UVODNO IZLAGANJE -1.1 / INTRODUCTORY LECTURE -1.1

IZAZOVI ENERGETSKIH TRANZICIJA U NEMAČKOJ – USPESI I PROMAŠAJI

CHALENGIES OF ENERGY TRANSITION IN GERMANY – SUCCESSES AND FAILURES

Dragan STEVANOVIĆ

ABSTRACT

Engineering & Consulting, Germany Energy transition in Germany, well known as "Energiewende", has reached some outstanding achievements, which are commented in this paper, mainly relating to the electrical energy.

First of all, that statement relates to a very high penetration of renewable electricity in the total electricity generation of some 38-40%. It is even more important to mention that in 2018 for the first time the electricity production coming from RES was higher than from coal (lignite und hard coal). That change has been achieved in a short time period: in 2002 the renewable electricity (nett generation) was only 8,6%. That is the result of renewable energy law and corresponding EEG surcharge, introduced in the year 2000. From that point on, the feed-in tariffs for renewable electricity were not paid by the state taxes, but from electricity consumers through the mentioned EEG surcharge.

Combined with the energy exchange market for the electricity, where the renewable electricity enters with the price zero, that resulted in some anomalies. No one had a direct market motivation to control the rise of that surcharge (the state was not directly involved anymore) and the consumer prices increased to more than 300 €/MWh for the households and to about 190 €/MWh for industry. Moreover, with higher penetration of the renewable electricity, the need for export increases continuously. The problem is that the export price was the market price of electricity, without the EEG surcharge, which is an inevitable part of the total generation cost of electricity in the system. On that way arises a loss of several billion euros, year for year, covered by electricity consumers who pay the EEG surcharge. On the other hand, in order to reduce that unfavourable export and to improve the stability of the system, there is a need for new power grids and additional electricity storage facilities. That is also very expensive, but those costs would be covered by the export loss reduction. The energy policy in Germany still did not introduce the right mechanism for such measures.

The main failure is the insufficient reduction of CO_2 emissions from the energy sector. Due to premature closure of some nuclear power plants coupled with increase of renewable electricity, the role of coal power plants has increased, in order to enable the system stability. The lignite power plant has generated the same amount of electricity in 2016 like in 2007! Similar case is with the hard coal power plants. Since several years, it is clear that the goal of

40% greenhouse gas (GHG) reduction until 2020 will not be reached, in spite of so intensive increase of renewable electricity and corresponding high investment in the RES.

In order to reduce further GHG emissions, it has been decided to close some lignite power plants. The year 2022 will be a great challenge for the electricity system in Germany. The remaining nuclear power plants (9.9 GW) have to be turned down, together with 12.5 GW of lignite power plants. Due to the existing overcapacity in the system, that removal of total 22.5 GW from the grid will probably not cause the problem for the supply safety. However, the market price will surely increase significantly, as the capacities with the lowest generation price will be removed. Moreover, as the new grids will not be erected until that year, and there is no plans for a significantly increase in the storage capacities, the closure of nuclear power plants will probably have an inverse effect on the GHG reduction goals.

1. INTRODUCTION

Energy transition in Germany, well known as "Energiewende", has reached some outstanding achievements, which are commented in this paper, mainly relating to the electrical energy. It deals with a very high penetration of renewable energy sources (RES) in electricity generation and successful reduction of coal power generation. That is the result of the Renewable Energy Law (**E**rneuerbare**E**nergie**G**estz-EEG) and the corresponding surcharge introduced in the year 2000. In combination with the energy exchange market in Leipzig (EEX), where the RES electricity enters with the price zero, that results in some failures and anomalies. The most important, it relates to the missing target values of GHG (greenhouse gas) reduction, in spite of very high investments and consequently high electricity prices, both for households and industry. Furthermore, there is a steady increasing export of electricity surplus, under unfavourable conditions, leading to significant losses, year after year. On the other hand, it is going very slow with planning and erecting modern grids and the energy policy has not introduced the right mechanism to make the energy storage profitable. Even the existing storage capacities are not used properly and the construction of new capacities is of symbolic pace. Those issues are also discussed in more details here.

2. EXTRAORDINARY SUCCESSES

The most extraordinary result of the German energy transition is the extremely fast increase of renewable electricity. It has increased from 38 TWh in the year 2000, to 229 TWh in 2018 [1], as seen in the Figure 1. There are different interpretations about the relative ratio in the total electricity. In relation to the total produced electricity in Germany in 2018 (649 TWh, as presented in Figure 2), it gives 35.2%, what is a remarkable result. In relation to the total electricity consumed in Germany (599 TWh in 2018 [1]) that gives 38.2%. However, that is based on the assumption that the total net exported electricity (50 TWh) is not based on the renewable energy. In [2] that assumption was proven wrong, showing that exactly in the time of high solar and wind electricity generation, the export rises.

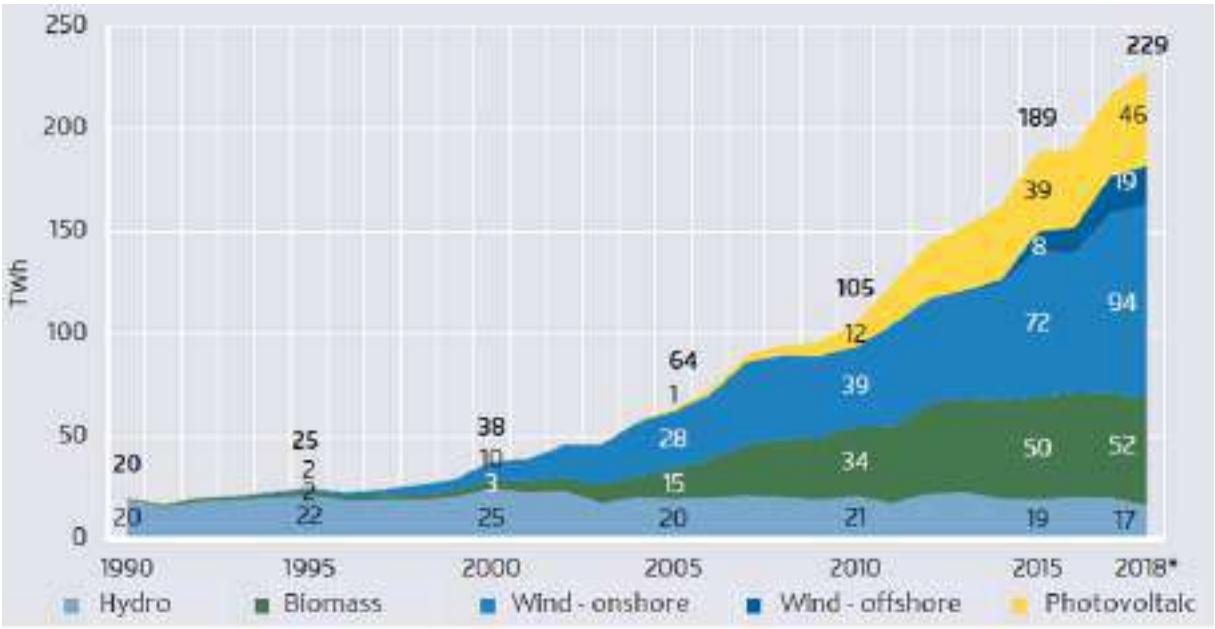

Figure 1: Electricity generation from RES, in the period 1990 – 2018 [1]

Figure 2: Development of the electricity generation 1990 – 2018 [1]

Some authors show that the ratio of the renewable electricity is even higher, reaching 40.3% in 2018 [3]. In that case, not just export electricity is excluded, but also the electricity produced in the industrial power plants, for the own supply. No matter how it is calculated, it seems that the goal of 45% of RES electricity in the year 2030 will be easily reached.

Favourably, in 2018 the increase in RES was not followed by the net export increase. That is for the first time, and could be a sign of a better integration of the intermittent generation sources in the system. The reason may be a very hot weather with long sunny periods, as well as the increase of the offshore wind capacities. It could be that the operators of the older coal

power plants, knowing that they would be off-grid in coming years, have allowed for faster load changes, which normally reduce the life expectation of the equipment.

Also favourably, for the first time the generation from RES was higher that the generation based on coal, as presented in Figure 3 [3]. Wind and solar generation was again, for the second year in a row, higher than the generation from lignite (see Figure 4).

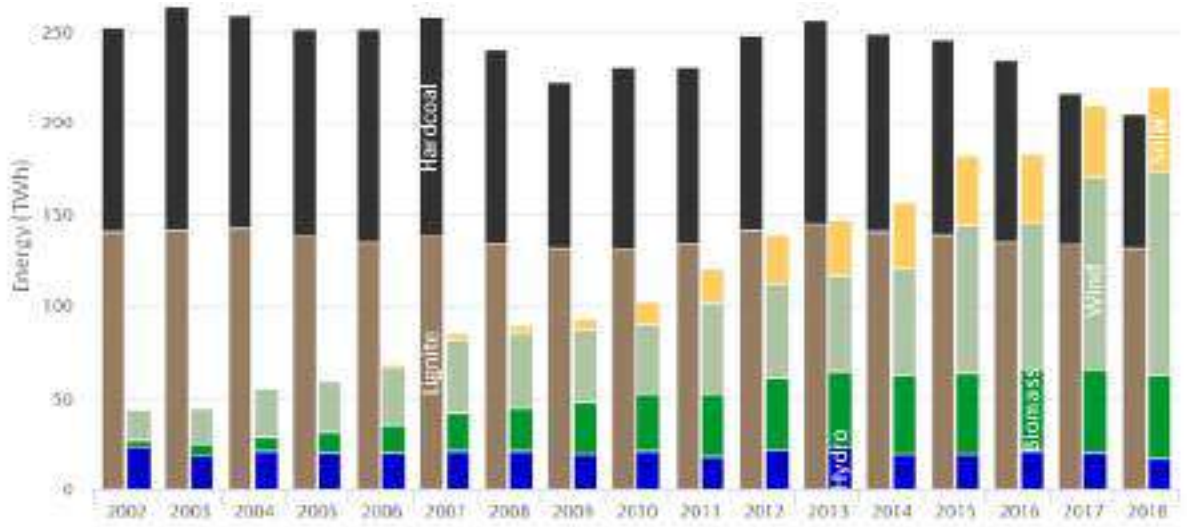

Figure 3: Comparison between the total generation from RES and coal [3]

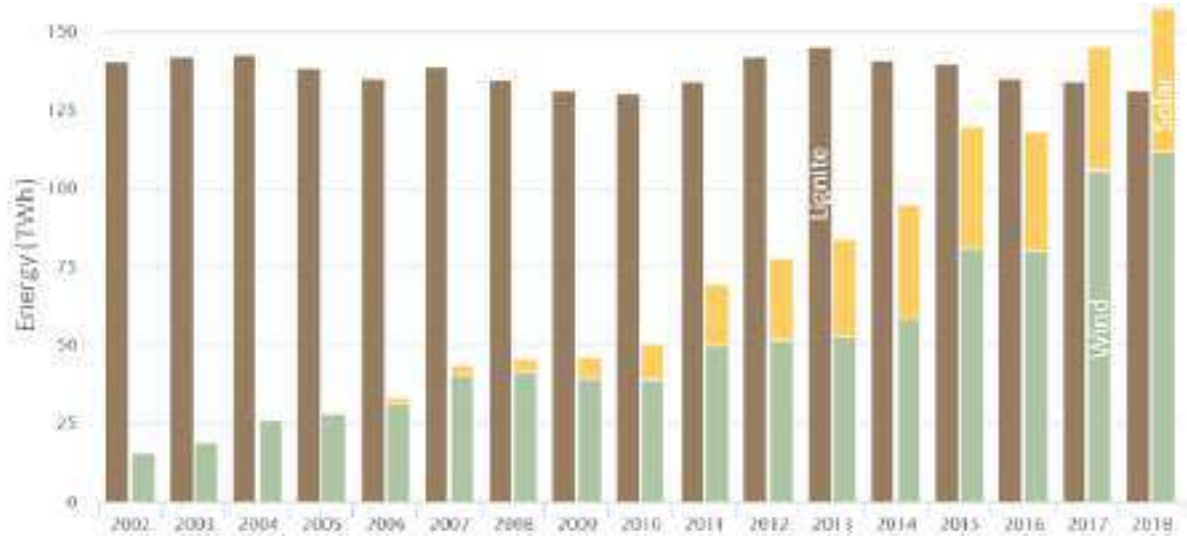

Figure 4: Comparison between electricity generation from lignite and wind + solar [3]

Good point is the increase in offshore wind generation (19 TWh in 2018), with considerably higher load factor compared to the on-shore wind. For different wind parks, it was between 29.6% and 51.8%, reaching a mean value of 40.1%! Together with better predictability of wind over the see, that leads to much better integration of that source into the electricity system.

The introduction of new Renewable Energy Law in the year 2000, together with corresponding EEG surcharge, was the main milestone for such development. According to that law, every consumer has to pay the mentioned surcharge, which is used to cover the costs

of renewable electricity generation. From that point on, the feed-in tariffs were not payed from the state taxes.

Apart from that positive effect, the EEG surcharge had also a negative effect. The electricity for the households increases with a rate of 5% per year, so that in 2019 it rises even above 300 €/MWh. For industry it depends on specific application, but the average price is about 190 €/MWh. The EEG surcharge rose from 4.1 €/MWh in 2003, over 21 €/MWh in 2010, to the maximum of 68.8 €/MWh. Last two years there is a slight decrease, but on a still high level. This year (2019) it amounts to 64.1 €/MWh. That is the result of new system: the guaranteed electricity price from RES is not fixed, but decided during the auction process. However, due to the increase on the exchange market (will be explained later) the total generation cost rose again.

3. EXPORT LOSS

The biggest anomaly of the EEG surcharge system is a very big money loss due to the export of the electricity. A certain export and/or import of electricity is normal and acceptable for every non-isolated power system, in order to maintain the system stability or to make advantage of favourable market conditions. In case of Germany, the net export (export – import) is increasing dramatically with increase of RES based electricity, as presented in Figure 5. Due to the high ratio of intermittent sources (wind + solar) of 70% (see Figure 1), it is not possible to maintain the system stability without exporting the surplus of so produced electricity. The conventional power plants cannot reduce their generation fast enough, nor cannot stop it, so the only solution is to export that surplus. It is still better solution than the curtailment. On the other hand, when the intermittent energy sources decrease their generation fast, the conventional power plants cannot ramp to higher power output fast enough. In such situation, an import is necessary, although just short time ago there was a plenty of surplus electricity.

As discussed in [2], more than 1/3 of the intermittent electricity generation has to be exported. In the year 2018 that trend has decreased for the first time. Despite the increase of RES electricity generation, the export has decreased compared to the previous year. That is a very positive trend, but the reason is still not known explicitly. It could be due to good predictable and mild weather, but also faster load changes of the conventional plants. The faster load changes and often stops and starts influence the life expectance of the plants. However, if they are going to operate only few more years, the operators may dare to wear out the existing equipment more intensively. It will be interesting to follow this trend in the coming years.

As indicated in [3], the import price is 42.67 €/MWh and the export price is 39.27 €/MWh. The problem is not in the fact that the export price is lower that the import price. The main problem is that the export price is the mean price on the electricity exchange market EEX in Leipzig and not the total generation cost in average. The renewable electricity comes on the EEX market with the price 0 (zero), as it has priority. Its costs are covered by EEG surcharge, which has to be paid by every (almost, as there is exception for some industries) inland consumer. The total generation cost is the sum of market cost and the EEG surcharge. However, the export price does not include the EEG surcharge. Calculating with 50 TWh net export (see Figure 5) and the EEG surcharge of 67.92 €/MWh, it gives a loss of 3.4 billion € in the year 2018! Calculating with the total export of some 80 TWh, it rises to 5.4 billion €. And it goes like that year after year. In 10 years those losses cumulate to the costs required for new grids and storage facilities!

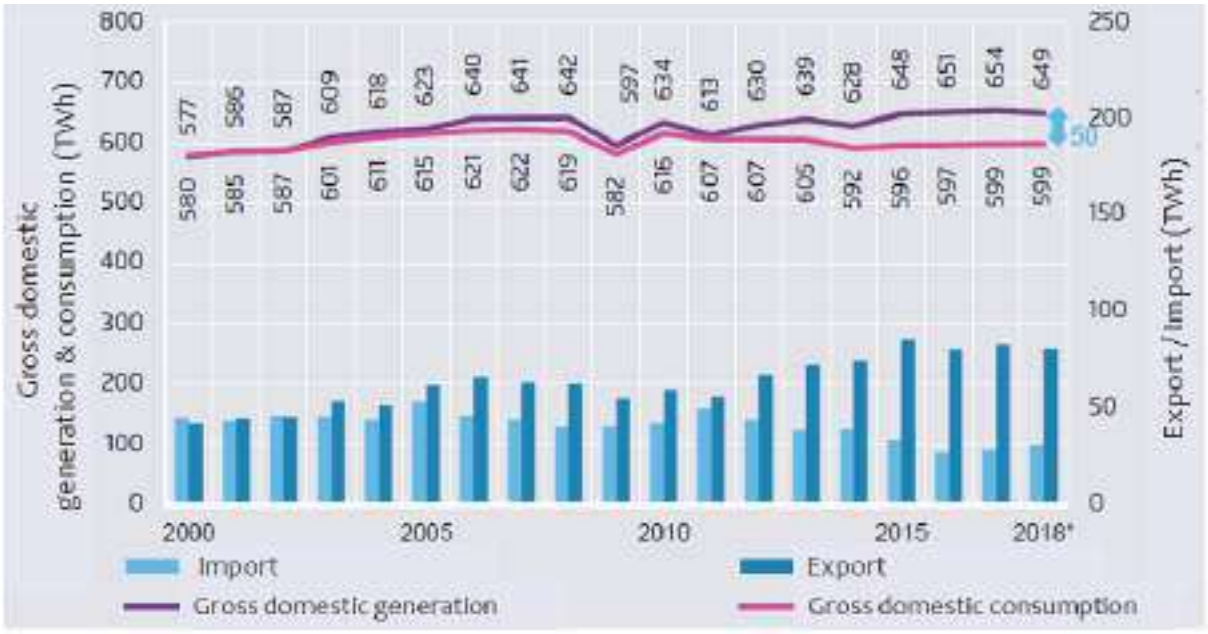

Figure 5: Increased electricity export from 2000 until 2018, with increased gap between the electricity generation and consumption [1]

4. LACK OF ENERGY STORAGE AND NEW GRIDS

It is clear that in order to reach a better integration of intermittent energy sources, the German electricity system requires more energy storage facilities and new grids for transporting the electricity from the region where there is in surplus to the regions where it is required. However, the energy policy is not in favour of those solutions. Last years there are plans to build new grid from the North to the South of Germany, however with very low acceptance in the public opinion. The main reason lies in the environment and landscape protection.

The accepted solution is to go with underground laying grid. It is more expensive – the newest estimation gives a figure of about 52 billion € [4]! Another anomaly is that the RES electricity generation should be distributed, without a need of big grids. Now there is an opposite effect: the grid capacity has to be even higher than in the case when there was a centralized generation with extremely big nuclear power plants, which are closing now.

It is undouble that new and modern grids are inevitable for a successful energy transition and that the investment will reduce the export loss discussed in the previous chapter. However, the new energy storage facilities are even more inevitable and could be more profitable. Due to the false energy policy, the existing storage facility cannot be profitable, as they are considered as both consumer and producer of electricity. The EEG surcharge, as well as the grid surcharge have to be paid twice. The only exception are the smaller household energy storage facility, mostly Li-batteries in connection with roof photovoltaics. However, those are relative the most expensive facilities and they could be profitable in some cases only due to extremely expensive electricity for the households. However, with the same investment the effects and the storage capacities could be considerably higher. The right energy policy, with favourable conditions for storage, is missing!

5. GHG EMISSIONS

The biggest failure of the present energy policy in Germany and its energy transition is its poor result in reducing the GHG emissions. Big investments in the energy transition may be justified only if there is a god result in reducing GHG, first of all CO_2 emissions. Without that, those investments are useless.

The target was to reduce GHG emissions for 40% till 2020, i.e. for 55% till 2030 (compared to emissions in 1990). It is clear that the first target is unachievable, as until the end of 2018 only 31.7% has been reduced. From Figure 6 it is obvious that even the second target will not be achieved, without some change in the energy policy.

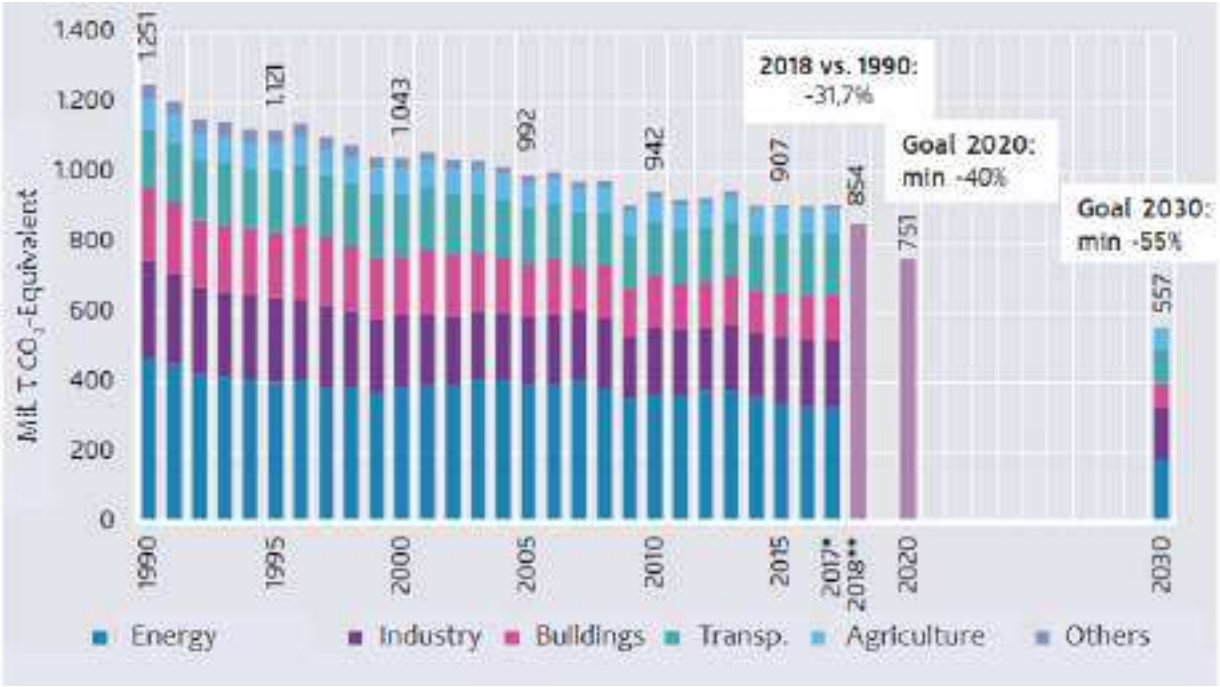

Figure 6: Reduction of GHG emissions from 1990 till 2018 with goals for 2020 and 2030 [1]

The situation in energy sector is even worse, especially in power generation, as presented in Figure 7. In spite of the impressive increase of RES electricity generation (as discussed before, between 35.2% and 40.3% according to different interpretations), the effect on CO_2 emissions is considerably weaker. The reduction towards the emissions in 1990 is only 92 million of tons, or 25.1%.

The reason lies in the fact that after the closure of most nuclear power plants, the base load took over the coal power plants, instead to build storage plants.

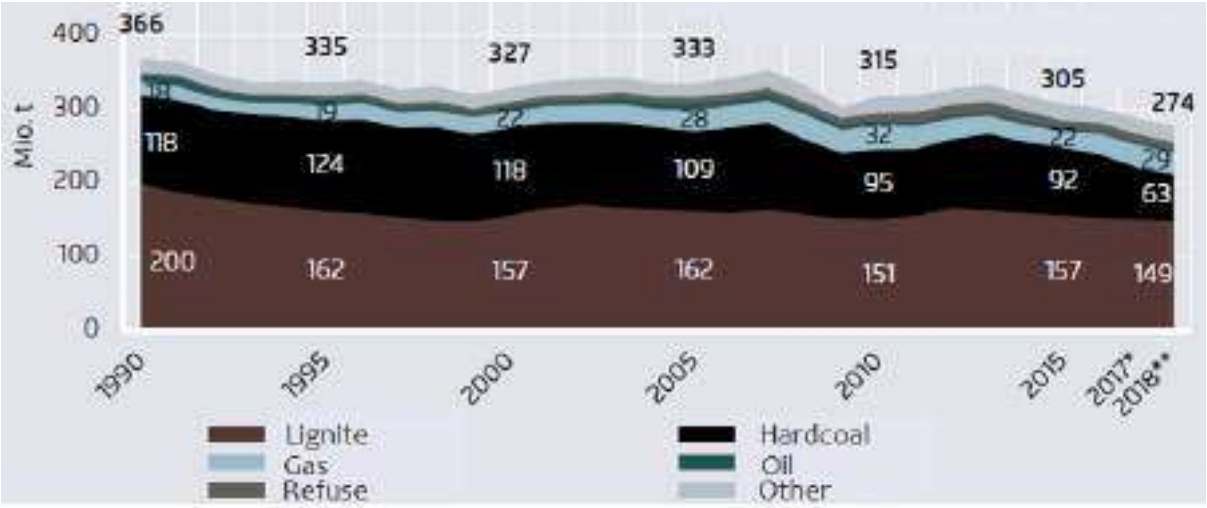

Figure 7: CO_2 emissions from power generation, from 1990 till 2018 [1]

6. BIG CHALENGE IN 2022

Until the end of 2022 all nuclear power plants will be closed - it means additional almost 10 GW capacity. According to the decisions from January 2019 [5], another 12.5 GW of coal power plants will be taken off the grid.

What will happen with the system without those 22.5 GW of base-load and low generating cost facilities? For sure, the electricity price will be considerably higher, although the EEG surcharge is expected to be lower. Even today the electricity in Germany is relative expensive, both for households and for industry. Therefore a subsidy of at least 2 billion € per year will be required [5] in order to compensate that increase, at least for some energy intensive industries. The exact amount would be possible to estimate accurately only at 2023.

The closure of coal power plants has the main goal to reduce CO_2 emissions and to bring them to the targeting values. The first impression is that it will be the case. However, the need for base-load and low price electricity (through the merit order effect on EEX) will provoke that the rest of still existing coal power plants operates with a higher load than nowadays. Only when they are completely utilized, gas power plants will start to generate electricity still required to the full system consumption. Further on, those coal power plants will not be in situation to change their load fast enough and bellow the technological minimum. They are going to generate electricity which would have to be exported, but they will also generate CO_2 further on. The only positive effect could be that the coal plants operators will allow steeper load changes and more stops than predicted in the design conditions, as their long lifetime is not required anymore. Maybe that will reduce the net export as well. It will be interesting to follow and analyze those phenomena in the coming years.

7. UNSTABLE MARKET CONDITION

Due to permanent changes in energy policy, the market conditions are also very unstable, not only for wind and solar facilities. The energy transition has created many new jobs in RES sector and many jobs in the fossil fuel sector are lost. In previous times the jobs in energy

sector were good and stable, while the jobs with renewable energies are very instable. That will be presented on two examples of wind and solar sector.

There were three very good years for solar sector: 2010, 2011 and 2012. As presented in Figure 8 in every of those years more than 7 GW new generation capacities were built. Just two years before, in 2008, it was less than 2 GW. That was tremendous increase for solar companies, but then it was noticed that the electricity system is not prepared for such increase and the energy policy has been changed. Due to new conditions (restrictions) in the 2013 the capacity of new solar facilities was halved and in 2014 it dropped to only 1.2 GW! Many solar companies, especially small and medium, entered into bankruptcy and were closed. Some bigger companies have survived, but was forced to dismiss lot of their workforce. The situation is improving slowly and in 2018 it rose to 3.2 GW. However, many of that new installed equipment was not produced in Germany, as the previous companies has disappeared.

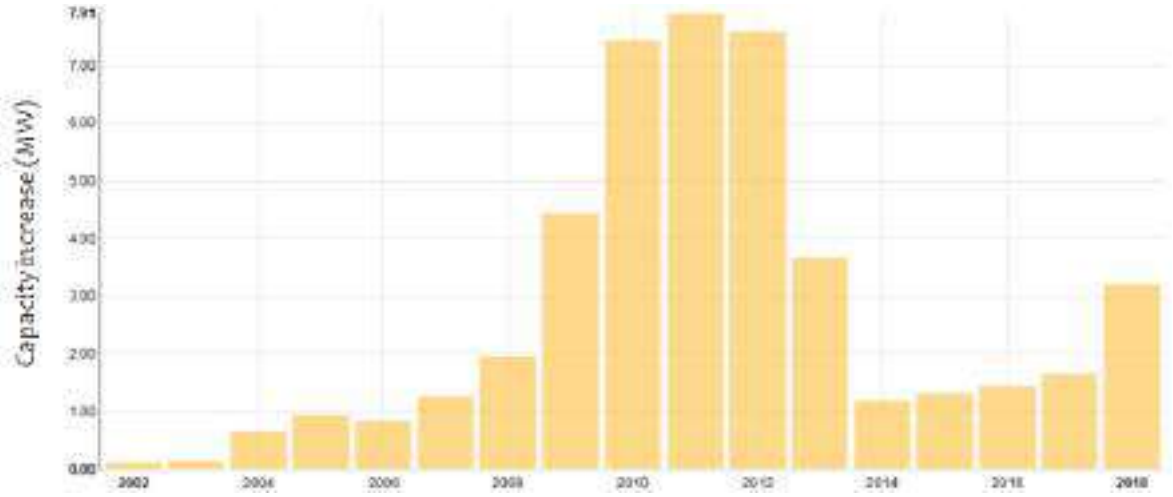

Figure 8: Yearly increase in solar generation capacity [3]

Similar situation is with the wind facilities, as shown in Figure 9. The capacity of new installations dropped from above 3 GW in 2002 to less than 1 GW in 2008. Then it started to rise again and four years (2014 – 2017) it was in the range 5-6 GW. Last year it dropped again to 3.5 GW. Again, very unstable condition for companies grow and only the biggest have survived.

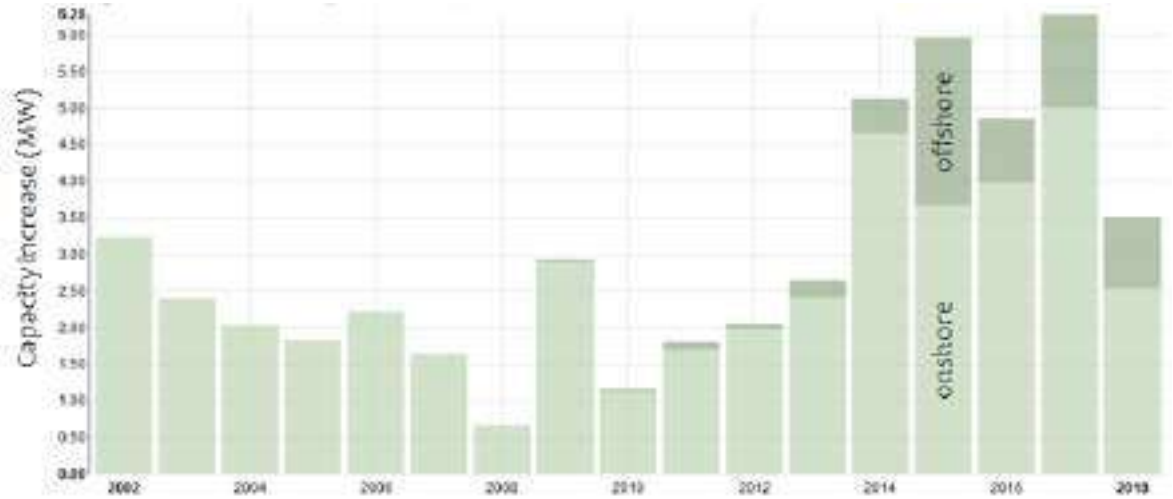

Figure 9: Yearly increase in wind generation capacity [3]

The lack of consistent and steady energy policy resulted in many anomalies. Except the well-known situation with a pump energy storage facilities, the similar situation is with some ultra-modern gas power plants. The best known is the case of gas power station in Irsching, Bavaria. There are two modern blocks, No. 4 and No. 5 (both with combined cycle, 561 MW and 846 MW capacities), commissioned in 2011 and 2010, respectively. The block No. 4 was the world-wide first plant with the efficiency over 60%.

Although they are both designed for approx. 4500 h of operation and for 200-250 starts per year, they are hardly in operation (No. 5: 100 h in 2017 and 15 h in 2018!) and are producing big loss for their owners [6]. The anomaly is that they are not allowed to be closed, as being the system relevant facilities. Even more, a new block No. 6, with 300 MW, has to be built and commissioned in 2022! That is requested by the grid operator, in order to enable system stability. Probably, it will operate only few hours per year. According to the energy policy, the grid operator is allowed to request such facilities, but it has to be new built. The costs will be switched to the consumers, of course.

Another example: The city of Leipzig wants to switch from coal to gas for its district heating system. It will get a subsidy (up to 100% is possible) for such gas heating plant, which should be commissioned in 2023 [7]. The present situation is that the city gets 80% of required heat from the coal power plant Lippendorf, which is one of the most modern lignite plants. Therefore, its shutdown will not be before 2030, maybe it will be one of the last coal plants in operation till 2038. It means that in the meantime the CO_2 emissions will be higher than nowadays (from coal + natural gas) and that the heating cost will be permanently higher.

8. CONCLUSION

The energy transition in Germany is a big success, if one considers extremely fast increase of electricity produced from RES, as well as more and more intensive substitution of nuclear and coal power plant. However, a deeper analysis shows some failures and anomalies. First of all, that is a lack of more significant reduction of CO_2 emissions, which is not in a right correlation with the ratio of RES generated electricity. The prices of electricity are very high, both for households and for some industries (which are not subsidized). Extensive export of electricity surplus, which is not integrated in the domestic system, leads to high losses, as the market price does not include the EEG surcharge. The energy policy leads to unstable market conditions, especially for equipment producers. That is a dangerous situation, as it may turn the public opinion against so needed energy transition. The bright assumption that Germany is a world leader in energy transition is very questionable. The World Economy Forum has shown that Germany is ranked on place 17 (after Uruguay, Ireland, Portugal…) and that only because some other criteria, like the quality and availability of the electricity supply, are taken into consideration [8]. The energy storage, together with modern grids, is the most important missing link for the integration of intermittent renewable energy sources.

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