International electricity exchange in Central and Western Europe: Problems and Challenges

Šimon Přecechtěl, Jakub Gregor

Abstract: Challanges of international exchange of electrcity across the whole Europe are significant, but we try to focus on Central and Western part and to ispect the main problems. After slight revision of the most problematic topics, we conclude solutions and answers that might be even used in practice. We have easily shown that grid in Central Europe is heavily underdeveloped, overlapping regulation is opening way to the dirtiest producers again due to bad framework of regulation from EU and that we can achieve energy stability only by focusing on energy security of Europe as whole.

.

Key words: electricity exchange, challenges in market, renewables, energy security, transmission

1. Introduction

During the introduction to this work we will cover basic ideas about the electricity exchange in Central and Western Europe. We will discuss not only the technological view but we will talk about the political, environmental and sociological scope of things. Before the actual start of this work we would like to state the electricity exchange is a very complex issue which requires complex solutions from all fields included. Electricity exchange is very often presented as technical problem but very often it is more of a political problem.

In our seminar paper we are going to be talking about countries within Central and Western Europe mainly about Czech Republic, Germany, Poland and Austria. These countries are the main transit countries in Europe. The import/export balance between the countries has been in balance for a very long time, but due to recent changes in electricity generation policies in most of those countries the balance has been disrupted and new state is causing many problems. Such as grid overloads, potential blackouts or lack of electricity in the grid. These are very serious problems which can affect the entire Europe within minutes. One of the most important points to understand is the fact that most of those problems can't be solved by single country or its part. These problems need to be solved on a bigger preferably European scale. If not on European scale at least one the scale of central European states or some kind of electricity grid partners.

One of the biggest issues we are seeing is the lack of public awareness about electricity exchange problems. Most of the public sees electricity as a thing they shouldn't worry about at all. Public doesn't understand the needs of investments into the grid or new technologies in producing electricity. This is a big issue for the political representation which has big problems justifying big investments into electricity grid.

Another issue we have identified in this field is the problem with types of electricity generation. There is many opinions about the future of electricity generation in Europe many of them not corresponding with each other and many of the very specific for a single country or area. We can see these differences in many cases one of the biggest contrasts right now is France and Austria. France is the biggest producer of nuclear power in Europe. France produces very big part of its energy from nuclear power plants. Austria on the other hand is the single biggest opponent of nuclear power

plants in the EU. Both countries have visions about electricity in the future but neither of them has a plan for the entire Europe. This European plan that we need, needs to come in a form of consensus of all the countries involved. One of the major problems with this plan is that it needs to be accepted across all fields involved. This pushes this issue into the position of very difficult problem to solve.

Another big topic which we are discussing in this work is energy security within regions. The important thing to mention about this section is that it is not just the regional security which is a problem right now but national and international as well. One of the major issues in this area is the fact that with the growth of renewables it is not profitable for private investors to build new power plants which could provide electricity when needed and in times when renewables aren't producing. This is an issue which has been around for some time for the nuclear power plants. Those plants have been considered extremely long time investment for a long time now. Recently the risks in building nuclear power plants are basically stopping private investors in investing into nuclear power plants. New issue of this kind comes for the CCGT power plants, which are vital for the electricity market in Europe, because they provide on demand clean energy. But even these plants are pushed out because the operational costs are higher than the profit. This is due to the fact that renewables come first in the merit order because their operational cost is much lower than the one of conventional power plants. Big issues come when renewables aren't producing enough electricity to meet demand and we have lack of other power plants to satisfy the demand. We could see the issue manifest itself couple years ago when France was on the brink of a blackout because it was hit by a front of very low temperatures, the renewables in the entire Europe were not producing at all and all the additional power plants were operating in full capacity. This was the time when we could see the lack of supplementary power generating facilities such as CCGT power plants.

Big challenge we are facing today is the unpredictability of power generation from renewables. We are facing the issue of having huge amounts of installed capacity in renewables but we can never be sure how much electricity will the renewables be producing at a given time. This forces us to have most of this installed capacity back up my conventional power plants such as coal power plant. This creates another issue which is link to the merit order. Because in this scenario we only need the conventional power plants for like 50% of the time. The other 50% they should be off. This is

obviously big problem for the investors because power plants operation at only 50% capacity are not going to be profitable. This puts us at a very dangerous position where soon we might be facing the problem of not having enough electricity on days when renewables are not producing to days of excess power when the wind is blowing and sun is shinning.

2. Challenges related to the grid

As we mentioned before in the introduction to this work one of the main problems with the exchange of electrical energy in the Central and Western Europe is the gird. The current status of the grid is not good especially considering the unpredictability of energy generation. The most vulnerable part of the European grid are the border parts especially between Germany and Czech Republic, Czech Republic and Austria and the Polish-Czech/Polish-German border. The German Austrian border and the grid along it is highly developed and is almost at the point of unlimited capacity. This is only temporary because as more and more power flows throw this border even this highly developed system is starting to reach its limits. Right now Europe is having difficulties because of the fact that big part of its power generation is at the Northern parts of Germany, because of the very high installed capacity of wind turbines and the good on shore location where the wind is almost guaranteed. The problem is with the distribution from the distant locations in Germany to the net importers such as Austria. Very often the energy can't go straight from one place to another but has to go through many loops and other countries than just Germany and Austria. This started to cause problems with unregulated power flows especially to the Czech and Polish grids. Both countries had to install very expensive phase shifters to basically stop the electricity from entering their grid and overloading it. This solved the problem for those countries but it is not solving the big European issue. This was one of the selfish but necessary steps to take. It is vital for each and every country to have stable and secure grid. These unregulated power flows were disrupting that function. Now that we have stabilized the situation of these flows we can start working on a European solution for better connected grids. Right now we are seeing many disputes on the European level between countries. This is a problem for the solution of this long term grid crisis we are living in. Because no single country in Europe can stand alone in electricity generation and consumption if we are to meet our environmental goals and to maintain our high quality of life. It is mandatory to push for a unified solution.

There are still some things that single countries can do to help the situation without the complex European solution. One of these things is building more power storages. In Europe the Australian super battery solution is not an option. Right now countries are focusing on small in house batteries which can help stabilize the grid unpredictability. This is only at the start now. Technologies and ways to store power on

a flat/house level are still in development or testing stages. Very small percentage of these technologies has been field tested with enough collected data to work on. There is however one technology that has been successfully used all over Europe before and is being used even today. Those are water pump storages. Water pump storages have the advantage as serving as huge battery which can either pump power into the grid or consume power to pump water and prepare for when the power generation is low. The big problem with these power storages is the face that they are immovable and in many cases we are encountering the same issue as we are on the European level but now on the level of a single country. This problem is tied to the fact that building water pump storage is highly dependent on the location. It has very specific criteria for location and the structure of terrain. During the time when water pump storages were build we didn't anticipate such problems with grid and these energy storages were build mainly as a back up and not for daily usage. The consequences of this fact are manifesting its self now in he fact that many of those water pump storages don't have sufficient grid connection to serve as needed.

Another major issue related to the grid is the so called "not in my backyard" issue. While establishing high quality grid connection across whole country or whole Europe. Developers have to very often lead the grid over privately owned land. Many private owners are refusing to give permission to the developers to build on their land. This causes major delays in many projects. Sometimes even ending with long law battles. This entire process can take years. All of these problems are slowing down or even stopping the development of quality grid connection all over Europe. This is one of the prime examples of the point that we stated during introduction - International electricity exchange is not only scientific or engineering issue but it goes through many other fields.

Big challenge in the future of electrical energy is solving the so called electricity islands. One of the prime examples of this is Italy. Italy has only 5 high voltage connection and all 5 of those are across the Alps. Right now there is basically no redundant line over the Alps. We could see the impacts of this during the blackout in 2003 where one of the lines was hit by a tree fall and the others got overloaded due to the fact that there is no redundant line. Even after precautions taken after this incident Italian connection to the rest of the Europe is very fragile and situation like this might happen again in the future. The fact that Italy a virtual island concerning electricity, is

affecting the price of electricity very heavily. Italy has one of the highest electricity prices in Europe together with for example Cyprus.

One of the hopes for the future is the E-Highway 2050 project which was created by the European research consortium and is supported by the European Commission. This project had prepared materials for creating the future secure and sustainable grid for the whole Europe. E-Highway is a research project with the life span of 40 month. It is preparing materials for the 2030, 2040 and 2050 grid expansions. All European TSOs are called to join in and consult the results of this research project. This project should lead to the successful implementation of plans that lead step by step to the sustainable and secure pan-European grid, which is vital for the future of Europe.

3. Unpredictable generation of electricity

The unpredictable generation of electricity has never been a bigger challenge, especially in European Union. The vigorous effort of EU to make generation of electricity cleaner and more sustainable is really respectable, but are they choosing right instruments? Are they considering all consequences that will come up eventually? They are surely making a way for new technologies and their goal is our common prosperity, but we should look at some challenges of these new and clean technologies from the economical point of view.

3.1 Green serves the dirtiest

First and maybe the most challenging problem is that the green serves the dirtiest. As some of the papers and research show (Böhringer 2009) – the support of green quotas is making already regulated market do something that was completely unexpected. The problem lies within the ETS (Emission Trading System) of EU that has been put together with systems such as TGC (Tradable Green Certificates) or feed-in tariffs. For general simplification we will refer to these instruments as black (ETS) and green (TGC, FiT) quotas. Black quotas are based on straight regulation of CO_2 emissions by cap and trade system, where pollution permits are emitted to the companies that generate CO_2 emissions. This means that if you want to generate "dirty" electricity you have to buy a permit that allows you to produce CO_2 emissions. Green quotas are based on feed in tariffs and green certificates that provide long term stability for producers of "clean" energy, thus they are not so vulnerable to the energy market.

These two regulation instruments or quotas work both on their own, but not many people were interested in consequences of putting these two systems together. This problem could be called a problem of overlapping regulation. As several studies could show after the regulation from both sides – green serves the dirtiest (Böhringer 2009).

Although the green quotas actually decrease total "dirty" power production the dirtiest producers will gain from this system the most. Reasoning behind this process is quite easy and could be seen as classical parable of a shattered window that was described by Frederic Bastiat. There is always a first-order effect that is seen by masses and is easily expected. But eventually behind this first-order effect lie consequences that

are unexpected at first glance and could be seen only after precise analysis. This is exactly what happened with the mixture of regulation.

So how is that even possible, that if you use two kinds of regulation the dirtiest producers of electricity can profit from the situation? The first order effect is quite simple – profitability of producers that produce dirty electricity reduces. This means that the output of producers is decreased. Thus demand for emission permits is going to go down too. This only means that price of emission permits or price of emissions falls, because this problem was fixed with black quotas before and no one expected demand to fall down. Who benefits the most from this situation? The most polluting or emission intensive producer, because it is actually more profitable situation for the dirtiest producers now when price of emission permits went down. One regulation is overlapping the other and support of the green technology serves the dirtiest producers after all. This is actually not only theoretical concept, but it has been tested and quantified with the numerical analysis for the Germany electricity system where researchers also included the implication of overlapping regulation on excess cost, carbon values and electricity prices (Böhringer 2009).

How could this happen? In my own opinion, I would say that most of the people that supported this way of regulation did not even expect this outcome or in worse case scenario they just did not want broad public to know about this problem. It might seem improbable but these problems of regulation and energy policy are policies after all and you have to have public on your side, because it is still part of the politics. Thus the idea of letting everyone know that we will not support another regulation of electricity market could be easily turn down on your side as you might be accused of not supporting the clean energy. Now reversed from your point of view it could be very hard to explain this challenge of overlapping regulation to public because it is not something that can be simplified. Overall this problem could be covered by increasing awareness about environmental energy economy in broad public or the other scenario is giving less opportunities to public participation in the field of energy policies. Of course, the second possibility is more feasible, but it is still quite unreal to rip off energy security from politics.

3.2 Unpredictable efficiency

But this problem is not the worst case scenario. Exactly the same effect as combining two regulation modules – black and green, can be achieved by making the producers and consumers more energy efficient (producing more, consuming less). It causes the same effect, because i.e. 20% energy efficiency improvement means fall in demand. And fall in demand spins the spiral of serving the dirtiest again. It wouldn't be such a considerable threat if famous "20-20-20" goal would not include 20% improvement of energy efficiency. In simplification – we can't get more efficient producers (produce more electricity) and expect consumers to act more responsibly (consume less electricity) in the same time, because the aftermath of this improvement would be a critical shortage of demand that might even cause a recession. This concern might be ridiculous on one side, but the "20-20-20" program is making this concern feel possible. Because this program has already picked a winning instrument that might not be even economically speaking - efficient.

It is the same situation as with the 20% decrease of CO_2 emissions by 20% increase of renewables capacity. They picked the winning instrument in the greater cause (increase of renewables through green quotas), but they did not expect the consequences that were not in the first order. And same thing could happen with the efficiency, there is only one solution – if producers will be more efficient and they will produce more energy then customers must consume more energy or some producers will have to leave market. But will it be the clean energy producers? No, they are subsidized and no one wants them to leave. Will it be the dirty producers then? Yes, but not the dirtiest. This overlap of energy production would lead to crowding out of gas power plants and not the dirtiest such as lignite power plants. After all this is a challenge for more than Central Europe, but the central part will be involved much more regarding the energy security within these countries nowadays. We analyze this in chapter 4.

3.3 Abating CO2 efficiently

We can just predict how decreasing of CO_2 would be efficient if green quotas were not included. But with regards to few papers it had been estimated in ex-post analysis of Germany for the years 2006-2010 (Marcantonini 2014), that costs of abating ton of CO_2 are the lowest if you rely on EU-ETS. In these papers they analyzed the cost of abating ton of CO_2 by subsidizing variable renewables. Cost of subsidizing wind power producers is merely higher than cost of emission permits per ton of CO_2 (tens of € per abated ton of CO_2). Solar power producers were the worse case scenario. Their costs of subsidizing were enormous opposed to EUA (European Emission Allowances) – hundreds of € per ton of CO_2 abated. The outcomes has shown that in case of Germany their support of wind power producers induced a decrease of CO2 production on the same order magnitude as with EUA, but generally their costs for abating a ton of CO2 were higher. However, supporting solar power producers has proven to be very costly way to abate CO2 emissions. Thus the unpredictability of renewables lies not only with weather, location, forecast errors or profiling costs, but also with market deformation with regard to overlapping regulation and ineffective money spending. It is actually very alarming to conclude that we are adding more unpredictable behavior to renewables by developing not suitable framework for these instruments that must be promoted as much as possible but only in the right way.

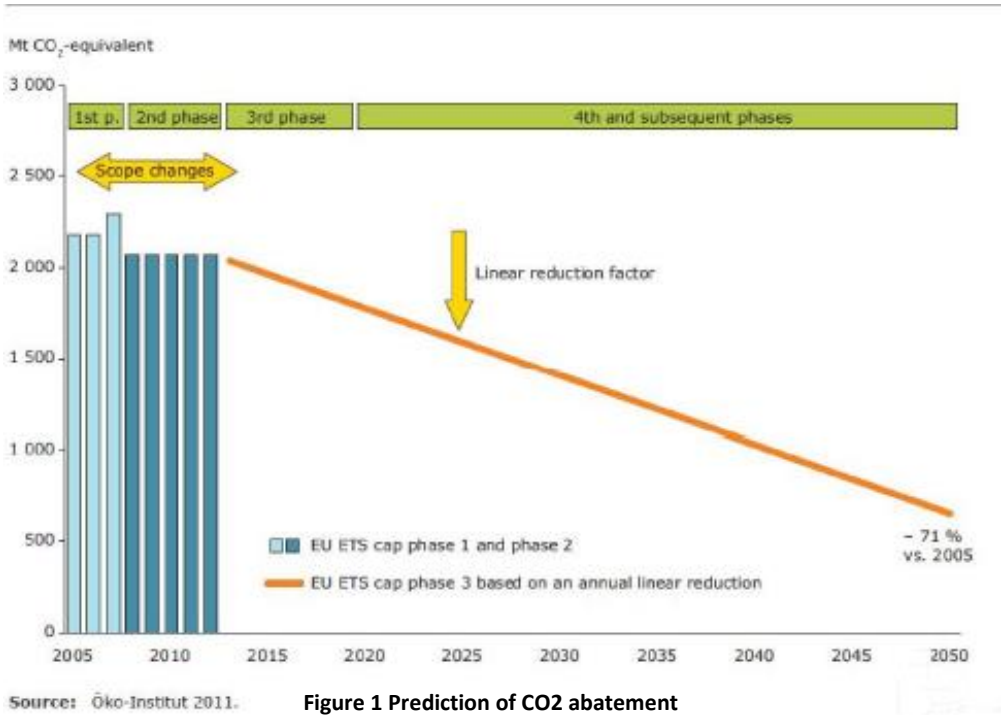

Figure 1 Prediction of CO2 abatement

4. Energy security within regions

Energy security is a well discussed topic within all EU countries and Central Europe is nowadays going to face some serious challenges that might wiggle with the stability of these countries. Two of these challenges include nuclear power plants and their shutting down that could possibly cause severe problems. Actually, not problems with energy supply but with overreacting of governments and opening doors again to the dirtiest producers such as lignite power plants. As it was said before – energy policy is still part of politics and energy security is the most vulnerable part because everyone wants to show that their country is not dependent on anyone else but themselves. At least this is how few countries within EU act and why the electricity market won't be perfect even with great transmission lines.

4.1 German Phase-out of nuclear power

The German government decided in 2000 to enforce nuclear Phase-out by 2022. This decision was even strengthened after the Fukushima meltdown, which demonstrated risks of energy strategy that is dependent on nuclear power. This decision seems very reasonable at first glance, but when we consider again the consequences there are several challenges that must be handled precisely and there is no space for mistakes.

In the long run the idea is simple and – nuclear power plants will be replaced by RES, but this process is not short at all. What happens in the short run then? The missing capacity of nuclear baseline power will be replaced by coal, lignite and gas power plants. The German government even decided to support efficient coal and gas power plants in order to ensure security of energy supply (Deutsche Bundesregierung, 2012). Of course that in the long run these power plants will be replaced or at least should be by RES, but this doesn't mean that this Phase-out is the best way to get rid of the nuclear power. Not at all. It is the fastest way around but I would say rather unfortunate.

When you are considering Phase-out of that much capacity you shouldn't just want to do it as fast as possible. This process has to be very well-advised, slow approached but mainly reasonable with regards to any potential threats. Overall Germany will face many challenges that are almost all related to the transmission problems and congestion of it. This Phase-out has been already analyzed and studied (Bruninx et al., 2012) and there are major conclusions that should be taken into consideration. First conclusion is that in the short run phased-out nuclear generation

will be replaced by coal and lignite power plants. These power plants should be then crowded out by RES, but there is a question if this broad RES share rise will be feasible with regards to grid stability and intermittency of RES electricity generation. This also means that there is needed curtailment of electricity generated by RES in order to prevent overloading of the grid, especially in the high RES scenario. Zones around Hamburg, the connection from North to South and grid between Berlin and Poland are critical areas.

Another problem is linked to CO_2 emission which should be decreasing as long as share of electricity generation by RES is increasing, but due to the problems with the grid this decrease of CO_2 emission is very limited. In all cases, German government should not underestimate that big deployment of renewables from the financial perspective too.

Nevertheless, the German way of nuclear phase-out seems a bit fast and however environmentally justified this move can be, I don't think that it is economically sufficient way to do this kind of process. It could be truly justified only if the grid interconnections were in a better shape or if there was invented and deployed an efficient cheap system for storing electricity, but both of these scenarios are really unlikely to happen unfortunately in the near future unlike the German Phase out of nuclear. From this extreme example we can transfer our view to another in Czech Republic.

Figure 2 Predicted deployment of coal power plants in Germany

4.2 New nuclear block in Dukovany

There is currently a big concern about energy security in Czech Republic. It is based on fear of one nuclear block in Dukovany getting shut down in 2035. It has simply aged enough and new one should be build. Or should it? Due to political instability of Czech government and other factors we can almost say - we won't make it in time. There is currently a big pressure from EU and Austrian government too and lately company Lazard published their investment analysis in which they show LCOE (levelized costs of energy) for each power generation type (Lazard 2017). The worst outcome for year 2017 is held by nuclear power generation and we can just assume why is that so. The main assumption might be the recent problems with development and building of the new nuclear blocks throughout the world – Hickley Point C (UK), Olkiluoto 3 (Finland), Flamanville (France). Problems with development and current mood in Europe, that is rather hostile to nuclear power, are the reasons why investors are being really cautious and LCOE are going up.

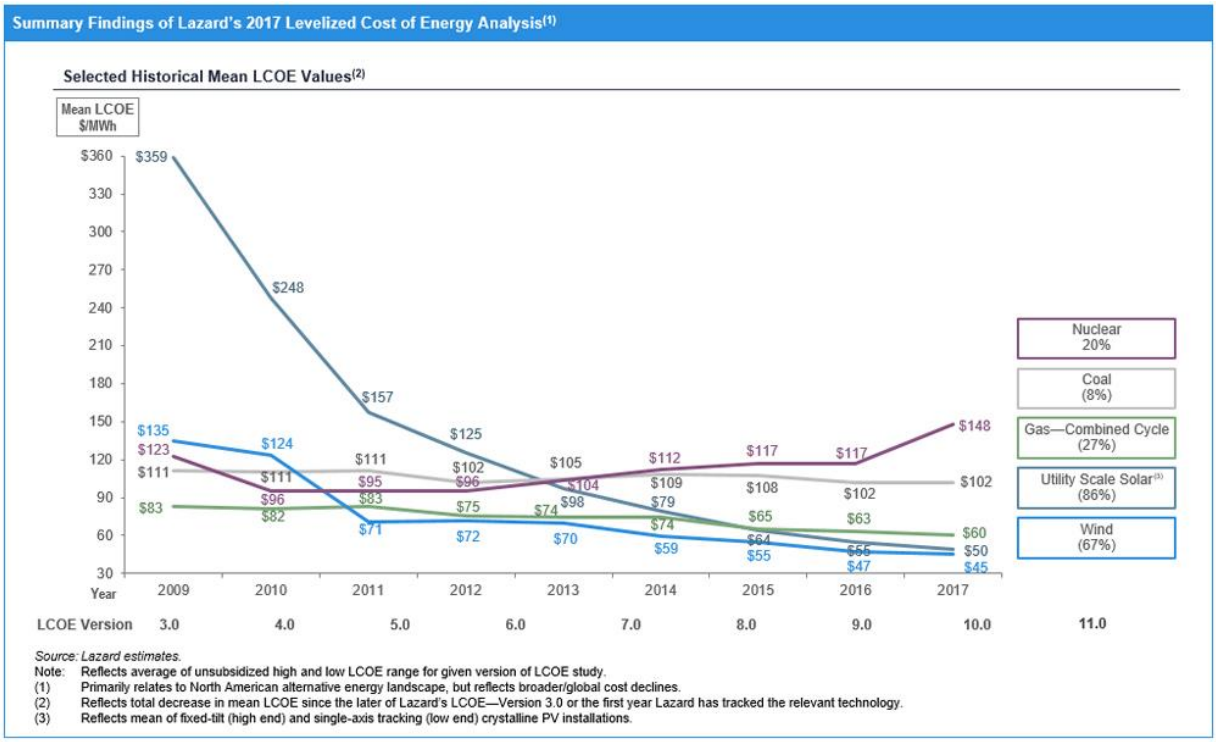

Figure 3 Levelized costs of electricity, Lazard

Back in Czech Republic there is also no consensus on the agreement which would say who will build and pay for that nuclear unit. It just seems like a lost case, but Czech government still believes that it is feasible. Even in the national energy strategy is a goal

that says - we need to persuade EU participants that nuclear is a clean instrument of energy strategy and we need to support enforcement of nuclear energy as acceptable instrument to produce electricity without emissions. However, it is quite understandable why Czech government is trying to make this happen. Due to EU CO_2 emission standards and policy there is a goal to slowly get rid of the dirtiest generation of electricity – lignite and coal power plants. But one problem occurred. The Czech nuclear power plants are ageing as mentioned above, thus if we haven't prepared enough and we won't make the new construction on time, what will replace the missing capacity?

One possibility is market, but this is not likely to happen regarding the Czech position as net exporters, there is almost none probability that we would become importers of electricity. Although, the ASEK conception says, that the goal is no more to be net exporters it is still not believable that we would go to importers side (considering that there are more depending countries – Austria etc.). The other possibility was some plan that we could call – Bavarian plan. The gist of the plan is in the deployment of gas power plants and RES, but due to recent development of electricity prices and other factors, the gas power plants are becoming less profitable and EU energy security program has a goal to be less dependent on Russian Federation (this means importing less gas). Thus there is only hope that the situation will get better. Last plan was to operate coal power plants as it is planned in Germany, but there is a problem with CO_2 emission standards.

To conclude this challenge – replacing nuclear power blocks with new ones is a needed thing for Czech Republic to have stability in energy security but it is certainly not a good time to start planning new power block that should start in year 2035. This challenge should have been discussed years ago and some plan with these risks included should have been done. Czech government is under some tough pressure and decision making but I would suggest to make depth in analysis for all of the costs for new blocks under different scenarios including opening the market for import of electricity because it might be a surprising solution of the whole situation.

5. Conclusion

To conclude our work we would like to summarize our points of view and our ideas about this topic. The main goal of this work was to bring broad point of view which covers many fields that are included in the energy sector. The brief introduction to this paper at the begging showed us how complex this problem is. It shows how it needs consensus across many fields to actually work. We have identified many issues that are currently in this sector and we have offered solutions to those problems. The most important point of this work is not to underestimate this problem and approach it with serious attitude. We, as the EU, have to put a lot of resources towards our energy strategies.

First major point we hope we achieved to make was the need for European solution of the energy issue. As we tried to describe in our work European countries are too small to solve this problem alone. We have to push for European solution especially the members of EU. Members of the EU are not only responsible to themselves but to the EU as well. All of the member states agreed to reach some quotas of renewable sources in their energy mix. This is very important goal to achieve, but many countries can't achieve this goal alone. Some because of their lack of development, some because of their geographical specifics. This is the prime example of an issue we have to face together.

Second major point is the stabilization of renewable energy sources. Stable energy generation is the major issue of the renewable field. Combining new technologies with the current ones and conventional way of generation energy might just provide enough generation to be sustainable. Thinking about the future we have to maintain nuclear power plants to in operation otherwise we are not going to meet our renewable goals we set to achieve. With the risk of nuclear power in Europe being almost insignificant as Europe is very stable region in both political and geographical point of view. We need to keep nuclear plants around until we are able to supply ourselves with clean energy from renewable resources. The other option to nuclear power right now is what we are seeing in Germany and that is massive restart of lignite and coal power plants which is not the way to meet our CO_2 reduction goals.

Overall we think the most important points are serious approach to this issue and European solution.

6. References

Böhringer, C., & Rosendahl, K. E. (2009). Green serves the dirtiest. On the interaction between black and green quotas, *Discussion Papers 581*, Statistics Norway, Discussion Papers in Economics V-315-09, Oldenburg University, and CESifo Working Paper No. 2837.

Böhringer, C., H. Koschel and U. Moslener (2008). Efficiency losses from overlapping regulation of EU carbon emissions. *Journal of Regulatory Economics* **33**, 299–317.

Bruninx, K., Madzharov, D., Delarue, E., D'haeseleer, W., (2013). Impact of the German nuclear phase-out on Europe's electricity generation - A comprehensive study. *Energy Policy* **60**, 251–261.

Bruninx, K., Madzharov, D., Delarue, E., D'haeseleer, W., (2012). Impact of the German nuclear phase-out on Europe's electricity generation—Model description & detailed results. WPEN2013-01. Available at: (http://www.mech.kuleuven.be/en/tme/research/energy_environment/PublicationsEnergyandenvironment/Journalpapers)

Bundesnetzagentur (2011). Auswirkungen des Kernkraftwerk-Moratoriums auf die Übertragungsnetze und die Versorgungssicherheit. Technical Report. Berlin, Germany.

European Commission (2014). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL. European energy security strategy. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0330&from=EN

Hirth, L. (2013). The market value of variable renewable: The effect of solar wind power variability on their relative price. *Energy Economics* **38**, 218–236.

Janda, K., Málek, J., Rečka, L. (2017). Influence of renewable energy sources on transmission networks in Central Europe. *Energy Policy* **108**, 524–537.

Lazard (2017). Levelized Cost of Energy 2017 analysis. Available at: https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

Marcantonini, C., Ellerman, D. (2014). The Implicit Carbon Price of Renewable Energy Incentives in Germany. EUI Working Paper RSCAS 2014/28.

MPO (2014). Státní energetická koncepce České republiky. Available at: https://www.mpo.cz/assets/dokumenty/52841/60959/636207/priloha006.pdf

OTE (2016). Year Report on the Electricity and Gas Markets in the Czech Republic for 2016. Available at: http://www.ote-cr.cz/o-spolecnosti/soubory-vyrocni-zprava-ote/rocni-zprava-2016.pdf

Rehner, R., McCauley D. (2016). Security, justice and the energy crossroads: Assessing the implications of the nuclear phase-out in Germany. *Energy Policy* **88**, 289–298.

Singh, A., Frei, T., Chokani, N., Abhari R. S. (2016). Impact of unplanned power flows in interconnected transmission systems – Case study of Central Eastern European region. *Energy Policy* **91**, 287–303.