

CARBON LOCK-IN IN TURKEY

A COMPARATIVE PERSPECTIVE OF LOW-CARBON TRANSITION WITH GERMANY AND POLAND

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EXECUTIVE SUMMARY

The Paris Agreement sets out a target of limiting global temperature increase to well below 2°C and even to 1.5°C above pre-industrial levels in order to tackle climate change. Achieving this goal entails considerable reduction of carbon emissions by 2050 and achieving zero net emissions in the second half of the century. The decarbonization of the global economy signifies transitioning to low-carbon systems in all sectors of the economy and most notably in the energy sector, which is the largest source of global emissions. This transition is as imperative as tackling climate change in reducing social and ecological costs such as adverse health effects and environmental degradation caused by fossil fuels. Low-carbon transition also has great importance for economic development.

The low-carbon transformation we are experiencing is slow and painful. The current patterns in this transition exemplify that the existence and applicability of alternative technologies by themselves are not enough for transitions that imply a paradigm shift in the economy. There are many countries that persistently resist this transition, most notably the United States, which is also the most important developer of the new technologies necessary for the transition. This can be explained by the fact that when it comes to the prospect of a transition in a socio-technical system, the role of politics with all its facets is as important as the ones played by technology and economics. The transition can be slowed down, even brought to an end by factors that are not easy to change, especially the impacts and interventions of politics (laws, regulations, taxes, subsidies, etc.) on the economic dynamics and the impacts of power relations, private benefits, consumer behavior, lifestyles, established beliefs and opinions, dominant corporate institutions, experts, and bureaucracy.

Remaining in the current fossil fuel-based economic system, despite all global transition trends moving away from the old system, constitutes an important dimension of the issue and requires further examination. An explanation as such first requires a look into the emergence of path dependency in climate and energy policies, which is referred to as carbon lock-in. Countries that depend on high-carbon economic development paths tend to fail to overcome this dependency because of certain dynamics in play and increase the extent of their lock-in.

Turkey is a country where more than 75 percent of the energy demand is met by fossil fuels. On the one hand, it is dependent on a fossil fuel-based development pathway in almost every sector of the economy from transportation to heating, from energy to agriculture. On the other hand, Turkey's escape from carbon lock-in would be relatively easy. Historically, Turkey began producing electricity by building dams, and it is rich in renewable resources such as water, wind, and sun. It is not a major fossil fuel producer. Its demand for new energy infrastructure is higher than the demand in established industrialized countries. Nevertheless, policies developed to increase coal's share in power generation and oil dependency in transportation indicate that the dominating dynamics are still focused on a high-carbon economic pathway and not a transition to a low-carbon economy.

A comparative analysis of Turkey and two important European countries, Germany and Poland, might prove useful in examining Turkey's inability to break the carbon lock-in. These countries share some level of similarity with each other and with Turkey yet follow quite separate paths. By comparing the situation of Germany, one of the leaders of the transition to a low-carbon economy despite being a leading industrialized country, and

Poland, whose energy system is largely coal-dependent and firmly maintains this dependency, with each other and with Turkey, new insights into the dynamics of a low-carbon transition can emerge. These three countries are countries that have a fossil fuel-dependent economic system displaying continuing or decreasing dependencies.

This report compares Turkey, Germany, and Poland's energy systems, perspectives, future energy policies, and how each country approaches the global trend toward a low-carbon transition. The research methods in this study included reviewing the pertinent literature, official documents, and reports regarding Turkey's, Germany's, and Poland's energy policies; conducting semi-structured interviews in Germany, Poland and the UK; and holding an open-ended panel discussion in Turkey.

What is Carbon Lock-in?

Carbon lock-in defines a situation that creates policy inertia. Our failure to start and/or endure the necessary low-carbon transformation is a crucial discussion, because the need for change in technological systems as well as social, economic, and institutional processes is inevitable. Transition to low-carbon systems is an integral part of climate change mitigation policies. However, since fossil fuel dependency is not merely about technology, it does not necessarily mean that viable alternatives can be translated into systems transition.

Unruh emphasizes, "the industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional returns to scale." Another definition by Seto et al. outlines that "the inertia of technologies, institutions, and behaviors individually and interactively limit the rate of such systemic transformations by a path-dependent process known as carbon lock-in, whereby initial conditions, increasing economic returns to scale, and social and individual dynamics act to inhibit innovation and competitiveness of low-carbon alternatives." In other words, carbon lock-in is a form of path dependency that occurs when the disadvantages created by a technological, economic, political, or social factor increase atmospheric carbon emissions or hinder emissions reduction. What is notable is that, while the path dependency may be normatively neutral, carbon lock-in is always a negative term because it obstructs the desired outcome for a low-carbon society.

One of the most debated aspects of carbon lock-in is stranded assets in the energy sector. Physical infrastructure for electricity production, transmission, and distribution—mainly power plants, grids, power lines, etc.—is built in anticipation of a long-term life cycle. When a company invests in an energy business, one does not expect a profit during the investment period, because capital costs always exceed operating returns. But, after the returns pay off the capital investment and profits begin to exceed the operating and maintenance costs, investors expect to operate the business as long as possible, until the end of an energy asset's physical lifetime. If new technology versus existing industry, as in the case of renewables versus coal power plants, becomes a norm and starts pushing for replacement before the end of the physical lifetime, the existing technology can turn into a stranded asset or sunk investment.

Carbon Lock-in and Barriers in a Comparative Perspective

Germany's large share in the world economy, its power system, and GHG emissions make its energy transition (*Energiewende*) extremely significant for international climate and energy policies. Furthermore, the current shift in Germany's energy structure represents a viable example of transitioning to a low-carbon economy and escaping carbon lock-in. On the other hand, Germany faces many challenges. The continuing high share of coal in

electricity production and the difficulties encountered by other sectors such as transportation and heating make it difficult for Germany to reach its targets. The main objective of Energiewende is to transform German energy policies from a fossil fuel- and nuclear-based system to a low-carbon system based on renewables and efficiency. Today, Energiewende has four pillars: phasing out nuclear power by 2022, mitigating climate change, improving energy security, and amending industrial policies targeting competitiveness and growth.

Poland's energy system and power production is largely dependent on coal—particularly, domestic coal. Despite a 2.7 percent drop in production figures over the last decade, the country is the biggest coal (hard coal and lignite) producer in the European Union. Polish hard coal accounts for 72 percent of all extraction in Europe and boasts of the largest share of fossil fuels for electricity generation after Australia. It holds sixth place for the lowest share of renewables in electricity generation among IEA member countries. Coal constitutes 79 percent of the country's energy production and 51 percent of total primary energy supply (TPES). As for the development of renewable energy policies in Poland, this is mainly limited to its involvement in short-term EU policies. The country does not have any other energy transition plan to shift its energy sector from fossil fuels to renewables, including medium- and long-term targets for 2030 or 2050.

Turkey's energy system is dominated by fossil fuels. Natural gas accounted for 34 percent, coal for 31 percent, hydropower for 24 percent, wind for 6 percent, geothermal for 2 percent, and other resources for 3 percent of electricity production. The basis of Turkey's official energy strategy is to reduce energy resource imports. The aim is to reduce natural gas and coal imports used for electricity production and increase the share of domestic coal and particularly water as well as renewable resources such as wind and solar. However, looking at the increasing and ongoing subsidies provided by the state to fossil fuels, we can deduce that Turkey does not have a policy to reduce fossil fuels in energy production. Even though coal's share in electricity production has increased considerably in recent years, there has been no significant increase in the use of domestic sources. Turkey intends to increase domestic coal's share in electricity production as well as the number of new renewable energy plants. It aims at keeping the share of renewable sources (including hydropower) at one-third by 2023. Since currently renewable sources account for approximately 32 percent of electricity production, we can see that Turkey intends to increase renewable energy capacity but does not foresee an increase in renewable's share in electricity production.

According to the developments in the energy sector and the information gathered during the interviews, Turkey's carbon lock-in situation is becoming increasingly tighter. Poland is a country with a long history of carbon lock-in and appears to further aggravate its situation. As for Germany, it embarked on the path to break carbon lock-in but has slowed down and been sidetracked in recent years. Some experts have even commented that Germany is back on a trajectory toward carbon lock-in. Nevertheless, out of the three countries Germany appears to have the best chance to escape from carbon lock-in, while Poland seems to resist. Turkey's situation appears to be somewhere in between. Turkey has many opportunities to escape lock-in; however, it does not make the necessary efforts and even adheres to policies that will further aggravate the problem. Therefore, Turkey will probably find itself in a stronger carbon lock-in situation in the coming years.

The economic, social, and political factors that enable and prevent low-carbon transition in Germany, Poland, and Turkey can be addressed under six headings.

1- The prominent reason for Germany playing a leading role in low carbon transition policies and for Energiewende becoming permanent and accepted on societal level even though it is a major industrialized country is political. All the experts agree that the anti-nuclear movement that emerged in the 1970s formed a strong social movement that politicized energy issues over time. Accordingly, the social acceptance of the alternatives that were developed over time were among the main factors behind Energiewende. The fact that Germany's Green Party entered the Bundestag in the early years and that it implemented the nuclear phase-out and the Renewable Energy Act as priority policies during the red-green coalition from 1998 to 2005 were game changers to start low carbon transition. As for Turkey and Poland, such issues remain far from the mainstream political debate. Environmental and energy policies do not constitute important political issues in either of the two countries. Also, the green parties are not important actors of the political spectrum in either Poland or Turkey. Therefore, neither climate change, nor low-carbon transition in both countries is an issue in electoral politics. The fact that green politics has not developed in either country, and political conditions similar to Germany's has not formed have impeded the positive impacts that politics can potentially have on low-carbon transition. This has, in turn, increased carbon lock-in.

2- On the other hand, policies that increase carbon lock-in can secure political gain in any country and this is most apparent in Poland. In the Polish case, even if the current number of people working in coal mines—which employed a large number of workers and were politically strong during Communist rule—is less than 100,000, coal-producing regions still have a considerable impact on politics today. In Germany, coal unions have an important influence on political parties, particularly on the Social Democratic Party in certain regions, and this is one of the factors that prevents coal phase-out policies from being brought to the agenda. In Turkey, the government defends domestic coal using the pretext that it is an important driver for employment and uses its support for coal to obtain votes from coal miners and residents living near coal mines and coal-fired power plants.

3- The production and distribution of energy according to the rules of the free market can have an enabling effect for low-carbon transition. This becomes especially evident in the comparison between Germany and Poland. In Poland, where all electricity production is in the control of the state, the determinative impact of politics surpasses the economic impact, and coal is protected by state incentives. The government in Poland, which owns the majority share of energy utilities and appoints their executives, steers these utilities towards supporting domestic coal production. Being in control of electricity production, the government also hinders the development of renewable energy generation by the private owners. In Turkey the privatization of the energy sector is in a much more advanced stage than in Poland; however, this is not enough to reduce the state's determinative influence and the role played by political concerns in decision-making processes.

4- The decentralization of energy policies to include more small businesses and individual producers has a supportive effect on low-carbon transition. The fact that in Germany almost half of the wind and solar installations used in electricity production are owned by private citizens and the rest by small investors and co-ops in which influential small farmers own a considerable share were the factors behind the widespread acceptance of the Energiewende. In Turkey's case, large and centralized facilities are favored not only for energy but for all economic policies. Decentralization is not an ideologically and politically favored approach. Poland also continues to prioritize centralized and large structures and ignores and even considers small and decentralized

systems harmful with an approach that dates back to the Communist era.

5- Germany is an example where scientists and experts had a positive influence on low-carbon transition. The studies of economic models and projections, the development of new technologies, and the work of civil society organizations, universities, and think tanks paved the way for the preparation of data-based policy recommendations, as well as for political parties to advocate these recommendations and for governments to implement them. In Poland and Turkey, experts have a mixed role in influencing low-carbon transition. Even though science and technology's influence in the decision making of national policies is limited, experts play a role in defending innovation and change or in keeping the status quo.

6. Voting and consumer behaviors as well as user practices may have a larger impact on low-carbon transition than we think. German citizens' driving habits—such as the perception that "strong German cars" are part of German national identity, similar to the way coal was considered in the past—may play an important role. While the final consumer cannot distinguish among the different sources of electricity production, vehicles are consumer goods that directly involve personal choices. As for Poland, the perception that electricity can only be produced by burning coal prevails. In Poland, coal is also considered an element of national identity and is accepted, at least by some, as the symbol of Poland's independence. A similar situation where nationalistic political ends can be used as a unifying ideological glue is also true in Turkey's case. Coal becomes easier to accept when it is presented as the tool of independence and to ward off external forces. In Germany as well as in Turkey and Poland, consumers' approach to energy consumption generally displays a conservative influence on situations where consumer behavior plays a determinative role, most notably in travel, housing, and heating.

Conclusion

Turkey can still escape from rapidly intensifying carbon lock-in. Even though its energy consumption is highly fossil fuel-dependent, Turkey can use the fact that it is a developing country to its advantage, particularly in power generation and the transport sector. It is much easier for developing countries to undergo rapid renewable energy transformation in power generation than it is for major industrialized countries. Road and construction are rapidly growing sectors in Turkey, and policy changes favoring low-carbon transition can enable the reduction of transport and building emissions. Turkey still has the chance to bypass a polluting development pathway and achieve ecological leapfrogging. By making this political choice, Turkey can break carbon lock-in, which constitutes a situation that will lead to important economic losses in the future. A policy change in this direction will also create an important opportunity for businesses to avoid the risk of stranded assets.

INTRODUCTION

The Paris Agreement sets out a target of limiting global temperature increase to well below 2°C and even to 1.5°C above pre-industrial levels in order to tackle climate change. Achieving this goal entails considerable reduction of carbon emissions by 2050 and achieving zero net emissions in the second half of the century. The decarbonization of the global economy signifies transitioning to low-carbon systems in all sectors of the economy and most notably in the energy sector, which is the largest source of global emissions. This transition is as imperative as tackling climate change in reducing social and ecological costs such as adverse health effects and environmental degradation caused by fossil fuels. Low-carbon transition also has great importance for economic development.

Low-Carbon Transition as a Global Trend

Low-carbon transition is no longer a mere necessity; it has become a global trend. Currently, renewable energy[1] accounts for more than half of all annual new power generation investments worldwide.[2] The share of renewable sources in the energy mix, and particularly in power generation, is rapidly increasing. This recent transformation in the energy sector initially began as part of the fight against environmental problems and climate change. However, the current widespread transition to low-carbon systems was made possible by technological developments, declining prices, and the easy implementation of these systems. Hence, this new energy policy based on renewable energy, energy efficiency, and energy saving has gone beyond being an option to becoming an increasingly hard to resist global trend.

The inevitability of transitioning to a zero-carbon economy was brought about not only by the requirements of international politics such as the obligation to observe the Paris Agreement or pressure from civil society and grassroots organizations, but also by changing market conditions. Very soon, countries that insist on maintaining a fossil fuel-based economy might be forced to support their energy sectors through state incentives as fossil fuels have become disadvantageous in global markets. We are already beginning to see this happen today.

The low-carbon transformation we are experiencing is slow and painful. The current patterns in this transition exemplify that the existence and applicability of alternative technologies by themselves are not enough for transitions that imply a paradigm shift in the economy. Thirty years ago, underdeveloped technology and high costs were regarded as important problems, particularly in the aftermath of the Chernobyl disaster, which began the trend of abandoning nuclear power and moving toward alternative resources. The acceleration of climate change brought about the necessity to move away from fossil fuels, and the use of renewable energy and low-energy consumption became imperative. This generated a new situation during which technology and cost were beginning to no

1 In this report, the term "renewable energy" includes hydropower plants. This inclusion is necessary in order to compare official figures, since in many countries the renewable energy data include water resources. However, large-scale hydropower plants with dams are no longer classified as "renewable energy" anywhere in the world due to the environmental and social problems they cause. As for the implementation of small-scale, run-of-river type hydropower plants, we have become aware in Turkey that these types of plants cause serious damage to nature and violate the water rights of local communities. Nevertheless, referring to renewable energy in the most general sense of the term was deemed acceptable for the purpose of this report, which focuses on fossil-fuel dependency.

2 Frankfurt School-UNEP Collaborating Centre/BNEF, *Global Trends in Renewable Energy Investment* (Frankfurt: Frankfurt School of Finance & Management, 2017), http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf.

longer be such an important problem. However, if the transformation of an established socio-technical system were to consist of nothing more than technological and economic dynamics, we would be witnessing many more countries starting to rapidly move away from fossil fuels.

Resisting Low-Carbon Transition

There are many countries that persistently resist this transition, most notably the United States, which is also the most important developer of the new technologies necessary for the transition. This can be explained by the fact that when it comes to the prospect of a transition in a socio-technical system, the role of politics with all its facets is as important as the ones played by technology and economics. The transition can be slowed down, even brought to an end by factors that are not easy to change, especially the impacts and interventions of politics (laws, regulations, taxes, subsidies, etc.) on the economic dynamics and the impacts of power relations, private benefits, consumer behavior, lifestyles, established beliefs and opinions, dominant corporate institutions, experts, and bureaucracy. (The opposite is also possible, in other words, politics and other factors can positively impact the transition process in a socio-technical system.)

Remaining in the current fossil fuel-based economic system, despite all global transition trends moving away from the old system, constitutes an important dimension of the issue and requires further examination. An explanation as such first requires a look into the emergence of path dependency in climate and energy policies, which is referred to as carbon lock-in. Countries that depend on high-carbon economic development paths tend to fail to overcome this dependency because of certain dynamics in play and increase the extent of their lock-in. Understanding these dynamics and the relationships among them can be more difficult than it initially seems. Even if competent, scientifically solid, and economically advantageous transition policies are developed by universities, think tanks, and experts, they may not be accepted by decision makers and ignored. Entrenched opinions, relationships, political calculations, habits, and cultural values may play a more determining role. Therefore, how to resolve a carbon lock-in situation is a difficult question to answer.

Turkey is a country where more than 75 percent of the energy demand is met by fossil fuels. On the one hand, it is dependent on a fossil fuel-based development pathway in almost every sector of the economy from transportation to heating, from energy to agriculture. On the other hand, Turkey's escape from carbon lock-in would be relatively easy. Historically, Turkey began producing electricity by building dams, and it is rich in renewable resources such as water, wind, and sun. It is not a major fossil fuel producer. Its demand for new energy infrastructure is higher than the demand in established industrialized countries. Nevertheless, policies developed to increase coal's share in power generation and oil dependency in transportation indicate that the dominating dynamics are still focused on a high-carbon economic pathway and not a transition to a low-carbon economy.

A Comparative Perspective

A comparative analysis of Turkey and two important European countries, Germany and Poland, might prove useful in examining Turkey's inability to break the carbon lock-in. These countries share some level of similarity with each other and with Turkey yet follow quite separate paths. By comparing the situation of Germany, one of the leaders of the transition to a low-carbon economy despite being a leading industrialized country, and Poland, whose energy system is largely coal-dependent and firmly maintains this dependency, with each other and with Turkey, new insights into the dynamics of a low-carbon transition can emerge.

These three countries are countries that have a fossil fuel-dependent economic system displaying continuing or decreasing dependencies.

Turkey, Germany, and Poland's energy policies can be compared by reason of their geographical proximity, relatively comparable populations, and economic sizes. They are coal-producing countries with no oil production and no nuclear power plants—or those nuclear plants are being phased out. Similar ideological political parties have been in power for years in all of the three countries. Even though these countries differ in their level of industrialization, technology, and economic wealth, the aforementioned similarities provide an interesting backdrop in showing that the obstacles to the transition are not limited to technology and economy.

This report compares Turkey, Germany, and Poland's energy systems, perspectives, future energy policies, and how each country approaches the global trend toward a low-carbon transition. The research methods in this study included reviewing the pertinent literature, official documents, and reports regarding Turkey's, Germany's, and Poland's energy policies; conducting semi-structured interviews with experts, eight from Germany, four from Poland, and two from the UK between May-September 2016; and holding an open-ended panel discussion, similar to a focus group meeting but using a less structured method, with a group of fifteen energy experts in Turkey in May, 2017.[3] The written reports and interview transcriptions were assessed, analyzed, and used in the writing of this report.

The second part of the report briefly introduces the concepts of socio-technical transition and carbon lock-in. Germany and Poland's energy systems and policies for a low-carbon transition are featured in chapters three and four. The fifth chapter provides brief information on energy systems and trends in Turkey and the sixth chapter compares its fossil fuel-dependent system and transition trend policy dynamics with Germany and Poland. The seventh and final chapter of the report discusses policy recommendations for undoing carbon lock-in.

3 The expert roundtable conducted in Turkey was made possible by the generosity of the Middle East Technical University Alumni Association's Energy Commission, who dedicated one of its closed meetings to these interviews. Therefore, all the experts interviewed were members of this commission and engineers worked or had worked in the public sector or in the private energy sector.

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WHAT IS CARBON LOCK-IN?

Carbon lock-in defines a situation that creates policy inertia. Our failure to start and/or endure the necessary low-carbon transformation is a crucial discussion, because the need for change in technological systems as well as social, economic, and institutional processes is inevitable. Transition to low-carbon systems is an integral part of climate change mitigation policies. However, since fossil fuel dependency is not merely about technology, it does not necessarily mean that viable alternatives can be translated into systems transition. Thus, the proper way to investigate methods to overcoming these challenges is to examine this through a wider lens to define a locked-in situation and its determinants.

Unruh emphasizes, "the industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional returns to scale."[4] Another definition by Seto et al. outlines that "the inertia of technologies, institutions, and behaviors individually and interactively limit the rate of such systemic transformations by a path-dependent process known as carbon lock-in, whereby initial conditions, increasing economic returns to scale, and social and individual dynamics act to inhibit innovation and competitiveness of low-carbon alternatives."[5] In other words, carbon lock-in is a form of path dependency that occurs when the disadvantages created by a technological, economic, political, or social factor increase atmospheric carbon emissions or hinder emissions reduction.[6]

What is notable is that, while the path dependency may be normatively neutral, carbon lock-in is always a negative term because it obstructs the desired outcome for a low-carbon society.[7]

While environmental externalities and market and policy failures create a need for precautions and corrective government intervention such as incentives and regulations leading to innovations, increasing returns anchor and stabilize the trajectories, as specified in the definitions.[8] On the other hand, barriers to socio-technical change are not limited to economic interests. Technological, organizational, institutional, and other barriers play a role on a multi-level perspective.

Geels defines technological transitions—which involve not only technological changes but also changes in user practices, regulations, industrial networks, infrastructure, and symbolic meaning—as major technological transformations in the way of societal functions, such as transportation, energy, communication, etc. Technological transitions can fulfill functions only in association with human agency, social structures, and organizations.[9]

Therefore, technological developments for electricity generation such as photovoltaic cells or storing power for an electric car using a lithium-ion battery constitute only a small part of the story. Shifting from coal power plants to solar roofs, or from cars with internal combustion engines fueled

4 G.C. Unruh, "Understanding Carbon Lock-in," *Energy Policy* 28 (2000): 817.

5 K.C. Seto, S.J. Davis, R.B. Mitchell, et al., "Carbon Lock-In: Types, Causes, and Policy Implications," *Annual Review of Environmental Resources* 41 (2016): 427.

6 Ibid, 427.

7 Ibid, 427.

8 Unruh, "Understanding Carbon Lock-in"; M.L. Djelic and S. Quack, "Overcoming Path Dependency: Path Generation in Open Systems," *Theory & Society* 36, no. 2 (2007): 161–186.

9 F.W. Geels, "Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-level Perspective and a Case-study," *Research Policy* 31 (2002): 1257.

by gasoline to electric cars run by renewable power is possible only through changes in other elements of a socio-technical configuration. These elements are linked to and aligned with each other and consist, namely, of maintenance systems, grids, taxes, fuel infrastructure—as well as perceptions, consumer behavior, cultural values and symbolic meanings such as comfort, freedom, individuality, state's role, etc.[10] Disregarding economic, social, and cultural determinants contributes to inertia.

A recent review identified three types of lock-in that limit the rate of systemic transformations to decarbonize the economy. These are "(a) lock-in associated with the technologies and infrastructure that indirectly or directly emit carbon dioxide and shape the energy supply; (b) lock-in associated with governance, institutions, and decision-making that affect energy-related production and consumption, thereby shaping energy supply and demand; and (c) lock-in related to behaviors, habits, and norms associated with the demand for energy-related goods and services... Infrastructural and technological lock-in, institutional lock-in, and behavioral lock-in, respectively."[11] Carbon lock-in may also be categorized according to whether it is supply- or demand-oriented: for example, "...lock-in related to energy supply (e.g., the infrastructure to generate and transmit electricity), ...lock-in of energy demand (e.g., end-use technologies, habits, and behavior)."[12]

One of the most debated aspects of carbon lock-in is stranded assets in the energy sector. Physical infrastructure for electricity production, transmission, and distribution—mainly power plants, grids, power lines, etc.—is built in anticipation of a long-term life cycle. When a company invests in an energy business, one does not expect a profit during the investment period, because capital costs always exceed operating returns. But, after the returns pay off the capital investment and profits begin to exceed the operating and maintenance costs, investors expect to operate the business as long as possible, until the end of an energy asset's physical lifetime. If new technology versus existing industry, as in the case of renewables versus coal power plants, becomes a norm and starts pushing for replacement before the end of the physical lifetime, the existing technology can turn into a stranded asset or sunk investment. During periods of rapid transformation, this stranded asset can occur at a time when the company is making considerable profit or before it has paid off the capital costs; hence, lost value may include "stranded investments" (i.e., unpaid capital costs) and/or "stranded profits" (i.e., anticipated operational profits).[13] (See Figure 1.)

10 Ibid, 1258.

11 Seto et al., "Carbon Lock-In: Types, Causes, and Policy Implications," 426.

12 Ibid, 427.

13 Ibid, 428.

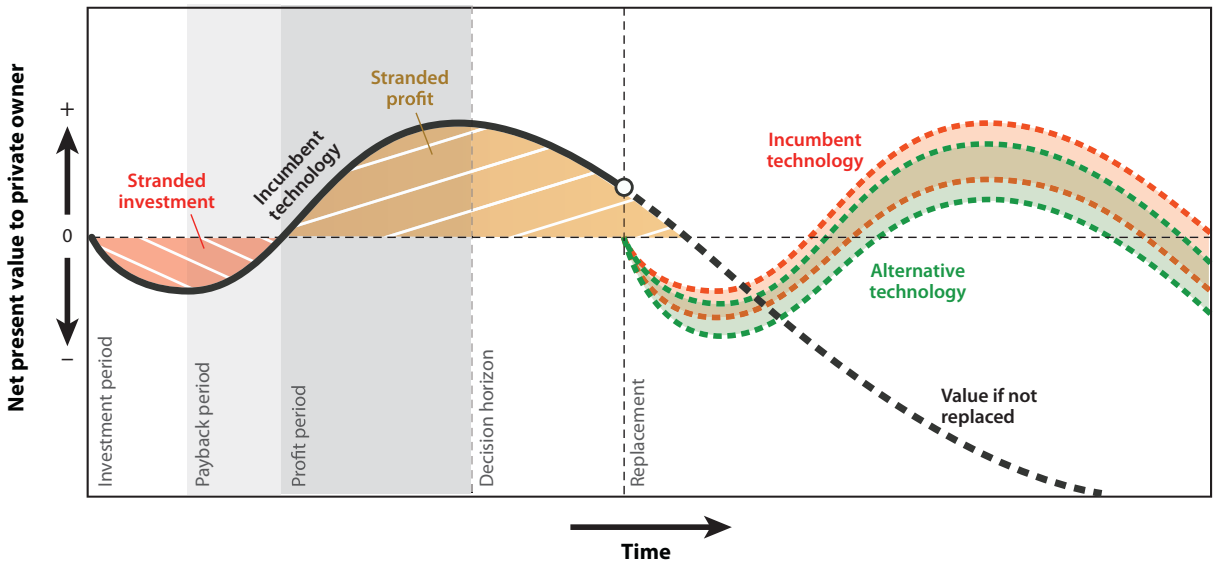


Figure 1: The graphic illustrates the value of a hypothetical energy asset over its lifetime. If an alternative technology becomes economically and socially preferable before the normal replacement period, profits or even the capital cost of the incumbent technology can become stranded.[14]

Because of their long life span and business expectations for sustained profits, fossil fuel infrastructures and other infrastructure (including roads, buildings, equipment, etc.) built around them have turned into insurmountable barriers to low-carbon transition. In other words, business interests to sustain lifetime profits prevail over not only environmental imperatives such as climate mitigation but also over the major economic gains of the emerging investments in new technologies. This situation is the case particularly when, with several political considerations and using specific discourse, political institutions adjust to protect certain industrial sectors or groups.

The expected lifetime of fossil fuel infrastructure varies between a minimum of 10-20 years (as for the internal combustion engine vehicles) and a maximum of 40-60 years (as for the coal power plants). On the other hand, the required carbon price to induce replacement is much lower for the coal power plants than for cars and trucks. Therefore, while replacing coal power plants with renewables is easier, economically more feasible, and more effective for the transition, resistance due to expected long-term returns as well as against carbon pricing sustains lock-in. Figure 2 graphically illustrates the lifespan, necessary carbon price for early retirement, and techno-institutional effect of a diverse range of fossil fuel-based equipment. Also, it should be noted that fossil fuel infrastructure is not limited to power plants and user devices. Coal delivery, pipelines, refineries, fuel stations, the spare part industry, repair shops, etc., are among the less visible part of long-term and lock-in investments. Energy-demanding infrastructures such as street networks, physical structures of building shells (e.g., walls, windows), and heating and cooling equipment can also be added to the picture. They may also be considered as assets with long life spans..[15]

14 Ibid, 428.

15 Ibid, 430.

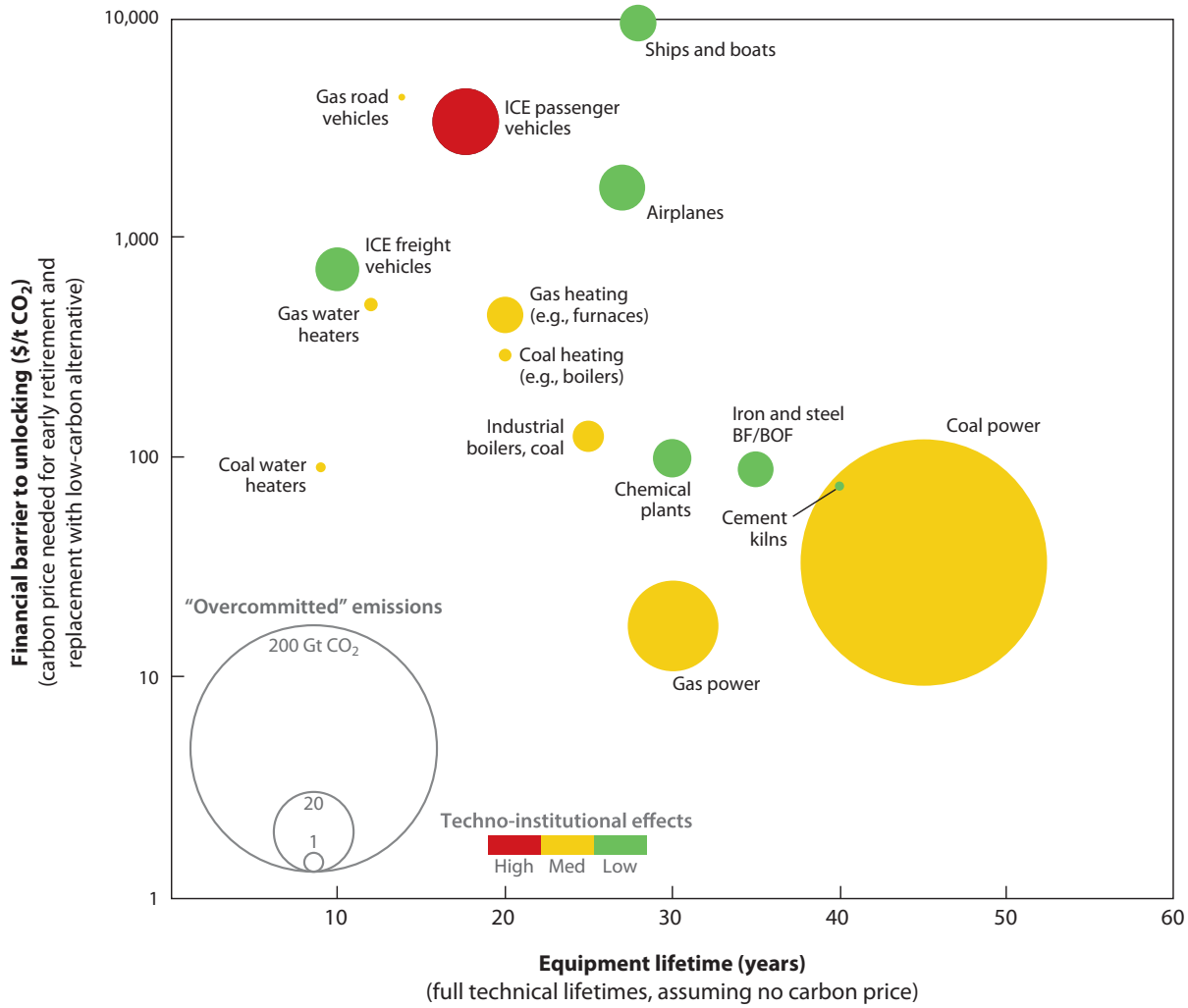


Figure 2: Schematic illustration of carbon lock-in in relation to equipment lifetime, financial barrier as carbon price, "overcommitted" emissions, and techno-institutional effects related to different types of CO_2-emitting infrastructure.[16]

16 Ibid, 430.

Institutional lock-in and behavioral lock-in are no less important than technological lock-in. Since institutions are designed to sustain the status quo, the political, economic, and social actors behind the institutions possess the intention (depending on the political competition and conflict among them) to reinforce technological lock-in. Hence, "the networks that arise among policymakers, institutional bureaucracies, and powerful energy interests further reinforce and stabilize carbon-intensive systems."[17] Behavioral lock-in is related to the carbon intensive choices of individuals. Preferences regarding daily transport, housing, heating, household electricity use, food choices, etc., contribute and legitimize the sustained use of high-carbon processes and products. Habits, automatic decisions, and avoidance of risk related to change can contribute to lock-in, for example:

> Numerous psychological barriers that explain why people do not feel a sense of urgency regarding climate change, including habit and other ingrained behaviors that are extremely resistant to change, limited cognition about the problem, worldviews that preclude pro-environmental behaviors, undervaluing risk, discredence toward experts and authorities, and a sense of lack of control over being able to make a difference.[18]

Because of the fact that climate change is a type of collective action problem and individuals act like free riders, "behaviors are locked in not by path dependency over time but by declining individual agency compared to the number of actors that are perceived to be part of the problem."[19]

17 Ibid, 433–434.

18 Ibid, 439.

19 Ibid, 440.

GERMANY'S ENERGIEWENDE

Germany is the fourth largest economy in the world[20] and has the largest power system in Europe.[21] In 2016, the total population of Germany was 82.2 million,[22] and its GDP amounted to 3.4 trillion USD.[23] The gross electricity consumption of Germany was 593.8 TWh in 2015,[24] and annual household consumption was 3,362 kWh[25] in 2014.

Germany's large share in the world economy, its power system, and GHG emissions make its energy transition (*Energiewende*) extremely significant for international climate and energy policies. Furthermore, the current shift in Germany's energy structure represents a viable example of transitioning to a low-carbon economy and escaping carbon lock-in. On the other hand, Germany faces many challenges. The continuing high share of coal in electricity production and the difficulties encountered by other sectors such as transportation and heating make it difficult for Germany to reach its targets.

Germany had an installed power plant capacity of 205.5 GW by the end of 2015. The share of renewable energy in the installed capacity was 97.9 GW (47.6 percent), while conventional fossil fuel capacity was almost the same (96.8 GW and 47.1 percent). The remaining nuclear power fleet after large-scale closures only account for 10.8 GW, or 5.3 percent. The share of renewable resources for generation is obviously much less due to the capacity factor.

Germany's total gross electricity production in 2015 was 645.5 TWh, with renewables accounting for 187 TWh of this total, approximately 29 percent.[26] The breakdown of renewable energy in Germany is as follows: 71 TWh produced from onshore wind, 8 TWh from offshore wind, 38.7 TWH from solar photovoltaic, 50.3 TWh from biomass, 19 TWh from hydropower, and 0.1 TWh from geothermal. Onshore wind is the leading source of renewable energy in Germany, with an 11-percent share in gross electricity production.[27] The remaining resources consist of conventional resources: Energy production from hard coal totaled 118 TWh (18.3 percent), lignite 155 TWh (24 percent), natural gas 62 TWh (9.6 percent), and nuclear energy 92 TWh (14.2 percent). Coal's share in total electricity generation was 42.3 percent. Although many new coal investments have been canceled, there is one 1100 MW coal power plant being constructed by Uniper Kraftwerke in Germany (Datteln-4), and another 1100 MW plant being constructed by RWE, which is listed in its pre-permit phase of construction.[28]

20 World Bank, World Development Indicators database, December 15, 2017, accessed January 12, 2018, http://databank.worldbank.org/data/download/GDP.pdf.

21 RAP, *Report on the German Power System*, Version 1.2, study commissioned by Agora Energiewende (RAP: Berlin, 2015).

22 Destatis Statistisches Bundesamt, accessed January 12, 2018, https://www.destatis.de/EN/Homepage.html.

23 World Bank, World Development Indicators database.

24 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report: The Energy of the Future*, (BMWi: Berlin, 2015).

25 Agora Energiewende, *Understanding the Energiewende. FAQ on the ongoing transition of the German power system* (Agora Energiewende: Berlin, 2015).

26 The share of renewable energy in gross electricity consumption is 31.6 percent at 187.3 TWh. Total gross electricity consumption equals domestic electricity production plus electricity imports, minus electricity exports. Germany is a net exporter.

27 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report*.

28 End Coal, "Global Coal Plant Tracker, published by Coalswarm," accessed January 12, 2018, https://endcoal.org/tracker/.

Energy policies, and especially GHG emissions, are not limited to electricity generation. While electricity covers 25 percent of Germany's energy demand, 50 percent of the demand comes from processing and heating, and 25 percent corresponds to the transportation sector's demand for fuel. The share of renewables accounts for 14.9 percent of gross final energy consumption, including industry, transport, heating, etc.[29] Annual GHG emissions in Germany totaled 902 $MtCO_2e$ in 2015.[30] This number accounts for about 20 percent of total EU emissions, putting Germany at the top of the European ranking.[31] The energy sector accounts for almost 40 percent of total emissions.[32]

Although challenged by decentralized renewable electricity generation in recent years, the German power system features an oligopolistic structure. Four large companies dominate the power production: E.ON, RWE, EnBW, and Vattenfall. These utilities are also responsible for most of the electricity distribution and supply. The important aspect here is that these four companies own the majority of conventional power plants (namely, hard coal, lignite, gas, and nuclear) but only five percent of renewable power stations; meanwhile, 46 percent of renewable power generation capacity is provided by private citizens and the rest by project developers and small entrepreneurs.[33]

The German power system is characterized by its reliability: Denmark and Germany have the most secure power systems in Europe with the lowest interruption times.[34] Thus, the most important feature of German energy transition policy is its clearly defined and monitored principles and targets based on the triple objectives of security of supply, affordability, and environmental compatibility.[35]

History of Energiewende

The Energy Concept that was adopted by the German government in 2010 provided the central structure of the goals and principles. The policy goals of the Energy Concept include climate targets, nuclear phase-out, and goals to guarantee competitiveness and security of supply, while the core objectives on expansion of renewables and reduction of energy consumption for electricity, transport, and heating, describe the central strategy of Energy Transition (Energiewende).[36]

Many experts interpret Energiewende as a long-term plan that emerged in the beginning of the early 2000s. Hence, attributing its existence solely to the decision taken by the German government in 2010 is misguided, because the Energy Concept can be seen as the acceleration of a longstanding trend that started with the environmental movement in the 1970s.

The history of Energiewende has several layers. It is rooted in the discussion about the role of energy systems in the ecological and social crisis of the

29 Ibid, 13.

30 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), *Climate Action Report 2016 on the German Government's Climate Action Programme 2020* (Berlin: BMUB, 2016).

31 Eurostat, "Greenhouse gas emission statistics—emission inventories," Total greenhouse gas emissions by countries (including international aviation and indirect CO2, excluding LULUCF), 1990 - 2015 (million tonnes of CO_2 equivalents), accessed January 12, 2018, http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics.

32 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, *Climate Action Report 2016.*

33 RAP, *Report on the German Power System.*

34 Ibid, 35.

35 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report*, 7.

36 Ibid, 8.

1970s. Debate on the challenges of consumer society, avoiding the risks of nuclear energy and environmental pollution, and alternative technological solutions converged into initial ideas on the transformation of energy systems. Early books such as *Ende oder Wende* (End or Transform) by Erhard Eppler in 1975 and *Energiewende* (Energy Transition) by Krause, Bossel, and Müller-Reissmann in 1980 introduced the concept under its current name.[37] In the 1960s, electricity generation in Germany was dominated by coal and lignite in the 1960s, accounting for 80 percent of all generation. After the oil crisis in 1974, however, use of nuclear power increased, although at that point anti-nuclear protests had already started. The Chernobyl accident in 1986 marked the beginning of the end of the German nuclear industry, and new nuclear reactor plans halted. Germany then became one of the forerunners of international climate politics in the early 1990s. Climate change received a very early cross-party consensus before the Rio summit in 1992. The first Conference of the Parties was held in 1995 in Bonn, which would later become the headquarters of the UNFCCC. Angela Merkel, who was the Minister of Environment at the time, played a significant role in launching the negotiations for the Kyoto Protocol.[38]

Germany's Kyoto commitment was a 21 percent GHG emissions reduction until 2012 compared to 1990 levels. The first policies to support renewable energy dated back to 1991 following the country's first Climate Action Plan. A feed-in tariff, which would be the core element of the support scheme for renewable energy, was introduced in a 1990 law that ensured grid access for electricity generated from renewable sources. The Feed-in Tariff Law (*Stromeinspeisungsgesetz*) required energy utilities operating the grids to pay premium prices (i.e., feed-in tariffs) for the electricity supplied from renewable power plants.[39] But, this early period was the preparatory phase for Energiewende renewable energy was still in a premature phase, and only 3.6 percent of the power production in 1990 in Germany came from renewables, mostly from small hydro power plants. The first actual move toward the transition, however, started during the red-green coalition government (Social Democratic Party and the Greens) between 1998 and 2005. Nuclear phase-out was an important element of the coalition agreement.

The implementation of Energiewende kicked off with the Renewable Energy Act (EEG) adopted in 2000 by the red-green government. The 20-year fixed price scheme for new renewable power installations, namely a new feed-in tariff, was the most important element of EEG, which mainly promoted wind and solar energy production. On the other hand, the feed-in tariff was not invented by the Social Democrats nor The Greens. The conservative party in Bavaria (CSU) was the first to use it in Germany as it aimed to incentivize disadvantaged hydropower plants in the region. The red-green government then used it as an innovative way to boost emerging renewable energy sources that were not competitive back then. The next grand coalition government between 2005 and 2009 proceeded with the same policy and strengthened the climate targets (e.g., 40 percent reduction of GHG emissions in 2020 compared to 1990 levels). Furthermore, the nuclear phase-out was already underway, and nuclear power plant retirements had already begun in the 2000s.

However, in 2010, the new right-wing coalition government decided to reverse this plan not by

37 Manfred Fischedick, "Energy System Transformation in Germany – Potential Pathways, Robust Strategies, Major Challenges and Requirements," presentation, Wuppertal Institute, April 12, 2016.

38 Agora Energiewende, *Understanding the Energiewende.*

39 International Energy Agency, "Electricity Feed-in Law of 1991 (*Stromeinspeisungsgesetz*)," last modified March 14, 2013, accessed January 12, 2018, https://www.iea.org/policiesandmeasures/pams/germany/name-21002-en.php.

building new nuclear stations but by extending the lifetime of existing ones. This long-term energy strategy was called Energy Concept (Energiekonzept) and was aimed at simultaneously keeping renewable energy and emissions reduction targets. Freezing the nuclear phase-out triggered large anti-nuclear demonstrations across Germany and on March 11, 2011, only six months after the adoption of Energiekonzept, the second biggest reactor meltdown in the history of nuclear power occurred in Fukushima, Japan. The government had to take a step back immediately after the accident and revived the phase-out law of 2002. The government immediately closed down the seven oldest nuclear reactors in Germany. Following the new phase-out law, which received large support (85 percent) in the parliament and was adopted in June 2011, the Energiekonzept, accompanied by new legislations aiming for an accelerated transition, transformed into a real official Energiewende plan.[40] The coalition government formed in 2013 by conservatives and social democrats renewed the Renewable Energy Resources Act (EEG) of 2000, and the new EEG 2.0 created an auction system, which aims to ensure cost-efficient expansion of renewables by controlling the level of increased capacity and reducing prices using a competitive bidding system.

Main targets of Energiewende

The main objective of Energiewende is to transform German energy policies from a fossil fuel- and nuclear-based system to a low-carbon system based on renewables and efficiency. Today, Energiewende has four pillars: phasing out nuclear power by 2022, mitigating climate change, improving energy security, and amending industrial policies targeting competitiveness and growth.

Major quantitative targets of Energiewende in the medium- and long-term are as follows[41]:

1. All nuclear power plants will be shut down by 2022.
2. Carbon dioxide emissions in all sectors will be reduced by 40 percent in 2020, 55 percent in 2030, 70 percent in 2040, and 80-95 percent in 2050 compared to 1990 levels.
3. Renewable energy targets:
    a. Renewables' share in final energy consumption will be increased to 18 percent in 2020, 30 percent in 2030, 45 percent in 2040, and at least 60 percent in 2050.
    b. Renewables' share in gross electricity consumption will be increased to at least 35 percent in 2020, at least 50 percent in 2030, at least 65 percent in 2040, and at least 80 percent in 2050. The Renewable Energy Sources Act states that interim targets for the increased share of renewables will be 40-45 percent in 2025 and 55-60 percent in 2035.
4. Energy efficiency targets:
    a. Primary energy consumption will be reduced 20 percent in 2020 and 50 percent in 2050 compared to 2008 levels.
    b. Gross electricity consumption will be reduced 10 percent in 2020 and 25 percent in 2050 compared to 2008 levels.
    c. Final energy productivity will be increased by 2.1 percent every year between 2008 and 2050.

40 Agora Energiewende, *Understanding the Energiewende.*

41 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report: The Energy of the Future*, 7.

The plan also aims for the long-term electrification of transport and heating/cooling systems. Maintaining energy affordability, expanding, and modernizing grids, fostering research and innovation, and creating jobs are some of Energiewende's other targets and policies.[42] It also aims at consistent policies with international and European climate and energy policies, including EU 20-20-20 targets, EU-ETS scheme, etc.[43]

Current indicators that the German energy system is conforming with the Energiewende targets are as follows[44]:

1. A total of 11 out of 19 original nuclear reactors have been shut down by the year 2015.
2. Greenhouse gas emissions were reduced by 27.2 percent in 2015 compared to 1990 levels.
3. Renewable energy:
    a. Renewables' share in final energy consumption was 14.9 percent in 2015.
    b. Renewables' share in gross electricity consumption was 31.6 percent in 2015.
4. Energy efficiency:
    a. Primary energy consumption is 7.6 percent lower compared to 2008.
    b. Gross electricity consumption is 4 percent lower compared to 2008.
    c. Final energy productivity increased 1.3 percent annually between 2008 and 2015.

The major targets of the Energiewende focus on the electricity sector, even though the plan is defined as an integrated policy covering all sectors of the economy.[45] The targets for heating and transport are modest and short-term. For example, primary energy consumption in buildings will be 80 percent less in 2050 compared with 2008: it was 15.9 percent less in 2015 compared with 2008. In contrast to this ambitious goal, the plan aims to increase the share of renewables in heating to 14 percent in 2020, even though this figure was already 13.2 percent in 2015. Further, the heat consumption target in buildings is also short-term: a 20 percent decrease in 2020 compared with 2008: this figure was 11.1 percent less in 2015 compared with 2008.

The transport sector's target for renewables comes from the European Union Renewable Energy Directive in 2009, which aims to increase the share of renewables in the transport sector to 10 percent by 2020. This share was 5.2 percent in 2015. Energiewende aims to decrease the final energy consumption in the transport sector by 10 percent in 2020 and 40 percent in 2050 compared to 2005. However, the final energy consumption in the energy sector in 2015 is 1.3 percent higher than the 2005 figure, thereby making transport the most challenging sector.

Evaluation of the Energiewende

Experts judge the current course of the Energiewende usually as a success story, not only because of the increasing share of renewables (3 percent in 1990 before the feed-in tariff system, 7 percent in 2000 before the Renewable Energy Act, and more than 30 percent today) but also due to its political and popular recognition.[46] In general, it receives universal recognition in the parliament and is well regarded among civil society. The far-right populist party, AfD, is perhaps the only political opponent of the energy plan as it has adopted a consistent

42 Ibid, 5.

43 Ibid, 10.

44 Ibid, 7 and 75.

45 Agora Energiewende, *Understanding the Energiewende*, 9.

46 Personal communication, 2016.

climate denialist position, which is quite unfamiliar for the German political and scientific communities.

Another characteristic of the Energiewende is that it is a transformation from centralized energy production relying on fossil fuels and nuclear power to a decentralized sustainable energy system that relies largely or completely on renewables. Private ownership of the small and decentralized renewable electricity systems is considered one of the most crucial aspects contributing to its popular support. One recurrent example is the conservative constituency in Bavaria.

During one of the previous federal elections in the late 2000s in Bavaria, which is one of the most conservative states in Germany, the leading CSU pledged to repeal the feed-in tariff system for renewables assuming that this system supported the Greens. However, the farmers immediately showed up and expressed their support for the feed-in tariff, because most of them had solar panels on their barn roofs and made profits selling electricity to the grid. Solar electricity generation had become a substantial source of revenue for the farmers next to food production, and they were convinced by the transition. CSU had to change their energy policy proposals in the middle of the election campaign and supported feed-in tariff.[47] As stated before, private citizens and farmers own 46 percent of renewable generation capacity in Germany.

Experts consider the Energiewende's short- and long-term electricity and emissions reduction targets as ambitious.[48] On the other hand, these ambitious goals are in line with European goals. What makes Germany a different case is its nuclear phase-out policy and more demanding short-term targets, namely the pace of the proposed transition. But, even though the share of renewables in electricity generation has exceeded the targets, there are still many challenges and failures: 1- The system is far away from achieving emission reduction targets, 2- The share of coal still exceeds 40 percent, 3- Grids cannot effectively transmit electricity between the regions, and 4- The success of the renewable electricity generation cannot be replicated by the other energy sectors, mainly transport and heating.

Increasing cost due to the growing share of supported renewable energy is considered as a major setback. Increased surcharge due to the accumulated feed-in tariff payments made the Energiewende an expensive plan for the private consumer. While every electricity consumer, and households in particular, must pay the feed-in tariff surcharge premiums, energy-intensive industries are exempt.[49] Therefore, Germany has one of the highest electricity retail prices in Europe for private citizens. But, German energy-intensive industries (steel, cement, aluminum) pay one of the lowest prices in Europe in order not to suffer amongst international competition. In addition, industries can purchase electricity on the wholesale market and make profit from the declining prices.[50] Those against the Energiewende raise this "social debate" as a counter argument to the plan, claiming poor people who buy electricity must pay the cost burden of those rich enough to possess a house with solar PV on their roof ("energy poverty"). Since renewables have been getting gradually cheaper, this debate could be somehow neutralized. However, more importantly, the government put the break on renewables with the auctioning system that was introduced in 2013. The government's main motivation for introducing the auctioning system was to slow down the renewable boom. The system stabilized the annual allowed capacity of

47 Personal communication, 2016.

48 Personal communication, 2016.

49 Agora Energiewende, *Understanding the Energiewende*, 31.

50 Ibid, 31.

new renewables and decreased the feed-in tariff premiums using a competitive system. This intervention aimed to reduce the increasing electricity prices by decreasing the feed-in tariff surcharge and also to neutralize the "energy poverty" discourse that started to undermine the Energiewende.[51]

Electricity generation from renewables has doubled since 2008, rising from 93 TWh to 187 TWh. The 2020 target for the share of renewables in electricity consumption is likely to be reached ahead of schedule; however, slowing down renewable expansion has fueled coal usage. Low coal and gas prices and low carbon prices in the European ETS system have created a very difficult environment for the transition. There was a significant (about 2 percent) decrease in GHG emissions per year in the 1990s, which was partly triggered by the reunification of Germany. In the 2000s, there was still a trend toward reduction; however, this was lower than the previous decade (around 1 percent per year). In recent years, GHG emissions have started to increase. Low CO_2 prices in the ETS system did not create incentives to stop the operation of coal-fired power plants, and Germany became an electricity exporter to neighboring countries, mainly to Switzerland and Austria. Although the emissions were 27 percent lower in 2015 compared to 1990 levels, there is still a broad gap between the current status and the midterm goal for 2020, which is 40 percent reduction in comparison to 1990 levels. This target would require a reduction of GHG emissions by more than 3 percent per year. Therefore, without additional instruments and policy measures, Germany will not meet its 2020 climate mitigation target.[52]

In 2012 and 2013, the absolute electricity production based on domestic lignite-fired power plants increased in the Rhine area, Northern Westphalia, Lausitz and some other parts of the eastern states of Germany. This domestic energy source is quite cheap with the low CO_2 prices of the European emission trading system, and there is no incentive to reduce the production of lignite-fired power plants, which was stable in 2014 and 2015.[53]

Some experts think that stalling emissions reduction was due to the government's big mistake of never having a coal policy.[54] Although renewables were able to overcompensate the phasing out of nuclear power, lack of a policy on coal in the context of low global coal and European CO_2 prices triggered a shift from gas to coal, so increasing renewables could not adequately produce emissions reduction. Since renewables are paid for through the feed-in tariff, the merit order curve in the electricity market brings down the electricity price and the next cheapest option after renewables in the wholesale market is coal. (Figure 3) Therefore, with the coal fleet remaining active, the overproduction of electricity paved the way for increasing electricity exports at cheap prices.

51 Personal communication, 2016.

52 Personal communication, 2016.

53 Personal communication, 2016.

54 Personal communication, 2016.

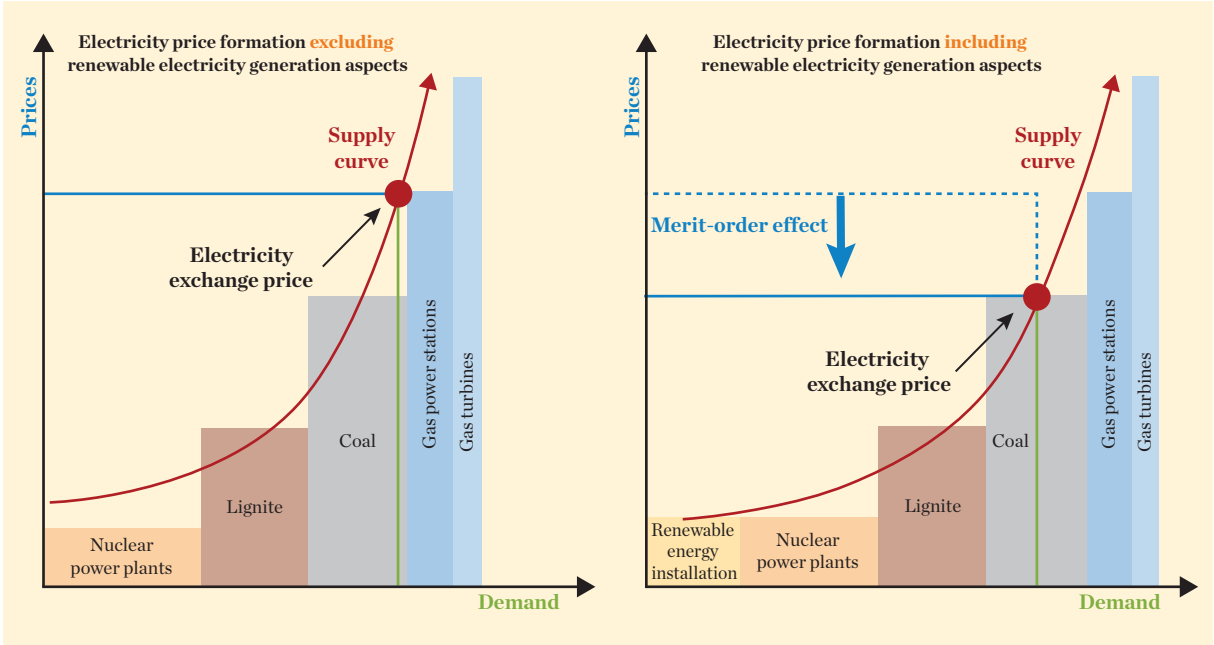


Figure 3 – Schematic representation of the merit-order effect. The merit-order curve shifts down due to the introduction of renewable energy. Reducing the electricity exchange price pushes gas out.[55]

Other reasons for the failure of the Energiewende are the lack of efficiency targets and lack of grid development. Although energy efficiency has been a popular concept in Germany since the oil crisis in the 1970s, the Energiewende did not focus on efficiency measures in the last couple of years, and total energy consumption remained stable. While the 2020 target for primary energy consumption reduces consumption, 20 percent compared to the 2008 level, primary energy consumption was only 7.6 percent less in 2015 compared to 2008.[56] Likewise, the targets for final energy productivity and gross electricity consumption are far from being achieved.[57] If energy consumption is not sufficiently reduced, the situation of getting stuck with fossil fuel use may intensify. Despite the fact that there is an oversupply in electricity production and cheap electricity export as a consequence of "keeping the coal plants online," it is claimed that the utilities try to avoid measures aiming at efficiency.[58] If efficiency policy is too successful, the need for coal-powered electric would be futile, and business would fade away.

55 F. Benhmad and J. Percebois, "Wind power feed-in impacts on electricity prices in Germany 2009-2013," Conference paper, 12th International Conference on the European Energy Market, Lisbon, 2015, p. 11.

56 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report*, 7.

57 Final energy productivity increase was 1.3 percent/year between 2008 and 2015, although the target was 2.1 percent/year between 2008 and 2050. Gross electricity consumption was 4 percent less compared to 2008 levels, but it is still far from the 2020 target, which aims at 10 percent reduction. Ibid., 7.

58 Personal communication, 2016.

Grid development is another big challenge limiting renewables' development. The infrastructure in place to deal with the further growth of the renewables is insufficient. Since the energy-intensive industries are located in the south of Germany but most of the wind power is produced in the north, there are problems in transmitting renewable electricity. This setback requires building high voltage lines from north to south, which creates resistance from citizen groups. Eventually, the production sites at the north can be relocated, or new power production sites can be built in the south. But at the moment, this becomes a major barrier to renewables' development.[59]

One criticism is that, so far, the energy transition has been considered as just an electricity issue and has focused mainly on the renewable support scheme (feed-in tariff). Additionally, the transport and heating sectors were neglected.[60] Although the transition is on track in the electricity sector, and achieving the rest of the electricity targets is just a matter of implementation, the transition seems to be just starting in the heating sector, and Germany has almost no policy for an energy transition in the transport sector. The targets for renewables in the transport and building sectors in the Energy Concept are quite small, and the implementation are yet to follow. There is only a short-term target for heat consumption in buildings, which is a 20 percent reduction in 2020 compared to 2008; however, an 11.2 percent reduction was already achieved in 2015. Furthermore, there is only a long-term target for primary energy consumption in buildings, which aims at 80 percent reduction in 2050 compared to 2008, although the reduction achieved in 2015 was 15.9 percent. There are also quite insignificant final energy consumption targets with regards to the transport sector, which are 10 percent reduction for the short-term in 2020, and 40 percent for the long-term in 2050 compared to 2005. On the contrary, there was a 1.3 percent increase in 2015.[61]

59 Personal communication, 2016.

60 Personal communication, 2016.

61 The Federal Ministry for Economic Affairs and Energy (BMWi), *Fifth 'Energy Transition' Monitoring Report*, 7.

COAL TRAP IN POLAND

Poland has the 23rd largest GDP in the world, approximately 469 billion USD in 2016.[62] The total population of Poland is 38.4 million.[63] Primary energy consumption in Poland was 90 Mtoe in 2015. Poland has the 8th largest power system in Europe. Gross electricity consumption was 154 TWh in 2015.

Poland's energy system and power production is largely dependent on coal—particularly, domestic coal. Despite a 2.7 percent drop in production figures over the last decade, the country is the biggest coal (hard coal and lignite) producer in the European Union, with a total production of 52.3 million tons in 2016. Polish hard coal accounts for 72 percent of all extraction in Europe[64] and boasts of the largest share of fossil fuels for electricity generation after Australia. It holds sixth place for the lowest share of renewables in electricity generation among IEA member countries.[65]

Coal constitutes 79 percent of the country's energy production and 51 percent of total primary energy supply (TPES). In 2015, while heat and power generation accounted for 71 percent of coal consumption, energy produced from coal accounted for 81 percent of Poland's electricity generation. Poland has a large district heating (DH) systems based on coal, which constitutes 86 percent of total heat production. Natural gas is the source of just four percent of Poland's electricity generation. There are no nuclear power plants in Poland.[66]

In Poland, most of the coal-fired power plants are old, inefficient, and polluting: six percent of coal capacity is over 30 years old, and 13 percent is between 26 and 30 years old. The government aims to replace existing, low-efficiency generation units with new, high-efficiency plants in order to decrease air pollution and GHG emissions,[67] making Poland one of the few countries in Europe that still builds new coal power plants. The Polish government expressed its intention to build 20 to 24 new units with a total installed capacity of 12 to 15 GW.[68] Currently, there are six coal power plants of 4,465 MW total installed capacity under construction: the Kozienice B11 unit by Elektrownia Wytwarzanie S.A. (1,075 MW), Opole B5 and B6 units by PGE (both 900 MW), Jaworzno 3 B7 unit by Tauron (910 MW), Turow B11 unit by PGE (460 MW), and Zabrze by Fortum (220 MW). There are also three proposed large coal power plants with 2,600 MW total installed capacity: the permitted Ostroleka by Energa (1,000 MW) and the Polnoc 1 and 2 units by Polenergia (both 800 MW) in the pre-permit development phase.[69] One very large coal power plant in Gubin by PGE (3000 MW) has also been announced. The total capacity of the pipeline is approximately 10 GW. This strategy signals that the Polish government aims to create a new fleet of coal-fired power plants with at least 40-60 years of economic life.

62 World Bank, World Development Indicators database.

63 Statistics Poland, "Basic Data," accessed January 12, 2018, https://stat.gov.pl/en/basic-data/.

64 Marcia Rocha et al., *A Stress Test for Coal in Europe under the Paris Agreement* (Berlin: Climate Analytics, 2017), 24, http://climateanalytics.org/files/eu_coal_stress_test_report_2017.pdf.

65 "Energy Policies of IEA Countries: Poland, 2016 Review" (Paris: International Energy Agency, 2017), 74.

66 Ibid, 17-22.

67 Ibid, 9.

68 Marcia Rocha et al., *A Stress Test for Coal*, 24.

69 End Coal, "Global Coal Plant Tracker."

Poland has expanded its renewable energy capacity in recent years, and the share of renewable energy in gross final energy consumption in 2015 was 11.8 percent. This share represents a mild increase from 10.2 percent in 2010. Solid biofuels (i.e., wood) constitute the major part of renewable sources in Poland, 76.6 percent in 2014. The same year, the EU's solid biofuels' share was 43.8 percent. As for the breakdown of renewable sources, wind accounts for 8.2 percent, hydro 2.3 percent, and solar 0.4 percent. The corresponding EU figures are 11.1, 16.6, and 6.1 percent, respectively. While renewables' share in gross final electricity consumption in the EU is 27.5 percent, in Poland it is 12.4 percent. The top three renewable sources for electricity production in Poland are solid biofuels, wind, and hydro (accounting for 46.2, 38.7, and 11 percent of renewables, respectively.) Solar PV electricity production has not yet begun in Poland. The new wind power plants in Poland increased renewables' share in gross final electricity consumption from 8.2 to 12.4 percent from 2011 to 2014.

Poland's GHG emissions in 2013 totaled 395 million tons, 16.5 percent less than 1990 levels. Like other EU states, Poland undertook joint reduction commitments to reduce annual emissions by 20 percent compared to 1990 levels by 2020. The total greenhouse gas emissions projected for 2030 are 358.8 million tons of CO_2eq with 24.3 percent reduction compared to 1990 levels and 9.1 percent reduction compared to 2013 levels.[70]

As for the development of renewable energy policies in Poland, this is mainly limited to its involvement in short-term EU policies. The country does not have any other energy transition plan to shift its energy sector from fossil fuels to renewables, including medium- and long-term targets for 2030 or 2050.

The energy sector in Poland is primarily composed of large, state-owned companies. The three largest producers own more than half of installed capacities and generated nearly two-thirds of the country's electricity. The largest companies in the energy sector include PGE, Tauron, Enea, EDF, PAK, and Energa. The majority of the shares of these companies are owned by the state except for Tauron, with the state owning 45 percent of the shares and the remaining shares being traded in the stock market.

Evaluation of Polish Energy System

One of the major challenges that Poland's energy system faces is the difference between the perception and reality regarding the abundance of coal. Although Poland is known as a "coal country," new reports show that both hard coal and lignite production in Poland are in decline. A recent analysis of the Polish power system highlights this problem as such:

> Geology has an adverse effect on the economics of Polish mines, too. Economically viable hard-coal deposits are being depleted. Since 1990, recoverable reserves in Polish mines have dropped by over 45 percent. Industrial resources dwindled by a staggering 75 percent, and the number of operating mines was down from 70 to 31.[71]

In the aftermath of this decline, only eight to ten hard coal mines will remain by 2040. Lignite mines are also being depleted. For example, Pątnów-Adamów-Konin (PAK) lignite mine is expected to shut down at the end of this decade, and one of the largest lignite mines in Europe, Bełchatów, will reduce its production at the end of this decade and will exhaust its deposits during the 2040s. Furthermore, opening new lignite mines is extremely challenging because of the local resistance. Most of

70 The Republic of Poland, *The Second Biennial Report to the Conference of the Parties of the United Nations Framework Convention on Climate Change* (Warsaw, 2015).

71 J. Maćkowiak-Pandera, J. Rączka, and M. Bukowski, *Polish Power Sector Riding on the Wave of Megatrends* (Warsaw: Forum for Energy Analysis, 2016), 26.

the existing lignite deposits will be depleted in the next 20 years, but local communities are against the highly polluting expansion of the open coal fields.[72]

An expert expressed that "lignite is extremely political, and there are no serious politicians or experts in Poland who could really push to increase lignite production or fight for new sites."[73] Consequently, the Megatrends report identifies a "coal gap," namely "the gap between the current electricity generated from hard coal and lignite (around 85 percent) and the potential electricity generation in the 2030s from coal extracted from the mines that were not closed due to a decrease in output."[74] This is an important phenomenon, because the Polish political elite defend coal as if it is a "Polish" resource, or in other words, "a national asset."[75] However, shutting down the depleted or unprofitable coal mines is inevitable, and the declining global coal prices will also make the new hard coal deposits economically unfeasible, therefore deepening the coal gap. This situation may in effect increase dependency on imported coal. Ironically, all the while coal dependency has increased under the pretext that it was a domestic resource.

As coal extraction becomes more expensive, labor-intensive, and risky because it requires that miners must dig deeper to reach it, Polish coal becomes less competitive in global markets. Since global coal prices have been in decline for the past few years, sustaining domestic coal use requires major subsidies. Direct national protection of a market sector is not possible within the European Union; however, Polish governments concoct indirect but equally effective subsidy mechanisms and ask power companies to invest hundreds of millions of zlotys in coal mines, or they put substantial pressure on companies to buy domestic coal even though it is more expensive than in global markets.[76] It should be noted that this is possible as a result of the ownership structure of the energy sector in Poland.

In Poland, energy utility ownership is as straightforward as ownership of the resources. There are only a few companies in the energy sector, and the state either owns them or is a strategic shareholder. The four major energy companies that split operations in the country among themselves are state-owned. Furthermore, there is only one transmission system operator (TSO), and it is also 100 percent state owned. Therefore, there is no room for competition within the Polish energy market. Experts define this market as one that is driven by politics rather than the economy.[77] The government controls the companies directly through the governance mechanism. The CEOs of the energy companies are appointed directly by the Minister of Energy. Some experts remember specific cases when relatively autonomous power companies' CEOs were replaced by the government because they objected to the expansion of coal facilities.[78] The situation is defined by experts as follows: "In a normal world a company executive would try to meet politicians to lobby them, but here executives and politicians meet on a regular basis, as part of 'business as usual'. Therefore, these are not lobbying efforts and there is no transparency here. Even lobbying efforts, when they do exist, are often more transparent."[79] An expert calls this a "command and control type of economic structure."[80]

72 Ibid, 27.

73 Personal communication, 2016.

74 Maćkowiak-Pandera, Rączka, and Bukowski, *Polish Power Sector Riding on the Wave*, 28.

75 Personal communication, 2016.

76 Personal communication, 2016.

77 Personal communication, 2016.

78 Personal communication, 2016.

79 Personal communication, 2016.

80 Personal communication, 2016.

One energy expert defines the outcome of this coal-based and state-owned energy system as having four attributes: it is unreliable, homogenous, noncompetitive, and inelastic. The power sector is not sufficiently reliable because the old coal infrastructure causes system failures. Since more than 80 percent of electricity is produced from coal, there is no diversity in the mix.[81] The absence of competition brings about one of the highest wholesale electricity prices in the region. Furthermore, the use of coal creates a non-elastic power load that is not suited to quick ramp-ups and downs. One more feature we can add is that, because of coal's high level of carbon emissions, other pollutant emissions, and excessive use of water, it is not environmentally sustainable. Therefore, as a consequence of the governments' political agenda to preserve large coal mines and power plants, the Polish power system suffers from economic, environmental, and technical disadvantages and is unable to meet present-day challenges as well.

The political interests of the energy sector come into play through their ties with trade unions.[82] The energy sector in Poland is a specific case because its state-owned structure was not challenged in the post-Communist period. In contrast, state-owned farms, other heavy industries, shipyards, steel factories, etc., were privatized if they were not bankrupt and shut down. On the other hand, while coal mines employed more than 400,000 people in the 1980s (and millions of people were directly linked to coal mines through family members and others who resided in these regions), today this number is less than 100,000 (85,000 according to some sources[83]) because many people were retired or discharged when the most inefficient mines were shut down. However, workers in this sector were very well organized in the trade unions and they protected their economic benefits. Currently, all workers in the coal sector are members of unions; and moreover, the majority are members of more than one trade union in order to secure their jobs. Hence, coal miners and other workers in the coal industry constitute the best organized labor force in the country by way of the direct relationships that unions have with politicians. They also have the capacity to resist the threats directed to their job security or economic interests using their ties to political parties, their economic weight in their regions, or sometimes through demonstrations. Politicians from different wings and parties are said to be prone to keep warm relations with the workers for the sake of not losing votes in the next elections. One of the experts expressed this relationship as follows:

> People in the coal regions of Poland are emotionally bounded with the coal mining industry and politicians do not want to lose them. They do not want to make those people angry. It is basically politics. And people in the unions and politicians probably know each other. They probably have much easier access to ministries and politicians than green NGO's.[84]

We should also note that trade unions and workers' lobbying efforts run compatible to the interests of big energy companies'. One of the experts stated that

> Miners, together with the power sector, are engaged in lobbying and day-to-day discussions with politicians, and they are proud of who they are. I admire that approach, except for the fact that it's very harmful to the society. They are well organized, aggressive, and

81 Personal communication, 2016.

82 Personal communication, 2016.

83 Marcia Rocha et al., *A Stress Test for Coal*, 25.

84 Personal communication, 2016.

> ready to fight on the streets. The left-wing government in 2004, for example, stopped the serious efforts of the previous government under street pressure and protests in the streets of the capital city.[85]

It should be pointed out that there is no real difference between left-wing unions or conservative unions, nor between right-wing or left-wing political parties in Poland on this issue.

Being proud of "Polish coal" is also tied to the sensitivity of the workers, families, and the regions. According to one of the experts:

> We were highly dependent on coal after the Second World War, and this became an important element of our culture. From the economic perspective, the mining sector's efficiency continues to decrease. It was not efficient at the end of the Communist period either, and the government tried to transform the sector during the transition period. But they could not complete the transformation. There is still a lot of inefficient coal mines in operation, and our coal is expensive because the miners are still very strong.[86]

This social phenomenon is represented by the political discourse of domestic coal as a symbol of national independence, national power, and national identity. But as discussed above, Poland cannot be considered as a country with abundant coal reserves. The contribution of the coal mines to economic growth is deemed to be zero because of the large subsidies. Therefore, insisting on domestic coal usage is a policy that is not based on any economic or technological rational.

Coal-based energy policies are also connected with the indifference to climate change. In fact, polls show that 70 percent of Polish society takes climate change seriously and position themselves as pro-renewables and not pro-coal. Furthermore, there are significant local movements against air pollution as four out of the ten most polluted cities in the EU are in Poland.[87] But, the politicians from current or former governments do not consider climate change an important topic. Some members of the current government even overtly declared their climate-denying opinions, while the previous governments were more diplomatic despite the fact that they had similar policies.[88] Interestingly, Poland organized two major UNFCCC climate conferences in the last few years (COP 14 in 2008 in Poznan and COP 19 in 2013 in Warsaw), and the next COP in 2018 will be organized again in Katowice, Poland, which is located at the heart of the coal region (Silesia). One of the experts commented on this and said, "The Polish government organizes climate summits because they use these occasions as a political tool in international diplomacy, to exercise influence over the outcomes and even constrain them or to get something they want."[89]

The approach to renewables is also quite unique in Poland. There has never been a feed-in tariff scheme implemented as a support mechanism, but there was a green certificate scheme. After 2005, the Energy Law required power suppliers to provide a certain amount of renewable electricity to their consumers. Whether this annual quota was fulfilled or not was verified by the number of green certificates presented to the Energy Regulatory Office. In order to subsidize the renewable electricity producer, the Energy Law required a certificate stating that the electricity was produced by a renewable resource.

85 Personal communication, 2016.

86 Personal communication, 2016.

87 Nick Van Mead, "Pant by Numbers: The Cities with the Most Dangerous Air – Listed," *The Guardian*, February 13, 2017, accessed January 12, 2018, https://www.theguardian.com/cities/datablog/2017/feb/13/most-polluted-cities-world-listed-region.

88 Personal communication, 2016.

89 Personal communication, 2016.

In July 2016, this quota system was replaced by an auction system for 3–10 kW installations; however, it is still valid for the older capacity.[90]

Experts said that the main problem about the green certificate scheme is the fact that the big energy companies stopped buying permits, and acting as a monopoly, they preferred paying substitute fees (penalties) even if these fees were higher than the price of green certificates because they did not want to support independent renewable energy producers by buying their certificates.[91] Since the companies that preferred to pay subsidy fees are state-owned companies, this can be considered as a political decision.

Experts do not consider the new auctioning system as a real support for renewables. In fact, experts commented that the current government is openly hostile to investments in renewables.[92] For instance, in 2015 the parliament voted in favor of a feed-in tariff scheme for micro-renewable energy units (less than 10 kW), but the new government discarded the scheme just before it was supposed to enter into force on January 1, 2016. This policy change was said to be detrimental to a lot of people who had bought rooftop installations after the law had passed, because they would not be able to get any feed-in tariff support even if they installed it. The current system features the metering scheme, where individual producers can sell electricity to the grid. But, the system requires that 20 percent of the power produced be given to the grid for free.

One expert pointed out that the Polish government has taken considerable measures to hinder the development of renewable energy:

> Politicians basically do not want renewable energy. They were engrossed in all the myths about renewable energy—that it is unstable, the technology comes from outside of Poland, it is expensive, etc. The current government basically "banned" the development of new onshore wind turbines in Poland. It set a rule whereby new wind turbines cannot be located closer than ten times their height in relation to existing buildings. So, if your wind turbine is about 60 to 100 meters high, then about one kilometer radius of the installation must be free of buildings. This is not easy in Poland. This rule was imposed as an answer to some bad wind developments whereby investors placed wind turbines too close to people's houses, and this led to the emergence of an anti-wind movement. But now, this new regulation made new wind developments almost impossible, based on a political decision and not on an environmental measure.[93]

Another expert commented, "The current government decided to kill the wind sector through administrative tools, by calling small renewables generation prosumer generations and labeling it as economically inefficient because it is not profitable."[94] Experts also remarked that "The government's party had a prejudice against the renewable energy business, but not the technology. These businesses were regarded as 'multinationals', and a lot of smaller companies were simply all bankrupt."[95]

Experts unanimously agree that Poland is locked in to a high-carbon system. One of the experts commented that the government wants this situation and does not see this as a disadvantage because it helps the government to push companies to further invest in coal, despite the many economic

90 *Energy Policies of IEA Countries: Poland*, 102.

91 Personal communication, 2016.

92 Personal communication, 2016.

93 Personal communication, 2016.

94 Personal communication, 2016.

95 Personal communication, 2016.

drawbacks, by convincing them that carbon lock-in is inevitable.[96]

One expert said that Poland had ignored an opportunity to escape lock-in a few years ago and had instead chosen to develop new coal-related projects:

> Poland missed a chance to avoid carbon lock-in four or five years ago. Back in 2011-2012 there was a wave of investments in Poland, and if we had really wanted, we would have had the opportunity to drop coal and begin a transformation similar to Germany. I remember the turmoil caused by the different state-owned companies when they proposed new projects, the different controversies that emerged around the energy policy, as well as on the cultural level because that was the time when the Ministry of Economy (former Ministry of Energy) had just started working on the new Polish energy policy. I think that after that moment, we got stuck with three new coal projects developed by the previous government and at least one new 1 GW coal project in Ostrolenka.[97]

Experts defined several other specific reasons for carbon lock-in in Poland:[98]

1- The engagement of Polish society with the public agenda and politics is limited, which is a typical within post-Communist societies. This lack of participation limits the significance of environmental concerns and alternative policies. Although Poles are reputed to be environment-friendly, the willingness to pay higher prices for clean energy is not very strong. Moreover, the energy issues are only a small part of the election discussions, if any, and politicians think that none of the changes in energy policies constitute priority issues for the elections.

2- A nationalist and anti-EU argument claiming that "The EU climate policy is used as a tool to de-industrialize the Polish economy" is still popular. For instance, in 2008, one of the biggest chambers of commerce published a report that claimed introducing the EU climate policy would cost 10 percent of the Polish GDP. Although many economists stated that this very high estimate was clearly fallacious misinformation, many people in society still remember this claim and believe in it. Therefore, this can be considered as a well-structured and successful narrative to sustain carbon lock-in. The same people think that coal mining is an important source of Poland's economic success.

3- The current government, which is very competent in manipulating the sensitivities of Polish society, is also successful in presenting Brussels-based ideas, concepts, and policies as strange, unacceptable, and difficult to implement. Issues regarding immigrants, the justice system, and climate and energy policies are used as tools to promote and aggravate anti-EU sentiments. In other words, nationalist ideology and opting for coal go hand-in-hand. The argument that "We like 'our coal', not Chinese PVs" is closely related to discourses of national identity.

When looking at the future of coal in Poland, market dynamics should not be underestimated. Experts who think that there is clearly a carbon lock-in problem in Poland also think that this will eventually be undone whether or not politicians acknowledge it, because mines will go bankrupt and the EU will finally have to step in. Experts claim that at least 20 percent of coal mining capacity will have to be shut down and that this trend will continue in the future because of the abovementioned reasons.[99]

96 Personal communication, 2016.

97 Personal communication, 2016.

98 Personal communication, 2016.

99 Personal communication, 2016.

TURKEY AT A CROSSROADS

Turkey has the 17th largest GDP in the world, approximately 863.7 billion USD in 2016.[100] The total population of Turkey was 79.8 million in 2016,[101] and by the end of 2015, coal's share in Turkey's total primary energy consumption (the equivalent of 126.9 million tons of oil) was 27.3 percent.[102]

Turkey's electricity consumption in 2016 was 278.4 billion kWH, and its installed electricity generation capacity was 80,546 MW at the end of July 2017. Hydropower accounted for 33.6 percent of this capacity, natural gas for 28.1 percent, coal for 21.5 percent, wind for 7.7 percent, and geothermal for 1.1 percent. Installed domestic coal capacity was 9,437 MW (12.1 percent), and the installed imported coal capacity was 7,879 MW (10 percent). Natural gas accounted for 34 percent, coal for 31 percent, hydropower for 24 percent, wind for 6 percent, geothermal for 2 percent, and other resources for 3 percent of electricity production. Coal's share in this capacity peaked in 2016 as coal-fired power plants produced a total of 92.3 TWh, bringing coal's share in total electricity to 33.9 percent.[103]

As of July 2017, the installed capacity of coal-fired power plants over 30 MW reached 16 GW, and there were 66 coal-fired generating units in 25 coal-fired power plants located in 15 provinces. The total installed capacity of the six generating units that are under construction is 2,640 MW. The total installed capacity of the 14 licensed generating units and 41 pre-licensed generating units is 8,229 MW and 22,410 MW, respectively. Furthermore, 10 generating units of a total installed capacity of 22,410 MW, which include large-scale coal-fired power plants, are in the preliminary "announced" stage. The total installed capacity of the 71 generating units in the pipeline—including those under construction—corresponds to 62,770 MW, which is three times the existing installed capacity. This trend that favors investments in new coal-fired power plant puts Turkey at the top of the list of European countries that are increasing their coal capacity.[104]

The electricity sector in Turkey has been privatized in the last decade. Seventy-five percent of installed capacity is in the hands of the private sector, while state-owned EÜAŞ accounts for 25.1 percent of electric plants' installed capacity.[105] According to the Ministry of Energy and Natural Resources (MoENR), 3.2 percent of the world's total lignite reserves are in Turkey. However, the calorific value of this lignite is relatively low. Nevertheless, lately the government repeatedly states that it aims to increase domestic coal production and is working to develop new lignite fields.

Even though coal's share in electricity production has increased considerably in recent years, there has been no significant increase in the use of domestic sources. In 2016, domestic

100 World Bank, World Development Indicators database.

101 Turkish Statistical Institute, "Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları, 2016 (Address Based Population Record System Results)," accessed January 12, 2018, http://www.tuik.gov.tr/PreHaberBultenleri.do?id=24638

102 Republic of Turkey Ministry of Energy and Natural Resources, "Kömür (Coal)," accessed January 12, 2018, http://www.enerji.gov.tr/tr-TR/Sayfalar/Komur.

103 Republic of Turkey Ministry of Energy and Natural Resources, "Elektrik (Electricity)," accessed January 12, 2018, http://www.enerji.gov.tr/tr-TR/Sayfalar/Elektrik.

104 End Coal, "Global Coal Plant Tracker."

105 TEİAŞ, "Türkiye Elektrik Üretim-İletim 2016 Yılı İstatistikleri (Turkey's Electricity Production-Transmission Year of 2016 Statistics)," accessed January 12, 2018, https://www.teias.gov.tr/tr/turkiye-elektrik-uretim-iletim-2016-yili-istatistikleri.

sources accounted for 49.4 percent of electricity production. This share has fluctuated in the last fifteen years but has not displayed any significant changes.[106]

The share of renewable energy in the Turkish market has grown significantly in recent years mainly due to increases in hydropower and wind. As for electricity production from renewables, the largest share belongs to large hydroelectric dams, accounting for 54 percent of electricity production from renewable energy sources in Turkey. The number of small hydroelectric power plants has increased in recent years, constituting an additional 20 percent of the electricity produced from renewable sources. Therefore, while hydro's share in renewables is 75 percent, other sources account for the remaining 25 percent of production, with wind at 17 percent, geothermal at 5.3 percent, and solar with unlicensed PV panels at 1.1 percent.[107]

Turkey intends to increase domestic coal's share in electricity production as well as the number of new renewable energy plants. It aims at keeping the share of renewable sources (including hydropower) at one-third by 2023. Since currently renewable sources account for approximately 32 percent of electricity production, we can see that Turkey intends to increase renewable energy capacity but does not foresee an increase in renewable's share in electricity production.

Numeric targets have been set for the increase in renewable energy. On the one hand, MoENR energy strategy documents feature targets to increase renewable energy's installed capacity to 36 GW in hydro, 20 GW in wind, and 5 GW in solar by 2023.[108] On the other, the INDC that Turkey submitted to the UNFCCC in 2015 features the renewable energy target of 16 GW in wind and 10 GW in solar by 2030. The target set for installed wind capacity by 2030 in the INDC is lower than the 2023 target featured in the energy documents.[109] Following the Regulation on the Renewable Energy Designated Areas (YEKA in Turkish) that entered into force in 2016, two big tenders for solar and wind energy were launched. The YEKA system, which allows technology transfer and aims at reducing import-dependency through components that are produced in Turkey, also allows price reduction through tenders. The Konya-Karapınar 1 GW solar PV tender in March 2017 was won by the bidders who offered 6.99 US cents per kWh, and the 1 GW wind energy tender in August 2017 was won by the companies with the lowest price of 3.48 US cents per kWh. Some speculate that the government will revoke the feed-in tariff scheme in the medium term and implement a reverse auction mechanism.

Turkey is the Annex 1 country with highest increase in GHG emissions. Turkey's 2015 GHG emissions amounted to 475 million tons, which represents a 122 percent increase from 1990 levels. Energy's share in total emissions is 71.6 percent.[110] Turkey's INDC features the target to reduce GHG emissions relative to the increase in GHG emissions according to the business-as-usual scenario levels. According to this, the target is to keep GHG emissions under 929 million tons in 2030, which is 21 percent less than the

106 Ü. Şahin, "Coal's Involvement in Turkey's Energy and Climate Policies," in *Coal Report: Turkey's Coal Policies Related to Climate Change, Economy, and Health*, edited by Ü. Şahin, 13–30 (Istanbul: Istanbul Policy Center, 2016).

107 TEİAŞ, "Türkiye Elektrik Üretim-İletim 2016."

108 Republic of Turkey Ministry of Energy and Natural Resources, "Türkiye Ulusal Yenilenebilir Enerji Eylem Planı (Turkey's National Renewable Energy Action Plan)," Ankara, 2014.

109 "Republic of Turkey Intended Nationally Determined Contribution," accessed January 12, 2018, http://www4.unfccc.int/submissions/INDC/Published%20Documents/Turkey/1/The_INDC_of_TURKEY_v.15.19.30.pdf.

110 Turkish Statistical Institute, "Seragazı Emisyon İstatistikleri, 1990-2015 (Greenhouse Gas Emission Statistics, 1990-2015)," accessed January 12, 2018, http://www.tuik.gov.tr/PreHaberBultenleri.do?id=24588.

predicted 1,175 million tons.[111] This target can also be interpreted as a target to increase emissions in 2030 by over 110 percent from 2010 levels. On the other hand, Turkey has not yet ratified the Paris Agreement and has not formalized these targets.

The basis of Turkey's official energy strategy is to reduce energy resource imports. The aim is to reduce natural gas and coal imports used for electricity production and increase the share of domestic coal and particularly water as well as renewable resources such as wind and solar. However, looking at the increasing and ongoing subsidies provided by the state to fossil fuels, we can deduce that Turkey does not have a policy to reduce fossil fuels in energy production. The coal subsidies, which are not in line with the main strategy, increase not only the amount of coal that is extracted but coal imports as well. The state provides support for coal in different forms: transfer payments from the Treasury, investment incentives for coal extraction, and electricity generation from coal-fired power plants, R&D support, subsidies for mineral exploration, improvement financing for coal mines and coal-fired power plants, investment guarantees, price and electricity purchase guarantees, coal aid to the poor, and other direct and indirect supports. Calculations revealed that the total amount of these supports in 2013 was 730 million USD.[112]

According to another report, state subsidies and exemptions provided to coal-fired power plants in 2016 exceeded 2 billons USD, and further incentive was provided for turbine and component import of 1.32 billion USD through customs tax exemption. The report also indicates that in 1990, when imported coal accounted for a large percentage of coal consumption, the coal import volume was 5.5 million tons. In 2015, this figure increased more than six-fold and reached 34.5 million tons. The report underlines that 235.2 million tons of the 261.1 million-ton increase in GHG emissions between 1990 and 2015 stem from carbon dioxide, and that fossil fuels account for 82 percent of this figure. While in 1990 coal-fired power plants emitted 24.1 million tons of carbon dioxide, in 2015 this figure had reached 80.3 million tons.[113] This shows the close relationship between the increase in GHG emissions and the increase in coal consumption in Turkey.

Evaluation of the Energy System in Turkey

The experts we interviewed define Turkey's energy outlook as a system that is dependent on fossil fuels, guided by the preferences of political power, where the need for financing plays a determining role. Experts state that governments' political decisions are much more determinative than economic, scientific, or technological needs, and therefore, we often observe that the decisions are in contradiction with global trends or are economically disadvantageous.[114]

According to experts, the government in Turkey wants to reduce the consumption of natural gas, which emits less pollutants than coal, because it is concerned about energy resource import-dependency and increasing electricity prices; in other words, it sees natural gas as a threat to energy security and affordability. The predominant opinion is that the existing energy resources in Turkey are limited to renewables and lignite, and the policy to replace natural gas with coal comes from the need to steer towards domestic energy resources.[115]

Another common opinion voiced by experts is that the increasing energy need in Turkey brings about

111 "Republic of Turkey Intended Nationally Determined Contribution."

112 S. Acar, "Coal Investments and Current Subsidies in Turkey," in *Coal Report: Turkey's Coal Policies Related to Climate Change, Economy, and Health*, edited by Ü. Şahin, 41–49 (Istanbul: Istanbul Policy Center, 2016).

113 Ö. Algedik, "Coal and Climate Change, 2017," accessed January 12, 2018, http://www.onderalgedik.com/wp-content/uploads/2017/11/Coal-and-Climate-Change-2017.pdf.

114 Personal communication, 2016.

115 Personal communication, 2016.

certain challenges. Turkey's increasing population, economic growth, and inefficient use of energy increases energy demand, and this demand needs to be met. The low-capacity factor of renewables is seen as another obstacle. In conclusion, the obstacles to shifting to a low-carbon energy system as identified by experts can be summarized as economic restrictions and, particularly, the need for financing, political choices, population increase, and economic growth.[116]

Experts with experience in the energy sector comment that only two actors, namely the government and the private sector, are influential in determining policies and that the remaining actors do not have any influence because "policies that are scientific, rational, and beneficial for society are not being developed." Furthermore, experts identify "politicians" as the most important actors in determining energy policies and their concern for votes as their main motivation. The government is criticized for not making use of experts' knowledge and for excluding them in the decision-making processes.[117]

One of the most important reasons for Turkey's inability to shift to a low-carbon energy system is considered to be the lack of technology. One of the reasons for Turkey's failure to sufficiently make use of its high wind and solar potential is explained by the fact that the country does not possess any domestic technologies for renewable energy. Some experts believe that a domestically developed technology would constitute a definite "driving force." The reason for this being that when a country does not have its own technology in a newly emerging field, owners of the old technologies and investment groups lobby the government and prevail. Experts also add that reports published by international institutions such as the World Bank are prepared in line with the vested interests of the private sector and international investors. Policy change and a plan that will enable technological development are needed to change this situation; however, this is not likely to happen in the near future.[118]

Experts also commented that technological developments and the increasing cost of solar and wind energies will prevail. Coal and nuclear will cease to be options as a matter of course, and the barriers to energy transformation are temporary. Therefore, Turkey will be forced to be a part of the transformation. However, experts add that it does not seem possible for this transformation to happen in the short term through policy changes and correct planning. International dynamics will play a determining role in this transformation, which can only occur by the 2030s. One of the principal criticisms in regards to this delay is the level of education in Turkey. Turkey is criticized for "never being the locomotive of any developments and entering the scene as the fourth or fifth wagon." Experts maintain that, "Being a power engine requires free individuals, a high-level of education and research: in other words, high-quality human resources. However, Turkey has settled for mediocrity."[119]

Per the experts we interviewed, a lifestyle based on consumption is also seen as an obstacle to transformation in Turkey. Experts voice that Turkey's late electrification became a symbol of development and "good life standards." "Smoking chimneys" became a source of pride, especially for engineers, and nobody wants to give up these achievements. Furthermore, the experts deduce that the neoliberal system has made consumption the basic indicator of happiness, whereas achieving the transition to a low-carbon economy requires first and foremost questioning the connection that has been established between consumption and happiness.[120]

116 Personal communication, 2016.

117 Personal communication, 2016.

118 Personal communication, 2016.

119 Personal communication, 2016.

120 Personal communication, 2016.

CARBON LOCK-IN AND BARRIERS IN A COMPARATIVE PERSPECTIVE

According to the developments in the energy sector and the information gathered during the interviews, Turkey's carbon lock-in situation is becoming increasingly tighter. Poland is a country with a long history of carbon lock-in and appears to further aggravate its situation. As for Germany, it embarked on the path to break carbon lock-in but has slowed down and been sidetracked in recent years. Some experts have even commented that Germany is back on a trajectory toward carbon lock-in. Nevertheless, out of the three countries Germany appears to have the best chance to escape from carbon lock-in, while Poland seems to resist. Turkey's situation appears to be somewhere in between. Turkey has many opportunities to escape lock-in; however, it does not make the necessary efforts and even adheres to policies that will further aggravate the problem. Therefore, Turkey will probably find itself in a stronger carbon lock-in situation in the coming years.

In Germany, the Energy Transition (Energiewende) policies, notably those regarding renewable energy targets, are proceeding quite successfully. The fact that renewable energy's share in electricity production increased from seven percent in 2000 at the onset of the Energiewende to its current share of 30 percent is an important achievement. Furthermore, the cross-party consensus and high social acceptance of the Energiewende increase its chances of success. The fact that renewable energy production spread at the grassroots level played as important a role as that of environmentally-conscious German citizens in the widespread social acceptance of low-carbon transitions. The support given to the Energiewende by the farmers and other citizens who sell the electricity they produce from renewable sources is an important indicator. Even the surcharge on consumer electricity prices as a result of the feed-in tariff scheme did not significantly reduce the level of popular support for low-carbon transition. This was by virtue of the rapid decrease in the prices of electricity produced by wind and solar and the most recent amendments to the Renewable Energy Act.

On the other hand, the trajectory of low-carbon transition in Germany is highly problematic. It appears that Germany will not be able to achieve its ambitious climate targets because of the fact that coal still accounts for around 40 percent of electricity production. Germany's target to reduce its carbon emissions by 40 percent relative to 1990 levels does not seem to be achievable anymore. With coal becoming the second cheapest source as wholesale coal prices in energy markets dropped in Germany due in part to subsidized renewable energy in power generation, together with low carbon price in the Emissions Trading Scheme (ETS), and the price drop in coal in the global markets, coal became the preferred source for electricity production. Consequently, while retired nuclear plants are replaced by renewables, the consumption of natural gas, which is considered expensive, is also decreasing; however, natural gas' substitute is not renewables, but coal.

Nationwide grids in Germany are insufficient and constitute another obstacle for renewable energy to gain a larger share in the energy system. Furthermore, transportation and residential heating, which are two of the most important energy-consuming areas after electricity, show no signs of real progress in fossil fuel phase-out, constituting an obstacle to the progress of low-carbon transition.

Poland has yet to implement any state policies working toward a low-carbon transition. It appears that Poland's targets for renewable energy and reducing GHG emissions stated in its energy policies exist for the sole purpose of harmonizing with common EU targets. Even though there was a slight increase in renewables' share in energy generation in Poland in the recent years, new regulations blocked the construction of new wind power stations, no support were provided to solar power plants, and incentives for coal increased. Poland considers its domestic coal-based energy policy indispensable. Looking at the policy for renewing existing coal-fired power plants, which was designed to reduce the impacts of coal-fired power plants such as air pollution and increase economic efficiency and considering that these power plants have an economic life of 40 to 60 years, we can see that Poland's policies will inevitably increase the gravity of the existing carbon lock-in situation and stabilize it. Moreover, the established infrastructure for district heating systems in Poland is coal-fired and difficult to change.

As for Turkey, despite the increase in new renewable energy production such as wind and solar—not including conventional hydropower with dams—there is no firm low-carbon transition policy. Turkey's energy policies focus on closing the current deficit with energy produced from domestic sources and reducing the country's energy import dependency. Meeting the rapid increases in energy demand by building new power plants and ensuring supply security with resource diversity are the strategic targets. Increasing domestic lignite consumption forms the basis of Turkey's current energy policy—using both energy independence and the cheap energy arguments. On the other hand, because it requires imported technologies, renewable energy, which is becoming cheaper and should be deemed domestic, is considered almost a foreign source that is preferred if it reduces energy prices. Therefore, Turkey continues to build new coal-fired power plants and, like Poland, disregards the fact that these power plants will prolong carbon lock-in by 40 to 60 years.

Turkey also places importance on its goal to reduce natural gas imports through resource diversity by building nuclear power plants. However, these coal and nuclear targets are inconsistent with low-carbon policies that are expected to be in line with climate protection. The energy sector is growing within defined boundaries, and Turkey wants the largest share to be allocated to fossil fuel sources and nuclear energy. Making use of this same strategy, the Renewable Energy Designated Areas (YEKA) Act adopted in 2016 aims to decrease the renewable energy support scheme as well as imports for renewable energy vis-à-vis technology transfer. Looking at the absence of targets to increase the share of renewables in power generation (and insufficient and inconsistent targets to increase capacity) as well as the existing targets to incentivize coal, we can say that there is no consistent low-carbon transition policy in Turkey, and the current policies aggravate the carbon lock-in situation.

The economic, social, and political factors that enable and prevent low-carbon transition in Germany, Poland, and Turkey can be addressed under six headings.

1- The prominent reason for Germany playing a leading role in low carbon transition policies and for Energiewende becoming permanent and accepted on societal level even though it is a major industrialized country is political. All the experts agree that the anti-nuclear movement that emerged in the 1970s formed a strong social movement that politicized energy issues over time. Accordingly, the social acceptance of the alternatives that were developed over time were among

the main factors behind Energiewende. The fact that Germany's Green Party entered the Bundestag in the early years and that it implemented the nuclear phase-out and the Renewable Energy Act as priority policies during the red-green coalition from 1998 to 2005 were game changers to start low carbon transition. In other words, this set a precedent for the world whereby a social demand found its political representative, thus policies of vital importance for climate mitigation were implemented early on. Moreover, these policies supported renewable energy technologies when they were not sufficiently cost-effective, therefore making it possible for them to develop and become cheaper. Climate and energy policies and even coal phase-out remain to be an important political issue in the coalition talks. As for Turkey and Poland, such issues remain far from the mainstream political debate. There are no studies that can prove that environmental awareness in these two countries is less significant than in Germany. However, environmental and energy policies do not constitute important political issues in either of the two countries. Also, the green parties are not important actors across the political spectrum in either Poland or Turkey. Therefore, neither climate change, nor low-carbon transition in both countries is an issue in electoral politics. The fact that green politics has not developed in either country and political conditions similar to Germany's have not formed have impeded the positive impacts that politics can potentially have on low-carbon transition. This has, in turn, increased carbon lock-in.

2- On the other hand, policies that increase carbon lock-in can secure political gain in any country and this is most apparent in Poland. In the Polish case, even if the current number of people working in coal mines—which employed a large number of workers and were politically strong during Communist rule—is less than 100,000, coal-producing regions still have a considerable impact on politics today. According to experts, political parties consider these regions critical constituencies as coal workers are organized in long-established and politically strong labor unions that can directly influence government policies. Thereby, coal is made to look as if it is still a part of national identity. Political parties do not dare to mention any policies that might phase out coal. This is the reason why the coal used in coal-fired power plants is being purchased from domestic mines through state subsidies at a price that is relatively higher than global prices. This policy gains further legitimacy using the energy independence argument. In Germany, coal unions have an important influence on political parties, particularly on the Social Democratic Party in certain regions, and this is one of the factors that prevents coal phase-out policies from being brought to the agenda. In Turkey, the government defends domestic coal using the pretext that it is an important driver for employment and uses its support for coal to obtain votes from coal miners and residents living near coal mines and coal-fired power plants.

3- The production and distribution of energy according to the rules of the free market can have an enabling effect for low-carbon transition. This becomes especially evident in the comparison between Germany and Poland. In Poland, where all electricity production is in the control of the state, the determinative impact of politics surpasses the economic impact, and coal is protected by state incentives. The government in Poland, which owns the majority share of energy utilities and appoints their executives, steers these utilities towards supporting domestic coal production. Being in control of electricity production, the government also hinders the development of renewable energy generation by the private owners. In Turkey the privatization of the energy sector is in a much more advanced stage than in Poland; however, this is not enough to reduce the state's determinative

influence and the role played by political concerns in decision-making processes. In order to create a setting that supports low-carbon transition, there is an evident need to build a system beyond the liberalization of the energy system, a system in which economic and environmental concerns will surpass political ones and open the decision-making processes to the people.

4- The decentralization of energy policies to include more small businesses and individual producers has a supportive effect on low-carbon transition. The fact that in Germany almost half of the wind and solar installations used in electricity production are owned by private citizens and the rest by small investors and co-ops in which influential small farmers own a considerable share were the factors behind the widespread acceptance of the Energiewende. A country that relies on centralized energy production methods, such as nuclear and coal-fired power plants, seized the opportunity to undo carbon lock-in by the virtue of this choice it made. In Turkey's case, large and centralized facilities are favored not only for energy but for all economic policies. Decentralization is not an ideologically and politically favored approach. Thus, old arguments such as base load, integrated grid, etc., continue to prevail and support the position that large fossil fuel-fired power plants are imperative. Even the renewable energy investments are preferred to make central and large scale as in YEKA. Poland also continues to prioritize centralized and large structures and ignores and even considers small and decentralized systems harmful with an approach that dates back to the Communist era.

5- Germany is an example where scientists and experts had a positive influence on low-carbon transition. The studies of economic models and projections, the development of new technologies, and the work of civil society organizations, universities, and think tanks paved the way for the preparation of data-based policy recommendations, as well as for political parties to advocate these recommendations and for governments to implement them. In Poland and Turkey, experts have a mixed role in influencing low-carbon transition. Even though science and technology's influence in the decision making of national policies is limited, experts play a role in defending innovation and change or in keeping the status quo. Alongside of the dominant effect of the state, under the influence of the domestic resource argument of the pro-independence ideologies as well as developmentalist energy needs and economic imperatives arguments, experts and the professional organizations may pave the roads of an aggravated carbon lock-in situation.

6- Voting and consumer behaviors as well as user practices may have a larger impact on low-carbon transition than we think. Even though the political power of car manufacturers is one of the factors that increases the negative impacts of the automotive sector on low-carbon transition, German citizens' driving habits—such as the perception that "strong German cars" are part of German national identity, similar to the way coal was considered in the past—may also play an important role. Furthermore, consumers' perceptions that electric vehicles are not "real cars" can play as important a role as insufficient infrastructure. While the final consumer cannot distinguish among the different sources of electricity production, vehicles are consumer goods that directly involve personal choices. As for Poland, the perception that electricity can only be produced by burning coal prevails. In Poland, coal is also considered an element of national identity and is accepted, at least by some, as the symbol of Poland's independence. Therefore, recommendations to phase-out coal can be perceived as anti-nationalist, utopian delusions. A similar situation where nationalistic political ends can be used as a unifying ideological glue is also true in

Turkey's case. Coal becomes easier to accept when it is presented as the tool of independence and to ward off external forces. Turkey is also a country where the influence of developmentalist ideology does not make it easy to question certainties regarding growth. Therefore, refusing to use coal would be considered contradictory to domestic and national developmentalist ideology. On the other hand, in Germany as well as in Turkey and Poland, consumers' approach to energy consumption generally displays a conservative influence on situations where consumer behavior plays a determinative role, most notably in travel, housing, and heating. In conclusion, we can affirm that in all three countries voter and consumer behaviors can aggravate carbon lock-in, even through different dynamics.

CONCLUSION AND RECOMMENDATIONS

Turkey can still escape from rapidly intensifying carbon lock-in. Even though its energy consumption is highly fossil fuel-dependent, Turkey can use the fact that it is a developing country to its advantage, particularly in power generation and the transport sector. It is much easier for developing countries to undergo rapid renewable energy transformation in power generation than it is for major industrialized countries. Road and construction are rapidly growing sectors in Turkey, and policy changes favoring low-carbon transition can enable the reduction of transport and building emissions. Turkey still has the chance to bypass a polluting development pathway and achieve ecological leapfrogging.[121] By making this political choice, Turkey can break carbon lock-in, which constitutes a situation that will lead to important economic losses in the future. A policy change in this direction will also create an important opportunity for businesses to avoid the risk of stranded assets.

The priority policy options that Turkey needs to adopt to break carbon lock-in can be listed as follows:

1- Turkey needs to make low-carbon transition the foundation of its economic development policy. Building a future based on renewable resources—not on fossil fuels—and thereby protecting the climate and preventing environmental pollution need to be included in the main strategies of economic and energy policies.

2- Turkey needs to look at renewable energy investments as a strategic choice. Renewable energy investments should not be used for the mere purpose of diversification or, given renewable sources' price drop, as a way to reduce electricity prices. Renewable energy should be supported not just because it is cheap and domestic, but also because it removes the need to import energy resources, does not cause GHG emissions, and is cheap and easy to implement.

3- Turkey should use renewable energy production to its advantage—particularly that solar PVs are becoming increasingly cheaper and enable electricity production in a decentralized system. Turkey should expand decentralized systems by encouraging the creation of energy co-ops, facilitating the installation of individual solar roof PVs, and utilizing modernized grid systems (e.g., smart grids) in transmission and distribution systems.

4- The primary factor that aggravates carbon lock-in and the risk of stranded assets is the construction of new coal-fired power plants, which have an economic lifetime of 40-60 years. The building of all new coal-fired power plants, including the ones that are currently under construction, needs to be halted, and their licenses need to be revoked.

5- Turkey should begin efforts to shut down existing coal-fired power plants over a defined timeframe and to phase out coal for electricity production in due course. A timeline for the closure of coal-fired power plants needs to be developed to take into account the following criteria: carbon dioxide and other pollutant emissions, economic lifetime, use of imported coal, and the demands of local commu-

121 Ecological leapfrogging is another way to examine the proposed development pathway for developing countries, a concept coined by Wolfgang Sachs and Tilman Santarius. The idea is that developing countries "could wager on bold ecological leapfrogging over the false paths of developed countries and, for that matter, move directly to modern renewable energies, perhaps investing earlier and more consistently than the Northern economies in solar energy. They could very soon find themselves with patterns of sustainability that the rich nations have not reached at all." See W. Sachs and T. Santarius (eds), *Fair Future: Resource Conflicts, Security and Global Justice (A Report of the Wuppertal Institute for Climate, Environment and Energy),* translated by Patrick Camiller (New York: Zed Books, 2007).

nities. Turkey needs to complete its coal phase-out with a just transition plan that will compensate for the economic losses of workers and local communities and within a timeframe that will allow for considerable reduction of GHG emissions.

6- Turkey needs to adopt a development trajectory that will expand non-motorized modes of transportation in urban centers, increase the share of rail transit, and increase reliance on rail networks for intercity and international transportation. Turkey needs to halt new investments in roads and bridges, which lead to the increased use of motorized vehicles instead of alleviating traffic.

7- As for the reduction of building emissions—particularly from buildings' heating and cooling systems—efficient designs for new buildings, the use of energy-efficient materials, and the use of methods such as green and passive buildings should become widespread. The rapid urban transformation currently underway in Turkey should be used as an opportunity to achieve this.

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