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Socio-economic and Environmental Impact of German Energy Transition: A Policy Review at Halfway

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Throughout the history, Energy transformations have had great impact on economies and societies in general. Today's global developments towards a decarbonized economy is also transforming energy systems and socio-economic organizations of countries in many ways. Germany, with its Energiewende, presents itself or sometimes perceived as a model in this regard. The progress of Germany is much commended due to fast development of renewables in a relatively short time span. However as with all radical far-reaching socio-economic changes, it has not been spared from heavy criticism, especially regarding cost to society and unanticipated technological consequences regarding grid problems.

In the areas of affordability, sustainability, supply security therefore, the scorecard is mixed. Among the achievements of the Energiewende one surprising issue has not received much attention: the increased community ownership and decentralization of power generation and its potential impact on the socio-economic organization of society towards more democratization and effective community involvement at all levels of energy and economic policy-making. This paper thus, along with other aspects of Energiewende tries to focus on this issue.

The German energy transition far from reaching its overall ultimate targets and the challenges lying ahead are huge and needs much careful policy adjustments for the coming decades.

Keywords: Energy transformation; "Energiewende"; renewable energy; policy-making; socio-economic change; democratization.

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1. INTRODUCTION

The German Energy Transition (the original German term “Energiewende”, literally meaning “Energy Turnaround”) has been receiving much attention globally from nearly all walks of life including academia, politicians, bureaucrats, small and mid-size investors, energy economists, industry experts and even layman that are just watching the fast-track developments, some in enthusiasm some in curiosity or anxiety. It is even dubbed as an “Energy Revolution” [1] or the country as being “Green Superpower” [2].

At the heart of this energy transition, lies the governmental policy aiming at an energy future, dominated by renewables and consequently away from conventional power generation, based on nuclear and fossil fuels. Such a big policy change with all its impact on all over the economy (which is the fourth largest in the world) and society (which is considered as the backbone of Europe) with a span of a couple of decades, has of course drawn much interest and coverage.

This transition is indeed very important in many ways. First of all, it is one of the first implementations in the European (even worldwide) renewable policy area and as such it became the main driver of European initiatives and later policy convergence, as pointed out by Jacobs [3]. Secondly, the sheer size of this transition makes it so visible in socio-economic organization of the society daily that it has become one of the main national topics across the political spectrum. The question is even phrased, whether “the Germans are able to change the 21st century with their renewable energy drive” [4]. Lastly, since Germany is regarded as being the pioneer in the design and deployment of renewables, it has become also a model in terms of innovative technology transfer and policy exchange, contributing to international relations as well as climate change discussions [5].

Emerging either from concerns on environmental quality, energy security, internal economics, job creation requirements or climate policies, leaning of EU towards renewables has clearly demonstrated a progress. As an aggregated objective, EU policies put forward the 20-20-20 target for the year 2020, which included 20% renewable energy and 20% improvement in energy efficiency [6]. In 2014, the targets are updated with more ambitious ones to increase renewable energy share and improvement in energy efficiency to 27% until 2030 [7]. Additionally, the European Commission’s 2011 Energy Roadmap set forth a goal of achieving 55% in gross final energy consumption from RES in 2050 [8]. When it comes to realization, within EU28, share of renewable energy in gross final energy consumption has increased from 8.5% in 2004 to 16% in 2014, where the ratios are 5.8% to 13.8% for German case [9]. 12 out of the 28 EU member states have surpassed their 2020 targets by 2014. According to BP’s 2035 energy outlook [10], the EU will continue its leadership in the renewables share of power generation by reaching almost 40% by 2035. Although the data indicates the renewable share development is on the track, renewable industry actors have requests for a new ETS integrated and sustainable strategy [11]. Strunz et al. [12] list fading support mechanisms for renewables, fragmented national and EU renewable policies as reasons of the concerns. Although it is called a “gamble” [13] because of the high economic burden, German energy transition is still a forerunner in order to be a model in overcoming the concerns.

In this paper, we have looked at the results of more than a decade of implementation, with a specific focus on the results and especially social-economic change impacts:

- Where does the country stand in realizing its aims?
- What are the implications of the transformation especially for the country’s social and economic structure?

This paper, thus, attempts to address the “issue” areas of the “Energiewende” and the challenges ahead of its way. We have reviewed (section 2) comprehensive descriptive and informative publications of some institutions and resources. Unfortunately, in the area of socio-economic effects of the transformation, limited resources are available. We have made use of online business reviews, journals, newspaper and current magazine articles, mostly in English, but occasionally original German and a few in Turkish language. In the third section, we have focused on the evaluation of results and overall impact.

The outcome of implementation has mixed results. In terms of market liberalization, there are serious concerns as summarized by Gerbert et al. [14]. From environmental policy aspect, in the way of so-called "decarbonization", there was even unexpectedly and paradoxically negative results (i.e., increase of emissions) for a certain period. As for the "risen cost of electricity and affordability", the households were clear losers. From a technological standpoint, Sturm [15] has demonstrated that the intermittency that comes along with renewables, remains as a formidable challenge. In the meantime, the need for reform and revisions were emphasized especially after 2014 and in July 2016. Some significant changes have been made towards capping the investment and introducing competition, thus aiming to reduce high-cost impact.

Amongst the key findings, is the fact that; the energy landscape of the country has been undergoing a transformation with a significant impact on social and economic life, especially with regard to ownership of new facilities and the emergence of tens of thousands of new middle class investors. Although 'Energiewende' has been commended in many ways, there has been little emphasis on this important sociological aspect.

In the conclusion part, we critically analyze the impact of results in order to be able to shed light on the most likely future developments for the remaining but ever-changing life of "Energiewende".

2. "ENERGIEWENDE" (THE GERMAN ENERGY TRANSITION)

The term "Energiewende" is known as the transition to a low-carbon, environmentally sound, more efficient energy supply and economy ultimately. It is designed to be relied heavily upon renewable energy (particularly wind, Solar PV and biomass), as opposed to thermal and nuclear that has been dominating the energy system for decades.

The term "Energiewende" was first used in a publication by the Öko Institut [16] in the context of an opposition to nuclear and oil. Although controversial in the beginning, the term gradually enlarged in its scope in later decades to reach its present concept by the turn of the century.

2.1 Renewable Energy Act (EEG – Erneuerbare Energien Gesetz)

The Renewable Energy Act of 2000, was the result of quite a large consensus of a broad political spectrum. The mainstay of "Energiewende" is Feed-in Tariffs. As an innovative system, this subsidy scheme requires that network operators to give priority (over conventional nuclear and thermal sources) to renewable energy producers. As such, renewable plant operators receive fixed FiTs for their electricity generation. In other words, technology-specific renewable energy investments are protected and generously supported with "above market" off-take and payment guarantees for a 20-year period. The subsidies that the system has brought about is designed to bring no additional burden on Treasury. It was formulated that the cost of the remuneration are passed to the final customer, that is, included in electricity bill. It was also intended that FITs decrease overtime by innovation in the expectation that technologies become more efficient and less costly.

2.2 Aims

The aims that the Government wanted to achieve through the implementation of sweeping changes can be identified as follows [17]:

- Combatting climate change by way of decarbonizing the energy supply through major shift towards renewables and reducing demand by greater efficiency. The aim was set as 80 percent renewable energy generation by 2050 with immediate targets of 40 percent share by 2015 and 60 percent by 2035.
- Reducing energy imports (and consequently increasing energy security) by means of greater reliance on "naturally domestic" renewables instead of fossil fuel imports.
- Promoting competitiveness, growth and exports by way of stimulating technological innovation in green industry: "to create a leading position for German Industry in renewable energy technologies" [18].
- Reducing and eliminating the risks and hazards of atomic power.

2.3 Implementation and Progress

2.3.1 Renewable Bonanza

The results of more than a decade of implementation is indeed impressive especially in the area of development of renewable power supply (Fig. 1). The renewable installed capacity has risen from around 6 % in 2000 reached to 28% in 2014 and finally more than one third as of the beginning of 2016. It has even reached to a point that, on one single day in the early summer of 2016, renewables were able to supply all of power demand of Germany for the first time, making a milestone in the history of “Energiewende” [19]. Out of the renewables, wind and Solar PV have been the two essential pillars of the Energy Transition. They have also been the winners of the technological competition that was intended and incentivized by the Renewable Energy Act. Underlying this fact is the enormous decline in the costs of these technologies in the last two decades: ~55 % in wind and nearly 100% in PV systems costs [20].

2.3.2 Social-economic changes

2.3.2.1 Community interest and public support

The model from the beginning made onshore wind projects economically feasible. Moreover, the economic success of German turbine producers (like Enercon, Husumer, Tacke etc.) boosted the fast wind development. To overcome initial unviability of Solar-PV, on the other hand, the government introduced a “1000 PV roof programme”, which attracted huge interest [23]. Consequently, especially after 2006, small-scale solar-PV systems were deployed by citizens; large-scale roof and ground-mounted systems were mainly installed by farmers and centralized systems were developed by investor-project developers. Between 2009 and 2014, high citizen and community interest [24], policy support and decreasing technology costs enabled much faster (higher-than-expected) growth of PV-systems (from 6.660 MW to 34.900 MW installed capacity).

It can safely be said that the majority of German People have supported the Energiewende [25]. Political parties have has also been behind the policy, some firmly, some less so, or halfheartedly at different periods. For a very comprehensive analysis of the standings of political parties over time, see [26].

2.3.2.2 “Democratization” of power generation

It is observable that the renewables revolution has not only greatly strengthened small and mid-size businesses, but also empowered local communities and citizens to generate their own renewable energy in a distributed and diverse way. The implementation of Energiewende has clearly supported, in practice, community ownership and thereby reducing NIMBYism (“Not in My Back Yard” syndrome) and increasing level of acceptance for renewable energies. In most countries, the energy sector has long been in the hands of large corporations because electricity came from large central power stations. Renewables offer an opportunity, therefore, to switch to a large number of smaller generators, and this distributed approach offers an opportunity for citizens and communities to get involved. Germany has a high level of citizen involvement in Energiewende.

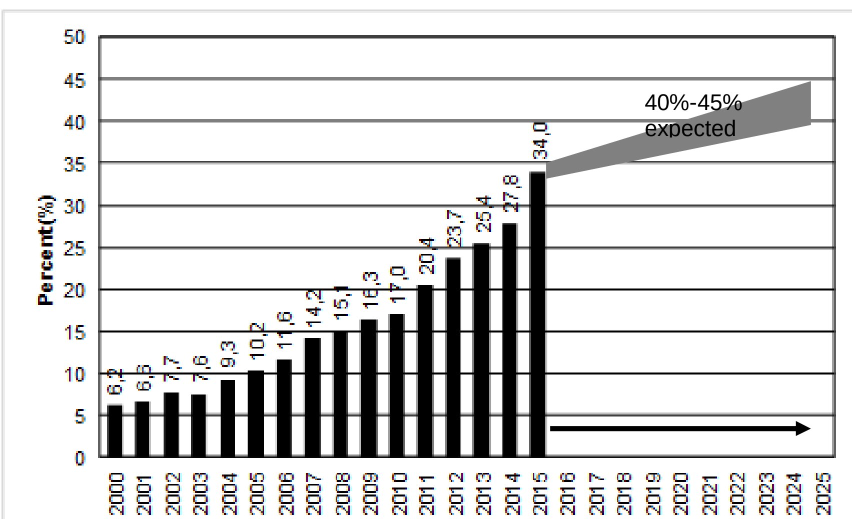

Fig. 1. Share of Gross Electricity Consumption Covered by Renewable Energy, data aggregated from [21,22]

It is estimated that “energy cooperatives” and community-owned renewables projects had leveraged more than 1.3 billion euros in investments from more than 130,000 private citizens in 2013, more than 90 percent of Germany’s energy cooperatives (which number almost 1000) have already set up solar arrays, and a single share in such cooperatives costs less than 500 euros, in two thirds of the cooperatives with the minimum amount being less than 100 euros. One can easily observe that the attractive investment opportunity was obviously seized by hundreds of citizens’ initiatives and cooperatives, and made them small entrepreneurs [27], nearly one third located only in Baveria (Table 1).

Table 1. Ownerships of Renewables in 2012. Total Installed Capacity 73 GW [28]

Ownership	Ratio (%)
Citizen and cooperatives	47
Institutional and strategic investors	41
Energy suppliers	12
Total	100%

From an industrial policy point of view, Solar-PV has actually developed into an industrial success story internationally, as total sales of the industry grew in 8 years (2000-2008) from 201 million Euro to 7 billion Euros. Exports have reached to 5 billion Euros.

2.3.2.3 Impact on big utilities

In the early phases of the transition, big utilities strongly opposed the renewable energy and lobbied against. Although this opposition was often interpreted as unwillingness to cope with new technologies, it was mainly driven by technical and economic reasons. But realizing that the ‘Zeitgeist’ would not allow them to reverse these policies, utility companies changed their strategies and started investing. However, it was slow and late: already sinking profits and dividends made them to separate renewable side of the business to better prospects and to focus on new renewable projects [29]. The biggest of the four, Eon for example announced its spin-off plans in 2014, when it has declared a record 3.2 Bio € in losses. RWE has also announced its first ‘loss’ since its history. The wholesale price has been so low that lay-offs and capacity closures of power plants were direct effects. Utilities argued that the dire situation was caused by “too fast Energiewende”. In short, the existing energy system has become unworkable overtime and currently the ‘big four’ (utilities) have actually been forced to technological as well as commercial changes for which they had been caught unprepared [30].

Furthermore, given their strategic importance for the economy, utilities were not allowed to phase out plants that hurt their balance sheets, in order to deliver back-up power for times of no sunshine and low wind. The increased dependence on intermittent sources of power, the complex balancing tasks, the legal requirements for non-discriminatory energy grid access and the small profit margins made the operation of transmission grids increasingly unattractive for utilities. Coupled with the early nuclear phase out and its tremendous decommissioning costs, this once-powerful industry was pushed to the brink of dissolution [15].

2.3.2.4 Employment effect

Regarding employment it is observable that (Table 2);

- The majority of Jobs is in PV and wind sectors.
- Although the majority is in investments, operation and maintenance services are growing.
- Exports has a significant contribution in employment creation in renewable electricity- generating technologies (around 40-45 percent).
- The overwhelming majority of the employment is highly skilled (university degree possessors
- Much higher than the national average of industrial work force).
- The most important trend however is that, starting from 2012, the number of jobs has started to decline, the renewable employment reached its peak (~380.000) in 2011, then declined a bit (around 350.000 in 2016).

Employment in PV Sector dropped to (by the end of 2014) just 38.300 from more than 100.000 in 2012 [32], mostly triggered or caused by the bankruptcies during 2011 and 2012 (that took place in about six months period involving 6 companies). Main reason was fierce international competition from Chinese low-cost panel producers. The increase in wind sector has continued in the meantime. But overall the slight decline has continued.

Table 2. Employment created by wind energy and solar PV, 2010 – 2012 [31]

	Investment related jobs		Jobs related to maintenance and operation		Total jobs	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**
Wind		98,600		19,300		117,900
- onshore	82,600	81,300	18,500	18,600	101.100	99,900
- offshore		17,300		700		18,000
Solar PV	103,300	78,900	7,600	8,900	110,900	87,800
Total renewable energies	242,000	227,100	75,800	80,700	381,600*	377,800*
Total Share of wind (per cent)	34	43	24	24	26	31
Total Share of Solar PV (per cent)	43	35	10	11	29	23

** Includes also jobs created by fuel supply activities (biogas, biomass, biofuel), as well as related jobs in public institutions (R&D, administration)*

2.3.3 Emissions-climate protection commitments

Regarding GHG emissions, it seems that some decreases have been achieved: by the end of 2015, 27 percent lower than 1990 levels. It can also be easily argued that if we look at simply directly avoided CO_2 emissions (between 2005 and 2012) the amount has more than doubled from 23 million to 56 million [33]. In other words, owing to renewable generation (basically wind and solar), around 11 percent of electricity-related CO_2 emissions could be prevented for the above-mentioned period. However, if we look at the overall picture of total amount of emissions (especially electricity generation related amounts), the picture is not that clear and the decreases are very slight, especially after the intensive start of Energiewende measures as of 2005.The total amounts have decreased 14% since 2001, and only around 9% since 2005. Energy-generation related emissions have been reduced by only 6% since 2001 (Figs. 2 and 3).

As it can be seen from the Fig. 4, emissions increased from 2011 through 2013 owing to bullish increase in coal-based generation, basically due to market advantage of coal, ongoing nuclear phase-out, the intermittent nature of renewables and weather factors. The fact that lignite-based generation reached to an all-time high in 2013 also points to that result [14]. In terms of climate targets, of course this last development was not a desirable outcome. Therefore, to keep the commitments and targets, a review was made by the government in July 2015. To cut an additional 22 million tonnes of CO_2 emissions by 2020, the most important measure (alongside the efficiency gains etc.) was introducing "capacity reserve": 2.7 GW of installed lignite power-plant capacity are to be gradually shifted into capacity reserve in 2015 and closed down totally by 2019 [34].

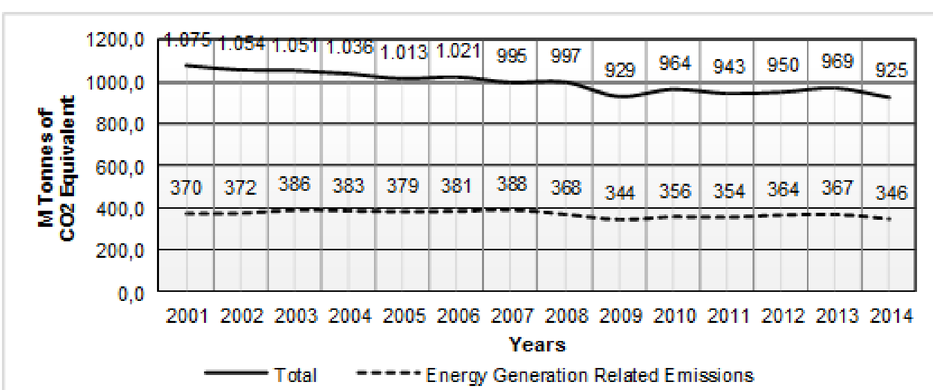

Fig. 2. Total GHG Emissions Amount Germany, data aggregated from [21,22]

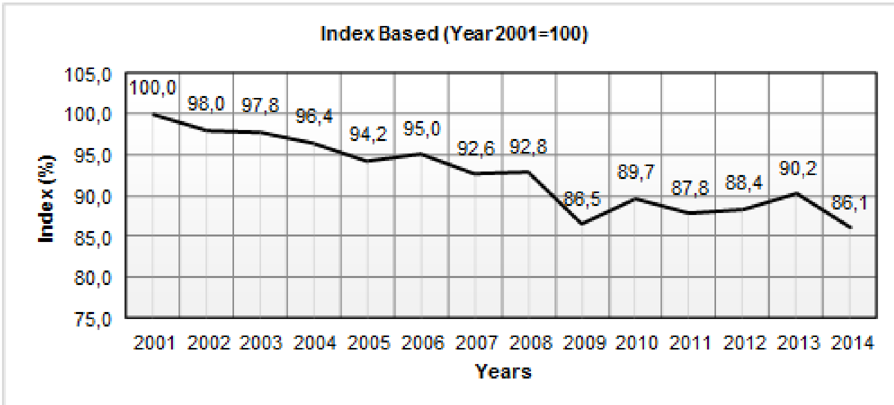

Fig. 3. Total GHG Emissions of Germany, data aggregated from [21,22]

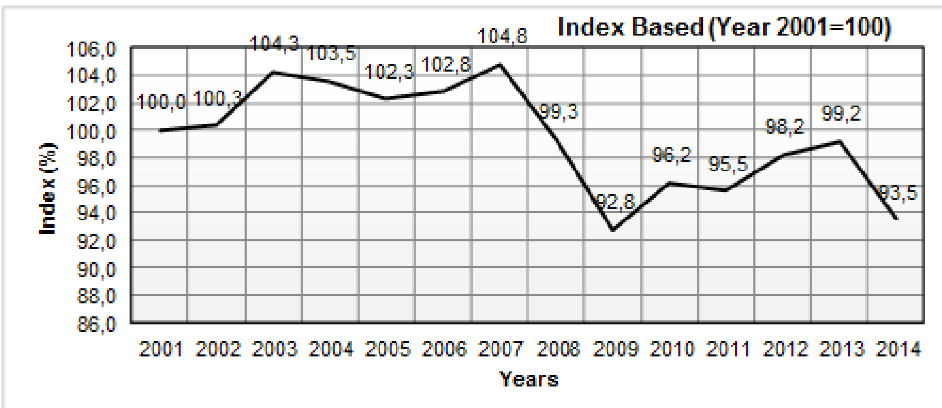

Fig. 4. Energy Generation Related GHG Emissions of Germany, data aggregated from [21,22]

Considering the already low and still decreasing wholesale electricity prices (Fig. 5) in Germany, one can assume that, in addition to above development, hard coal will be less competitive and its use in energy generation will further be reduced overtime, from nearly 20% in 2013, to less than 15% in 2020. As Fig. 5 implies, the price is expected to be keep the decrease. At some point below 20 EUR, low-priced lignite and even nuclear plants of the major power generation actors will be shut down [35], which in turn reduces the back-up capacity of the grid, to fill the gap created by renewables. As a policy, it should be noted that the German Government has already decided to phase out the German nuclear power plants (eight out of seventeen of them already offline) by 2022. One of the aims of the Energiewende, therefore is already firmly planned to be successfully implemented by then. [36]. Besides above issues, Rintamaki et. Al. [37], also reports, under current energy market conditions renewable energy generation may increase or decrease volatility of energy price. The Economist (2017) argues firmly on the other hand that the more RES is deployed, the more it lowers the price of power [38].

3. THE RESULTS AND 'ISSUE' AREAS

3.1 The 'Cost' Effect (of Fast Renewable Deployment)

Average industrial prices in Germany now, at roughly 9 ct/kwh, are twice those in US. Being around 14 eurocents per kWh in 2000, the price for households has risen to 29 eurocents in 2014 (6.24 cent of which being the EEG surcharge). Thus the price has risen nominally by 68%, and in real terms by 34% [39]. This has been alarming news to the industry and political circles too. As a matter of fact, the industry has grown too concerned about its competitiveness due to high cost of energy despite generous rebates it receives (around 1600 big companies are exempted from EEG surcharge or levy).

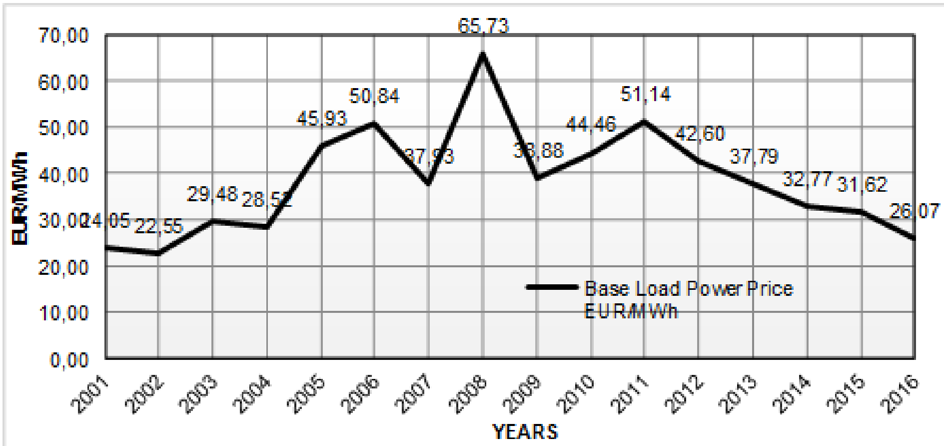

Fig. 5. Wholesale Electricity Prices in German EEX market, data aggregated from [21,22]

As the economic newspaper Handelsblatt, [40] reported, the total cost of green energy transformation has increased to 28 billion Euros annually (from its earlier levels of 20, 22 and 24 billions). That means € 270 additional surcharge due to renewable support for each household bill annually (currently € 0.0624 per kWh).

Furthermore, it is also known economically that a low elasticity of electricity demand put an above-average burden on the lowest income levels of society. That has caused concern and even triggered the debates of “energy or electricity poverty”. In fact, it is reported that the utilities sent 6.3 million dunning letters for delayed bills and disconnected more than 350 thousand households from the grid network for non-payment [15]. It was therefore by 2014, high time to review this subsidy scheme and gradually end in near future [41]. Via another legal shake-up in 2016, which was prompted by rising bills as well as grid capacity concerns and EU pressure towards more market based approach of supporting renewables, the Government decided to cap the renewable development and to replace FiTs with competitive auctions [42,43].

Starting from 2014, with the gradual effect of legal changes aiming at reducing the speed of Energiewende, the investment into renewables has already decreased its pace. Therefore, in 2015 contrary to global trends, significantly less investment was made in renewables: in amount of 8.5 billion USD which is 47% less than in 2014. The reason was given as policy uncertainties and changes [29].

3.2 Decentralized Networks with “Prosumers” and Security of Supply: “Grid Effect”

As explained above, renewable pace was so rapid that the capacity reached beyond what had been expected. Due to lack of adequate planning investments in grid expansion lag behind requirements. Therefore, in order to safeguard the energy system, currently there seems to be two energy systems in parallel and increasingly interacting each other : a base-load, centralized, fossil fuel-based system; and an intermittent, decentralized and renewable system. As a back-up to renewables, the government has decided to support efficient new coal fired power stations. Due to unexpectedly high generation from renewable sources, Germany sometimes produces much more electricity than it consumes [18].

Because of renewable obligations, the principle of locating generation close by the customer can no longer be maintained. Furthermore, volatile renewable generation leads unpredictability. Grid analyses therefore give signals that electricity security might be threatened in the future. Mainly for this reason, it was decided to develop national grid development plans, which show how and where to modify the electricity transmission system. For example, a superhighway transmission line (north – south) needs to be constructed underground. The relevant operator company already announced an 80% increase of transmission fees mainly due to this investment [44].

Until now, 'System Average Interruption Duration Index' (SAIDI) shows that electricity supply security has been at a constantly high level during the past years. The unplanned downtime was about 15 minutes between 2008 and 2014: which is quite safe indeed. However, to make a reliable statement about the level of supply security, one should also consider other indicators like the number of redispatch actions, or net capacity reserve to ensure grid stability. Regarding redispatch actions, they have considerably increased recently. The current German SAIDI level and the increasing required number of actions to stabilize the grid thus indicate that although the rising share of fluctuating renewable energy has not triggered a negative trend on supply security, it has become at the same time more challenging and costly to ensure and maintain this high level of supply security [34].

Regarding the energy security, another study looking at the issue from diversity aspect, has also concluded that Energiewende increased neither energy security nor import dependence, thus no considerable effect [45]. As a matter of fact, the Country still have a considerable reserve margin with traditional conventional coal and gas plants.

3.3 Reversing Democratization and Community Involvement? : "Socio-political Effect"

We have argued above that from socio-economic viewpoint, the least emphasized but a surprising side effect result of the Energiewende has been democratization of energy supply. In fact, as of 2013, 51% of renewable capacity is owned by citizens, farmers and cooperatives. Communities have generally profited from this development via receiving leases or shares from profits of FiTs. One can thus argue that through investments and ownerships, the communities have had a chance in determining the future of electricity provision. As Sühlsen noted [46], the renewable sector is no longer a niche but it is incorporated in German energy system. On the other hand, because of the recent legal and regulatory changes there are signs that these achievements may be set to a reserve course. Renewable employment has already reduced. In the future, less percentage ownership of communities and citizens is expected due to the fact that they may not be able to compete (because of auctioning and caps) with big corporations and institutional investors. In the words of Morris [47] "German government policies since 2014 are pushing back community energy proponents who got the Energiewende started and preventing the grassroots movement from remaining involved". This needs to be seen in the coming years.

3.4 Evaluation: The Balance Sheet

In evaluation of the achievements, we compare the actual results with the proclaimed aims.

- From renewable deployment, sustainability and supply security point of view; until 2014, there has been a boom in renewable installations, since then, a slow-down in investment and even capping was introduced. It may still be concluded that it is very much on track: nearly 40% by 2016. However, as for the emissions although, one may expect a significant reduction as a result of the above achievement, there is actually not a considerable decrease. Despite renewable increase, coal was needed as a back-up power, which actually temporarily increased emissions, and gave the Energiewende a "credibility problem" [42]. Without further action, it is likely that decrease of 40 % target by 2020 will be missed (underachievement).
- One outcome to be drawn from the fast renewable deployment is that technological impact of changes had not been anticipated: the effect of intermittent and fluctuating renewable feed on the grid. Grid expansion has been the bottleneck holding back the Energiewende. While it can generally be said that grid stability was manageable, huge new investment is needed to connect the renewables, safely manage their output and to cope with increasingly 'decentral' generation. In short, the necessary extension of transmission system could become the Achilles's heel of the country's energy transformation [14]. As an ultimate solution, large scale electricity storage system must be developed for a full transition to renewables in the long run.
- Regarding the prices (i.e. evaluation of affordability and competitiveness), one can see that transformation is coming with a considerable cost especially to households in addition to hurting the backbone of the industry (a clear underachievement and negative impact). This outcome is one of the reasons forcing government to make policy revisions to slow down the pace.

Thus, it can be foreseen that even the cost of investment in renewable technologies drastically reduced, due to the increased grid fees and intermittency problem end-user prices may not decrease as desired.

- One social structure impact is less touched upon but has been very interesting and seems to have more tangible effects: democratization of energy supply with increased community and citizen involvement in stake-holding and entrepreneurship. This development contributes to breaking the power of oligopolistic big corporations and the witnessing the emergence of "prosumer" in newly evolving distributed generation system. This has been one of the most important but less studied aspects of transition with its accompanying long-term economic implications in social structure. However, recent legal changes-revisions may actually limit this effect in future. As for the employment, Energiewende has not actually been a job creation machine, as its proponents had advocated.
- One symbolically important result is that 'Energiewende' is now an English or even a global term, a trademark, designating Germany as the pioneer of energy system transformation [48]. Internationally, it has received much attention: so far more than 100 countries around the world have – to differing extents – introduced renewable support systems, mainly based on FiTs system, following the German example [25]. The renewable technology and services exports of Germany, as in other high-tech products, have reached significant levels, barring however, the solar industry fallout.

4. CONCLUSION

As a big energy transformation, it is not all going smoothly in Energiewende: The policy had to be revised several times and still needs fine-tuning. At this juncture of history, the scorecard is certainly a mixed one. Judgements mostly depend on where one stand politically and what kind of socio-economic views one has. Proponents and critics point out different areas, results and dimensions for emphasis. Although, on the one hand there is a high level of acceptance about the general concept and goals of Energiewende, on the other hand the essential components of the policy, the specific route and investments to reach the long-term targets, are currently under intense discussion and criticism.

The Energiewende is far from reaching its ambitious targets, as some of these aims are actually irreconcilable with each other. Reaching emission targets with simultaneously addressing affordability, sustainability, competitiveness of industry and social fairness concerns together with market efficiency and safe and secure energy supply principles is going to be the main socio-economic policy agenda item in the coming decades. Especially dealing with the new type of stakeholder "prosumer" and reconciling new decentralized and distributed generation system with the aims of transformation (affordable, clean, safe-secure energy) in the long run with the right mix of trade-off options will be the main challenge.

In short, the implementation of policies has not been free from conflicts, hot public and political discussions, leading to the fact that the country is actually in search of a balanced approach. It will ultimately be judged by whether and how far it succeeds in organizing the sustainability of the energy supply. What is obvious though is as an "intergenerational social contract", it needs more coherent coordination of the policy at all levels of the public organization and society. The dimensions of the issue, therefore especially with regard to gradual transformation of a complex socio technical system and the challenges lie ahead could prove even much more important than today's short-term question of the allocation costs and burden-sharing.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Nicola S. Four lessons Obama should learn from Merkel's energy revolution. Bloomberg Business; 2015. Available:http://www.bloomberg.com/news/articles/2015-08-05/four-lessons-obama-should-learn-from-merkel-s-energy-revolution (Accessed on 15.08.2015)
2. Friedman TL. Germany, the green superpower. Op-ed column, New York Times, May 6th; 2015.

3. Jacobs DE. Renewable energy policy convergence in the EU: The evolution of feed-in tariff in Germany Spain and France. Routhledge, London and Newyork, Oxon 0X144RN; 2016.
4. Çağlar N. Almanlar 21. Yüzyılı Değiştirebilecekler mi? Enerji Günlüğü; 2016. Available:http://www.enerjigunlugu.net/icerik/18587/almanlar-21-yuzyili-donusturebilecek-mi-nilay-caglar.html#.V7F27uJ96Uk (Accessed on 30.05.2016)
5. Reiche D. Rahmenbedingungen für erneuerbare energien in deutschland. Möglichkeiten und Grenzen einer Vorreiterpolitik", Verlag Peter Lang, 240 S; 2004. ISBN: 3-631-52857-4
6. European Commission. An energy policy for Europe, communication from the commission to the European Council and the European Parliament. Brussels, January 10; 2007.
7. European Council. 2030 Climate and Energy Policy Framework. Brussels, 24 October; 2014.
8. European Commission. Energy Roadmap 2050, COM (2011) 885 final; 2011.
9. Eurostat. Energy statistics - supply, transformation and consumption nrg_10; 2017. (Accessed in February 2017)
10. BP. BP Energy Outlook: 2017 Edition; 2017.
11. European Trade Union Syndicat Confederation. ETUC Position on the Structural Reform of the EU Emissions Trading System; 2016. Available:https://www.etuc.org/documents/position-structural-reform-eu-emissions-trading-system#.WFp5ZlOLTIU (Accessed February 2017)
12. Strunz S, Gawel E, Lehmann P. The political economy of renewable energy policies in Germany and the EU (No. 12/2015). UFZ Discussion Papers; 2015.
13. David Buchan. The Energiewende - Germany's Gamble, Oxford Institute for Energy Studies; 2012. Available:https://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/06/SP-261.pdf (Accessed February 2017)
14. Gerbert P, Rubner H, Herhold P, Steffen B. "Germany's Energiewende: The End of Market Liberalization; 2014. Available:https://www.bcgperspectives.com/content/articles/sustainability_energy_environment_germany_energiewende_end_power_market_liberalization/ (Accessed on 05.05.2016)
15. Strum C. "Germany's energiewende: The intermittency problem remains; 2016. Available:http://thebulletin.org/germany%E2%80%99s-energiewende-intermittency-problem-remains9469 (Accessed on 21st of June, 2016)
16. Krause F, Bossel H, Müller-Reissmann KF. Energiewende Wachstum und Wohlstand ohne Erdöl und Uran. Frankfurt am Main, Fischer Verlag; 1980. ISBN: 3-10-007705-9
17. Morris C, Pehnt M. "Energy Transition German Energiewende, Heinrich Böll Stiftung; 2015. (Revised July, 2015) Available:http://energytransition.de/wp-content/themes/boell/pdf/en/German-Energy-Transition_en.pdf (Accessed on 19.10.2015)
18. Pegels A, Lüttenkorst W. Is Germany's energy transition a case of successful green industrial policy? Contrasting wind and Solar PV. Energy Policy. 2014;74:522-534.
19. The Independent. Renewable energy just provided germany with almost all of its power. 19 May; 2016. Available:http://www.independent.co.uk/environment/germany-just-got-almost-all-of-its-power-from-renewable-energy-a7037851.html (Magazine, accessed on 30.08.2016)
20. Agora Energiewende. 12 Insights on Germany's Energiewende: A Discussion Paper exploring Key Challenges for Power Sector. Printed in Berlin; 2013. Available:https://www.agora-energiewende.de/fileadmin/downloads/publikationen/Impulse/12_Thesen/Agora_12_Insights_on_Germanys_Energiewende_web.pdf (Accessed on 12.07.2016)
21. BMWi. "Making Success of the Energy Transition", Federal Ministry for Economic Affairs and Energy, Berlin; 2015. Available:https://www.bmwi.de/English/Redaktion/Pdf/making-a-success-of-the-energy-transition,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf (Accessed on 06.11.2016)

22. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety; 2016.
    Available:http://www.bmub.bund.de/en/
23. Geels FW, Kern F, Fuchs G, Hinderer N, Kungl G, Mylan J, Neukirch M, Wassermann S. The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). Research Policy. 2016;45:896-913.
24. Dewald U, Truffer B. Market formation in technological innovation systems: Diffusion of photo-voltaic applications in Germany. Industrial Innovation. 2011;18(3):285-300.
25. Maatsch HW. "Energiewende: Energy Transition in Germany", The Guardian; 2014.
    Available:https://www.theguardian.com
    (Accessed on 25.08.2014)
26. Hake JF, Fischer W, Venghaus S, Weckenbrock, Christoph. The German Energiewende – History and Status quo. Energy 92, Elsevier. 2015;5:32-546.
27. BSW- German Solar Industry Association; 2015.
    Available:https://www.cleanenergywire.org/experts/bsw-german-solar-industry-association
    (Accessed on 15.07.2016)
28. Heinrich Böll Stiftung. Energy transition 7-key findings; 2012.
    Available:http://energytransition.de/2012/10/key-findings/
    (Accessed on 20.08.2016)
29. Spiegel. Deutschland investiert weniger in erneuerbare Energien. Energie Quelle, Spiegel; 2016.
    (Accessed on 27.03.2016)
30. Süddeutsche Online. Energie Quelle: Strategie der Verzweiflung; 2016.
    (Accessed on 08.06.2016)
31. O'Sullivan M, Edler D, Bickel P, Lehr U, Peter F, Sakowski F. "Gross employment from renewable energy in Germany in 2013", Research project commisioned by Federal Ministry for Economic Affairs and Energy, 0324052B; 2014.
    Available:https://www.bmwi.de/English/Redaktion/Pdf/bericht-zur-bruttobeschaeftigung-durch-erneuerbare-energien-jahr-2013,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf
    (Accessed on 11.06.2016)
32. Dörnfelder A, Hussla G, Koenen J, Underhill W. Up in Smoke. Handelsblatt, Summer. 2016;02(16):76-77.
33. Lütkenhorst W, Pegels A. Germany's green industrial policy stable policies – turbulent markets: The costs and benefits of promoting solar PV and wind energy. Research report, The International Institute for Sustainable Development. 2014;55.
34. REMap 2030 Analysis; 2015;47.
    Available:http://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_Germany_report_2015.pdf
    (Accessed on 14.07.2016)
35. Handelsplatt. Electricity Prices in Free Fall; 2016.
    (Accessed on February 2017)
36. Dempsey J, Ewing J. Germany, in Reversal, will close Nuclear Plants by 2022. The New York Times, February 6th; 2013.
37. Rintamäki T, Siddiqui AS, Salo A. Does renewable energy generation decrease the volatility of electricity prices? An Analysis of Denmark and Germany. Energy Economics; 2017.
38. The Economist. Leaders: "Clean Energy' dirty Secret", February 25th March 3rd; 2017.
39. Fischer W, Hake JF, Kuckshinrichs W, Markewitz P, Schröder T. Reflections on the German Energiewende. Institute of Energy and Climate Research, Paper presented to 23rd World Energy Congress, Istanbul; 2016.
40. Handelsblatt. Die grüne rechnung; 2015; (Accessed on 25.08.2015)
41. Vasagar J. Germany's green energy transformation. Financial Times-Energy, June 23rd; 2014.
42. The Economist. It is not easy being green. August 13th. 2016;19.
43. Chazan G. Legal shake-up threatens germany's 'energy revolution. Financial Times –Energy, July 10th; 2016.
44. Michel M. The Energiewende is running up against its limits", Energy Post; 2016. Available:http://energypost.eu/energiewende-running-limits/
    (Accessed on 25.10.2016)
45. Lehr U, Nieters A. The German Energiewende-Additional Risk or Opportunity for Energy Security. 38th IAEE International Conference, Energy Security,

Technology and Sustainability Challenges Across the Globe, May, Antalya, Turkey; 2015.
46. Sühlsen K, Hisschemöller M. Lobbying the Energiewende. Assessing the effectiveness of strategies to promote renewable energy business in Germany. Energy Policy. 2014;69:316-325.
47. Morris C. German hands power sector back to energy corporations; 2016. Available:http://energytransition.de/2016/06/german-government-hands-power-sector-back-to-energy-corporations/ (Accessed on 28.06.2016)
48. Goodman J. The climate dialectic in energy policy: Germany and India compared. Energy Policy; 2016. Available:http://dx.doi.org/10.1016/j Enpol.2016.03.014 (Accessed on 25.10.2016)