 2018; Matthes, 2018; Kuhlmann, 2018) indicated that Germany's climate goals cannot be achieved without drastic changes in the political course.

insufficient to achieve its ambitious decarbonization goal. In short, the collective will to change and willingness to make sacrifices to achieve change are not, even together, enough to ensure successful outcomes in the face of sociotechnical system complexity.

### Patterns of error

The mistakes that prevented Germany from achieving its ambitious decarbonization targets can grouped in four categories: (1) the combination of best intentions, technical ignorance, and rapid change; (2) lack of coherence in the overall plan and use of inappropriate means to achieve goals; (3) distorted information policy and manufacturing a broad societal consent; and (4) the seduction of power and the desire to maintain influence.

#### Best Intentions, Technical Ignorance, and Rapid Change

The policy makers' best intentions and their ardent desire to successfully steer Germany's energy systems to low-carbon technologies, combined with technical ignorance, unquestioned confidence in technological fixes, and arrogance, are the source of these mistakes. This combination led to ideologically driven, "head through the wall" policies, and to irreversible losses in knowledge and power-plant infrastructure. In the rush to please their constituencies, decision makers ramped up renewables without developing the grids accordingly. To achieve goals faster, policy makers simultaneously modified a tremendous number of variables, and implemented a vast array of rules and regulations without being able to coordinate them (which is called "harmonization" in Europe). The daunting complexity that resulted from the overlapping and conflicting political tools that sprang up like "mushrooms after the rain" made it increasingly difficult to even understand the legislation in place, let alone to comply with it. For example, the EEG 2000 was simple. It had only a few pages and defined the important rules for incentivizing RE. Everyone could read and understand what was written in it.  Later EEGs have hundreds of pages and are extremely difficult to comprehend. To understand their stipulations and comply with them, actors have to be aware of intermediate amendments resulting from new and unrelated article-laws, and follow the trails of a multitude of cross-references to information embedded in acts, ordinances, directives, and working papers.[443] The situation is even more complex with the energy economy act (EnWG).

While crafting rules, and then even better ones, which fixed the imperfect versions that preceded them, and afterwards even more "fixes" for the loopholes that resulted from prior "fixes" in a continuous "act-react" dynamic, policy makers considered the "technological core" of large energy systems as negligible mass in the transition game, and assumed that the technological breakthroughs necessary for the transition (e.g., large-scale storage facilities) would fall from the sky just in time to ensure the success of Germany's bold experiment. Moreover, instead of making the intellectual effort of distinguishing between installed capacity and generated electrical work (energy),[444] in order to understand and solve the problems related to the intensive deployment of renewable energies, the government painted a rosy picture of Germany's *Energiewende*, celebrating its success and suggesting that it would be on track. This behavior is not just arrogant it is also irresponsible. It not only obscured the truth, it also led to an incoherent plan and a selection of instruments that were  inappropriate to direct the nation to a carbon-free future.

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443 E.g., to amendments, in different article-laws, ordinances that define the frame for the deployment of RE, and other acts, working papers, directives, or ordinances that interfere with the EEG act (e.g. KWKG, EnWG, FW 308

444 This distinction is particularly significant in the case of intermittent sources of power, because it directly impacts the interpretation of the *Energiewende* outcomes.

**Lack of Coherence and Inappropriate Selection of Means**

Ignoring the fact that renewable energies were only a means to achieve the nation's decarbonization goals and not a substitute for its ambitious carbon-mitigation targets, the government defined their deployment as a goal in its own right, and it did the same with other *Energiewende* instruments.[445] As one participant in this study claimed, "No politician of sound mind would ever confuse goals with means to achieve goals," but Merkel's government managed to make this "cardinal mistake," and consequently, "goals and means got mixed-up in a weird patchwork."[446] The multitude of competing *Energiewende* goals not only became autonomous, exacerbating the complexity of Germany's energy transition, but also blurred its outcomes. Is the *Energiewende* a success because the share of renewable energy in Germany's gross electricity generation exceeded by far its targets, or is it a flop because it did not succeed in meeting its carbon-mitigation targets or in keeping its affordability promise? What should Germany pursue first? How should it proceed, when its efforts to meet one goal retard or even prevent the achievement of other goals? And what should be the measure for a successful transition?

Whether supporters or opponents of Germany's *Energiewende,* most participants in this study considered the lack of a coherent action plan and the escalating transition costs as major weaknesses of Germany's energy transition. Yet it is not possible to implement a sound action plan without finding answers to the questions listed above, without distinguishing between goals and means to achieve the goals, and without eliminating diverging definitions of success. Moreover, the dissonance between study participants'

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445 E.g., defining goals for combined heat-and-power generation, for measures meant to increase energy efficiency in different economic sectors, and for denuclearizing Germany's energy generation.

446 Compare Chapter 8, p. 207.

overwhelming support for the *Energiewende* and their extremely critical views of the way this experiment unfolded is rooted, to a large extent, in diverging definitions of success.

To direct the nation towards a more sustainable future, Germany's policy makers applied command-economy tactics, and massively intervened in the development of markets. These interventions resulted in a huge subsidy economy and exploding transition costs. This does not mean that there is no need for "rules of the game" in a society, nor that there was no progress at all during the different phases of change. But even if assertions about what might have happened are alwaysspeculative, because there is no empirical evidence about how systems would have evolved with a different set of rules, one can reasonably assume that selection of well-coordinated instruments would have avoided more GHG emissions and limited the transition costs.

For example, without the European Emission Trading System (ETS), RWE, the utility group with the highest carbon emissions in Europe, would have decommissioned its older and inefficient lignite and coal power plants, and this would have led to a significant reduction in CO2 emissions. RWE already planned to do this in the late 1990s. In that period of time, the company took a "multi-utility approach," seeking to cooperate with large consumers (with huge heat sinks) in order to switch to natural gas and build highly efficient CHP facilities based on gas turbines. It is a major political failure that this did not happen.

Later, when conventional power-plant assets became uneconomic due to falling energy prices on the wholesale market, and utilities applied to phase-out these power plants, decommissioning permits were restricted to facilities that were irrelevant to the stability of the grid. So called "system-relevant" power plants were obliged (despite their high carbon emissions) to continue operation, deliver grid back-up capacity, balance intermittencies, and compensate for the lack of large-scale storage facilities. The resulting carbon emissions could have been avoided if the deployment of RE had been coordinated with grid development plans, technology advancements in the storage realm, and the phase-out of nuclear power.

A carbon tax would have been without doubt much more effective in reducing carbon emissions than the market-compliant instrument ETS. Yet a carbon tax might have strained Germany's economy, and particularly its energy-intensive industries, more than the ETS, reducing the nation's GDP and its wealth. Even less market-intrusive climate-mitigation mechanisms, such as voluntary commitments to reduce carbon emissions (which were common during the late 1990s and early 2000s) have proven to be much more effective than a dysfunctional European cap-and-trade system.

Several examples of inappropriate selection of means can be found in the successive EEGs. The privileged access for renewable energies stipulated in these acts resulted in facilities located in places with low availability of renewable sources and, even worse, in places that superfluously strained the grids, increasing the transition burdens for all actors. More could have been achieved by focusing efforts where the resources were available. Instead of incentivizing RE using fixed feed-in-tariffs (FITs), Germany could have implemented a "quota-model," obliging suppliers to have a certain amount of RE power in their portfolios (10%, 20%, 30%). Power suppliers would have had simple incentives to acquire cost-efficient RE, facility owners would have had incentives to build their plants where resources are available, facility locations wouldn't have put such a burden on grids and consumers, fewer additional grid kilometers would have been necessary, fewer re-dispatching costs and forced exports would have occurred, etc. If part of the money that was spent had been directed to electricity storage research, the deployment of RE had been coordinated with the grid-extension plans, and technology had advanced in the storage realm, Germany would have had a less costly and more efficient transition process. If there had been no confusion between decarbonizing Germany's economy and deploying RE in the power sector, the other sectors would have been included in the program instead of falling into oblivion. If the goals and the means to achieve the goals had been properly separated, the dynamics in the RE sector wouldn't have gotten out of control.

**Distorted Information Policy and Manufacturing a Broad Societal Consent**

The government and public media have the duty to properly inform the people about *Energiewende* processes and costs, policies, alternative technologies and transition pathways, and the risks and opportunities of alternative decarbonization pathways. Yet Germany's distorted and unilateral information policy created the impression that all required solutions for the problem at stake (i.e., climate change) already existed. By deliberately omitting from the public discourse the problems related to the intensive deployment of renewable energies, policy makers succeeded in gaining broad societal support for the *Energiewende* and manufacturing consensus about the feasibility and affordability of energy transitions. While obscuring the facts, the government unwittingly committed the nation to an expensive "march of folly"[447] with unknown outcomes. There is no evidence that Germany's citizens would have changed their values, norms, and preferences if they had had access to undistorted information, but at least they could have made better-informed choices.

[447] Reference to Barbara Tuchman's book *The March of Folly: From Troy to Vietnam* (1984).

**The Seduction of Power, the Desire to Maintain Influence**

The various values and norms that motivate stakeholders to pursue societal change lead to behavioral patterns that do not necessarily comply with concepts of common interest or morality. Consequently, "near is my shirt, but nearer is my skin" attitudes towards political measures are no exception in the *Energiewende* arena. There are no categories of actors who are completely free from such attitudes. Commitments to certain ideologies, as well as self, party, group, or corporate interests motivate stakeholders to behave in ways that sometimes diverge from those generally attributed to their particular category of actors. Moreover, these profoundly human attitudes can negatively impact the outcomes of societal transitions even when there is a broad consensus about the need to steer our economies towards low-carbon technologies.

For example, the apparently unquenchable desire of political leaders to remain in power exceeded their commitment to making sound decisions and eventually led to Germany's nuclear twist—an example of "manufacturing consent"[448] that motivated the nation in a revolutionary mood to burn its bridges before realizing how helpful they would have been for reaching the desired goals.

The willingness of scientists to adjust their studies' assumptions until they fit the mandated outcomes is another case in point. Like the political leaders who abandoned nuclear energy, researchers adjusted their scientific approaches to preserve their power, their influence, and their privileged position in society.

The lightning pace of change favored nimble economic actors in search of regulatory loopholes, offering them numerous opportunities for "gaming the system" and taking "legal

[448] Reference to Hermann and Chomsky's book, *Manufacturing Consent: The Political Economy of the Mass Media* (1992).

free-rides" on the back of the commons. Such self-interested attitudes made it not only impossible for other actors, including policy makers, to anticipate and cope with the successive changes, but also resulted in increasing transition costs and heavier burdens for less-privileged societal members.

Finally, power games, reality denial, and fairytale thinking are common strategies[449] used by *Energiewende* actors to preserve their illusions by keeping "uncomfortable knowledge" at bay. These strategies were used not only by policy makers and ideologically driven masses, but sometimes also by the most knowledgeable segment of the population —the energy experts. However, despite being appropriate for coping with "clumsy solutions," these strategies distort the perception of successful transitions, creating parallel worlds in which harmonized goals, efforts, strategies, tools, and technologies lead to desired outcomes.

Societies have little experience in steering large and extremely complex systems in desired directions, and Germany's case shows that a participatory process, indeed a national political consensus, is not all it takes to overcome obstacles to system transformation.

**So what can we do?**

First, and most importantly, a nation must design its transition in light of what is technically possible. When Germany set targets and enacted laws for renewable energy deployment, it ignored the fact that storage technology did not, and still does not, exist at the necessary scale. It also glossed over the absolute necessity of investing in the grid infrastructure necessary to handle peak renewable generation, because German citizens objected to such development. These were the same citizens who both wanted a greener energy supply and pushed deployment forward by investing in decentralized solar energy

[449] According to Rayner, actors use denial, dismissal, diversion, and displacement as strategies to cope with "clumsy solutions" and "uncomfortable knowledge" (2012).

when they had the financial means to do so.  Good intentions and the will to change cannot make up for missing technology and infrastructure. A vision, however worthy, and even when it is broken down into small steps, is not alone sufficient to transform a complex socio-technical system.

Likewise, there is no point in setting targets that cannot possibly be reached. Instead of lofty ideals and plans that are successful in redistributing societal wealth without any climate benefit, it would be preferable to take climate change seriously and focus on mitigating carbon emissions.[450] Germany should adjust the nation's ambitious decarbonization targets to feasible ones and complement them with sound action plans. To do this, it is necessary to first recognize the conflict among desired societal goals (e.g., climate mitigation versus economic growth) and decide how to balance them. It is also necessary to be clear about the tensions among value preferences, available technologies, and *Energiewende* goals. For example about the fact that climate goals are harder to achieve without nuclear power, or that the intermittent availability of renewable energies induces problems that cannot be solved without technologies able to store power at a large scale and huge investments in the grids, etc. Finally, it is necessary to make a clear distinction between goals (i.e., the decarbonization of our economies) and the means to achieve these goals (e.g., deployment of renewable energies or combined heat-and-power technologies).

Germany needs to face the fact that the process of steering its large and complex energy systems in desired directions is costly and messy. Moreover, the "clumsy" solutions that result in this context are often more about satisfying political pluralism than making necessary but difficult choices. To avoid unmanageable complexities, the government should

[450] E.g, by implementing a functional emission trading system that restricts allocations of emission allowances, or by introducing a carbon tax.

reduce the pace of change and limit the number of variables that are simultaneously changed in its energy systems. This does not mean that humans can transform the large and complex socio-technical systems they have built into simple ones, nor that they can be liberated from continuously muddling through the complexities they have created. But there are several ways to approach energy transitions, and Germany could at least increase its systems' robustness and ability to adapt to climate change, by simplifying, harmonizing, and prioritizing rules and regulations so that they can be understood by all affected players, even those without a degree in energy legislation. Links between unrelated rules[451] that lead to more bureaucracy and even more complexity must be eliminated. Exemptions from rules should be critically revised and limited. Simpler, harmonized, and clearly prioritized rules are not only easier to understand, they also make it easier to identify causal chains that lead to unexpected consequences, and to correct undesired developments. Moreover, they automatically reduce the potential for legislative loopholes and opportunism incentives. Although it is not realistic to completely eliminate such loopholes, it is possible to reduce opportunistic gains and windfall profits by sanctioning unethical behaviors that are detrimental to the commons, even if they comply with the legislation in use (e.g., by holding "free riders" accountable for their behavior and imposing a retroactive reimbursement[452] of gains that place additional burdens on other societal members).

Policy makers and citizens must recognize that large-scale renewable energy transitions cannot succeed without technological breakthroughs in the power-storage realm,

[451] Uncouple, for example, the amount of energy taxes to be paid by an employer from his completely unrelated contribution to his employees' pensions.

[452] If any piece of legislation included a clause indicating that the act was conceived based on incomplete knowledge, and that the legislator reserved his right to ask for reimbursement of all gains resulting from legislation loopholes, independently of the moment in time when they were identified, perhaps the hurdle for unethical behavior would rise and legislative "grey areas" would lose their significance for "opportunistic gains."

nor without a grid infrastructure capable of transporting energy from generation sites to consumer ones. They have to understand that intensive renewable-energy deployment is neither equivalent nor sufficient to mitigate climate change. Thus, Germany must synchronize the deployment of renewable energies with grid-expansion plans and the development of appropriate storage solutions. Instead of continuing to incentivize renewable technologies that have already reached market maturity, the nation should encourage research in technological breakthroughs and reduce the hurdles to realizing power-storage projects.

Policy makers, scientists, energy experts, and public media must objectively inform the population about competing energy-supply alternatives and their consequences, without ignoring the state-of-the-art of our energy systems and the problems related to the intensive deployment of renewable technologies. Instead of spreading ideologies and distorting reality, public discussions should rather clarify key concepts[453] and objectively address problems related to energy transitions. Moreover, all categories of actors in the *Energiewende* arena should acknowledge the fact that the electricity sector is – despite its relevance – not alone responsible for greenhouse gas emissions. They need to recognize the merits of nuclear and fossil power, which are both necessary – despite their hazards, their pollution potential, or their carbon emissions – to secure the supply and stabilize the grids as long as there is no technology in place to store electricity at a large scale. Actors should also understand the importance of sustaining existing infrastructure and existing knowledge until reliable replacements can be fully deployed.

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[453] For example, the difference between installed capacity and actual energy generation.

To bridge the lack of storage technology, Germany should craft rules that encourage the use of low-carbon conventional power and highly efficient fossil processes. Inefficient fossil power plants should either optimize their operation or be phased-out. Moreover, policy makers need to find appropriate solutions for power plants that are system relevant, for example by introducing a capacity market, or by transferring system-relevant assets to the state, instead of forcing utilities to operate their power plants in an unprofitable way. Domestic and international efforts to mitigate carbon emissions must include all sectors. Yet decision makers must acknowledge the problems and the limitations of current sector-coupling concepts (e.g., the tremendous increase in power demand, the related grid requirements, and the huge transformation costs) and find solutions that limit the increase in power demand.

Germany should reduce its transition costs and eliminate most energy-related subsidies.[454] Given that the *Energiewende* costs are related to a large extent to the intensive deployment of renewable energies, policy makers should craft alternative deployment rules for these energies,[455] to fully integrate them into the energy markets,[456] and to restrict their privileged grid access.[457] They should also craft rules that protect less-wealthy members of German society from energy poverty.

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[454] For example, industrial CHP generation is efficient and highly economical. It always was, and it doesn't need additional financial support.

[455] For example, by replacing FITs with a quota model (that requires power suppliers to have a certain amount of RE in their portfolios). A quota model would save costs by incentivizing players to: (1) invest where resources are available, and (2) search for the most appropriate and least expensive technology for a certain region.

[456] First attempts have already been undertaken in this direction. The EEG 2017 tries to solve this problem by limiting the electricity capacity that can be built in a certain region, and by auctioning this capacity.

[457] To avoid plants being constructed without any consideration for grid bottlenecks, the facility owner should pay not only the direct connection costs, but also the costs generated by his facility in the grid. EEG 2017 tries

Finally, Germany should foster international cooperation and understand that local actions are necessary and laudable, but insufficient for solving global problems.

## Epilogue

I started this research project with the intention of finding out whether it is possible or not to steer large socio-technical systems in desired directions, to critically analyze Germany's energy transition process, to identify governance barriers, and to suggest ways for avoiding transition pathways that tend to put the achievement of decarbonization goals at risk. My primary focus was thus on the multitude of problems related to: Germany's accelerated nuclear phase-out, its rapid shift to renewable energies, the competing interests of actors in the *Energiewende* arena, the various *Energiewende* processes, and the complex, overlapping, and conflicting rules. The intention behind my critical stance is by no means to leave the reader with the impression that transitions towards low carbon technologies should not be pursued. On the contrary, they are – given the urgent need to find solutions to mitigate climate change – very important. But energy systems are complex amalgams of technologies, institutions, markets, regulations, cultural inclinations and social arrangements, and nations have little experience in successfully directing fundamental change in such complex socio-technological systems over specified periods of time. That is why the real-life experience with Germany's *Energiewnde* is - despite its exploding costs and its poor carbon-mitigation achievements – valuable. Alongside the multitude of transition problems listed above, the *Energiewende* remains a unique example of functional participatory democracy, demonstrating that organized citizens are powerful enough to turn political decisions around. The *Energiewende* also showed that power grids are much more resilient than they

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to solve this problem by defining regions open to the deployment of RE, and by limiting the capacity to be installed yearly.

were considered to be, and that they can be safely operated[458] with a renewable energy share of about one third of the nation's energy consumption. The amount of renewable power feed-in to the grids could probably even be increased up to 50% without a significant loss in grid and supply security. Moreover, Germany succeeded in phasing out 10 of 17 nuclear power plants without power blackouts, and will certainly succeed in decommissioning the facilities that are still in operation by 2022. This phase out may have compromised the climate-related goal of the nation's transition process, and it may not have protected German citizens from threats related to nuclear accidents, but it proved that a developed country is able to secure its energy supply without relying nuclear power. Despite the steadily increasing transition costs, Germany succeeded in preserving the nation's economic power and its wealth. Moreover, the transition burden is, from the perspective of most German citizens, reasonable and bearable, since they support the *Energiewende* and are willing to pay more for "clean" energy. At the moment it seems that Germany's bold plan got derailed, but given the daunting complexity of energy systems this shouldn't be really surprising and shouldn't interrupt the nation's effort to find better and less costly solution for energy transitions. The errors and correctives that I have drawn from my study of the *Energiewende* cannot, even if fully implemented, transform the problem of sociotechnical transition from wicked to tame, but they point toward the potential for a transition pathway that keeps the main goal of climate mitigation clearly in sight, even if it is pursued with a bit less exuberance, and a bit more humility.

[458] The number or required dispatching and reallocation interventions increased, but the grids could be operated safely and remained stable.

REFERENCES

4. BImSchV. (1975). *Vierte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über genehmigungsbedürftige Anlagen - 4. BImSchV)*. February 14, 1975 (BGBl. I S. 499 & 727). Revised on May 2, 2013 (BGBl. I S. 973 & 3756). Lastly amended May 31, 2017. (BGBl. I S. 1440 & 1441).

13. BImSchV. (1983). *Dreizehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes*. June 22, 1983 (BGBl. I S. 719). Revised on May 2, 2013 (BGBl. I S. 1021 & 1023). Lastly amended December, 19, 2017. (BGBl. I S. 4007).

17. BImSchV, 1990. *Siebzehnte Verordnung zur Durchführung des Bundes Immissionsschutzgesetzes (Verordnung über die Verbrennung und die Mitverbrennung von Abfällen)*. November 23, 1990 (BGBl. I S. 2545).

Abelshauser, W. (1983). *Wirtschaftsgeschichte der Bundesrepublik Deutschland. (1945–1980).* Suhrkamp, Frankfurt am Main 1983

Agora Energiewende (2017). *Deutschlands Klimaziel 2020 ist noch weiter weg als gedacht. Ohne kräftiges Gegensteuern reduziert die Bundesrepublik ihren Treibhausgas-Ausstoß bis 2020 nur um 30 statt um 40 Prozent. Die Handlungslücke beträgt 120 Millionen Tonnen CO2*. September 7, 2017.

Allenby, B. & Sarewitz, D. (2011). *The Techno-Human Condition.* Cambridge MS / London: MIT Press.

Althaus, M. (2012). Schnelle Energiewende bedroht durch Wutbürger und Umweltverbände? Protest, Beteiligung und politisches Risikopotenzialfür Großprojekte im Kraftwerk- und Netzausbau. *Wissenschaftliche Beiträge 2012*. TH Wildau.

Anderies, J. M. (1998). Culture and Human Agro-ecosystem Dynamic: the Tsembaga of New Guinea. *Journal of theoretische Biology*, pp. 515-530.

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society, 9*(1), S. 18.

Anderies, J. M. (2006). Robustness, institutions, and large-scale change in social-ecological systems: The Hohokam of the Phoenix Basin. *Journal of Institutional Economics*, pp. 133-155.

Arnold, T., Birkenmaier, D., & Rösler, A. (2017).Windenergie und öffentliche Planungsträger: Scheitern des Gegenstromprinzips in Horb am Neckar? *Erneuerbare Energien in der Raumplanung*, 38/2017, Eberhard Karls Universitaet Tübingen, pp. 16-27.

AtomG (1959). *Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren.* December 23, 1959 (BGBl. I S. 814).

AtomG (2010). *Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren.*

AtomG (2011) *Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren.*

Baake, R. et al. (2012), Agora Energiewende: 12 Insights on Germany's Energiewende, Berlin 2012

Baur, J. F., Salje, P., & Schmidt-Preuß, M. (Eds.). (2015). *Regulierung in der Energiewirtschaft: ein Praxishandbuch.* 2nd edition. Carl Heymanns Verlag.

BBC News. (1989, December 3). *1989: Malta summit ends Cold War.*

BDI – Bundesverband deutscher Industrie (2004). *Freiwillige Vereinbarungen und Selbstverpflichtungen. Bestandsaufnahme freiwilliger Selbstverpflichtungen und Vereinbarungen im Umweltschutz* (Stand: Dezember 2004)

bdew – Bundesverband Energie- und Wasserwirtschaft (2008). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2007 (auf Basis WP-Bescheinigungen).* Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2007.pdf

bdew – Bundesverband Energie- und Wasserwirtschaft (2009). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2008 (auf Basis WP-Bescheinigungen).* https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2008.pdf

bdew – Bundesverband Energie- und Wasserwirtschaft (2010). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2009 (auf Basis WP-Bescheinigungen).* https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2009.pdf

bdew– Bundesverband Energie- und Wasserwirtschaft (2016).

Benedick, Richard E. (2001). *Striking a New Deal on Climate Change, in Issues in Science and Technology*, available online: http://www.issues.org/18.1/benedick.html

Berger, P. L. and Luckmann, T. (1966). *The Social Construction of Reality. A Treatise in the Sociology of Knowledge.* New York, Doubleday Anchor Books

Bettzüge, M. O. (2018). Zuviel nationale Zuversicht? – Lehren aus der Zielverfehlung 2020 *ifo Schnelldienst.* 1/2018 of January 11, 2018

Bijker, W. E., Hughes, T., & Pinch, T. (1987). *The Social Construction of Technological Systems: new Directions in the Society and History of Technology*. Cambridge MS / London: MIT Press.

Bijker, W. E. (2001). Social construction of technology. In Smelser, N. J. and Baltes, P. B. (eds). *International Encyclopedia of the Social & Behavioral Sciences*. Vol. 23, pp. 15522–7

Bijker, W. E. (2010). How is technology made? - That is the question! *Cambridge Journal of Economics*. Vol. 34, pp. 63–76.

BImSchG. (1974). *Gesetz zum Schutz vor schädlichen Umwelteinwirkungendurch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG).* The Federal Pollution Control Act of March 15, 1974. (BGBl. I S. 721 & 1193).

BImSchG. (2002). *Gesetz zum Schutz vor schädlichen Umwelteinwirkungendurch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG).* The Federal Pollution Control Act of October 4, 2002. (BGBl. I S. 3831).

BImSchG. (2013) *Bekanntmachung der Neufassung des Bundes-Immissionsschutzgesetzes. Gesetz zum Schutz vor schädlichen Umwelteinwirkungendurch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG).* The Federal Pollution Control Act of May 27, 2013. (BGBl. I S. 1274).

BImSchG. (2017) *Gesetz zum Schutz vor schädlichen Umwelteinwirkungendurch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundes-Immissionsschutzgesetz – BImSchG)* The Federal Pollution Control Act of July 18, 2017. (BGBl. I S. 2771, 2773).

Block, F. L., & Keller, M. R. (2011). *State of innovation*. Paradigm Publishers.

BMJV–Bundesministeriums der Justiz und für Verbraucherschutz. (1949). *Grundgesetz für die Bundesrepublik Deutschland in der im Bundesgesetzblatt Teil III, Gliederungsnummer 100- 1, veröffentlichten bereinigten Fassung, das zuletzt durch Artikel 1 des Gesetzes vom 13. Juli 2017* (BGBl. I S. 2347) *geändert worden ist.*

BMU & KfW– Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit & Kreditanstalt für Wiederaufbau. (2003, June). *100.000 Dächer-Solarstrom-Programm kurz vor dem Ziel.* Pressemitteilung 108/03 of 23 June 2003

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. (2004, July). Jürgen Trittin: *The support for renewable energies cost an average household only 1 Euro per month – as much as a scoop of ice cream*. (BMU-Pressedienst No. 234/04, Berlin, 30 July 2004)

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. (2007a, August). *Startschuss für die zweite Handelsperiode des Emissionshandels. Zuteilungsgesetz 2012 tritt in Kraft* (BMU-Pressedienst No. 214/07, Berlin, 10 August 2007)

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. (2007b, December). *Das Integrierte Energie- und Klimaprogramm der Bundesregierung.*

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, (2011, September). *Selbstverpflichtungen (nicht mehr in Kraft).* www.bmub.bund.de/P1706/

BMU – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, (2012, April), *The transformation of our energy system is feasible and it pays off.* (BMU-Pressedienst No. 046/12, Berlin, 5 April 2012).

BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, (2014, December). *The German Government's Climate Action Programme 2020.* Cabinet decision of 3 December 2014.

BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, (2016, October). *Hendricks: Einigung von Kigali ist Meilenstein für den Klimaschutz.* (BMU-Pressemitteilung Nr. 249/16, Berlin, 15 Oktober 2016).

BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, (2016, November). *Klimaschutzplan 2050. Klimaschutzpolitische Grundsätze und Ziele der Bundesregierung.*

BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, (2016, November). *Climate Action Plan 2050. Principles and goals of the German government's climate policy. Executive Summary.*

BMWi – Bundesministerium für Wirtschaft und Technologie, Forum für Zukunftsenergien, Friedrich-Ebert-Stiftung. ( 2000a, June). *Leitlinien zur Energiepolitik. Schlussdokument – Energiedialog 2000.* Koschützke, A. Ed., Friedrich-Ebert-Stiftung, Berlin, 5. Juni 2000.

BMWi – Bundesministerium für Wirtschaft und Technologie . (2000b, June) *Vereinbarung zwischen der Bundesregierung und den Energieversorgungsunternehmen,* Berlin 14. Juni 2000/ Berlin 11. Juni 2001

BMWi – Bundesministerium für Wirtschaft und Technologie . (2000c, November). *Vereinbarung zwischen der Regierung der Bundesrepublik Deutschland und der deutschen Wirtschaft zur Klimavorsorge, 9. November 2000.*

BMWi & BMU– Bundesministerium für Wirtschaft und Technologie, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. (2010, September). *Energiekonzept für eine umweltschonende, zuverlässigeund bezahlbare Energieversorgung.*

BMWi – Bundesministerium für Wirtschaft und Technologie. (2011, November). *6th Energy Research Programme of the Federal Government. Research for an environmentally sound, reliable and affordable energy supply.*

BMWi – Bundesministerium für Wirtschaft und Energie. (2015a, November). *Die Energie der Zukunft. Vierter Monitoring-Bericht zur Energiewende.*

BMWi – Bundesministerium für Wirtschaft und Energie. (2015 b, November). *The Energy of the Future. Fourth "Energy Transition" Monitoring Report – Summary.*

BMWi - Bundesministerium für Wirtschaft und Energie, AGEE-Stat: Arbeitsgruppe Erneuerbare Energien Statistik. (2016 a, January). *Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland*

BMWi- Bundesministerium für Wirtschaft und Energie. (2016 b, April). *Zahlen und Fakten. Energiedaten Nationale und internationale Entwicklung.*

BMWi – Bundesministerium für Wirtschaft und Energie. (2016 c, December). *Die Energie der Zukunft. Fünfter Monitoring-Bericht zur Energiewende.*

BMWi – Bundesministerium für Wirtschaft und Energie. (2016 d, December). *The Energy of the Future. Fifth "Energy Transition" Monitoring Report.*

BMWi - Bundesministerium für Wirtschaft und Energie, AGEE-Stat: Arbeitsgruppe Erneuerbare Energien Statistik. (2017 a, February). *Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland*

BMWi - Bundesministerium für Wirtschaft und Energie. (2017 b, January). *Zahlen und Fakten. Energiedaten Nationale und internationale Entwicklung.*

BMWi - Bundesministerium für Wirtschaft und Energie. (2017 c, March). *Report of the Federal Government on Energy Research 2017. Research Funding for the Energy Transition.*

Bontrup, H. J. & Marquardt, R.M (2015). Die Zukunft der großen Energieversorger. Studie im Auftrag von Greenpeace. Hannover/Lüdinghausen, January 2015.

Borggrefe, F., & Nüßler, A. (2009). Auswirkungen fluktuierender Windverstromung auf Strommärkte und Übertragungsnetze. *UmweltWirtschaftsForum*, 17(4), 333-343.

Bosch S., Peyke G. (2011): Gegenwind für die Erneuerbaren – Räumliche Neuorientierung der Wind-, Solar- und Bioenergie vor dem Hintergrund einer verringerten Akzeptanz sowie zunehmender Flächennutzungskonflikte im ländlichen Raum. *Raumforschung und Raumordnung*, 69 (2), 105-118.

Bowker, G. C., & Star, S. L. (2000). *Sorting things out: Classification and its consequences* . The MIT Press.

Börse.de (2015 a). *Kurshistorie RWE St Aktie.* Retrievable from: https://www.boerse.de/historische-kurse/RWE-St-Aktie/DE0007037129

Börse.de (2015 b). *Kurshistorie E.ON Aktie.* Retrievable from: https://www.boerse.de/historische-kurse/EON-Aktie/DE000ENAG999

Börseonline. (2015). *E.ON, RWE und Co: Die Atomklagen der Energiekonzerne.* February 3rd , 2015.

Brundtland, G. H. et al. (1987). *Our common future: Report of the World Commission on Environment and Development.* World Commission on Environment and Development.

Busch, L. (2011). *Standards: recipes for reality.* The MIT Press.

Butler, L., & Neuhoff, K. (2008). Comparison of feed-in tariff, quota and auction mechanisms to support wind power development. *Renewable Energy*, 33(8), 1854-1867.

BVerfGE – Bundesverfassungsgericht. (1994) *BVerfGe91,186 –Kohlepfennig, des Zweiten Senats vom 11. Oktober 1994 -- 2 BvR 633/86 -- in dem Verfahren über die Verfassungsbeschwerde des Herrn K... gegen das Urteil des Amtsgerichts Moers vom 28. April 1986 - 6 C 757/85.* October 11th,1994.

Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In Law, J. (ed.). *Power, Action and Belief: A New Sociology of Knowledge?.* Boston, Routledge and Kegan Paul, (pp. 196–233).

Callon, M. (1987). Society in the Making: The Study of Technology as a Tool for Sociological Analysis. In Bijker, W., Hughes, T. & Pinch, T. *The Social Construction of Technological Systems: new directions in the Sociology and History of Technology.* Cambridge MA/ London: MIT Press, (pp. 51-82).

Callon, M. (1995). Four models for the dynamics of science. In Jasanoff, S., Markle, G. E., Petersen, J. C., and Pinch, T. (eds). *Handbook of Science and Technology Studies.* Thousand Oaks, CA, Sage

Calvert, R. L. (1995). Rational actors, equilibrium, and social institutions. In Knight, J. & Sened, I. (eds). (1998). *Explaining social institutions.* University of Michigan Press. (pp. 57-95).

Chandler, A. D. (1977). *The visible hand: The managerial revolution in American business.* Harvard University Press.

Coutard, O. (1999). *The Governance of Large Technical Systems.* London/New York: Routledge.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches.* Sage Publications, Incorporated.

DailyNK.( 2014). *What Kind of Effort Did Chancellor Helmut Kohl Put Into Reuniting Germany?* October 11th, 2014

DAtF – Deutsches Atom Forum e.V. (2012, January 18). *Betriebsergebnisse Kernkraftwerke 2011*. Berlin: DAtF Press.

DAtF – Deutsches Atom Forum e.V. (2013, January). *Stilllegung und Rückbau von Kernkraftwerken*. Berlin: DAtF Press.

DAtF – Deutsches Atom Forum e.V. (2014, January 15). *Betriebsergebnisse Kernkraftwerke 2013*. Berlin: DAtF Press.

DAtF – Deutsches Atom Forum e.V. (2015, April). *Betriebsergebnisse Kernkraftwerke 2014*. Berlin: DAtF Press.

DAtF – Deutsches Atom Forum e.V. (2016, January 18). *Betriebsergebnisse Kernkraftwerke 2015*. Berlin: DAtF Press. Berlin: DAtF Press.

DAtF – Deutsches Atom Forum e.V. (2017, January 19 ). *Betriebsergebnisse Kernkraftwerke 2016*.

David, P. A. (1994). Why are Institutions the 'Carriers of History': Path Dependence and the Evolution of Conventions. *Structural Change and Economic Dynamics, 5*(2), pp. 205-220.

Dawes, R. M. (1973). The commons dilemma game: An n-person mixed-motive game with a dominating strategy for defection. *ORI Research Bulletin*, 13(2), pp. 1-12.

Deutsche Bundesregierung. (2011) - *Regierungserklärung von Bundeskanzlerin Angela Merkel zur Energiepolitik „Der Weg zur Energie der Zukunft“*. Government declaration of June 9, 2011.

Deutscher Bundestag. (1971, October). *Das Umweltprogramm der Bundesregierung*. Bundesdrucksache VI/2710

Deutscher Bundestag. (1973, October). *Die Energiepolitik der Bundesregierung*. Bundesdrucksache 7/1057

Deutscher Bundestag. (1974, March). *Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnlichen Vorgängen*. Bundesdrucksache 7/1057

Deutscher Bundestag. (1987a, June). *Antrag zur Einsetzung einer Enquete-Kommission „Vorsorge zum Schutz der Erdatmosphäre"* . Bundesdrucksache 11/533

Deutscher Bundestag. (1987b, October). *Beschlußempfehlung und Bericht des Ausschusses für Umwelt, Naturschutz und Reaktorsicherheit zur Einsetzung einer Enquete-Kommission „Vorsorge zum Schutz der Erdatmosphäre"* . Bundesdrucksache 11/971

Deutscher Bundestag. (1988, November). *Erster Zwischenbericht der Enquete-Kommission "Vorsorge zum Schutz der Erdatmosphäre"* . Bundesdrucksache 11/3246

Deutscher Bundestag. (1989, March). *Erste Beschlußempfehlung und Bericht des Ausschusses für Umwelt, Naturschutz und Reaktorsicherheit zu dem Ersten Zwischenbericht der Enquete-Kommission "Vorsorge zum Schutz der Erdatmosphäre"* . Bundesdrucksache 11/4133

Deutscher Bundestag. (1991, April). *Beschluß des Deutschen Bundestages vom 25. April 1991.* Bundesdrucksache 12/419

Deutscher Bundestag. (1992, March). *Erster Bericht der Enquete-Kommission "Schutz der Erdatmosphäre" zum Thema Klimaänderung gefährdet globale Entwicklung Zukunft sichern - Jetzt handeln.* Bundesdrucksache 12/2004

Deutscher Bundestag. (1994 a, July). *Zweiter Bericht der Enquete-Kommission "Schutz der Erdatmosphäre" zum Thema Mobilität und Klima - Wege zu einer klimaverträglichen Verkehrspolitik* . Bundesdrucksache 12/8300

Deutscher Bundestag. (1994 b, October). *Schlußbericht der Enquete-Kommission "Schutz der Erdatmosphäre" zum Thema Mehr Zukunft für die Erde- Nachhaltige Energiepolitik für dauerhaften Klimaschutz.* Bundesdrucksache 12/8600.

Deutscher Bundestag. (1999 a). *Gesetz zum Einstieg in die ökologische Steuerreform vom 24. März 1999.* BGBl. I S. 378. March, 1999.

Deutscher Bundestag. (1999 b). *Gesetz zur Fortführung der ökologischen Steuerreform vom 16. Dezember 1999.* BGBl. I S. 2432. December, 1999.

Deutscher Bundestag. (2000). *Entwurf eines Gesetzes zum Schutz der Stromerzeugung aus Kraft-Wärme-Kopplung (KWK-Vorschaltgesetz).* Bundesdrucksache 14/2765. February, 2000.

Deutscher Bundestag. (2001a). *Entwurf eines Gesetzes zur geordneten Beendigung der Kernenergienutzung zur gewerblichen Erzeugung von Elektrizität.* Bundesdrucksache 14/6890. September, 2001.

Deutscher Bundestag. (2001b, October). *Entwurf eines Gesetzes für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (Kraft-Wärme-Kopplungsgesetz).* Bundesdrucksache 14/7024.

Deutscher Bundestag. (2006, February). *Ökologische Steuerreform in Deutschland: Umsetzung, Pro und Contra, Konzepte. Ökosteuern in Europa.* Ausarbeitung Fachabteiling IV Haushalt und Finanzen vom 7. Februar 2006

Deutscher Bundestag. (2007, February). *50 Jahre Römische Verträge.* Wissenschaftliche Dienste Nr. 10/07

Deutscher Bundestag. (2008, February). *Entwurf eines Gesetzes zur Förderung der Kraft-Wärme-Kopplung.* Bundesdrucksache 16/8305.

Deutscher Bundestag. (2012, February). *Entwurf eines Gesetzes zur Änderung des Kraft-Wärme-Kopplungsgesetzes.* Bundesdrucksache 17/8801

DEHSt – Deutsche Emissionshandelstelle. (2008, May). *Ex-Post-Korrekturen 2005-2007.*

Die Welt (2004). *Karl Otto Pöhl ist überzeugt: „Der Kurs beim Umtausch war verhängnisvoll."*, August 29th, 2004.

Die Welt. (2011a). *Vattenfall verlangt Entschädigung für Atomausstieg.* June 7 th, 2011.

Die Welt (2011b). *Vattenfall prüft Milliardenklage.* November 2 nd, 2011.

Die Welt (2011c). *E.on verklagt Bundesrepublik auf Milliardensumme.* November 14 th, 2011.

Die Welt (2011d). *Industrial consumers loged complaints regarding electricity shortfalls.* December 29 th, 2011.

Die Welt (2015). *Nachbarn wollen den deutschen Strom nicht.* August 4 th,2015

Die Welt (2016a). *Als die Atomkraft „ein Geschenk des Himmels war".* March 11 th*,* 2016.

Die Welt (2016b). *Energiewende kostet die Bürger 520.000.000.000 Euro – erstmal.* October, 10th, 2016.

Die Welt (2016c). *Konzernen steht Entschädigung für Atomausstieg zu.* December, 6th 2016.

Die Zeit (2003). Schöllgen, G. *Der Kanzler und sein Spion.* September 25th, 2003.

Die Zeit (2012). *Atom-Klagen könnten AKW-Rückbau bremsen.* December 13th, 2013.

Die Zeit (2013). *Energieversorger dürfen säumingen Kunden den Strom abstellen.* April 18th, 2012.

Die Zeit (2015). *RWE lagert Teile des Unternehmens aus.*. December 1st, 2015.

Dietsche, F. & Kiefer, W. (2008). *Das Schönauer Gefühl.* Documerntary Film.

Douglas, M. (1978). *Cultural bias.* Royal Anthropological Institute.

Douglas, M. (1986). How institutions think. Syracuse University Press.

Drechsler, Denis (2001). *Die beiden Enquete-Kommissionen des Deutschen Bundestages.* Seminar: Klimapolitik – national, europäisch, global. 05/16/2001.

DSD (1991). *Duales System Deutschland.*

Durkheim, E. (1912). *Les formes élémentaires de la vie religieuse.* Paris, Presses universitaires de France, 1979.

EC – European Council. (2014). *Conclusions on 2030 Climate and Energy Policy Framework*, SN 79/14, Brussels, 23 October 2014.

EC – European Commission. (2011). *Energy roadmap 2050*. COM (2011) 885 final, Brussels, 15 December 2011

EC - European Commission. (2004). *Decision C(2004) 2515/2 final of 7 July 2004 concerning the national allocation plan for the allocation of greenhouse gas emission allowances notified by Germany in accordance with Directive 2003/87/EC of the European Parliament and of the Council.*

ECJ (2007). European Court of Justice. Judgment of the Court of First Instance (Third Chamber, extended composition) of 7 November 2007. Federal Republic of Germany v Commission of the European Communities (Case T-374/04).

EEA – European Environment Agency. (2001). *Late lessons from early warnings: the precautionary principle 1896–2000*, Environmental issue report, No 22, Copenhagen

EEG 2000. (2000). *Gesetz für den Vorrang Erneuerbarer Energien(Erneuerbare-Energien-Gesetz - EEG).* Renewable Energy Act of March 29, 2000. (BGBl. I S. 305)

EEG 2004. (2004). *Gesetz für den Vorrang Erneuerbarer Energien(Erneuerbare-Energien-Gesetz - EEG).* Renewable Energy Act of July 21, 2004. (BGBl. I S. 1918)

EEG 2009. (2008). *Gesetz für den Vorrang Erneuerbarer Energien(Erneuerbare-Energien-Gesetz - EEG).* Renewable Energy Act of October 25, 2008. (BGBl. I S. 2074)

EEG 2012a. (2011). *Gesetz zur Neuregelung des Rechtsrahmens für die Förderung der Stromerzeugung aus erneuerbaren Energien.* Renewable Energy Act of July 28, 2011 (BGBl. I S. 1634).

EEG 2012b. (2012). *Gesetz zur Änderung des Rechtsrahmens für Strom aus solarer Strahlungsenergie und zu weiteren Änderungen im Recht der erneuerbaren Energien.* Act for the modification of the legal frame for solar facilities, of August 17, 2012. (BGBl. I S. 1754).

EEG 2014. (2014). *Gesetz zur grundlegenden Reform des Erneuerbare-Energien-Gesetzes und zur Änderung weiterer Bestimmungen des Energiewirtschaftsrechts.* Renewable Energy Act of July 21, 2014. (BGBl. I S. 1066)

EEG 2017. (2016). *Gesetz für den Ausbau erneuerbarer Energien*. The Renewable Energy Act of July 21, 2014 (BGBl. I S. 1066), amended by Article 2 of the Act of Dezember 22, 2016 (BGBl. I S. 3106).

EIA (2016). U.S. Energy Information Administration. *2016 Average Monthly Bill- Residential (Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U)*. Retrievable from: https://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf

Eiselt, J. (2012). *Dezentrale Energiewende: Chancen und Herausforderungen*, Springer.

Ekardt, F. (2013). Energiewende und EU-Beihilfenrecht: EEG-Förderung, EEG-Ausnahmen, Atomrecht, Energiesteuern. *EurUP – Zeitschrift für Europäisches Umwelt- und Planungsrecht*. Vol. 11 (2013), Issue 3, pp. 197 – 205.

Ekardt, F. (2015). Umweltschutz im EU-Beihilfenrecht. In Nowak,C (Ed.) *Konsolidierung und Entwicklungsperspektiven des Europäischen Umweltrechts*. Pp. 134 – 158. Nomos , Baden-Baden, 2015.

Ekins, P., Simon, S., Deutsch, L., Folke, C., & De Groot, R. (2003). A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecological economics*, 44(2), 165-185.

Ekins, P., & Max-Neef, M. (Eds.). (2002). *Real life economics*. Routledge.

Ellerman, A. D. (Ed.). (2000). *Markets for clean air: The US acid rain program*. Cambridge University Press.

Elspas, M., Salje, P., & Stewing, C. (2006). *Emissionshandel. Ein Praxishandbuch*. Carl Heymanns Verlag.

EnBW. (2017). *EnBW reprioritises its storage projects: The Atdorf pump storage project will not be pursued further*. Press release from October 11, 2017.

Engels, J. I. (2003) Der Widerstand gegen das Kernkraftwerk Wyhl. In Kretschmer, K. (Eds.) *Wahrnehmung, Bewusstsein, Identifikation: Umweltprobleme und Umweltschutz als Triebfedern regionaler Entwicklung*.Technische Universität Bergakademie, Freiberg, 2003, pp. 103-130.

ENTSO-E (2017). European Network of Transmission System Operators for Electricity. *Power Statistics -Monthly Hourly Load*. Retrievable from: https://transparency.entsoe.eu/dashboard/show

EnWG (1998) – *Gesetz zur Neuregelung des Energiewirtschaftsrechts. Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz - EnWG) vom 24. April 1998*. Energy Economy Act of 1998. BGBl I S. 730; BGBl III 752-2.

EnWG (2003) - *Erstes Gesetz zur Änderung des Gesetzes zur Neuregelung des Energiewirtschaftsrechts vom 20. Mai 2003. Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz - EnWG)* Energy Economy Act of 2003. BGBl I S. 686.

EnWG (2005) – *Erstes Gesetz zur Änderung des Gesetzes zur Neuregelung des Energiewirtschaftsrechts; Gesetz über die Elektrizitäts- und Gasversorgung (Energiewirtschaftsgesetz - EnWG) vom 7. July 2005*. Energy Economy Act of 2005. BGBl I S. 1970; BGBl III 3621.

Ergen, T. (2015). *Große Hoffnungen und brüchige Koalitionen: Industrie, Politik und die schwierige Durchsetzung der Photovoltaik*. Campus Verlag, Frankfurt.

EU (1996) - *Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity.*

EU (1998) - *Directive 1998/30/EC the European Parliament and of the Council of 22 June 1998 concerning common rules for the internal market in natural gas.*

EU (2003) - *Directive 2003/87/EC the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC*

EU (2004) - *Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms.*

EU (2009) *Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community.*

EU (2009) – *Decision 2011/278/EU. Commision Decision of 27 April 2011determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council.*

EWS (2017) Geschichte der EWS. https://www.ews-schoenau.de/ews/geschichte/

Farrell, A.E., Plevin, R.J, Turner, B.T., Jones, A.D, O'Hare, M. & Kammen, 2006. D.M, *Ethanol Can Contribute to Energy and Environmental Goals*, Science 311 (2006), pp. 506-508.

FAZ- Frankfurter Allgemeine Zeitung (2016a). Budras, C. *RWE-Schadenersatzforderung: Was das schon wieder kostet*. January 3rd, 2016.

FAZ- Frankfurter Allgemeine Zeitung (2016b). Bündner, H. *Nach der Konzernspaltung*. November 15th, 2016.

Fischedick, M. et al. (WI) & Nitsch J. et al. (DLR) (2002) *Langfristszenarien für eine nachhaltige Energienutzung in Deutschland.* Forschungsvorhaben für das Umweltbundesamt UFOPLAN FKZ 200 97 104 (BMU 2002)

Fischedick, M. (2018). Klimaziel 2020: Eine Rückkehr zu einer erfolgreichen Klimapolitik ist möglich. *ifo Schnelldienst.* 1/2018 of January 11, 2018

Fleck, L. (1935a). *Entstehung und Entwicklung einer wissenschaftlichen Tatsache; Einführung in die Lehre vom Denkstil und Denkkollektiv.* Frankfurt am Main: Suhrkamp, 1980.

Fleck, L. (1935b). *Genesis and development of a scientific fact.* Translation, 1979. Chicago: University of Chicago Press.

Forstner, T. et al. (2014). *1974–2014: 40 Jahre Umweltbundesamt.*

Freeman, C., & Louçã, F. (2002). *Freeman, C., & Louçã, F. (2002). As time goes by: from the industrial revolutions to the information revolution.* OUP Catalogue. (2nd part only; from p. 139)

Frum, D. (2000). *How We Got Here: The '70s.* New York: Basic Books. p. 318.

Galambos, L. (1970). The emerging organizational synthesis in modern American history. *The Business History Review*, S. 279-290.

Gawel, E. (2018). Neustart der Klimapolitik erforderlich. *ifo Schnelldienst.* 1/2018 of January 11, 2018

Gerner, D (2012). *Zuteilung der CO2-Zertifikate in einem Emissionshandelssystem.* Kassel university press GmbH.

Gobert, J. (2015). *Widerstand gegen Großprojekte: Rahmenbedingungen, Akteure und Konfliktverläufe.* Springer-Verlag.

Golovanov, L., & Sarkisyan, S. (1978). Forecasting the Development of Large Technical Systems. *Technological Forecasting and Social Change*, pp. 175-184.

Gore, A. (2016, February, 23). *The case for optimism on climate change.* Presented at TED Conference, rubric 'Ideas worth spreading', Vancouver, BC. Retrieved from: https://www.climaterealityproject.org/blog/ideas-worth-spreading

Graham, L. R. (1993 a). *The ghost of the executed engineer: Technology and the fall of the Soviet Union* (Bd. 87). Cambridge, MA: Harvard University Press.

Graham, L. R. (1993 b). *Science in Russia and the Soviet Union: A short history.* Cambridge University Press.

Greif, A., & Kingston, C. (2011). Institutions: Rules or Equilibria?. In N. Schofield & Caballero (eds.).(2011). *Political economy of institutions, democracy and voting* (pp. 13-43). Springer Berlin Heidelberg.

Grüne Punkt (1990)

Gundel, J. & Lange, K.W Eds. (2013), *Die Energiewirtschaft im Instrumentenmix: Wettbewerb, Regulierung und Verbraucherschutz* nach der Energiewende Tagungsband der Vierten Bayreuther Energierechtstage 2013

Guss, A. & Zipp, A. (2015), *Bestandserhalt und systemdienlicher Ausbau der Kraft-Wärme-Kopplung. Vorschläge zur KWKG-Novelle 2016*. IZES gGmbH. Institut für ZukunftsEnergieSysteme.

GWB (1998). *Sechstes Gesetz zur Änderung des Gesetzes gegen Wettbewerbsbeschränkungen.* The Anti-Trust Act, of August 26, 1998 (BGBl I S. 2521 & BGBl I S. 2546).

Haberstroh, R., & Schwarz, J. (2017) Bürger und Windenergie. *Erneuerbare Energien in der Raumplanung*, 38/2017, Eberhard Karls Universitaet Tübingen, pp. 6-15.

Hackstock, R. (2014) - *Energiewende: Die Revolution hat schon begonnen*, Verlag Kremayr & Scheriau, Wien

Handelsblatt. (2011).*Companies loged complaints regarding electricity blackouts.* December, 29, 2011.

Handelsblatt. (2015). *REKORD AN STROMSPERREN. Konzerne drehen Kunden immer öfter den Saft ab.* November 15, 2015.

Handelsblatt. (2016). *Verfassungsgericht zum Atomausstieg: Eon und RWE müssen entschädigt warden.* December 6, 2016.

Handelsblatt. (2017). *Windkraft wird deutlich günstiger. Durch die Umstellung auf ein staatliches Ausschreibungs-System wird der Wettbewerb in der Wind-Branche angekurbelt. Nutznießer sind vor allem Bürgergesellschaften. Bei Auktionen haben sie einige Vorteile.* May 19, 2017.

Hardin, G. (1968). The Tragedy of the Commons. *Science*, 162(3859), pp.1243-1248.

Haucap, J., Loebert, I., & Thorwarth, S. (2016). *Kosten der Energiewende. Untersuchung der Energiewendekosten im Bereich der Stromerzeu- gung in den Jahren 2000 bis 2025 in Deutschland.* Ein Gutachten im Auftrag der Initiative Neue Soziale Marktwirtschaft (INSM)

Hausman, W., Hertner P., and Wilkins, M. (2008). *Global Electrification: Multinational Enterprise and International Finance in the History of Light and Power, 1878-2007.* Cambridge University Press.

Häder, M. (2010) *Energiepolitik in Deutschland: eine Analyse der umweltpolitischen Rahmenbedingungen für den Strommarkt aus Sicht der Ornungspolitik. Universitaetsverlag Brockmeyer, Bochum, 2010.*

Hecht, G. (1998). *The Radiance of France: Nuclear Power and National Identity after World War II.* Cambridge/London: MIT Press.

Hecht, G. (2011). *Entangled geographies: empire and technopolitics in the global Cold War*. The MIT Press.

Hedges,C. (11/02/2015). Sheldon Wolin and Inverted Totalitarianism. *CommonDreams*. Retrieved from: http://www.commondreams.org/views/2015/11/02/sheldon-wolin-and-inverted-totalitarianism

Hennicke P. & Welfens, P., (2013) *Energiewende nach Fukushima: Deutscher Sonderweg oder weltweites Vorbild?* [Energiewende after Fukushima: A German specialty or a role model for the world?].

Herman, E. S., & Chomsky, N. (1988). *Manufacturing Consent: The Political Economy of the Mass Media*. Pantheon Books. New York.

Hirsh, R. F. (1989). *Technology and Transformation in the American Electric Industry*. Cambridge: Cambridge University Press.

Hirsh, R. F., & Serchuk, A. H. (1996). Momentum shifts in the American electric utility system: Catastrophic change-or no change at all? *Technology and Culture*, 37(2), pp.280-311.

Hirsh, R. F. (1999). *Power Loss: the Origins of Deregulation and Restructuring in the American Electric Utility System*. Cambridge / London: MIT Press.

Hirt, P. W. (2012). *The Wired Northwest; The History of Electric Power, 1870s-1970s*. Lawrence: University Press of Kansas.

Holler, F., Schuster, F., & Hamdan, J. (2016) *Der „Konzern Kommune" in der Krise?* Institut für den öffentlichen Sektor in Kooperation mit KPMG

Holling, C.S. (1979). "Myths of ecological stability," in: G. Smart and W. Stansbury (eds.) *Studies in Crisis Management*. Butterworth, Montreal.

Holling, C.S. (1986). "The resilience of terrestrial ecosystems,"pp.292-316, in: W. Clark and R. Munn (eds.) *Sustainable Development of the Biosphere*. Cambridge University Press, Cambridge.

Holling, C.S. (1995). "What Barriers? What Bridges," pp. 3-34, in: L. Gunderson, C.S. Holling, and S.S. Light (eds.) *Barriers and Bridges to the Renewal of Ecosystems and Institutions.* Columbia University Press, New York.

Hötker, H., Thomsen, K.-M., & Jeronim, H., (2006). Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats – facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto_institute in NABU, Bergenhusen, pp. 1-65

Hughes, A. C., Allen, M. T., & Hecht, G. (2001). *Technologies of power: essays in honor of Thomas Parke Hughes and Agatha Chipley Hughes.* The MIT Press.

Hughes, T. P. (1969). Technological momentum in history: Hydrogenation in Germany 1898-1933. *Past & Present, 44*, S. 106-132.

Hughes, T. P. (1979). Emerging themes in the history of technology. *Technology and Culture, 20*(4), S. 697-711.

Hughes, T. P. (1986). The seamless web: technology, science, etcetera, etcetera. *Social Studies of Science.* Vol. 16, pp. 281–92

Hughes, T. (1987). The Evolution of Large Technological Systems. In W. Bijker, T. Hughes, & T. Pinch, *Construction of Technological Systems: new directions in the Sociology and History of Technology* (pp. 51-82). Cambridge MA/ London: MIT Press.

Hughes, T. P. (1993). *Networks of power: electrification in Western society, 1880-1930.* Baltimore: John Hopkins University Press.

Hughes, T. P. (2004). *American genesis: a century of invention and technological enthusiasm, 1870-1970.* Chicago: University of Chicago Press.

Irwin, A., & Wynne, B. (1996). *Misunderstanding science?: the public reconstruction of science and technology.* Cambridge University Press.

Janzig, B. (2008). *Störfall mit Charme: Die Schönauer Stromrebellen im Widerstand gegen die Atomkraft.* Dold, Wilfried.

Jarass, L., & Obermair, G. M. (2005). Netzeinbindung von Windenergie: Erdkabel oder Freileitung? *Energiewirtschaftliche Tagesfragen*, 55(6), pp.398-403.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica.* 47(2), pp. 263-291.

Kehrberg, J.O.C. (1997). *Die Entwicklung des Elektrizitaetsrechts in Deutschland - Der Weg zum Energiewirtschftsgesetz von 1935*. Rechtshistorische Reihe (157). Peter Lang Verlag. Frankfurt am Main, 1997.

Kemfert, C. (2018) Schnelles Umsteuern in Energiewirtschaft und Verkehrssektor erforderlich. *ifo Schnelldienst*. 1/2018 of January 11, 2018

Kevles, D. J. (1995). *The physicists: The history of a scientific community in modern America*. Harvard University Press.

Klag, N. D. (2003). *Die Liberalisierung des Gasmarktes in Deutschland*. Tectum Verlag, Marburg, 2003.

Klimaretter.Info (2017) Hendricks: Deutschland verfehlt Klimaziel. Kurz vor Beginn der Jamaika-Sondierungsgespräche geht Noch-Umweltministerin Hendricks mit einer Hiobsbotschaft an die Öffentlichkeit: Deutschland wird sein Klimaziel für 2020 viel deutlicher verfehlen als bislang schon befürchtet. Kern, V. in *Klimaretter.Info*. Octorber 11, 2017, Berlin.

Klump, R. (1985). *Wirtschaftsgeschichte der Bundesrepublik Deutschland. Zur Kritik neuerer wirtschaftshistorischer Interpretationen aus ordnungspolitischer Sicht*. Beiträge zur Wirtschafts- und Sozialgeschichte. Bd. 29. Steiner-Verlag-Wiesbaden, Stuttgart 1985

Kohlhaas, M. , & Praetorius, B. (1995). *Selbstverpflichtung der Wirtschaft zur C02-Reduktion - Beitrag zum Klimaschutz?* IÖW/VÖW - Informationsdienst 2 /95.

Krause, F., Bossel, H., & Müller-Reißmann, K.-F. (1980). *Energie-Wende: Wachstum und Wohlstand ohne Erdöl und Uran*. Germany: Fischer Verlag.

Krugman, P. (2014) Salvation Gets Cheap. *The New York Times*. April 18, 2014. Retrieved from: http://www.nytimes.com/2014/04/18/opinion/krugman-salvation-gets-cheap.html?hp&rref=opinion&_r=0#story-continues-1

Krugman, P. (2016). *Wind, Sun and Fire*. The New York Times. February 1, 2016. Retrieved http://topics.nytimes.com/top/opinion/editorialsandoped/oped/columnists/paulkrugman/index.html

KrWG (1994).Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen, of September, 1994, (BGBl I S. 2705).

Kuhlmann, A. (2018). Für einen Klimaschutz mit Mut und Weitblick. *ifo Schnelldienst*. 1/2018 of January 11, 2018

KWKG (2000). *Gesetz zum Schutz der Stromerzeugung aus Kraft-Wärme-Kopplung (Kraft-Wärme-Kopplungsgesetz)*. Combined Heat and Power Act of May 12, 2000 (BGBl. I S. 703).

KWKG (2002). *Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung.* Combined Heat and Power Act of March 19, 2002 (BGBl. I S. 1092).

La Porte, T. R. (1994). Large Technical Systems, Institutional Surprises, and Challenges to Political Legitimacy. *Technology in Society, 16*(3), pp. 269-288.

Laird, F. N. (2001 a). Just Say No to Greenhouse Gas Emissions Targets. *Issues in Science and Technology* 17(2). Winter 2001.

Laird, F. N. (2001 b). *Solar energy, technology policy, and Institutional Values.* Cambridge: Cambridge University Press.

Latour, B. and Basite, F. (1986). Writing science - fact and fiction: the analysis of the process of reality construction through the application of socio-semiotic methods to scientific texts. In Callon, M., Law, J. and Rip, A.(eds). *Mapping the Dynamics of Science and Technology*. London, Macmillan, (pp. 51–66).

Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. *Shaping technology/building society: Studies in sociotechnical change*, pp. 225-258. Reprinted in Wetmore and Jonson eds. (2008). Technology and Society, pp. 151-180.

Latour, B. (1996). *Aramis, or, the love of technology* (Bd. 1996). Cambridge, MA: Harvard University Press.

Law, J. (1986). *Power, Action and Belief. A New Sociology of Knowledge?* London, Routledge and Kegan Paul.

Law, J. (1987). Technology and Heterogeneous Engineering: The Case of Portuguese Expansion. In Bijker, W., Hughes, T., & Pinch, T. (1987). *Construction of Technological Systems: new Directions in the Society and History of Technology.* Cambridge MS / London: MIT Press (pp. 111-134).

Leslie, S. W. (1993). *The Cold War and American science: The military-industrial-academic complex at MIT and Stanford.* Columbia University Press.

Lester, R. K., & Hart, D. M. (2012). *Unlocking Energy Innovation: How America Can Build a Low-Cost Low-Carbon Energy System*. The MIT Press.

Lovins, A. B. (1977). *Soft Energy Paths: Toward a Durable Peace*, Ballinger Publishing Co.

Manssen, G. (2012). Zukunft der EEG-Umlage –weiter auf verfassungswidrigen Wegen? *Energiewirtschaftliche Tagesfragen*. 62 (11), pp. 49-51.

March, J. G. (1978). Bounded rationality, ambiguity, and the engineering of choice. *The Bell Journal of Economics*, pp. 587-608.

Matthes, F. C. (2018). Neue Schwerpunktsetzungen für die Klimapolitik in Deutschland. *ifo Schnelldienst*. 1/2018 of January 11, 2018

Maubach, K.D. (2014) *Energiewende: Wege zu einer bezahlbaren Energieversorgung*. Springer, Wiesbaden, 2nd edition.

Mautz, R. (2010). *The Transformation of the German Electricity Sector: Neither Abrupt Change nor Continuous Path*. Paper presented at the Sussex Energy Group Conference "Energy transitions in an interdependent world: what and where are the future social science research agendas?" 25th-26th February 2010, University of Sussex.

Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. (1972). *The limits to growth. A report for The Club of Rome's project on the predicament of mankind*. Universe Books, New York.

Meyer, R. (2005). Large System Theory, Actor Network Theory, and Relations in Design. *6th EAD Conference March 2005*, (pp. 29-31). Bremen, Germany.

MM-Manager Magazin. (2016). *Bundesverfassungsgericht rügt Atomausstieg: Staat muss RWE, Eon und Co. Entschädigen*. December 6, 2016.

MM-Manager Magazin. (2017). *Erste Offshore-Windparkbetreiber verzichten komplett auf Subvention*. April 13, 2017.

Munzel, B. (2014). *Preisentwicklung und Handelsinstrumente*. Carbon-Scout Presentation, GUTcert Akademie, Berlin, November 2014.

Nelles, H.V. (2005). *The Politics of Development: Forests, Mines, and Hydro-electric Power in Ontario, 1849-1941*, 2nd edition. McGill-Queens University Press.

Nelson, R. R. (1996). *The sources of economic growth*. Cambridge, MA: Harvard University Press.

Netztransparenz (2011). *EEG- Mengentestat 2010 auf Basis von WP-Bescheinigungen per 31.07.2011. Stromeinspeisemengen, Direktvermarktung, Vergütungen und Letztverbräuche*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2010.pdf

Netztransparenz (2012). *EEG- Mengentestat 2011 auf Basis von WP-Bescheinigungen per 20.07.2012. Angaben Stromeinspeisemengen und Vergütungen nach EEG*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2011.pdf

Netztransparenz (2013). *EEG- Mengentestat 2012 auf Basis von WP-Bescheinigungen per 26.07.2013. Angaben Stromeinspeisemengen und Vergütungen nach EEG*. Retrieved from:

https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2012.pdf

Netztransparenz (2014). *EEG- Mengentestat 2013 auf Basis von WP-Bescheinigungen per 25.07.2014. Angaben Stromeinspeisemengen und Vergütungen nach EEG*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2013.pdf

Netztransparenz (2015). *EEG- Mengentestat 2014 auf Basis WP-Bescheinigungen per 24.07.2015. Angaben Stromeinspeisemengen und Vergütungen nach EEG*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2014.pdf

Netztransparenz (2016). *EEG- Mengentestat 2015 auf Basis WP-Bescheinigungen per 31.07.2016. Angaben Stromeinspeisemengen und Vergütungen nach EEG*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2015.pdf

Netztransparenz (2017). *EEG-Mengentestat 2016 auf Basis von Prüfungsvermerken: Angaben zu Stromeinspeisemengen und Einspeisevergütungen nach EEG*. July 28, 2017. Retrieved from: https://www.netztransparenz.de/portals/1/EEG-Jahresabrechnung_2016.pdf

NetzResV (2013). Verordnung zur Regelung der Beschaffung und Vorhaltung von Anlagen in der Netzreserve. Netzreserveverordnung vom 27. Juni 2013 (BGBl. I S. 1947), die zuletzt durch Artikel 4 des Gesetzes vom 22. Dezember 2016 (BGBl. I S. 3106) geändert worden ist.

Neuhoff, K. (2005). Large-scale deployment of renewables for electricity generation. *Oxford Review of Economic Policy*, 21(1), 88-110.

Neuhoff, K., Martinez, K. K., & Sato, M. (2006). Allocation, incentives and distortions: the impact of EU ETS emissions allowance allocations to the electricity sector. *Climate Policy*, 6(1), 73-91.

Nitsch, J., Pehnt, M., Fischedick, M. et al. (2004). *Ökologisch optimierter Ausbau der Nutzung erneuerbarer Energien in Deutschland.* DLR Stuttgart, IFEU Heidelberg, WI Wuppertal, Forschungsvorhaben FKZ 901 41 803 im Auftrag des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, April 2004. (BMU 2004).

Nitsch, J., Staiss, F., Wenzel, B., Fischedick, M. (2005) *Ausbau Erneuerbarer Energien im Strom-sektor – Vergütungszahlungen und Differenzkosten durch das Erneuerbare – Energien –Gesetz.* DLR Stuttgart, ZSW Stuttgart, WI Wuppertal. Untersuchung im Auftrag des BMU, Berlin, Dezember 2005. (BMU 2005)

Nietsch, J. et al. (2007). *Leitstudie 2007. Ausbaustrategie Erneuerbare Energien. Aktualisierung und Neubewertung bis zu den Jahren 2020 und 2030 mit Ausblick bis 2050*. Untersuchung im

Auftrag des Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Februar 2007. (BMU 2007)

Nietsch, J. et al. (2008). *Leitstudie 2008. Weiterentwicklung der Ausbaustrategie Erneuerbare Energien vor dem Hintergrund der aktuellen Klimaschutzziele Deutschlands und Europas.* Untersuchung im Auftrag des Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Februar 2008. (BMU 2008)

Nitsch, J., Wenzel, B. (2009). *Langfristszenarien und Strategien für den Ausbau erneuerbarer Energien in Deutschland - Leitszenario 2009*. DLR, IFne. Im Auftrag des BMU. Stuttgart, Teltow, August 2009. (BMU 2009)

Nitsch, J., Sterner, M., Wenzel, B. (2010a). *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global*. DLR, IWES, IFne. Im Auftrag des BMU. Stuttgart, Teltow, August 2010. (BMU 2010)

Nitsch, J., Sterner, M., Wenzel, B. (2010b). *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global*. DLR, IWES, IFne. Im Auftrag des BMU. Stuttgart, Teltow, August 2010. (BMU 2010)

Nietsch, J., Pregger, T., Scholz, I., Naegler, T., Heide, D., De Tena, D.L., Trieb, F., Niehaus, K. (DLR), Gerhardt, N., Trost, T., Von Oehsen, A., Schwinn, R., Pape, C., Hahn, H., Wickert, M., Sterner, M. (IWES), Wenzel, B. (IFnE).(2012, March). *Long-term scenarios and strategies for the deployment of renewable energies in Germany in view of European and global developments*, Summary of the final report (BMU-FKZ 03MAP146, pp. 1-38)

Nietsch, J., Pregger, T., Scholz, I., Naegler, T., Heide, D., De Tena, D.L., Trieb, F., Niehaus, K. (DLR), Gerhardt, N., Trost, T., Von Oehsen, A., Schwinn, R., Pape, C., Hahn, H., Wickert, M., Sterner, M. (IWES), Wenzel, B. (IFnE).(2012, March). *Langfristszenarien und Strategien für den Ausbau der Energien in Deutschland bei berücksichtigung der Entwicklung in Europa und global*, Sclussbericht (BMU-FKZ 03MAP146, pp. 1-331)

Nietsch, J., Pregger, T., Scholz, I., Naegler, T.(DLR), Sterner, M., Gerhardt, N., Von Oehsen, A., Pape, C., Saint-Drenan, Y.M. (IWES), Wenzel, B. (IFnE).(2010, December). *Langfristszenarien und Strategien für den Ausbau der Energien in Deutschland bei berücksichtigung der Entwicklung in Europa und global*, Leitstudie 2010 (BMU-FKZ 03MAP146, pp. 1-201)

Nietsch, J., (DLR), Wenzel, B. (IFnE).(2009, August). *Langfristszenarien und Strategien für den Ausbau der Energien in Deutschland*, Leitstudie 2009 (BMU-FKZ 03MAP146, pp. 1-105)

Noble, D. F. (1984). *Forces of production.* Transaction Books.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance.* New York: Cambridge University Press.

NTV (2016) - Eon und RWE spalten sich auf. Welcher Weg ist besser? Wednesday, June 8, 2016.

NTV (2018) - *Bund will Emissionsrechte kaufen. Deutschland schafft auch EU-Klimaziel nicht.* Wednesday, January 24, 2018.

Nye, D. E. (1990). *Electrifying America: Social Meanings of a New Technology, 1880 - 1940.* Cambridge/ London: MIT Press.

Odén, S. (1968). *Nederbördens och Luftens Försurning, dess Orsaker, Förlopp och Verkan i Olika Miljöer* [The acidification of precipitation and air, causes and effects in different environments], Statens Naturvetenskapliga Forskningsråd, Ekologikomiteen, Bulletin No. 1.

Oppelland, T. (1996) Domestic political developments I: 1949-1969. In Larres, K. & Panayi, P., *The Federal Republic of Germany since 1949: Politics, Society and Economy before and after Unification* (pp. 74-99). Routledge London and New York.

Ostrom, E. (1990). *Governing the Commons, The Evolution of Institutions for Collective Action* (2003 ed.). Cambridge New York Melbourne: Cambridge University Press.

Ostrom, E. (2005). *Understanding Institutional Diversity.* Princeton: Princeton University Press.

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences, 104*(39), S. 15181-15187.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Socio- Ecological Systems. *Science, 325*, pp. 419-422.

Ostrom, E. (2011). Background on the Institutional Analysis and Development Framework. *The policy Studies Journal, 39*(11).

Paul, J.P. (2010). *Bilanz einer gescheiterten Kommunikation. Fallstudien zur deutschen Entstehungsgeschichte des Euro und ihrer demokratietheoretischen Qualität.* PhD dissertation at the Johann Wolfgang Goethe-Universität, Frankfurt am Main, July 26, 2010.

Perrow, C. (1984). *Normal Accidents; Living With High-Risk technologies.* New York.

Pezzey, J. C., & Anderies, J. M. (2003, July 1). The effect of subsistence on collapse and institutional adaptation in population - resource societies. *Journal of Development Economics*, pp. 299-320.

Pinch, T. J. and Bijker, W. E. (1984). The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science*. Vol. 14, pp. 399–441.

Popp, M.,(2013), *Deutschlands Energiezukunft: Kann die Energiewende gelingen?* [Germany's energy future: Can the Energiewende succeed?], Wiley-VCH

Rapp, H. (2013) *Energieversorgung im Wandel: Hoffnungen und Fakten zur Energiewende*

Rayner, S. (2012). Uncomfortable knowledge: The social construction of ignorance in science and environmental policy discourses. *Economy and Society*. Vol. 41(1), pp.107-125.

Reisman, D. A. (1990). *Theories of Collective Action: Downs, Olson and Hirsh*. New York: Palgrave Macmillan.

Rest, J. (7/2011) *Grüner Kapitalismus?: Klimawandel, globale Staatenkonkurrenz und die Verhinderung der Energiewende*, Springer

Roberts, K. H. (1993). New challenges to Understanding Organizations. NY: Macmillan.

Rochlin, G. I. (2011, November 1). How to Hunt a Very Reliable Organization. *Journal of Contingencies and Crisis Management*, p. March.

Rochlin, G. I., La Porte, T. R., & Roberts, K. H. (1987). The self-designing high-reliability organization: Aircraft carrier flight operations at sea. *Naval War College Review*, *40*(4), 76-90.

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Romm, J. (2016). Why The Renewables Revolution Is Now Unstoppable. *The New York Times*. February 1, 2016. Retrieved from: http://krugman.blogs.nytimes.com/2016/02/01/more-about-renewables/?_r=0

Rosenberg, N. (1982). *Inside the black box: technology and economics*. Cambridge University Press.

Rosenberg, N. (1994). *Exploring the black box: Technology, economics, and history*. Cambridge University Press.

Ruttan, V. W. (2006). *Is war necessary for economic growth? Military procurement and technology development* (Bd. No. 13534). University of Minnesota, Department of Applied Economics.

Salje, P. (2012). Wind, Wasser, Biomasse, Sonne, Geothermie – (aktuelle) Rechtsfragen der EEG-Vergütungsregelungen. In Carl Heyma Müller, T., Filbert, A., Grobrügge, H., Neldner, W., Nitzschke, M., Pilarsky-Grosch, S., ... & Wübbels, M. (2012). *20 Jahre Recht der Erneuerbaren Energien*. Nomos, pp. 507-539.

Salje, P. (2015). *EEG 2014 – Gesetz für den Ausbau erneuerbarer Energien*. 7th Edition. Carl Heymanns Verlag.

Sarewitz, D. (1996). *Frontiers of illusion: Science, technology, and the politics of progress*. Temple University Press.

Sarewitz, D. and Nelson, R.(2008). Three rules for technological fixes. *Nature*, 456(18), pp. 871-872.

SAT.1 (2014). *Sigmar Gabriel nimmt in Kassel Stellung zur Energiewende.* April 17, 2017. Retrieved from: http://www.1730live.de/sigmar-gabriel-nimmt-in-kassel-stellung-zur-energiewende/

Schaaf, C. (2000). *Die Kernenergiepläne der SPD in den 1970er Jahren.* Grin, 2000.

Scheer, H., (2009), DESERTEC: *Why roam far and wide, as the Good is found close to home.* EUROSOLAR Press release, Bonn, 17 June 2009.

Schiermeier, Q. (2013). Germany's energy gamble: An ambitious plan to slash greenhouse-gas emissions must clear some high technical and economic hurdles. *Nature*, vol. 496, 11. April 2013, pp. 156-158

Schiffer, H. W. (1997). *Energiemarkt Bundesrepublik Deutschland*, Verlag Tur Rneinland, Köln.

Schiffer, H. W. (2017). Energiepolitische Programme der Bundesregierung 1973 bis 2017. *Enegiewirtschaftliche Tagesfragen,* 67, 2017, Heft 11, pp. 2-9.

Schily, Otto. (2017). *Wie weiter mit der Energiepolitik? Denkverbote oder offene Debatte.* Presetation in Zürich 2017.

Schmiedke, K. (2012). *Dii reference projects in Morocco, Tunisia and Algeria*. Munich, Germany. November 2012

Schleisinger, M., Hofer, P., Kemmler,A., Kirchner, A., Strassbourg, S. (Prognos AG), Lindenberger, D., Fürsch, M., Nagl ,S., Paulus, M., Richter, J., Trüby, J. (EWI), Lutz, C.,Khorushun, O., Lehr, U., Thobe, I (GWS). (2010). *Energieszenarien für ein Energiekonzept der Bundesregierung* (Projekt Nr. 12/10 des Bundesministeriums für Wirtschaft und Technologie, Berlin). August, 2010. (BMWi 2010)

Schwarz, M., & Thompson, M. (1990). Devided We Stand: Redefining. Politics, Technology and Social Choice, Pennsylvania.

Scott, J. C. (1998). *Seeing like a state: How certain Schemes to Improve Human Condition have Failed.* Yale: Yale Univesity Press.

Semb, A. (2001). *Sulphur dioxide: from protection of human lungs to remote lake restoration.* in EEA-European Environment Agency. (2001). *Late lessons from early warnings: the precautionary principle 1896–2000*, Environmental issue report, No 22, Copenhagen, pp. 101- 109.

Semrau, G. & Hufschmied, P. (2000). Prognos-ewi Gutachten: Die langfristige Entwicklung der Energiemärkte im Zeichen von Wettbewerb und Umwelt. *Glückauf : die Fachzeitschrift für Rohstoff, Bergbau und Energie.*

Siekmeier, M. & Larres, K . (1996) Domestic political developments II: 1949-1990. In Larres, K. & Panayi, P., *The Federal Republic of Germany since 1949: Politics, Society and Economy before and after Unification* (pp. 100-136). Routledge London and New York.

Simon, H. A. (1972). Theories of bounded rationality. *Decision and organization*, 1(1), pp.161-176.

Sinn, H. W. (2012). *The green paradox: A supply-side approach to global warming.* MIT press.

Sinn, H.W. (2013). *Energiewende ins Nichts*. Vortrag an der Ludwig-Maximilians-Universität, München. December 16, 2013. https://www.youtube.com/watch?v=jm9h0MJ2swo

Sinn, H.W. (2016). Buffering Volatility: A Study on the Limits of Germany's Energy Revolution. *CESifo Working Paper No. 5950 Category 10: Energy and Climate Economics, June 2016*.

Sinn, H.W. (2017). Buffering Volatility: A Study on the Limits of Germany's Energy Revolution. *European Economic Review.* (99), pp. 130–150.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations.* Oxford, Clarendon Press, 1976, p.26.

Smith, C. (2006). *Palestine and the Arab–Israeli Conflict*, New York: Bedford, p. 318.

Smits, R. E., Kuhlmann, S., & Shapira, P. (2010). *The theory and practice of innovation policy: an international research handbook*. Edward Elgar.

Sohre, A. (2013). *Strategien in der Energie- und Klimapolitik: Bedingungen strategischer Steuerung der Energiewende in Deutschland und Grossbritannien* [Strategies in the Energy & Climate Policy: Conditions: Conditions for strategic steering of energy transitions in Germany and Great Britain], Springer

Sokolski, H. (2006). *Taming the Next Set of Strategic Weapons Threats.*

Solar Millennium, (2008) *Die Parabolrinnen-Kraftwerke Andasol 1 bis 3, Die größten Solarkraftwerke der Welt; Premiere der Technologie in Europa*, Erlangen 2008, www.SolarMillennium.de

SPD (2012). *Vor dem Brandenburger Tor demonstrierten am Montag etwa 11.OOO Menschen in Berlin gegen die Pläne der Bundesregierung, die Förderung der Solarenergie radikal zu kürzen.* March 5, 2012. Retrieved from: https://www.youtube.com/watch?v=9P6HIHHUePo

SpiegelOnline (2005). *Kanzler im Pech - Gerhard Schröder und das Arbeitsmarkt-Desaster.* March, 7, 2005.

SpiegelOnline, (2011a). *Atomkraft ade - Ende eines Jahrzehnte-Kampfs.* [Nuclear power goodbye – The end of a fight over dacades]. June 30, 2011.

SpiegelOnline (2011b). *AKW-Abriss kostet mindestens 18 Milliarden Euro.* [Nuclear power decommissioning costs at least € 18 billion]. September 28, 2011.

SpiegelOnline (2012). *Bürger scheitern mit Klage gegen Windrädern –Streit um die Energiewende.* [Citizens fail with lawsuits against windmills – Conflict about the energy turnaround]. March 29, 2012.

SpiegelOnline (2015). *Energiekonzernen fehlen 30 Milliarden Euro.* [Utility corporations are short of € 30 billion]. September 14, 2015.

SpiegelOnline, (2018). *Deutschland muss für verfehlte EU-Klimaziele zahlen. Erneute Klimaschutz-Blamage für Deutschland: Nicht nur die selbst gesteckten Emissionsziele, auch die EU-Vorgaben bis 2020 werden nicht erreicht. Die Bundesregierung muss nun CO2-Zertifikate zukaufen.* January 24, 2018.

SRU (2017a) - Sachverständigenrat für Umweltfragen [Expert Council of Environmental Advisors]. *Kohleausstieg jetzt einleiten*. SRU-Statement of October 2017.

SRU (2017b) - Sachverständigenrat für Umweltfragen [Expert Council of Environmental Advisors].*Umsteuern erforderlich: Klimaschutz im Verkehrssektor*. SRU-Statement of November 2017.

Statistisches Bundesamt, August 2013, *Statistisches Jahrbuch 2013* [Annunal statistic book 2013].

Statistisches Bundesamt, August 2015, *Statistisches Jahrbuch 2015* [Annunal statistic book 2015].

Statistisches Bundesamt, October 2017, *Statistisches Jahrbuch 2017* [Annunal statistic book 2017].

Steinberg, T. (2006). *Acts of God: The Unnatural History of Natural Disaster in America,* 2nd edition. Oxford University Press.

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation.* Brookings Institution Press.

StromEinspG. (1990). *Gesetz über die Einspeisung von Strom aus erneuerbaren Energien in das öffentliche Netz,* The Electricity Feed-in Act of December 7, 1990 (BGBl. I S. 2633)

Storey, W. K. (1999). *Writing History.* New York: Oxford University Press.

Sturm, C. (2012). Life cycle Assessment on the effectiveness of Germany's energy and climate policy. *Course Project Report Series SSEBE-CESEM-2012-CPR-010.* Arizona State University, CESEM -Center for Earth Systems Engineering and Management, School of Sustainable Engineering and the Built Environment.

Sturm, C. (2016). Germany's *Energiewende*: The intermittency problem remains. *Bulletin of the Atomic Scientist,* 20 May 2016. Germany's Energiewende: The intermittency problem remains.

Sturm, C. (2017). Inside the Energiewende: Policy and Complexity in the German Utility Industry. *Issues in Science and Technology*, 33(2), pp. 41-47.

Süddeutsche Zeitung (2011). *Brüderle: AKW-Moratorium ist nur Wahlkampf-Taktik.* March 24, 2011.

Süddeutsche Zeitung (2017). *Umweltministerium geht auf Distanz zu Klimastudie.* September 7, 2017.

TALuft (1986). *Technische Anleitung zur Reinhaltung der Luft. Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz.* (GMBl. S. 95)

Tarr, J. A. (1999), Transforming an energy system: The evolution of the manufactured gas industry and the transition to natural gas in the United States (1807–1954). In Coutard, O., Ed., *The Governance of Large Technical Systems.* (pp. 19–37). Routledge, London.

TASi (1993). *Technische Anleitung zur Verwertung, Behandlung und sonstigen Entsorgung von. Siedlungsabfällen,* of Mai, 1993, (BAnz, 99a).

TEHG (2004) *Gesetz zur Umsetzung der Richtlinie 2003/87/EG über ein System für den Handel mit Treibhausgasemissionszertifikaten in der Gemeinschaft.* Emission Trading Act of July 8, 2004.(BGBl I S. 1578).

TEHG (2007). *Gesetz über den Handel mit Berechtigungen zur Emission von Treibhausgasen (Treibhausgas-Emissionshandelsgesetz -TEHG) unter Einschluss der Änderungen durch Art. 2 des Gesetzes zur Änderung der Rechtsgrundlagen zum Emissionshandel im Hinblick auf die Zuteilungsperiode 2008 bis 2012.* Emission Trading Act of August 7, 2007 (BGBl. I, S. 1788).

TEHG (2011). *Gesetz zur Anpassung der Rechtsgrundlagen für die Fortentwicklung des Emissionshandels.* Emission Trading Act of July 21, 2011 (BGBl. I, S. 1475).

Teske, S., Sawyer, S., Schäfer, O., Pregger, T., Simon, S., Naegler, T., ... & Rutovitz, J. (2015). *Energy [R] evolution-A sustainable world energy outlook 2015*.

The Economist. (1999). The sick man of the euro. The biggest economy in the euro area, Germany's, is in a bad way. And its ills are a main cause of the euro's own weakness. June 3rd, 1999.

Trieb, F. et al. (2005). *Concentrating Solar Power for the Mediterranean Region*. DLR Stuttgart, Abt. Systemanalyse und Technikbewertung, Stuttgart, April 2005.

Trieb, F. et al. (2006). *Trans-Mediterranean Interconnection for Concentrating Solar Power.* DLR Stuttgart, Abt. Systemanalyse und Technikbewertung, Stuttgart, Juni 2006.

Tuchman, B. W. (1984). *The march of folly: From Troy to Vietnam.* Alfred A Knopf, New York.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), pp. 1124-1131.

UBA – Umwelt Bundes Amt. (2004, Dezember). *Emissionshandel in Deutschland: Verteilung der Emissionsberechtigungen f für die erste Handelsperiode 2005-2007.*

UBA – Umwelt Bundes Amt. (2007, Oktober). *Wirkung der Meseberger Beschlüsse vom 23. August 2007 auf die Treibhausgasemission in Deutschland im Jahr 2020.*

UBA - Umweltbundesamt. (2015, Mai). *Emissionshandel in Zahlen.* DEHSt Press.

UBA – Umweltbundesamt. German Environment Agency. (2016, September). *CO2 Emission Factors for Fossil Fuels.* UBA Press.

UBA – Umweltbundesamt. German Environment Agency. (2018, March). *Erneuerbare Energien in Deutschland. Daten zur Entwicklung im Jahr 2017.* UBA Press.

UN – United Nations. (1972, December 15). *Resolution adopted by the General Assembly 2997 (XXVII). Institutional and financial arrangements for international environmental cooperation.*

UNECE -United Nations Economic Commission for Europe, (2004), *Handbook for the 1979 Convention on Long-Range Transboundary Air Pollution and its Protocols,* Unied Nations Publication No. 04.II.E.9, Geneva and New York 2004.

UNEP – United Nations Environmental Protection (1985, March 22). *Vienna Convention for the Protection of the Ozone Layer. Vienna, 22 March 1985.*

UNEP – United Nations Environmental Protection (2016). *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer.*

UNFCCC -United Nations Framework Convention on Climate Change, (2002, June), Pages 31-42, *Agreement Between The European Community and its Member States under Article 4 of the Kyoto Protocol* (Burden Sharing, 2002).

van Hook, J. C. (2004). *Rebuilding Germany: The Creation of the Social Market Economy, 1945–1957*. New York: Cambridge University Press. 2004.

van Son, P., & Wieland, A. (2013). *Dii Annual Report 2012*. Munich, Germany: Dii GmbH.

Vaughan, D. (2009). *The Challenger launch decision: Risky technology, culture, and deviance at NASA*. University of Chicago Press.

VDN – Verband der Netzbetreiber (2001). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2000 (WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2000.pdf

VDN – Verband der Netzbetreiber (2002). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2001 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2001.pdf

VDN – Verband der Netzbetreiber (2003). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2002 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2002.pdf

VDN – Verband der Netzbetreiber (2004). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2003 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2003.pdf

VDN – Verband der Netzbetreiber (2005). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2004 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2004.pdf

VDN – Verband der Netzbetreiber (2006). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2005 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2005.pdf

VDN – Verband der Netzbetreiber (2007). *Erneuerbare-Energien-Gesetz (EEG). Jahresendabrechnung 2006 (auf Basis WP-Bescheinigungen)*. Retrieved from: https://www.netztransparenz.de/portals/1/Content/Erneuerbare-Energien-Gesetz/Jahresabrechnungen/EEG-Jahresabrechnung_2006.pdf

VerpackV (1991).*Verordnung über die Vermeidung und Verwertung von Verpackungsabfällen*. Juni 21, 1991. (BGBl. I S. 1234).

VerstrG3. (1974). *Gesetz über die weitere Sicherung des Einsatzes von Gemeinschaftskohle in der Elektrizitätswirtschaft (Drittes Verstromungsgesetz)*. Third electrification act of December 13, 1974 (BGBl. I S. 3473).

VerstrG5. (1995). *Gesetz zur Umstellung der Steinkohleverstromung ab 1996*. Modified Coal Electrification Act after 1996, of December 12, 1995. (BGBl. I S. 2633).

von Weizsäcker, E. U., *German Nuclear Policy*. Chapter 8 in Sokolski. H (2006). *Taming the Next Set of Strategic Weapons Threats,* (pp 151-160).

von Weizsäcker, R. (2001). *Drei Mal Stunde Null?* Siedler Verlag Berlin.

Vonnegut, K.(1963). *Cat's Craddle*. New York : Holt, Rinehart and Winston, NY

VVI Gas (2000). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für Erdgas*. Agreement on the criteria for the calculation of fees for the access to the natural-gas grid between the associations: Bundesverband der Deutschen Industrie (BDI), Verband der industriellen Energie- und Kraftwirtschaft (VIK), Bundesverband der Deutschen Gas- und Wasserwirtschaft (BGW), and Verband kommunaler Unternehmen (VKU). July 4, 2000.

VVI Gas (2001). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für Erdgas*. Agreement on the criteria for the calculation of fees for the access to the natural-gas grid between the associations: Bundesverband der Deutschen Industrie (BDI), Verband der industriellen Energie- und Kraftwirtschaft (VIK), Bundesverband der Deutschen Gas- und Wasserwirtschaft (BGW), and Verband kommunaler Unternehmen (VKU). Amendments of March 4, 2001 and September 14, 2001.

VVII Gas (2002). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für Erdgas*. Agreement on the criteria for the calculation of fees for the access to the natural-gas grid between the associations: Bundesverband der Deutschen Industrie (BDI), Verband der industriellen Energie- und Kraftwirtschaft (VIK), Bundesverband der Deutschen Gas- und Wasserwirtschaft (BGW), and Verband kommunaler Unternehmen (VKU). Amendments of May 3, 2002.

VVI Strom (1998). *Verbändevereinbarung Verbändevereinbarung über Kriterien zur Bestimmung von Durchleitungsentgelten*. Agreement on the criteria for the calculation of fees for the access to the electricity grid between the associations Vereinigung Deutscher Elektrizitätswerke (VDEW), Bundesverband der Deutschen Industrie (BDI), and Verband der Industriellen Energie- und Kraftwirtschaft (VIK). April 2, 1998.

VVII Strom (1999). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für elektrische Energie*. Agreement on the criteria for the calculation of fees for the access to the electricity grid between the associations: Vereinigung Deutscher Elektrizitätswerke (VDEW), Bundesverband der Deutschen Industrie (BDI), and Verband der Industriellen Energie- und Kraftwirtschaft (VIK) Deutsche Verbundgesellschaft (DVG), Arbeitsgemeinschaft Regionaler Energieversorgungsunternehmen (ARE), and Verband kommunaler Unternehmen (VKU). December 13, 1999.

VVII plus Strom (2001). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für elektrische Energie*. Agreement on the criteria for the calculation of fees for the access to the electricity grid between the associations: Vereinigung Deutscher Elektrizitätswerke (VDEW), Bundesverband der Deutschen Industrie (BDI), and Verband der Industriellen Energie- und Kraftwirtschaft (VIK), Deutsche Verbundgesellschaft (DVG), Arbeitsgemeinschaft Regionaler Energieversorgungsunternehmen (ARE), and Verband kommunaler Unternehmen (VKU). December 13, 2001.

VVII plus Strom (2002). *Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für elektrische Energie*. Agreement on the criteria for the calculation of fees for the access to the electricity grid between the associations: Vereinigung Deutscher Elektrizitätswerke (VDEW), Bundesverband der Deutschen Industrie (BDI), and Verband der Industriellen Energie- und Kraftwirtschaft (VIK), Deutsche Verbundgesellschaft (DVG), Arbeitsgemeinschaft Regionaler Energieversorgungsunternehmen (ARE), and Verband kommunaler Unternehmen (VKU). April 23, 2001.

Weber, M. (1904) *Die protestantische Ethik und der Geist des Kapitalismus*. CH Beck, 2010.

Weber, M. (1920) *Wirtschaft und gesellschaft: Grundriss der verstehenden Soziologie*. Mohr Siebeck, 2002.

Wetmore, J. M. (2003). Systems of Restraint: Redistributing Responsibilities for Automobile Safety in the United States since the 1960s. S. 1-284.

Wicke, L. & Schulte, M.C. (2013) - *Die Energiewende-Wende: Mehr Klimaschutz, aber sozial- und wirtschaftsverträglich*, Wacholz Verlag

Windram, C. (2009). *Falling EUA & CER Prices – and the questions we should be asking*. Februay 4, 2009. Available online: https://thinkcarbon.wordpress.com/2009/02/04/will-eua-prices-continue-to-fall-or-will-they-be-supported-by-cer-prices/

Winner, L. (1977). *Autonomous technology: Technics-out-of-control as a theme in political thought.* Cambridge, MA: Mit Press.

Winner, L. (2010). *The whale and the reactor: A search for limits in an age of high technology*. Chicago: University of Chicago Press.

Wirtschaftswoche, 9 December 2011, Energiewende, Wie sich der globale Energiehunger zusammensetzt, was bei der Energiewende auf uns zukommt und wer davon profitiert, availible online, wiwo.de | Illustration: Kristina Düllmann | Online-Umsetzung: Gruhn Webproduktion

Wittneben, Bettina B.F., 2012, *The impact of the Fukushima nuclear accident on European energy policy*, in Environmental Science &Policy 15 (2012), pp. 1-3.

Wolin, S. S. (2010). *Democracy incorporated: managed democracy and the specter of inverted totalitarianism*. Princeton University Press. P.14

Wüstenhagen, H. H. (1975). *Bürger gegen Kernkraftwerke. Wyhl der Anfang?* Rowohlt, Reinbek.

Wynne, B. (1988). Unruly technology: Practical rules, impractical discourses and public understanding. *Social Studies of Science, 18*(1), S. 147-167.

Yergin, D. (2008). *The Prize: The Epic Quest for Oil, Money, and Power*. Simon & Schuster, New York.

ZDF. (2017). *Klartext, Frau Merkel!Bürger fragen die Bundeskanzlerin. Themen: Integration, innere Sicherheit, soziale Gerechtigkeit, Flucht, Arbeit und Wirtschaft, EU und Europa.* TV debate of September 14, 2017. https://www.zdf.de/politik/wahlen/klartext-merkel-100.html

Zickfeld, F., Wieland, A., Blohmke, J., Sohm, M., Yousef, A., Buttinger, F., . . . Sensfuß, F. (2012). *2050 Desert Power- The Case for Desert Power - Executive Summary*. Munich, Germany: Dii GmbH.

Ziekow, J., Ewen, C., Barth, R., & Schütte, S. (2015). Neuartiger Öffentlichkeitsdialog in Verfahren mit Umweltprüfung am Beispiel bestimmter Vorhabentypen/ Vorhabeneigenschaften. Leitfäden für Behörden und rechtliche Verankerung. *Umweltbundesamt TEXTE*, 7, 2015.

ZuG 2007(2004).*Gesetz über den nationalen Zuteilungsplan für Treibhausgas- Emissionsberechtigungen in der Zuteilungsperiode 2005 bis 2007 ( Zuteilungsgesetz 2007 - ZuG 2007).* Allocation Act of August 26, 2004 (BGBl. I S. 2211).

ZuG 2012 (2007).*Gesetz über den nationalen Zuteilungsplan für Treibhausgas-Emissionsberechtigungen in der Zuteilungsperiode 2008 bis 2012 ( Zuteilungsgesetz 2012 - ZuG 2012).* Allocation Act of August 7, 2007 (BGBl. I S. 1788).

ZuV 2020 (2011) *Verordnung über die Zuteilung von Treibhausgas-Emissionsberechtigungen in der Handelsperiode 2013 bis 2020 (Zuteilungsverordnung 2020 - ZuV 2020).* The allocation Ordinance of September 26, 2011 (BGBl. I S. 1921).

APPENDIX A

INTERVIEW QUESTIONS

1. How would you qualify Germany's integrated climate and energy policy (success, failure)? Do you believe that Germany will achieve its ambitioned climate and energy goal 2050?
2. What do you think about the evolution and the perspectives of the German *Energiewende*? "Quo vadis" Germany?
3. What are the strengths and the weaknesses of Germany's radical energy policy?
4. What are from your point of view the impacts of the *Energiewende* on the:
    - 4.1. Infrastructure costs?
    - 4.2. Energy transportation costs?
    - 4.3. Energy prices and costs?
    - 4.4. Is the distribution of costs/benefits fair?
    - 4.5. Households?
    - 4.6. Large utility companies?
    - 4.7. Manufacturing industry?
    - 4.8. Employment?
    - 4.9. Just energy access?
    - 4.10. Society?
5. Do you perceive the distribution of costs/benefits as fair?
6. How can Germany reach its ambitioned climate goals, without relying on nukes & how can Germany meet its energy demand without nukes and fossil energy?
7. What do you think about the nuclear phase-out?
8. What do you think about the DESERTEC initiative? How realistic do you estimate the official statement that Germany will import renewable energies from North Africa and the Middle Eastern Region (DESERTEC initiative)?

9. Can you enumerate some of the unexpected and/or undesired consequences of the successive energy and climate regulatory frameworks between 1990 and 2014?

10. I am particularly interested in regulatory and legislative stipulations (EnWG, NZVo, EEG, KWKG, BiomasseVo, TEHG, ZUG, ZUV, AtomG, ReserveVo, etc.) that were meant to encourage a certain behavior of market players and to benefit the entire society but led either to a different/adverse market behavior or even to a generalized "legal misuse" and to an additional burden for the society. Have you heard about such practices? Were you confronted with such practices? Can you name some examples?

11. How do you explain that Germany has chosen a different energy transition trajectory than all other countries on the globe?

12. How will the EU decision to lower the aims of the RE Roadmap 2050 affect German policy?

13. How long can/will Germany continue a singular policy and how would this impact the global change?

14. Can you identify risks and/or opportunities related to the *Energiewende*

    14.1. For your company?

    14.2. For other categories of market participants?

    14.3. For society?

15. What should be changed in Germany's energy and climate policy?

16. Is it possible to formulate a regulatory framework in a manner that avoids adverse effects? Is it possible to elaborate a regulatory frame that does not favor some actors in the energy arena at the costs of others?

17. How mature are technologies required for energy transitions? What is their state of the art for:

    17.1. Electricity storage?

    17.2. CCS?

    17.3. Renewable energy technologies?

    17.4. Transmission lines?

18. How do you explain negative electricity prices?

19. How did the intensive deployment of renewable energies impact the 'merit-order'?

20. How did the intensive deployment of renewable energies impact the grid-operation (stability/dispatch/reallocation)?

21. How do you explain the nearly identical electricity price level offered at a given moment in time by different energy traders?

22. How do you estimate the liberalization initiative and its result?

23. Name some important turning points in the strategic approaches used by utility companies (for instance transition from client orientation and competition philosophy to trading dominance and standardization)?

24. What is your opinion about the Emission Trading regulation? (Is it necessary or not? Would other forms of incentives/constrains (own commitment, taxation) be more appropriate to achieve the ambitious decarbonization goals)?

25. How do you estimate the instrumental harmonization process in the energy and climate policy? Is it finalized? Does it work properly?

26. How do you estimate the different energy taxations (MiOlSt, OekoSt), the exemptions and the impact of the exemptions on not exempted consumers?

27. How do you estimate the evolution of additional cost generated as consequence of specific energy regulations (EEG, KWKG)? How does the exemption of some consumers from the obligation to pay these burdens (EEG/KWK contributions) impact not exempted consumers?

# APPENDIX B

# A DIAGNOSTIC MODEL FOR ENERGY POLICY FAILURE

This *Diagnostic Model for Energy Policy Failure* was adapted from Bozeman& Sarewitz (2011, p. 17, Table 2) using examples from Germany's energy and climate policy.

| # | **Public Failure Criterion** | **Failure Definition** | **Energy Policy Example** |
|---|---|---|---|
| 1. | Mechanisms for values articulation and aggregation | Political processes and social cohesion are insufficient to ensure communication and processing of public values. | Public values drove German protests against nuclear power. Most of Germany's citizens support the country's efforts to steer its energy systems away from coal and nuclear power. They found ways to communicate their values to the nation's political leaders. To preserve their legitimacy the political elites were willing to implement exactly the policies their constituencies asked for. They commissioned scientific studies to attest the feasibility and affordability of the *Energiewende*. Researchers manipulated the assumptions of their studies' to obtain the desired outcomes and maintain their influence. They published their findings obscuring that their assumptions were not plausible and developed strategies to keep *uncomfortable knowledge* at bay. Although public values, scientific findings, and political will converged, unifying the nation and pushing it in an unprecedented renewable rush, the *Energiewende* regulation led to unsatisfactory results, demonstrating that a broad societal consensus about what ought to be done with our energy systems is not enough for successful energy transitions. |
| 2. | Imperfect monopolies | Private provision of goods and services are permitted, even if the government's monopoly is deemed in the public interest. | Despite having the responsibility to severe the public, creating a safe and healthy environment for their citizens, democratic governments tend to delegate a part of this responsibility to private entrepreneurs. Germany's government is no exception. In the energy realm utilities, private associations, entrepreneurs, initiatives, and science were commissioned to ensure the nation's energy security, its nuclear safety, to develop solutions for deregulating markets, find repository of nuclear waste, reduce carbon emissions, ensure the affordability of energy transitions, etc. But – despite best intentions and broad public support – it failed to meet its targets. Poor results violate public expectations and generate potential for mistrust. Yet Germany deregulated its energy markets, and the problems related to its transition are not caused by *permissive monopolies* but rather by lofty goals, lack of sound concepts, and extremely complex systems. The private provision of good and services lies moreover at the foundation of capitalist economies and it is rather doubtful that omnipotent states that abolished private entrepreneurship would better meet public expectations. |
| 4. | Short time horizon | When a long-term view shows that a set of actions is counter to public value a short-term time horizon is employed. | Short-term views on wicked energy and climate problems fail to capture the costs of global climate change for future generations. But Germany's efforts to capture long-term climate mitigation costs in an integrated energy and climate policy ignore the short, medium, and long-term affordability of energy transitions, and do not necessarily lead to the desired outcomes. |

| # | Public Failure Criterion | Failure Definition | Energy Policy Example |
|---|---|---|---|
| 4. | Scarcity of providers | Despite recognizing their public value and agreeing on their public provision, goods and services, cannot be provided, if there are no providers available. | The experience with the deregulation of the German gas market shows that neither a large number of providers (more than 700) can alone improve the conditions for the provision of services. Although the public service (gas supply) was provided even in very remote places, providers were not willing to compete one with another. Their consequent refusal to make offers outside their direct area of influence, resulted in an artificial scarcity of providers at local levels. Despite governmental efforts this public policy failure could not be completely remediated. |
| 5. | Substitutability vs. conservation of resources | Policies focus either on substitutability or indemnification, even if there is no satisfactory substitute. | Germany's government aims to substitute almost its entire fossil and nuclear energy with energy from renewable sources by 2050, although the intermittent patterns of wind and solar, the impossibility to accurately forecast their availability, and the lack of large-scale storage solutions do no necessarily make these sources to appropriate substitutes. Sub-terrestrial exploitation of resources (e.g., coal) can cause - despite sustained stabilization and indemnification efforts - landslips and the destruction of human settlements. Large-scale solar facilities ignore the lack of substitutability of biological organisms (endangered tortoises in the Mojave Desert solar plant). Large hydropower construction trades electricity access against irreparable biodiversity loss. The deployment of wind turbines, and high-voltage power lines endanger several species of birds. |
| 6. | Benefit hoarding | By capturing public commodities and services individuals, firms, or groups of interest limited the distribution of these commodities to the population. | Leading researchers of the US national laboratories captured benefits of public funded research (new patent regulation) and established renewable energy enterprises diverting funds meant to benefit all people. German firms and households took the opportunity opened by generous EEG feed-in-tariffs, the privileged access to power grids, and the guaranteed long-term returns (i.e., no entrepreneurial risk) to massively invest in renewable facilities (i.e., on- and offshore wind farms, rooftop solar, utility scale solar plants, etc.) increasing the nation's transition burden. Each change in the taxation of oil-products led in Germany to windfall profits for natural-gas companies, to double taxations, and situations in which small and middle-sized consumers were not able to renegotiate their contractual terms. |

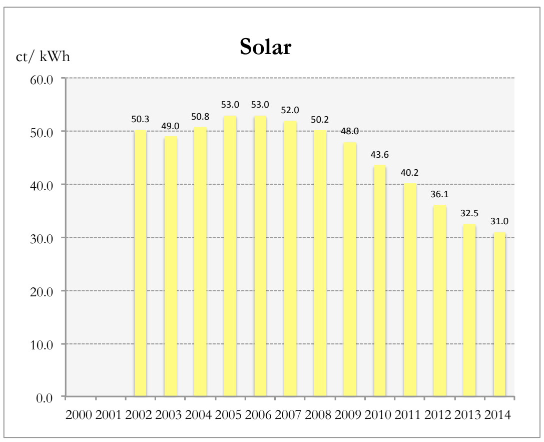
Germany's political elites crafted rules in a participatory process trying to integrate public values in their policies. The results of their efforts are mixed. Many listed examples show that models are suitable to identify categories of public policy failure, but limited in capturing complexities, or offering solutions for steering them in desired directions.

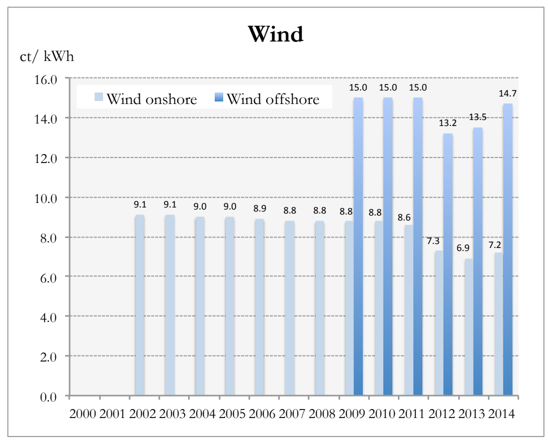
# APPENDIX C

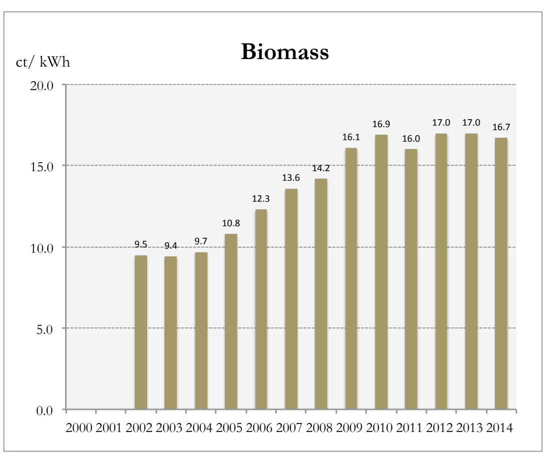
# AVERAGE PAYMENTS IN EURO CENTS PER KILOWATT-HOUR FOR THE GENERATION OF POWER USING RENEWABLE ENERGY SOURCES

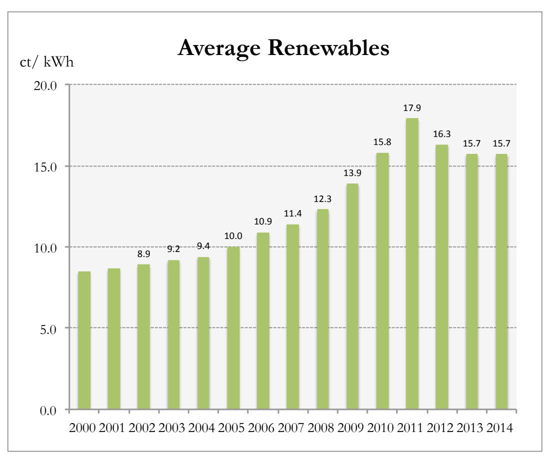
The Table and the four Figures below show how average payments for renewable energies evolved between 2000, when the first EEG was enacted, and 2014. They represent yearly average payments in Euro cents per kilowatt-hour and were calculated by dividing the "EEG Difference Costs" (i.e., the net payments per year for each renewable energy source) by the renewable power generated and fed in the grid (i.e., the kilowatt-hour generated yearly based on hydro, gases,[459] biomass, geothermal, wind on- and offshore, solar).

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydro | – | – | 7.2 | 7.2 | 7.3 | 7.4 | 7.4 | 7.5 | 7.6 | 7.8 | 7.4 | 4.8 | 6.4 | 6.7 | 7.1 |
| Gases | – | – | – | – | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.1 | 4.2 | 2.0 | 2.6 | 2.7 | 5.0 |
| Biomass | – | – | 9.5 | 9.4 | 9.7 | 10.8 | 12.3 | 13.6 | 14.2 | 16.1 | 16.9 | 16.0 | 17.0 | 17.0 | 16.7 |
| Geothermal | – | – | – | – | – | – | – | – | 15.0 | 19.8 | 20.6 | 20.7 | 24.0 | 23.4 | 23.2 |
| Wind onshore | – | – | 9.1 | 9.1 | 9.0 | 9.0 | 8.9 | 8.8 | 8.8 | 8.8 | 8.8 | 8.6 | 7.3 | 6.9 | 7.2 |
| Wind offshore | – | – | – | – | – | – | – | – | – | 15.0 | 15.0 | 15.0 | 13.2 | 13.5 | 14.7 |
| Solar | – | – | 50.3 | 49.0 | 50.8 | 53.0 | 53.0 | 52.0 | 50.2 | 48.0 | 43.6 | 40.2 | 36.1 | 32.5 | 31.0 |
| Average Renewables | 8.5 | 8.7 | 8.9 | 9.2 | 9.4 | 10.0 | 10.9 | 11.4 | 12.3 | 13.9 | 15.8 | 17.9 | 16.3 | 15.7 | 15.7 |




Data sources: VDN 2000, 2001, … 2007; bdew 2008, 2009, 2010; Netztransparenz 2011, 2012, … 2015.

[459] Sewage-, landfill-, and pit-gases.

# APPENDIX D

## NUCLEAR DEPLOYMENT PLANS BETWEEN 1957 AND 1973

Germany's governments adopted three nuclear programs between 1957 and 1973. Eleven nuclear power plants with a total capacity of 1766 MW were installed and additional capacities were in construction, or planed prior to Brandt's energy program of 1973.

**Experimental and commercial nuclear power plants that started operation in Germany prior to Chancellor Brand's nuclear program in 1973**

| Location | Owner | Installed Capacity | Operation start |
|---|---|---|---|
| Kahl | | 16 MW | 1962 |
| Karlsruhe | | 57 MW | 1966 |
| Grundremmingen A | RWE | 250 MW | 1967 |
| Lingen | RWE/VEW | 268 MW | 1968 |
| Obrigheim | EnBW/EVS | 357 MW | 1969 |
| Jülich | | 15 MW | 1969 |
| Großwelzheim | | 25 MW | 1970 |
| Stade | PreussenElektra | 672 MW | 1972 |
| Niederaichbach | | 106 MW | 1973 |
| **Total NPP Capacity in 1973** | | **1,766 MW** | |

**Installed, in construction and planned nuclear power plant capacity in December 1972, prior to Chancellor Brand's nuclear program in 1973**

| NPP capacity in operation and construction | Planed NPP capacity | Total installed, in construction and planned NPP capacity |
|---|---|---|
| 7,258 MW | 13,002 MW | 20,260 MW |

Data source: Deutscher Bundestag, 1973.

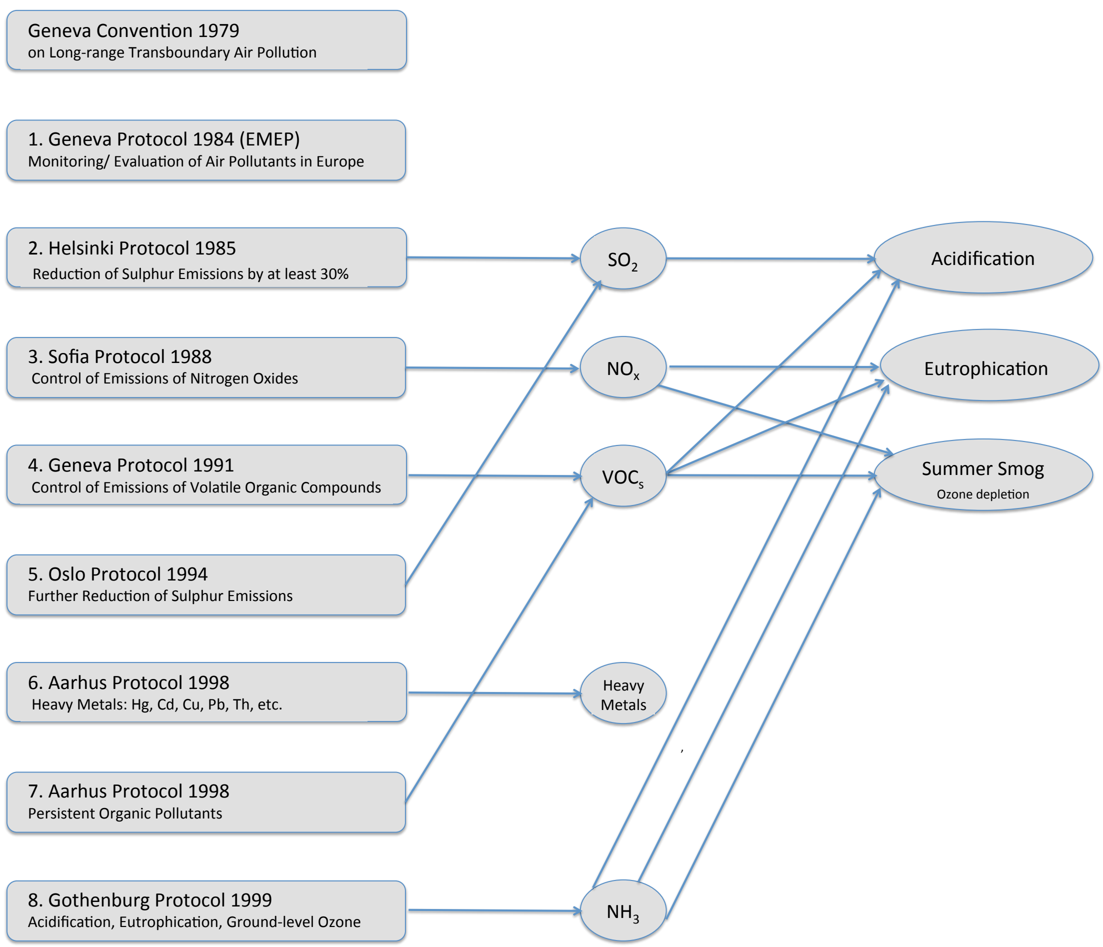
With his energy and nuclear programs 1973 Willy Brandt aimed to increase the nation's nuclear capacity between 1973 and 1985 from 1766 MW to 40-50,000 MW (Deutscher Bundestag, 1973; Schiffer, 2017, p. 3; Schaaf, 2000).

# APPENDIX E

# CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

# GENEVA CONVENTION OF 1979

The *UN Convention on Long-Range Transboundary Air-Pollution (Geneva Convention)* was adopted in 1979 by the European Community, USA, Canada, and the Soviet Union. Since 1983, when it became effective, the convention has been extended by eight protocols addressing undesired consequences of trans-boundary air pollution like acidification, eutrophication, and ozone depletion; and encompassing specific measures for mitigating emissions of sulfur-dioxide, nitrogen-oxides, volatile organic compounds, heavy metals, and ammonia. The figure below shows an overview of the *Geneva Convention* and its protocols.




Source: UNECE, 2004.

# APPENDIX F

# GERMANY'S INTEGRATED ENERGY AND CLIMATE PROGRAM

# THE MESEBERG DECISIONS

On August 23, 2007 the federal government decided to implement Germany's *Integrated Energy and Climate Program* and defined 29 distinct action fields for mitigating climate change. The program is also known as *Meseberg Decisions* or *Meseberger Beschlüsse*. It aimed to reduce carbon emissions by 219.4 million tons of CO2 equivalent by 2020. The measures and their expected carbon mitigation effects were:

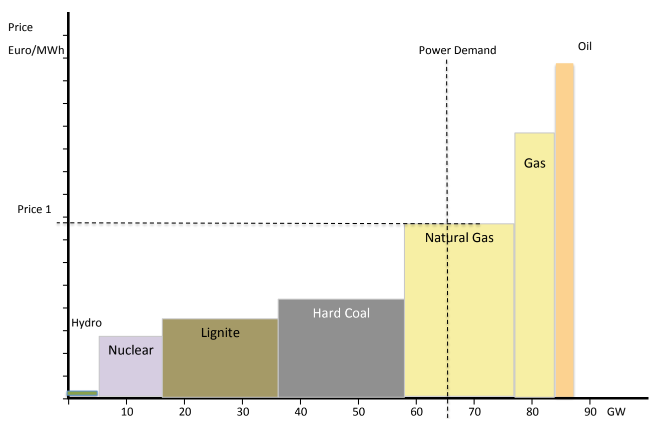
| **Measures** | **Estimated CO2 Reduction by 2020** | |
|---|---|---|
| **Fossil power plants** | **15** | Million tons CO2 equiv. |
| - New ETS allocation plans and rules | | |
| **Renewable energies in the power sector** | **54.4** | Million tons CO2 equiv. |
| - New EEG | | |
| - Repowering wind onshore facilities | | |
| - Energy Services Act | | |
| - Feed-in priority for offshore windmills | | |
| - Deed-in rules for biogas | | |
| **Combined heat and power** | **14.3** | Million tons CO2 equiv. |
| - New KWKG (CHP Act) | | |
| - CHP incentives in the EEG | | |
| **Building remodeling and heating** | **31** | Million tons CO2 equiv. |
| - Building remodeling program | | |
| - Heating Costs Ordinance | | |
| - Contracting facilities | | |
| - Modernization of the built infrastructure | | |
| - Remodeling federal buildings | | |
| **Renewable heat** | **9.2** | Million tons CO2 equiv. |
| - Heat EEG / Wärme EEG | | |
| **Reduced power consumption** | **25.5** | Million tons CO2 equiv. |
| - Eco-Design Directive | | |
| - Incentive programs for climate and efficiency | | |
| - New metering rules (smart meter) | | |
| - Night heat storage | | |
| **Transport** | **33.6** | Million tons CO2 equiv. |
| - CO2 strategy for cars | | |
| - Use of bio-fuels | | |
| - Airplane emissions in emission trading | | |
| - Ship transport | | |
| - Electro mobility | | |
| **Other GHG (Methane, N2O, F-Gases)** | **36.4** | Million tons CO2 equiv. |
| - CO2 reduction in coal mining sector | | |
| **Total carbon mitigation potential** | **219.4** | Million tons CO2 equiv. |

Data sources: UBA (2007, pp. 4-5); BMU (2007b, p. 8, Table 1).

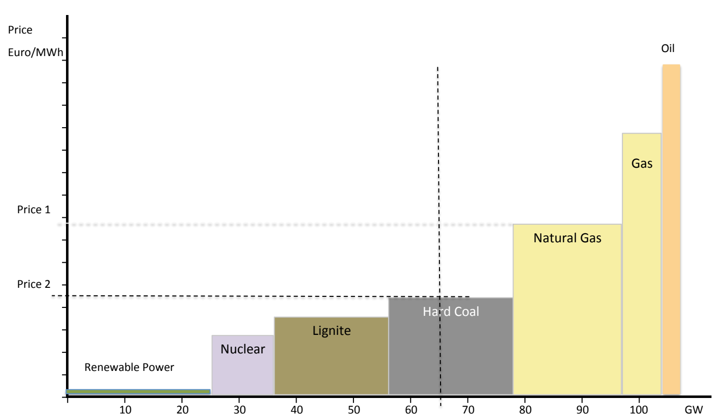
# APPENDIX G

# THE MERIT-ORDER-EFFECT

To determine the power price at the wholesale market available power-generating capacities (GW) are ranked in ascending order of their short-term marginal costs. The least expensive capacities are bought first. More expensive capacities continued to be bought until the supply matches the demand. This procedure is repeated for each trading period (1 hour). In Germany, the necessary capacity necessary to meet the demand varies between about 45 and 85 GW. The power price at the wholesale market for a certain period corresponds to the most expensive bid accepted to meet demand for this period. Traditionally Germany used large hydro-, nuclear-, lignite-, and hard-coal-facilities to deliver base-load power. More flexible natural-gas and oil power plants were used to deliver the mid- and peak-load. The two figures below show merit order curves for a hypothetical demand of 65 MW.




I. When RE are not available (e.g., on a windless night) the price at the wholesale market (Price1) corresponds to the marginal generation costs of natural gas.




II. On sunny and windy days, RE power (with no marginal costs) is sold first. This pushes the merit order to the right and marginal costs of coal determine the price (Price 2).

The intensive deployment of renewable energies leads to the decrease of power prices at the wholesale markets (Price 2 is lower than Price 1). It also pushes efficient gas fired power plants out of the merit-order curve. Moreover, coal-power plants have to react fast on wind and solar intermittencies, although they are not designed for steadily changing loads and cannot be operated under their minimal load. Owners of coal facilities overcome periods of very low demand (e.g., on holydays) offering negative prices for their coal power, because it would be more expensive to completely run-down the power plants.

# APPENDIX H

# ELECTRICITY BILLS OF GERMAN, ARIZONIAN, AND US HOUSHOLDS

The table below compares the consumption and the electricity costs of German, U.S. and Arizonian households for the year 2016.

| | Germany | United States | Arizona |
|---|---|---|---|
| Consumption of Power per Houshold (average 2016) | 3,500 kWh | 10,764 kWh | 12,360 kWh |
| Price in Euro ct/kWh | 28.72 ct/kWh | | |
| Price in $cents/kWh | 31.88 cents/kWh | 12.55 cents/kWh | 12.15 cents/kWh |
| Annual electricty bill (exchange rate 2016 Euro 1= $1.1) | Euro 1,005.2<br>$ 1,115.8 | $ 1,351.1 | $ 1,502.3 |
| Costs EEG | Euro 222.3 | | |
| Additional EW surcharges | Euro 320.6 | | |
| Share EW surcharges | 54% | | |
| Average US or AZ users would pay in Germany | | $ 3,431.5 | $ 3,940.3 |
| Their bills would include EW surcharges of | | $ 1,853.1 | $ 2,127.9 |

Data sources: bdew, 2016; EIA, 2016

# APPENDIX I

## CHANCELLORS AND GOVERNMENTAL COALITIONS

The successive coalition governments, parties, and chancellors can be seen in Table below:

| Bundestag | From | To | Admin. | German Coalition Governments | | | Chancellor/Party | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1949 | 1953 | I | CDU/CSU | FDP | DP | Konrad Adenauer | CDU |
| 2 | 1953 | 1957 | II | CDU/CSU | FDP | DP/GB/BHE | Konrad Adenauer | CDU |
| 3 | 1957 | 1961 | III | CDU/CSU | DP | | Konrad Adenauer | CDU |
| 4 | 1961 | 1963 | IV | CDU/CSU | FDP | DP | Konrad Adenauer | CDU |
| 4 | 1963 | 1963 | I | CDU/CSU | FDP | | Ludwig Ehrhard | CDU |
| 5 | 1963 | 1963 | II | CDU/CSU | FDP | | Ludwig Ehrhard | CDU |
| 5 | 1963 | 1969 | I | CDU/CSU | SPD | | Kurt G. Kiesinger | CDU |
| 6 | 1969 | 1973 | I | SPD | FDP | | Willy Brandt | SPD |
| 7 | 1973 | 1974 | II | SPD | FDP | | Willy Brandt | SPD |
| 7 | 1974 | 1978 | I | SPD | FDP | | Helmut Schmidt | SPD |
| 8 | 1978 | 1982 | II | SPD | FDP | | Helmut Schmidt | SPD |
| 9 | 1982 | 1982 | III | SPD | FDP | | Helmut Schmidt | SPD |
| 9 | 1982 | 1983 | I | CDU/CSU | FDP | | Helmut Kohl | CDU |
| 10 | 1983 | 1987 | II | CDU/CSU | FDP | | Helmut Kohl | CDU |
| 11 | 1987 | 1991 | III | CDU/CSU | FDP | | Helmut Kohl | CDU |
| 12 | 1991 | 1995 | IV | CDU/CSU | FDP | | Helmut Kohl | CDU |
| 13 | 1995 | 1998 | V | CDU/CSU | FDP | | Helmut Kohl | CDU |
| 14 | 1998 | 2002 | I | SPD | Grüne | | Gerhard Schröder | SPD |
| 15 | 2002 | 2005 | II | SPD | Grüne | | Gerhard Schröder | SPD |
| 16 | 2005 | 2009 | I | CDU/CSU | SPD | | Angela Merkel | CDU |
| 17 | 2009 | 2013 | II | CDU/CSU | FDP | | Angela Merkel | CDU |
| 18 | 2013 | 2017 | III | CDU/CSU | SPD | | Angela Merkel | CDU |
| 19 | 2017 | - | IV | CDU/CSU | SPD | | Angela Merkel | CDU |

| | |
|---|---|
| CDU | *Christlich Demokratische Union Deutschlands* - Christian Democratic Union of Germany |
| CSU | *Christlich-Soziale Union in Bayern* - Christian Social Union in Bavaria |
| DP | *Deutsche Partei* - German Party |
| FDP | *Freie Demokratische Partei* -Free Democratic Party |
| GB/BHE | *Gesamtdeutscher Block/Bund der Heimatvertriebenen und Entrechteten*<br>All-German Bloc/League of Expellees and Deprived of Rights |
| Grüne | *Bündnis 90/Die Grünen* - Alliance 90/The Greens |
| SPD | *Sozialdemokratische Partei Deutschlands* - Social Democratic Party of Germany |

# BIOGRAPHICAL SKETCH

Christine Sturm is a mechanical engineer and holds a master's degree in energy technology from the Polytechnic Institute Bucharest. Her professional experience ranges from working on pilot projects for coal gasification and optimizing the operation of Romanian coal power plants, to developing combined heat-and-power concepts, negotiating commodity contracts, carrying out all activities related to the European Emission Trading System, and optimizing energy systems in Germany and other member stated of the European Union. She worked in the German energy sector between 1992 and 2016, both for major energy consumers such as the paper industry (Stora Feldmühle, Haindl, and UPM), and for the energy-producing giant RWE, one of the largest German utility groups. In 1999 and 2000 she was the spokesperson for the Association of Industrial Power Generation and the Federal Association of German Industries, and headed their negotiations with Germany's gas-supplier associations on deregulation of the German gas market. Between 2004 and 2016 she worked as expert for biomass and decentralized energy concepts in different business units of the RWE group, serving as Head of their Energy- and Feedstock-Management Departments. In 2012 she began doctoral studies in the School of Sustainability at ASU, working on sustainable energy solutions. Her PhD research critically explored the German *Energiewende,* with the goal of finding out whether it is possible to steer large socio-technical systems in desired directions.