Security, Justice and the Energy Crossroads:
Assessing the Implications of the Nuclear Phase-out in Germany

Abstract

The nuclear melt-down in Fukushima resulted in diverging energy policy decisions across the world where Germany decided to opt out of nuclear electricity production. Yet, the government's decision-making framework for energy policy decisions does not accurately reflect important drivers for the strategy change. This paper presents the Energy Crossroads framework as a more comprehensive tool to analyse the drivers and impacts of the nuclear phase-out. 20 expert interviews were performed across business participants as well as policy makers in the national and international energy context. Results show that Germany has adopted an environmental justice, rather than energy security, stance in their nuclear phase out policy, with significant long-term consequences.

Keywords; Energy transition**;** Energiewende**;** nuclear energy; energy security**;** environmental justice**;** energy crossroads

1 Introduction

The nuclear meltdown in Fukushima dramatically demonstrated the social, environmental and economic risks involved in an energy strategy relying on nuclear technology. Within days after these events, the German government decided to phase-out all its nuclear electricity capacity by 2022, and the 8 oldest of Germany's 17 nuclear power plants (NPPs) were immediately put out of operation. This phase-out constitutes part of the overall energy strategy called "*Energiewende*" (translated: energy turnaround), which sets out the goal of increasing the share of renewables within the electricity mix, to reduce oil and gas imports, contribute to the mitigation of climate change, as well as terminating the reliance on nuclear electricity generation (BMWi, 2014).

We propose a new framework of analysis, which captures the impacts of the Energiewende with regards to energy security, economic, social and environmental dimensions more accurately than the frameworks currently used. It does so by extending the current decision-making framework used by the government in the context of the Energiewende by including a social sphere, allowing for an overall more accurate impact assessments of energy strategy decisions. Further, by taking a broad perspective on impacts emerging from the Energiewende, the investigation goes beyond existing research, as it identifies and acknowledges the reciprocal relationship across the dimensions.

2 Conceptual framework: The Energy Crossroads

Within the context of an effective transition towards a renewable energy future, involving the disengagement of nuclear energy, German political discourse is dominated by the energy policy triangle (SPD, 2011) similar to the energy trilemma notion (Gunningham 2013). This consists of three aspects: (1) energy security, (2) economic feasibility and (3) environmental compatibility as seen in the triangle represented in Figure 1 below. The triangle is used by the German government as a guiding principle for decision-making and is driving energy policy decisions (Mahnke, 2013). The geometrical properties of the energy policy triangle, where sides are of equal length and angles are of equal size, shape an image which suggests that the same weighting of importance is devoted to the different aspects within the triangle, as declared explicitly in the coalition contract between the two ruling parties (CDU/CSU & SPD 2013). Governments and energy companies across Europe are using the triangle within their strategic documents (EC, 2007, 2012; BDEW 2009; RWE, 2014; E.ON, 2006). The phase-out of nuclear energy after the events in Fukushima in 2011 was driven by the social and environmental risks of nuclear technology pointed out again by the Fukushima incident. Four years later, experts still discuss the energy security implications of the phase out. This might suggest that some aspects of the triangle were prioritized when others were neglected in haste. Furthermore, longstanding public opposition seems to have influenced the decision (Goodfellow et al., 2011). To analyse the driving dimensions of the policy decision to phase out nuclear, an adaptation of the framework is required to develop a clearer picture.

Figure 1: Original energy policy triangle

The new energy strategy pursued by Germany moves from a rather centralized energy production by few, large power plants to a decentralized strategy, consuming more physical space and therefore affecting more people directly as well as impacting more upon the natural environment. Following this reasoning it comes as a surprise that the triangle, used to guide energy policy decisions, does not explicitly contain a social dimension.

This social dimension is critical to the decision to phase-out nuclear energy. Germany has a long-standing history of social movements against nuclear energy. Peaceful protests in Whyl led to the cancelation of the NPP construction plans. Other less peaceful protests also contributed to shape German public opinion and discussion over time. In 1983 anti-nuclear opinion effectively led to the first election of the Green party into Parliament, where their foremost goal was to abandon nuclear electricity production in Germany (Glaser, 2012; Schreurs, 2012). Another contributory factor is the active participation and public involvement in the Energiewende. Already in 2010 about 40% of the German renewable energy capacity was owned by members of the public (Trendresearch, 2011). At the same time the decision for the nuclear phase-out in favour of more RES reduces the oligopolistic power over electricity production of the "big 4" energy companies in Germany. Thus, energy policy must seek to actively encourage greater public participation.

The ethics commission on safe energy provision was convened by the German government to assess ethical and technical aspects of the nuclear phase-out and to suggest measures for the transition to more renewable energy solutions. The commission found that increased public involvement in both planning as well as participation in the final technological solutions is key for a successful Energiewende. Members of the public have multiple roles here. In their role as consumers they are to increasingly demand efficient energy solutions and services to foster a reduction of electricity needed. Furthermore they are encouraged to strengthen their role of co-producers of electricity both at home, and in participating in municipal energy systems (Ethics Commission, 2011). These roles reinforce the importance of the social dimensions within the Energiewende.

For these reasons Knopf *et al.* (2011) add a fourth dimension of *societal acceptance* to the triangle. While this attempts to include social measures, it is rather inaccurate as societal acceptance can stem from other factors like economic or contextual reasons, not necessarily touching upon issues of social justice.

The original energy policy triangle as well as the alteration by Knopf *et al.* (2011) neglect to sufficiently account for political decisions from either governments or companies. The desire to achieve all aspects in the triangle is laudable, and yet, rather naïve. Energy policy involves inescapable choices. We explore here a central dichotomy between prioritizing energy security or environmental justice concerns (as set out in Figure 2 below). The conceptual novelty of this framework is indeed the implication that energy policy is often pursued in either a security or justice direction, sometimes in spite of the best intentions of policy actors. As we explore in this paper, such prioritizations often change over time. With regards to the dimension of energy security, this study focuses on the security of electricity supply, as the Energiewende and the nuclear phase-out primarily imply a change in the electricity system. There is a wide range of definitions of energy security within the literature (see Sovacool & Saunders, 2014), assuming different scopes for energy security whilst representing the complexity as well as the contextual nature of energy security. Kruyt et al. (2009) define energy security as *availability, accessibility, affordability* and *acceptability* of energy, combining all aspects covered by the extended energy policy triangle into one concept.

Figure 2: The Energy Crossroads

The four A's of Kruyt et al. (2009) are, however, from the perspective of energy security. This leads to an over-prioritization of security of supply and economic viability concerns. Environmental justice allows us to question more thoroughly issues of social acceptance and environmental compatibility. We often assume government decisions are made upon the realpolitik hardheaded decisions of finance and resources. We argue below that the German government has adopted a more environmental justice stance towards nuclear energy, and indeed the Energiewende. Environmental justice is "based on the principle that all people have a right to be protected from environmental pollution and to live in and enjoy a clean and healthful environment" (Agyeman 2004). This new dimension seems especially relevant in the German context, where strong anti-nuclear opinions have hindered nuclear construction projects in the past (Knopf et al., 2011), as well as other infrastructure projects as "Stuttgart21" currently hindered by public opposition where environmental concerns played a significant role (Novy & Peters, 2012).

3 Methodology

3.1 Research Design

The aim of the employed research methodology is to gather data which, when analysed, answers the research questions below. Figure 2 above serves as the basis for a framework to assess the drivers of the Energiewende, which are categorized into:

(1) energy security

(2) environmental justice

More specifically, the following overarching questions will be answered:

- Is there a dichotomy between the aspects of energy security and environmental justice with regards to the Energiewende?
- Which of the two is the main driver for the nuclear phase-out?

For this study, the research design is based upon qualitative analysis through semi-structured expert interviews. Dorussen et al. (2005) advocate that expert interviews are a useful tool to identify central dimensions within the field researched and to get insider information on those dimensions. A subset of questions was pre-defined in accordance with the conceptual framework in Figure 2 and addressed to each expert to allow for the comparability of different participants. Sufficient room for maneuver was accorded in the interviews for experts to elaborate on issues, which they considered important.

The employment of expert interviews proved to be effective in other, comparable research settings. Kowalski, et al. (2009) performed research where the sustainability of renewable energy scenarios was to be assessed for Austria. Expert interviews were useful as: "decision-making for sustainable energy futures requires methods that allow for the complexities of socio-economic and biophysical systems and that address uncertainties of long-term consequences" (Kowalski et al., 2009; p.1063). This set of characteristic are equally applicable for the Energiewende, as its implications are shaped by complexities in relation with long time horizons (Pidgeon et al., 2008), making expert interviews a well suited research approach to this study.

Elite interviewing has been the subject of much debate in the academic literature (Rice 2010). We follow the definition of Tansey (2007) in understanding an elite as someone holding a privileged position in society, often resulting in more influence than a member of the public. This method provides the researcher with a window into how key individuals in energy policy perceive and construct their context and the common assumptions which help shape it (Morris 2009). The focus on elite understandings can therefore lead to a credible dataset for analysing past, present and future energy policy trajectories. The advantage of this approach is time-efficiency and relative feasibility (Tansey 2007). It is also criticized as providing only limited subjective accounts of reality (Hertz and Imber 1996)

Elite interviewing is most reliable and effective for small N studies. Hertz and Imber (1996) underline that such a methodological approach is naturally suited to studies that emphasize depth, rather than breadth, of understanding a given issue. Based on the ontological assumption and the aims of this research, the epistemological position taken is therefore that of interpretivism. This position prioritises people's subjective interpretation and understanding of social phenomena and their own actions. It is most closely associated with single case studies as in the case of this paper (Matthews and Ross 2010). In following, we limit ourselves to one national context, being Germany, in spite of the obvious benefits of comparative studies. This is a necessary discipline when using elite interviews. Our scope is also focused upon the energy sector, and the nuclear industry in particular.

3.2 Research Context

We outline below the prevailing context of the research focusing since the nuclear phase out of 2011 in Germany, in terms of both security and justice

3.2.1 The Energiewende

The *Energiewende* (translated: energy turnaround) describes a long-term transition based energy strategy pursued by successive German governments, rooted in the anti-nuclear movements in the 1970s. Thus it is more than the decision from 2011 to phase-out of nuclear energy. The long-term strategy comprises all levels of energy production and distribution by shaping, both directly and indirectly, production capacities, local and national distribution networks and the energy trading market. Further the *Energiewende* also addresses the consumption side of electricity by establishing and implementing efficiency strategies which include issues of housing and mobility (BMWi, 2015).

Different steps paved the way for the *Energiewende*. In addition to an increasing nuclear opposition and supporting the later phase-out of nuclear energy, policy making ignited the drive to establish alternative electricity sources. In 1991 the “Electricity Feed-in Act” was introduced and updated by the “Renewable Energy Act” (EEG) in 2000 (Wüstenhagen & Bilharz, 2006) which, in revised form, is still in place today. Amongst its original key features were the obligations of the grid operators to give electricity from renewable energy sources (RES) priority to the grid, and to guarantee minimum prices for electricity produced by RES for 20 years (Madlener et al, 2001). It provided incentives to supply and invest in renewable energy as guaranteed prices limited the risks of investment in these technologies (Fürsch et al., 2011; Morris, 2014; Schreurs, 2012; Wüstenhagen & Bilharz, 2006).

Further, the combination of the invigorated renewable energy sector, due to the EEG policy and the anti-nuclear positions in Parliament, led to the initial decision in 2002 by the Social Democrats to phase-out nuclear energy in Germany by the year 2022 (Morris, 2014). In 2009, the Christian Democrats, who were in office at the time, passed legislation which counteracted the phase-out, expanding the lifetimes of German NPPs beyond the period agreed upon in 2002 (Dehmer, 2013; Nestle, 2012). Just over a year after the prolongation of Germany's nuclear lifetime, the nuclear melt-down in Fukushima underlined the possible disastrous consequences of nuclear technology, of which the German public was already acutely aware of following Chernobyl in 1986 (Schreurs, 2012). As a reaction, the Christian Democratic chancellor Angela Merkel revised the decision taken in 2009 to prolong the nuclear lifetime (Dehmer, 2013; Jorant, 2011).

3.2.2 The Energy Security Context of the Nuclear Phase-out

In terms of energy security, there is little evidence of compromised energy security by the partial nuclear phase-out. Geopolitical developments as well as the electricity grid are significant variables contributing to the provision of energy security. Analysis about the availability and accessibility of electricity in the month after the partial phase-out, looking at electricity production, imports and the demand of electricity, found that no supply shortcomings occurred (Knopf et al., 2011; Lechtenböhmer & Samadi, 2013; Matthes et al. 2011a). In a more recent study carried out more than a year after the phase-out, Lechtenböhmer & Samadi (2013) found similar results to the ones above, indicating that even with peak demand in winter there was still an abundance of German electricity generation (Glaser, 2012).

Electricity price modelling after Fukushima and the partial phase-out have been performed for the German market, ranging between electricity price increases of low Euro-cent amounts (Kunz et al., 2011; Matthes et al. 2011a, 2011b) to a maximum of 10 Euros/MWh (Fürsch et al, 2011; Schliesinger et al., 2011) between 2020 and 2030. The latter scenario would correspond to a price increase of 15% for energy intensive industries and 2-4% for the service sector and private consumers (Matthes, 2012). In support of Matthes' (2012) predictions, one year after the phase-out, with 40% less nuclear capacity than in pre-Fukushima times, spot prices of electricity were found to be even lower than before the nuclear melt-down in Fukushima (Lechtenböhmer & Samadi, 2013). Therefore, given planned expansions of the electricity grid (Knopf et al., 2011) and expansion of production capacity (Matthes et al., 2011a) can be realised, the above findings indicate an increase of 5 Euros/MWh for periods between 2020 and 2030, which are attributable to the phase-out (Matthes, 2012). While this might be perceived as a moderate price increase, other costs must be taken into consideration to assess other economic factors more fully.

Figure 3: State support 1970 - 2012 in bn € (real prices)

Küchler & Meyer (2012) compared state subsidies for different electricity sources over time. It was found that past subsidies for renewable energy amount to a total of €67 billion (3,4 c/kWh), while coal was subsidised with €311 billion (3,3 c/kWh) and nuclear power with €213 billion (4,0 c/kWh) (Küchler & Meyer, 2012). Despite a visual representation of the numbers above, figure 3 above outlines individual types of subsidies granted to different electricity sources. However subsidies for RES (Renewable Energy Sources) started as late as in the 1990s, while coal and other technologies have been supported for longer time frames. For this reason, direct comparisons of the absolute amount of past subsidies covering different time frames have to be treated with caution

3.2.3 The Environmental Justice Context of the Nuclear Phase-out

Energy systems are important for modern social structures which tend to depend on energy in many parts of the world. This dependence also makes societies vulnerable with regards to the danger inherent within these systems in the form of direct adverse effects as encountered in Fukushima or indirect effects like their anthropogenic climate change potential (Blewitt, 2008). Following Chernobyl it is estimated that 5 million people were subject to excess radiation exposure by ingesting, inhaling or absorbing radiation through wounds (Christodouleas et al., 2011). Yet, health concerns are not solely directed to nuclear catastrophes but mixed evidence also exists for adverse effects on human health through NPP's regular operations. Many epidemiological studies have been performed where a recent meta-study of 17 research papers covering 136 nuclear sites in different countries found evidence for increased leukaemia rates among children in areas in proximity to NPPs (Baker & Hoel, 2007). A correlation between leukaemia among children and proximity to NPPs was also found by a study comprising 16 NPPs in Germany (Kaatsch et al., 2008). There are other earlier studies which tended not to have drawn this conclusion (UNSCEAR, 2000), but no credible alternatives have been found to explain the recent studies (Ramana, 2009) and further research is necessary in this area for clearer assessments of health issues related to the production of nuclear power.

In terms of environmental impacts, the lost electricity capacity of the partial German phase-out in 2011 resulted in an increased combustion of coal in the second half of 2011 and 2012 to compensate for the electricity capacity lost (Morris, 2012). Therefore, there was a short-term rise in CO_2 emissions[1], compared to the scenario in which nuclear energy production was employed (Matthes, 2011a; Lechtenböhmer & Samadi, 2013; Fürsch et al., 2011). However, emissions increased just slightly (+0,7%) in the year after the partial phase-out, compared to pre-Fukushima levels (Lechtenböhmer & Samadi, 2013). In the medium- to long-term, CO_2 emissions are expected to decrease to a level lower than in a scenario employing nuclear energy production, as the phase-out of nuclear energy fosters the expansion of RES beyond the level of capacity needed to simply replace nuclear (SRU, 2010; Lechtenböhmer & Samadi, 2013). Thus, the Energiewende as a whole foresees the replacement of nuclear and fossil capacity by RES (see schedule of reduction targets in line 2 of Table 2) (Fürsch et al., 2011; Schliesinger, 2011) to support the government`s emission reduction plans depicted in line one of the Table 2.

Table 1: Energy mix and emission targets

3.3 Data collection and analysis

The recruitment of individuals from various institutions and backgrounds was designated to increase the diversity in expert opinions retrieved. Experts here are identified to have a professional interest within nuclear energy and the overall workings of the energy sector more broadly. Interview participants were either part of the researcher's network or were selected by "cold calling". A sample of 20 experts was recruited from academia, institutions with political affiliations, and businesses active in the energy industry, all representing major

[1] An estimation about the extend of carbon emissions saved or increased by replacing nuclear power depends on the scope applied when calculating emissions and is subject to considerable debate within the parties involved (see Pidgeon et al. 2008). Not just emissions during the production of electricity are to be considered, but also other lifecycle emissions caused during the construction of the plants, fuel mining, decommissioning and waste disposal must be accounted for.

stakeholder groups of the Energiewende. (See Appendix A for participants` institutional affiliations).

The interviews were either performed in the expert's offices, or in semi-public places like restaurants or cafés. Interviews took an hour on average where the shortest was 45 minutes and the longest 1 hour and 15 minutes and were voice recorded and transcribed verbatim, while notes were taken at the same time during the course of the interview.

Template analysis was performed and is a tool to thematically organize and analyse textual data (King, 2004), and was thus applied to the transcripts of the interviews, which were finalised within few days after the interviews to incorporate non-verbal implications of the participants. The transcripts were checked on reoccurring themes which were then coded to summarize, compare and contrast expert opinions on those common themes. This enabled the themes to be categorised as either predefined to provide the framework of the semi-structured interviews, or which emerged during the interviews and to put them in relation to each other. Repetitive analysis of transcripts led to the identification of new themes, as well as the refining and separation of existing ones. Finally, the most important themes were selected.

4 Results

Expert interviews point to a general dichotomy between issues of energy security and environmental justice resulting from the nuclear phase-out in Germany. This section will cover energy security aspects which are influenced by a more volatile electricity supply from RES while also financial implications influence accessibility aspects of energy security. Subsequently environmental justice will be covered, more specifically health, social justice, carbon emissions and waste in the context of the nuclear phase-out.

4.1 Energy security: managing the transition to Renewables

Within the Energiewende, nuclear and fossil electricity sources are to be replaced stepwise by more volatile and unpredictable renewable sources. This introduces the challenge of an increasingly unpredictable electricity supply which needs to match the respective demand (#10). The nuclear phase-out is framed as a means to create space and satisfy the demand for more electricity generation from renewable energies in the long run (#6). Several respondents indicated that the vast expansion of PV in the past, significantly fostered by government investments mainly in the form of feed-in tariffs (FiTs), gave an indication that Germany was capable to quickly introduce significant amounts of electricity capacity. This points to the potential to provide sufficient electricity even under an increasingly RES heavy electricity mix. However, the issue of increased volatility of electricity supply from RES when compared to steady and predictable supply of nuclear electricity is defined as one of the key issues of the Energiewende by most participants.

Some RES are limited in their contribution to energy security due to uncertain electricity supply in times of peak demand. However, the security of electricity supply in such situations has to be provided through other means (#19). A diversification of different RES as well as the spatial distribution of certain sources as wind energy for example is found to decrease volatility and therefore aids the security of supply in an energy mix constituted primarily of RES (#8). There is of course criticism that current FiTs foster the development of a broad range of RES including ones which seem less efficient in the German geographic and climatic context such as PV. Such policies have to be, nevertheless, maintained and further refined. Guaranteed prices for electricity from different RES within the FiTs must better reflect and adapt to the technological development of the respective technology in order to not overly support one particular technology as happened with PV in the past (#10) or neglect other technologies in the future. If a balanced policy is achieved across a broad range of different technologies the portfolio of complementary RES technologies will be diversified. The result will be an electricity supply with reduced overall volatility in Germany, contributing to energy security while reducing the dependence of fossil, carbon emitting technology (#18).

4.1.1 The need for a more integrated European energy strategy

A number of respondents pointed to the fact that limited provision of energy security by RES in the context of the Energiewende also stems from a national rather than intra-European energy strategy. With regards to the former, Germany would typically be primarily self-sufficient for its supply of electricity by using the capacity of its national electricity potential. An intra-European energy strategy would address an integrated electricity system on the European level where capacities would be installed there, where a respective technology (i.e. solar, wind, biomass) could produce electricity most efficiently (#12). Respondents pointed out that while this would enable more effective spatial distribution of RES, an intra-European electricity system would result in an internationally reciprocal responsibility for energy security between neighbouring countries, which could potentially result in political difficulties (#6, #8). Even though electricity is exchanged across European countries, no explicit coordination of electricity capacity is yet in place.

However the practicability of such an inter-European strategy seams questionable in the current context of the EU. On the one hand national laws designed to increase electricity from a wide range of RES in individual countries would have to be adapted or reversed (#19). On the other hand the unwillingness of local politicians to take responsibility for shortages in the electricity supply stemming from the international context, mostly being beyond their immediate control, are in conflict with a common European solution (#16). Thus, despite the usefulness of an intra-European energy strategy implying a greater and more effective spatial distribution of RES, such policies seem unfeasible under the current political system. Therefore energy policy integration and coordination on the European level would facilitate the process for smoothing European electricity supply (#10).

4.1.2 Increased levels of price insecurity

Developments of electricity prices play a major role with regards to the accessibility of electricity for private households, as well as businesses. Price developments on the energy market are driven by supply and demand of energy. Despite a brief period immediately after the partial phase-out after the Fukushima incident, a number of respondents point to the fact that Germany became a net exporter of electricity just weeks later, suggesting Germany´s ability to secure supply. However, one respondent indicated that *"challenges to energy security will not find expression through black-outs or brown-outs but will lead to higher energy costs which can come from a number of sources" (#3).* On the one hand the costs at which electricity can be produced feeds into electricity prices as well as the construction as well as maintenance costs of electricity infrastructure which are reflected by energy prices and are charged to electricity consumers (#5, #19).

Overall, (1) FiTs, (2) electricity grid extensions and (3) fossil back-up capacities were identified as major drivers for energy price developments during the expert interviews. Several respondents identified FiTs as a major driver of the Energiewende in Germany while at the same time increasing electricity costs for end consumers (#4). This effect is expected to increase with the share of RES growing in the German electricity mix. Current legislation under the German Renewable Energy Act (referred to as the native Erneuerbare-Energien-Gesetz, EEG) guarantees minimum prices over a 20-year period at which producers can feed their electricity from RES into the grid. This is effectively a subsidy which in this case is financed by the *EEG-Umlage* (levy). This levy is paid by every consumer of electricity on top of their regular electricity bill to cover the expenses for the RES electricity producers under the EEG legislation.

The extension and change of the electricity grid required to support the rapid increase of more volatile electricity production of RES translates into electricity prices as well (#10). In 2011 and 2013 reforms in the planning, authorization and regulation processes of infrastructure were implemented. All the stages are now under the auspices of one regulator, which should allow for faster extension. The financing of grid infrastructure will be made possible, next to state subsidies, by recovering investment via electricity prices. This will in turn reflect infrastructure investments. Yet, participant #8 expressed that investments in the grid will be of a much lower nature than the costs for the RES production capacity itself. However financial implications of capacity expansions themselves were less frequently discussed while more general critique was expressed in that *"the expansion of RES proceeds in a rather disorganized manner, without an accompanying regulatory framework" (#3)*. This disorganised manner potentially results in spatial inefficient use of RES or to a focus on very few different technologies, leading to high production volatility, which at times might not be able to cover demand. Thus a lack of regulation could lead to high costs for investors who cannot recover their investments and ultimately to consumers as a result of ineffective technologies.

At least in the short and medium run, national electricity systems can act as backups to ensure the security of electricity supply in times of peak demand (#8 #15). These backup systems need to be able to readily produce electricity whenever shortages are expected. Due to the lack of available renewable electricity storage capacity such as hydro or technological development in alternative renewable storages (#10), fossil back-up systems were found to be necessary to secure a steady electricity supply. Maintenance of these critical systems, mostly owned by the large energy corporations, will feed into electricity prices as well, despite their low usage.

Thus, FiTs, grid extensions, back-up systems and other mechanisms of electricity market pricing underline that oil drives the price of electricity bills for consumers. Ultimately increasing energy prices do have an influence of the affordability and accessibility of electricity to some households or businesses. It shapes the energy security dimension. As availability of electricity at all times is central and must apply to the whole population, security during the Energiewende must be achieved by effective regulation and coordination within every instance along the electricity supply chain (#9).

4.2 Environmental Justice

Different dimensions of environmental justice are affected both positively and negatively by the nuclear phase-out as will be outlined in this section. Health issues from the regular operation of nuclear power are partly resolved. Such risks resulting from a nuclear melt-down are only marginally addressed in the context of neighbouring countries who continue to engage in nuclear power generation. Further distributional injustices with regards to the financing of the Energiewende emerge. On the other hand environmental justice effects vary according to given time horizons. While carbon emissions are found to increase in the short run as a result of the nuclear phase-out, a longer-term view emerges with a focus on establishing a new trajectory of emission reductions and avoiding as far as possible nuclear waste and other harmful substances.

4.2.1 Health and social justice

The timing of the final decision to phase-out nuclear energy just days after the disastrous effects of the nuclear melt-down in Fukushima was generally seen a indication that environmental justice factors played an important role in the decision. The phase-out policy at first sight circumvents the risk of a melt-down in Germany. It was, however, pointed out that "*radiation from a potential melt-down in a neighbouring country would not respect country borders.*" (#2) Thus health and safety concerns with regards to such events still remain present in the context of neighbouring countries employing nuclear technology, where spillover effects are to be expected (#1, #2, #6). The Chernobyl accident is viewed as a case in point (#16, #13). Even an incident in a non-neighbouring country can affect Germany and the rest of Europe with devastating consequences.

Yet, issues related to the regular operation of nuclear power plants are also important, where interviewees refer to potential cancer implications. This stemmed from discussions on nuclear waste disposal, which of course remains an issue after the phase-out. While medical expertise is limited among the interviewees to assess concrete health implications from nuclear power generation, other health discourses are pointed to in relation to the Energiewende: electric smog from the expansion of the electricity grid potentially influencing peoples' health, as well as addressed mental health concerns due to the noise originating from wind turbines (#10). Thus, certain health concerns are positively addressed by the nuclear phase-out while technologies replacing NPPs may cause other health risks. These risks are found to be an influential driver for the acceptance of the Energiewende (#10, #7, #1).

In the context of the environmental justice dimension, distributional social justice implications must be considered as well. There is a burden related to the financing of the Energiewende. It will be transferred directly to the consumers of electricity through the "EEG

Umlage" where FiTs are effectively financed by the end consumers, which is expected to lead to a disproportionate distribution of the financial burden on the public (#10). This is aggravated by the fact that many highly energy intensive industries are exempted from the *Umlage* as their competitiveness is dependent on prices they pay for energy. Thus, having to co-finance energy intensive industries as well, the financial liability on households will rise even more. Households with lower income brackets will pay a larger part of their income just to cover their electricity bills, raising concerns of social justice (#14). A fair distribution of benefits and risks of the Energiewende has to be achieved, where the financing of FiTs should consider the financial capabilities of different income groups. Despite considerations about health and social justice explored above, environmental implications discussed are addressed below.

4.2.2 CO_2 emissions

Carbon emissions represent a key intergenerational issue in justice. Several interviewees underlined the small contribution that Germany can make on a global level while non-OECD countries produce increasing levels of carbon emissions (#10). The Energiewende is, nevertheless, predicated on lowering emissions for future generations in Germany. Through the Energiewende, Germany will in effect phase-out low carbon nuclear electricity production capacity to ideally replace it with CO_2 neutral electricity from RES, which in itself would not result in a net change of emissions (#6). While insufficient renewable capacity was readily available to fully compensate for the partially phased-out nuclear capacity in 2011, some former low carbon capacity had to be replaced by fossil fuelled power stations (#8). This makes it difficult to reduce emissions from electricity generation in the short term. Thus in the short term, GHG emissions as a relevant aspect of environmental justice, could not be reduced.

The steady rise of German electricity exports to European neighbours observed in the past is expected to continue in the future (#19). It is, however, dependent upon fossil fuels to some extent in order to serve their domestic energy demand. This will continue to put pressure on CO_2 emission targets. The FiTs, are often deemed an expensive policy instrument (Tveten et al., 2013) whilst among the most effective schemes to foster the development and implementation of RES (Verbruggen and Lauber, 2012; Martins et al., 2011). It should, nevertheless, be accompanied by other complementary schemes. The European Union

Emission Trading Scheme (EU ETS) could be one such complementary scheme. Participant #10 points out that the current abundance of permissions traded means that potential emission allowances are simply traded onwards, resulting in pollution elsewhere. Current EU ETS allowance prices favour the continuous engagement in brown coal power plants, as the high CO_2 emissions come at a low price and the resource is readily available in Germany. As the abundance of coal in Germany keeps national coal prices low, a financial incentive to switch to less polluting electricity sources would be created by higher ETS allowance prices (#6).

4.2.3 Nuclear waste

The discourse within the Energiewende is dominated by issues related to nuclear waste. However, this issue refers equally to other types of by-products with regards to the shift in electricity production. The longevity and difficulty in the process of finding a final nuclear repository, not just in Germany but in all parts of the world (#2, #6, #1, #10), alludes to the complexity of the problem. According to participant #10 *"continued engagement in an activity which produces waste for which there is no solution to manage the inherent dangers will subsequently be bequeathed to potentially hundreds of future generations, is morally reprehensible"*. This was supported by many experts interviewed, while some referred to it as nuclear as a technology with little incremental risk, especially in Germany where we are faced with modern nuclear technology (#11). The issue of nuclear waste has both an environmental and a social dimension. As radioactive material continuously radiates harmful particles and rays, the environmental impacts are hard to foresee (#18).

While the interviewees attest that problems related to nuclear waste are by no means solved by the German nuclear phase-out, participant #10 is the only one pointing to a common fallacy in underestimating other social and environmental impacts resulting from the nuclear phase-out. There is the potential to have an unforeseen shift in harmful substances as a result of the Energiewende. An example of this would be decreasing nuclear waste due to reduced nuclear capacity which has to be compensated in the short run by more power from coal fired power plants and higher carbon emissions. In addition the uncertainty inherent in the long time-horizons of the Energiewende in this case leads to the underestimation of the anticipated impact of technologies which today are considered less problematic, like many renewable energy technologies (#11). Yet, these technologies may become the source or cause of other adverse effects not accounted for today.

5 Discussion

The results have shown certain dichotomies between the different goals of the Energiewende, which are energy security and environmental justice. It is shown that the time horizon does matter when it comes to some of these dichotomies. It is argued below that environmental justice offers a longer-term view in policy making, which we find is the dominant position adopted in Germany in the case of the nuclear phase-out. Whilst the adoption of an environmental justice outlook in Germany provides a long-term driver of change, other shorter term drivers have also influenced the phase-out decision. In light of our results, we focus on political calculus, decreasing energy demand over time as well as the FiTs effects on public share- and stake-holdership.

5.1 Environmental justice as a long-term driver of the nuclear phase-out

Historically, Germany (like other countries) was faced with different situations where its energy supply was threatened. In the aftermath of World War II Germany had to secure the supply of coal. More recently the oil crisis in the 70s raised concerns in Germany and many other parts of Europe, where adequate and sufficient oil supplies were endangered. With an economy predominantly shaped by producing industries and thus heavily reliant on electricity, the security of electricity is of great concern and importance. The ability to provide energy security always remained a precondition for policies. With RES expanding at unprecedented rates thanks to the FiTs, dependency on nuclear and fossil energy capacity as a means to provide energy security has decreased over time. As a result of the growing share of RES and in anticipation of continued growth at comparable rates (which proved to be right in hindsight), it becomes more realistic to work towards an overall energy strategy dominated by RES which excludes nuclear while reducing fossil electricity generation, without endangering a secure electricity supply.

Next to energy security, distributional and procedural aspects of environmental justice are paramount to the nuclear phase-out. There are two arguments to phase out nuclear in Germany within the context of environmental justice: (1) social acceptance and (2) environmental compatibility. The former is clearly influenced by the Fukushima accident. However, our interviewees remind us of how social acceptance is always understood in comparison to competing energy sources where acceptability problems are equally clear (e.g.

wind farms). The environmental compatibility argument reveals the enduring legacy of the waste issue. And yet, we find environmental concerns similarly applicable to other renewable sources. We discuss here one overarching theme across both environmental justice arguments – long-term intergenerational justice

A distinction with regards to time horizons is important to point out. While a secure energy supply is essential at any time as it literally fuels the economy, a short-term interest will always be the ability to provide energy. Beyond providing security of energy supply, a long-term strategy as the one of the *Energiewende* rather focuses on the tackling of issues within the environmental justice perspective. Thus, given the decision to eliminate the risk of nuclear incidents, the government safeguarded its possibility to provide sufficient electricity in the short run by accepting to compromise issues touching upon environmental justice, in this case short-term GHG emission increases. In order to ensure security of electricity supply the government decided to support efficient coal and gas power plants, to compensate for capacity from phased-out nuclear plants which could not be replaced by RES (Deutsche Bundesregierung, 2012).

Despite the expected short- and medium term increase in GHG emission due to the required back-up capacity, it becomes clear that longer-term CO_2 reduction targets are an important driver for the Energiewende. In 2012 the German Energy sector was responsible for about 83% of the German GHG emissions (United Nations, 2013). Thus in order to achieve the ambitious goals set in the context of the Kyoto protocol and the Durban platform, reductions in the energy sector will most effectively contribute to achieving GHG reduction targets. As energy systems are built for long time horizons, are very capital intensive and require a lot of infrastructure, Governments are often faced with high levels of path dependency with regards to the employed energy system. Changing paths – in our case the distribution within the electricity mix – is thus linked with significant investments and will be often a continuous changing process. Yet, the investment needed to mitigate climate change is growing exponentially over time in the case of non-action, thus the longer they are postponed and avoided the higher the financial burden becomes (IEA, 2010). Thus the phase-out decision with its significant costs can be argued to have initiated a process, which otherwise would have resulted in even higher costs.

5.2 Underlying short-to-medium term drivers for policy change

The political strategy of the CDU has contributed to the sudden policy change on nuclear. Just 9 months prior to the moratorium of the nuclear power plants which was called upon by Merkel and the CDU, the same political party did change previously existing phase-out policy by prolonging nuclear life times for over a decade. How did this sudden change of political opinion come into being, triggered by an event which did not change any scientific facts or technical realities? At the time of Fukushima, important regional elections in three federal states were to take place. In the light of recent events at the nuclear power plant of Fukushima the Christian democrats feared a drop of political approval for their rather pro-nuclear attitudes and thus initiated the moratorium and returned to the original phase-out schedule already agreed upon in 2002.

In addition to political factors, slowed growth in German energy demand can be seen as a driving factor for the Energiewende, or at least as a permitting factor for the latter. Despite some volatility across the years, German electricity consumption remained fairly constant between 1992 and 2013, with a slight decline in the years after 2007 (BDEW, 2014). Industrialising economies show over-proportional energy use in relation to their GDP where electricity capacity has to grow fast. They often have rather limited means to invest into expensive electricity technologies. Such countries are primarily shaped by relatively high GHG emissions from their energy sectors, as they mostly depend on fossil energy sources. In contrast, energy demand in mature economies has peaked already, tending to decrease due to efficiency gains with technology and changing behaviours (Goldthau & Sovacool, 2012). Germany as a net exporter of electricity has sufficient installed electricity capacity to tackle their electricity demand. In fact even with the loss of about half of their nuclear capacity in 2011 Germany was still capable to cover its electricity demand in the subsequent period. Thus Germany´s mature economy and existing energy infrastructure allows Germany to gradually replace nuclear and fossil electricity sources by RES.

Finally, the FiT policy made it possible for the general public to get involved in the Energiewende and offered the opportunity to actively shape and promote the move away from fossil and nuclear electricity sources, rather than just expressing their opinion against those forms of energy generation. The features of the FiTs with long-term guarantees for price stability for electricity producers from RES lead to a very high share of RES owners to be private ones (40%) while the large energy companies owned only about 6,5% of total RES capacity in 2010 (Trendresearch, 2011). Thus FiTs created a large RES-coalition amongst the broad population. This includes even rather traditional conservative parts of the population, previously reserved towards the Energiewende (Strunz, 2014), even leading to a "broad shift in thinking in the CSU", a conservative Bavarian based political party, affiliated with Angela Merkel's CDU (Hockenos, 2013).

6 Conclusions and Policy implications

This paper introduced the energy crossroads framework as a means to more effectively assess the implications of the nuclear phase-out within the context of the German Energiewende. Current policy making frameworks are lacking the important dimension of environmental justice, while focusing to a large extent on issues of energy security. Yet, our analysis of 20 expert interviews with leaders in the energy sector revealed that the Energiewende is targeted and at least partly driven to introduce environmental justice in energy policy making. In answer to the first research question, we did therefore find that a dichotomy does exist between energy security and environmental justice in relation to the Energiewende. The importance of the two different concepts of energy security and environmental justice were found to vary across different time horizons.

In relation to the second question on the key driver of the nuclear phase-out, energy security is found to be a short to medium term driver for policy makers in the face of a changing electricity supply from base load producing centralised (fossil) power plants, to a decentralised, volatile electricity provision from RES. Yet, the volatile nature of RES poses threats to energy security due to the potential to not be able to produce energy in times of peak demand. Environmental justice is, therefore, a more long-term approach to policy making. In following, FiT policies have to be refined to better target effective RES for specific areas to reduce distributional inequalities. They should also be focused upon providing more balanced electricity generation throughout the energy mix. Investments in such infrastructures are likely to be reflected in future electricity prices, potentially impacting upon the affordability of electricity which is important for international competitiveness of the industrial sector as well as for the well-being for the public. Policy making must ensure that the financial burden on different parts of the modern society are fairly distributed, to increase wellbeing rather than to compromise it.

We therefore call for more research into how Germany is approaching the post nuclear phase. In doing so, we must reflect upon the durability of the environmental justice approach that it appears to have taken with the nuclear phase-out. Comparative research should reveal when and if other national policy makers adopt a similar long term environmental justice approach, and exactly where its limitations may lie. In developing the energy crossroads framework, we suggest that the emerging concept of energy justice may offer some fruitful insight (McCauley *et al.* 2013). Sovacool *et al.* (2013) attempt to explicitly bring together security and justice. Heffron and McCauley (2013) and Jenkins *et al.* (2014) underline how policy-making priorities can differ throughout the whole energy system. In turn, the energy crossroads framework reminds energy justice scholars to fully respect the inherent binary nature of security and justice concerns. Our analysis suggests that uniting the two in practice may be more difficult than in theory.

Acknowledgements

We would like to thank the EPSRC for their grant (EP/I035390/1) on which this work was conducted.

Appendix

We want to thank the participants for their time and efforts to take part in the study. The participants' institutions were listed alphabetically while the numbers in the results section are not in the same order to provide highest possible level of anonymity.

Appendix A. Affiliation of interviewed experts with institutions

- Areva
- Bund-Friends of the Earth
- Bündnis 90/ Die Grünen, political party
- BurgerBegehren Klimaschutz (BBK)
- Citizen association for environmental protection
- Electricite de France (EDF)
- German syndicate energy woods and pellets
- German syndicate of Chemical Industry
- German syndicate of Steel and Energy Technologies
- Institute Research on European Policy
- International Atom Energy Agency
- KPMG Germany; Audit and Consulting services
- Npower
- Nuclear Energy Institute
- PowerShift – Verein für eine ökologisch-solidarische Energie- & Weltwirtschaft
- Renewables International, International Journal
- University of Burgos
- University of St Andrews
- World Nuclear Association
- Wuppertal Institute for Climate, Environment and Energy; Research Institute

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