Europe / Russia Electricity Market

About the opportunity of a fully integrated power market over geographical Europe

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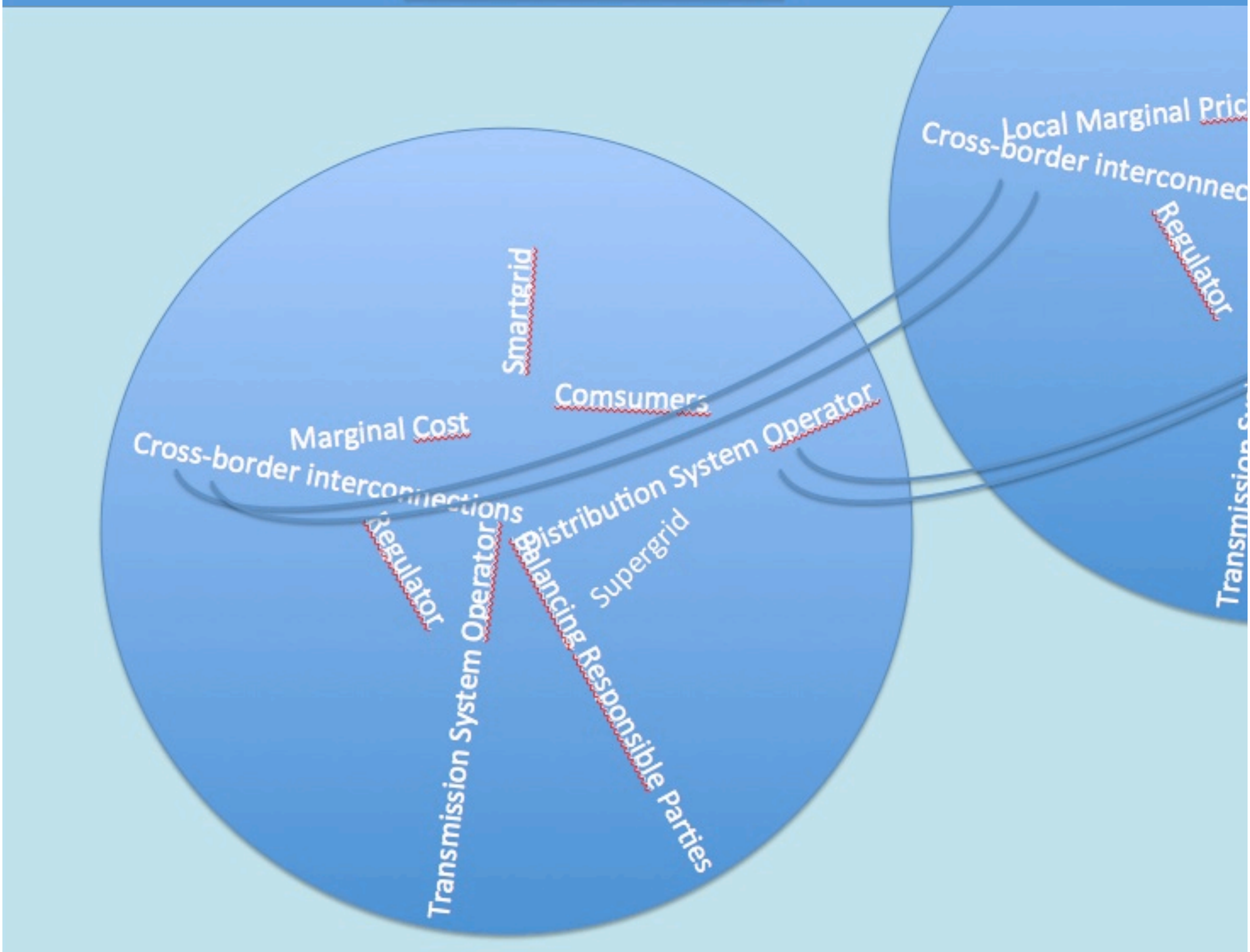
Arnaud Philibert
Alexander Kvitnisky
Daria Samarenko

ESCP EUROPE

London, Berlin, Madrid, Paris



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EXECUTIVE SUMMARY

This paper provides the readers with the evaluation of the potential for the electricity interconnection of two major areas: the power system of the European Union (globally represented by ENTSO-E) and UPS of Russia. The pilar of the Thesis is the assumption of an energy-based cooperation of these areas, which is also one of the most important topics in the relationship between the EU and Russian Federation. The tensions on the field of gas supply in Europe and the issue of security of supply address the need for diversification of energy sources. One of diversification opportunities could stand with the bilateral power exchange. As European Union is already coupling the electricity markets into the Integrated Energy Market, its extension to the East, already initiated with the Energy Community, sounds plausible and rational.

The main focus of this paper is to set the comparison of the market structures and regulatory regimes. The evaluation of the challenges caused by the current development stage is made.

The core part of the report starts with the historical data and the short overview of the potential benefits in case of success implementation of the interconnection initiative.

The second chapter gives an outline of technical issues and concludes with the most feasible technology for such project – the High Voltage Direct Current (HVDC) links.

In the next section of the report, the reader has a possibility to compare the electricity interconnection project of this paper with previous similar projects in order to evaluate lessons learned and mistakes made.

Next major chapter focuses on the regulatory analysis of the two involved sides. The differences and similarities are described and compared, al well as some examples of existing electricity interconnections, such as Baltic area and Finland-Russia interconnections.

With the background information given in the previous chapters of the report, the next section presents an analysis of the electricity markets structures across Europe and Russia and their functioning. In the chapter Market Modeling we have used a price modeling tool, based on the marginal-cost and merit-order method, to reproduce the electricity spot price of one relevant region – Finland- and re-calculate this wholesale price, should interconnection with North-West region of Russia be emphasized. The behavior of this spot price is reflecting the possible effect over the EU28 integrated market, assuming an efficient electricity market interconnection between the European Union and Russia.

As a conclusion for to the topic we estimate the HVDC technology to be the leading one for such interconnection, paying attention to its cost structure evolution. With the current development of the Russian gas price, the bidirectional electricity interconnection will make even more sense. In terms of political influence, Russia could become a big support for Europe in achieving 20/20/20 goals, produce more renewable-originated electricity, and offer social benefit, should adequate political mindset be adopted.

Such report could not have been conducted without an extensive reading of the literature over both Europe and Russia, and definitely not achieved without the interviewed experts from the energy industry across the EU and Russia, who shared their time and knowledge.

This report was prepared on the base of information, available for the Authors at the moment of its compilation (August 2014).

Some declarations in this report aren't real facts, but only declarations, related to the future. Such words as "plans", "will", "is expected", "will come", "considers", "will form", "will happen" and etc. are based on forecasting and imply the risk of possible non-fulfillment of the predicted events and actions. Due to these reasons the Authors warn that actual development of some events may significantly differ from the forecasted way, presented in this paper.

Excluding the cases, foreseen by legislation, the Authors are not responsible for review and confirmation of expectations and assessments, and also for the publication of updates and changes on the declarations in connection with consecutive events or acquisition of new information.

Although every effort has been made to ensure the accuracy of the material and the integrity of the analysis presented herein, the Authors accept no liability for any actions or investment decisions taken on the basis of its contents.

INTRODUCTION

The EU-Russian official relations date back more than 20 years. The first major step towards a closer cooperation was the conclusion of the Partnership and Cooperation Agreement (PCA) in 1994. The PCA established a framework for the political dialogue between Russia and the EU and promotes trade, investment and harmonious relations. Both EU and Russian nationals can even claim certain individual rights under this agreement. The PCA serves also as the legal basis for the EU-Russia Energy Dialogue. It is to be replaced by the currently negotiated New Agreement.

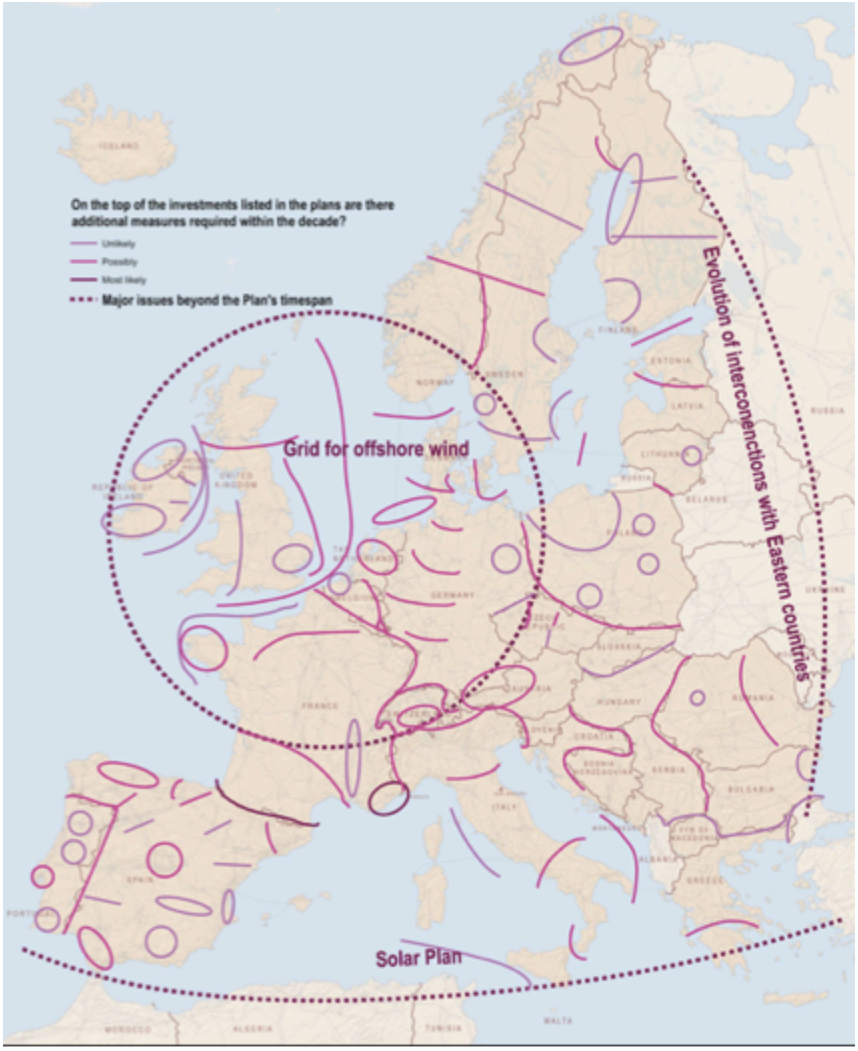


Figure 1 - Transmission adequacy, TYNDP 2012, ENTSOE

The second milestone in EU-Russia relations was the definition of four common spaces at the EU-Russia St. Petersburg Summit in May 2003. The common spaces cover covers four main policy areas: the **Common Economic Space, whom main area is Energy**, the Common Space of Freedom, Security and Justice, the Common Space of External Security and the Common Space of Research and Education, which also includes cultural aspects.

Another key instrument in the EU-Russia partnership are bilateral summits, which take place twice a year. At the summits, the EU is represented by the President of European Council, the President of European Commission and the High Representative of the Union for Foreign Affairs and Security Policy, while Russia is represented by the President and Ministers responsible for specific areas of cooperation with the European Union. Since the entry into force of the PCA on 1 December 1997 Russia and the EU have held a total of 27 summits.

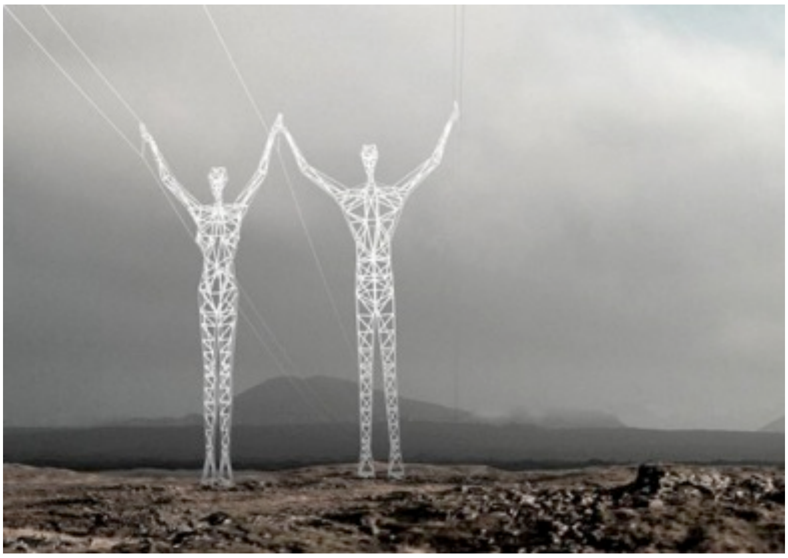
How long is « long » ?

Anonymous, Paris, February 2014

Obviously putting aside the recurrent political turmoils, commercial balance and energy always gather around the table these 2 actors, demonstrating neighbours have a mutual interest in optimizing their relationship. Our investigation is one of the opportunities of profitable partnership.

Energy being the the main reason for tension, this might also be the source of mutual benefits. This report intends to draft the main over gaps to be overruled to open the way.

Regulations and market approach are the main concerns. Two societies thinking differently, with different pasts, and thus looking after uncertain horizons, have lead their reforms to reduce dependancy on one side, grow the external trading balance on another side. Current geopolitics seem to push forward such independant policies, and naturally each party try to pull the blanket to its side. There might be alternative ways, less conventional but actually already economically incumbant : Instead of limiting the interactions to primary resources, diversification of trades can be considered over electricity and all related services. Gas is set around long-term agreements, obviously bringing stability through the events, but also freezing the cooperation with respects to the terms of these contracts. Any deviation is mitigated to stick to what was decided whatever would be the new expectations. Hence, gas trading is, to make it sharp, a matter of volume exchanges. Power is a more dynamic agent. As there is no (not yet) storage possible, the fluidity is critical, and every single actor can play its move as far as the market is clearing the transactions. Pending ones is connected to the grid, there is an opportunity for him to act supplier (if not of pure power, by offering dispatchable demand), or consumer, even better : « prosumer », by selecting contractually its providers wherever it is over the grid. This is still a daily market mainly (waiting for long-term capacity markets integration), allowing adaptation of the terms should it bring mutual interest. The only predicted future is an extension of the market place, through a better integration of what is already meshed, and consideration of neighboring potentials. Barriers are in place of course, and as said, are a result of respective policies. This is indeed the opportunity : technology makes it already possible, and a section of this report is clarifying this topic, a regulations are a matter of writing new books. Obviously a long process, however a possible one.



This report aims to dig beyond the emotional convictions, if not to demonstrate the immediate interest of the EU/Russia power-oriented Energy dialogue, to identify the indicators to watch out to flag the proper future timeframe when electrical interconnection between the 2 continents will be mutually beneficial. For political representatives, this report will provide tools to know when to push forward the negotiations, other than gas-related, and what would be the regulatory cost for this ambition. For corporations and investors, the same listed criteria will provide support to their decision process on when and where to focus their investigations.

For that matter, identified signposts shall be continuously flagged along this report by the following icône, as a tag for the reader to retain this particular piece of information.

I CHALLENGES POSED BY THE MARKET

[1]European power utilities usually gather quite easily over the conclusion that power capacity is going to fail meeting the demand in a not so far-away future. For instance, RTE, French transmission system operator, anticipate that by 2017, the available reserve to ensure the security of supply during peak demand will not be sufficient, without considering the 7,2GW power capacity provided by cross-border interconnections. Similar forecast for each European member are publically available, and ENTSOE communicated in their latest SO&AF report (Scenario Outlook & Adequacy Forecast upon which is based the TYNDP), that even though Europe as a whole will mitigate the risk of failure, some countries shall be under stress, even from 2015 : Latvia is forecasted upon Scenario EU 2020 to read a negative (-3%) portion of Remaining Capacity (RC) over its Net Generating Capacity (NGC), following by other countries whom RC/NGC ratio is too close to 0 to remain confident. Net Generating Capacity being the power generation potential of one country, its Remaining Capacity is the part of Reliable Capacity (NGC minus unavailable capacity due to outages and reserves) remaining after the baseload coverage. In other words, this is the capacity available for peak seasonal load management, a kind of buffer for extraordinary events. Knowing a failure in balancing supply and demand can cascade into a gobal blackout, it is critical such risk to be mitigated, either

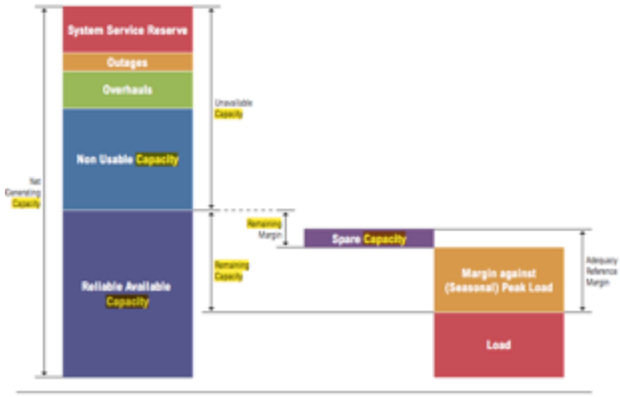


Figure 2 - Generation Adequacy Analysis, SO&AF, ENTSOE

- by increasing the NGC of the supervised perimeter
- through demand management, incentivized or undergone
- enhance the liquidity of physical electrical flows between congested areas

First point is under stress as utilities claims periodically the lack of investment funds occured by the current energy-only market : The merit-order based market which is the characteristic of European zonal market favors the generators with lower marginal cost (renewables, nuclear), leaving the thermal plants running only when they face an opportunity cost, meaning demand pushes the curve toward peakload areas. Indeed, thermal-fire units are breakeven when the MWh price is high. Utilities communicate their thermal peakload-dedicated plants are « in the money » only few hundred of hours in the year, not profitable, and under the risk, if not already the case, of being decommissioned[2]. Second bullet focuses on dropping or postponing the consumption when anticipated, to erase or minimize the peak. Obviously already an emergency solution from TSO/DSO to avoid extended damage over the grid, this is going to be the subject of another power market, with dispatchable demand management, bringing additional market actors such as Demand Responsible (DR) Aggregator[3]. At last, and definitely not the least, the community might think of managing the grid beyond the domestic frontier. Already characterized by important flows, cross-border interconnections initially targeted the import of energy when reaching the limit of domestic generation capacity ; coming to renewable and intermittent energy, they

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[1] Scenario EU 2020, Scenario Outlook & Adequacy Forecast 2012, ENTSOE. Net Generation Capacity and Remaining Capacity definitions

[2] To that matter, European commission and state members are working on an additional capacity market dedicated to garantee enough reserve capacity, utilities receiving revenues for maintaining such power generation capacity, even though not producing. Some economists claim capacity market should not be considered as this is no more than an additional subsidy to fossile-based electricity producers, in the sense, it garantees a minimum stream of revenues, against the principle of liberalized market. To them, wholesale spot market is issueing relevant signal-price, and will do in the future, by increasing their value, and justify investment on peakload management units. Thermal plants, which are in fact not decommissioned, but put on standby, could easily fire again and be « in the money ».

[3] NEBEF (Notification d'Echanges de Bloc d'Effacement) market allow the valuation over intraday and day-ahead market in France, since the Brottes Law in April 2013. Currently under experimentation stage, under the leadership of RTE.

allowed the export of surplus to avoid any overflow over the grid, to neighboring countries which might be either in need, or interested in relying on cheaper source of electricity. Already TSO members of ENTSOE adhere to regulations to coordinate emergency grid management through the interconnections in case of one node failure. Already the wholesale spot market are coupling to each other with the benefit of aligning MWh prices. By improving the capacity of the interconnections, it shall first optimize the building and/or maintenance of high-marginal-cost generation units, and then increase the liquidity of the power exchange market, occuring economical welfare over the zone.

II SCOPE OF ANALYSIS

The field of possibilities is wide, and ones must focus on specific areas in order to keep this report tight. Integration of the market being at stake, the study shall concentrate on the 2 main barriers that are policies and commercial exchange terms.

i. Regulatory Framework

Regulations are binding the actors around common conditions not only on how to enter the commercial activities, but also on how to clear the transactions, how to run litigation and how to quit the market place. It must address the removal of barriers, but also ensure the fluidity of future transactions without, or with minimum tension. The frame must be flexible enough to open the door to future mechanisms. Before doing so, the list of constraints must be drafted, and this report is focusing on this task. Russia is a monopolistic market, centralized, with pretty clear set of regulations, nation-wide, for who might be native in this area. Europe is a patchwork of national regulations and organizations, with their own strategy, covered by a European set of policies which compell to the same ambition. That is re-inforcing the complexity of the review as interconnection terms might vary depending on the state-member of entry. Baltic countries are an in-between, swinging between their historical partner from former Soviet Union, and the attraction of European Community. This unbiased position might tough be the required neutral regulatory frame for an efficient interconnection.

ii. Market Framework

The strategic target is the integration of Europe of the 28 and Russian Federation. This study is dedicated to the first tactical step which is the analysis of the 2 immediate neighboring regions : Finland and North-West node of Russia. Already some interconnections are in place, transactions are happening. Outcome of the living exchanges can be used. Nordpool on one side is a perfect data supplier for merit-order European market, ATS Energo on the other side is the administrator of energy trades, providing to whom are reading cyrillic, reliable historical data. The market analysis of this report has been based on these 2 dataset.

III PREVIOUS STUDIES ON EU/RUSSIA INTERCONNECTIONS

Outside from European Commission, through the EU/Russia Energy Dialogue 2050, not so many studies have been performed. ENTSOE and contacted TSO representatives confirms that there might be an opportunity however this interconnection is definitely not in their immediate priorities. Finland, and by extension NordPool, are alreadty interfacing and thus have lead analysis. It is worth mentionning all reports available on NordPoolSpot website (www.nordpoolspot.com/How-Does-It-Work/), Finnish Transmission System Operator Fingrid (www.fingrid.fi), and Lapperaanta University (www.lut.fi) who position themselves as International Hub of Russian relations. We extend a special thank to these institutions representatives who were particularly helpful.

IV CHALLENGES POSED BY THE STUDY

First challenge of the study is to continuously constrain the analysis. Every step forward was the discover of the correlation of the analysis with external factors. Naturally, there is a will to integrate these external factors, which would have extended the field of investigation without limit. The methodology has been sharpen and has required shortcuts to be decided, assumptions to be made.

Another challenge has been to collect relevant data : Over European side, the data is enormous and a tremendous selection had to be made to ensure relevancy and fairness in the message. Over Russia, from European prospective, there is a necessity of undertanding the culture and read cyrillic as critical inputs are not supposed to be translated. Obviously, the 2 Russian representatives of this workforce were of great value.

V OUTLINE

The report starts by briefly reminding the background (from page 12) and geopolitics (from page 14) of Europe and Russia relationship, focusing over Energy. The feedback from Christian Cleutinx[4] has been of value for this chapter. This is introducing the following section about the expected mutual benefit of this dialogue.

Even though the study does not intend to review all the technology of the interconnectors, the assumption has been made about the possibility of building them, and it is worth showing some proofs over section 3, supplementary inputs being available in appendice for who might be willing to read further.

Chapters 4 and 5 are the core of this study by reviewing similar case of Desertec as a previous analysis of interconnection of Europe with external contributors, and drawing the comparative analysis of Europe and Russia dataset of regulations, with a dedicated focus over Baltic countries case.

Parts 6 and 7 focus on the market study, and a modelization of what could be the impact of commercial exchanges between the two blocs. A simulation tool has been build for the occasion and results are analysed over this section.

[4] Christian Cleutinx, Coordinator of the EU-Russia Energy Dialogue with European Commission

1. BACKGROUND & HISTORY

1.1. GEOGRAPHY

Refering to Europe and Russia is actually quite simplistic, as various blocs are overlapping : Europe of the 28, lead by European Commission are facing Russian Federation for sure, however this is critical to remind that close by or in-between stand Baltic Countries (Latvia, Estonia, Letonia who belongs to EU28 and have interconnection with Europe and Russia, not synchronized though), Ukraine and Belarus.

Talking about power grids, European countries are fully meshed, meaning synchronized since interconnected over various AC lines. The specificities of AC synchronization is networks are merged without physical control of which path the electrons shall take. Beside the allocation mechanisms operated by the Transmission System Operators at the borders, the European grid can be considered as one (the expending market coupling between various European areas is strenghening this correlation at the level of commercial transactions). Norway and Swiss can be considered as included in this European grid, even though not politically attached. Russia, Ukraine and Belarus are also AC synchronized resulting into a physical meshed network, whereas commercial transactions are obviously not fluid. The members of the Energy Community are principaly other Eastern countries, including Balkans who are connected, by treaty, to European Community. They commit themselves to comply to European regulations in terms of energy management with the objective to eventually couple the markets. The positions of all these actors are tricky as there is an underlying mutual financial and economical interest, which is constraints by, aside from geopolitics, environmental, technological and cyber securities. The security of supply and demand can move from a shared interest to a conflicting interest.

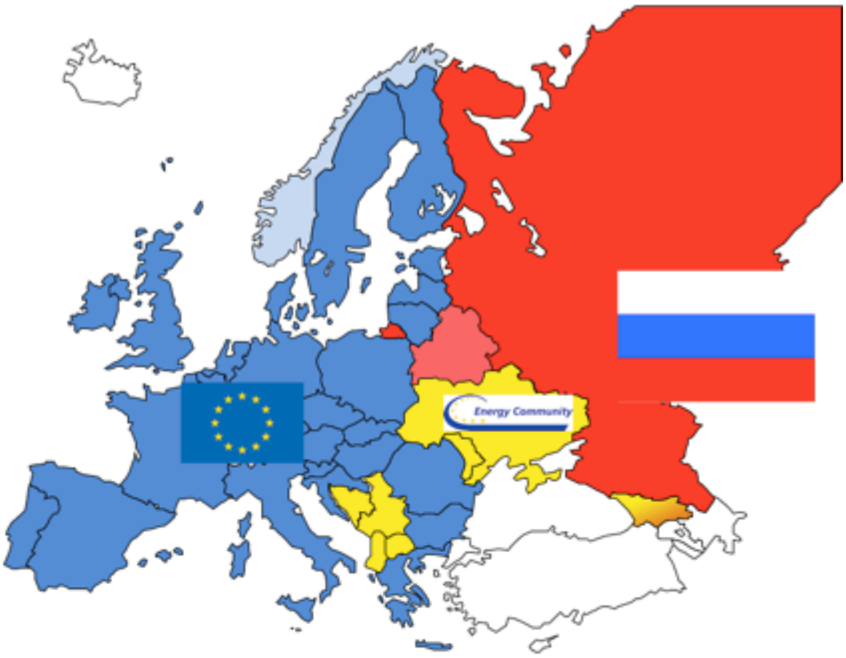

Figure 3 - Geopolitics behind power market, author's creation

Finland and Russia are historically connected, since Russia electricity suppliers saw an economical interest of selling power whereas Finland was in need. The transmission is however at stake due to the capacity market on Russia side as it will be reviewed later in this report.

Kaliningrad, an exception into the Federation is offering opportunities for cross-border transactions. This sole enclave must invest in domestic generation units to cover its own demand, but the capacity would be over-dimensionned and need to sell the surplus to come back to profitability.

1.2. ENERGIES AT STAKE

European Community is mainly focusing on the domestic market, where market coupling is the priority. Talking about market coupling is actually a fair way to demonstrate future of Electricity is the move to fully integrated market.

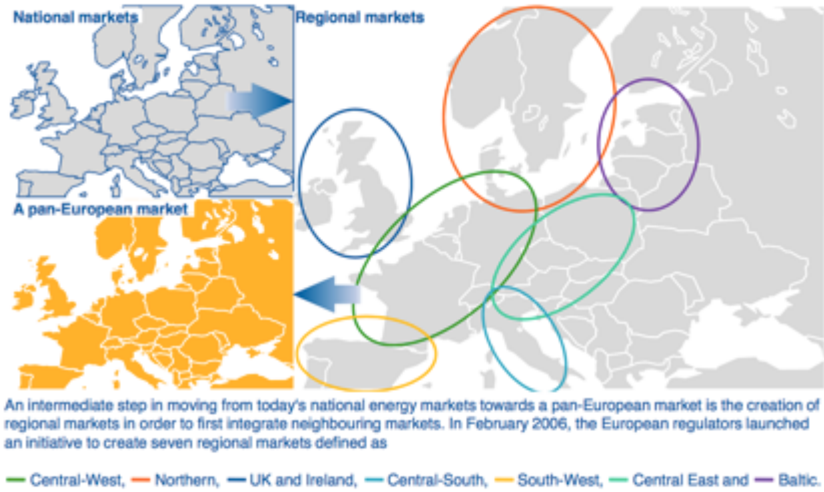

Figure 4 - Market Coupling vision, EMCC

However internal studies report that already NordStream gas pipeline capacity should be doubled to cover forecasted demand, and could be joint in parallel by Telecom and Power interconnection. All the grids are reaching an expected saturation, and on each of them, there must be a contingency plan for garanteeing their liquidity.

Energies are the core of the trade balance between Europe and Russia : in 2011, these are 27,5% of EU imported coal coming from Russia, 25% of Uranium for nuclear production, a large portion of oil, and well known 35% of gas.

From the 120 billions cubic meters of gas that are imported from Russia, that are 80 billions which are used for electricity generation. This is rational to investigate whether an import of power would be potentially prefered to an import of primary resources. Even more, from European prospective, power can be traded over the 2 ways depending of the peak demand, and can be another trade opportunity.

2. BENEFITS OF EU-RUSSIA INTERCONNECTION

2.1. POWER VS GAS

Europe seek for security of supply, whereas Russia must ensure security of demand. Gas is the primary resource that can be traded as one party owns huge reserve, and other party can store it easily and use it for power and heating. Gas grid already demonstrated its flexibility during first Ukraine crisis : reverse flow and deviation allowed the supply to continue. This grid management is close to Electricity grid management already.

As for gas, there is an investment barrier by building the grid, however the continuous densification of both networks proves there is profitability in such large projects.

The main difference stands in the fact that electricity flows over a synchronized network can not be controled (it goes following Kirchoff's law to where energy is lower in intensity and voltage), whereas gas pipelines identify the delivered customer. This sensitive matter is already properly appreciated over Europe since commercial transactions rules over physical transactions, but confidence could be brought to external entities using HVDC interconnectors (systems which can regulate the flow of energy, and desynchronizing the linked networks).

2.2. STABILITY OF THE GRID

As mentioned, newly deployed HVDC technology as it will be described later on in this report allow the separation of two interconnected grids. Reports from various European TSO representatives as well as members of the taskforce for EU/Russia Energy Dialogue 2050 establish the risk for frequency management should the European network be synchronized with the Russia sector. The synchronization would require the technical adaptation of 30 to 40 power plants in Russia, evaluated unreliable by European technical experts. Indeed, all Europe is under the risk of spreading blackout in case of mismanagement.

HVDC is however compelling for higher level of investment. The new interconnection between France and Spain is estimated at 700M€ for a 65km-long underground interconnection, with a 1,400MW capacity, 8 times more than traditional electricity aerial line.

2.3. STABILITY OF THE MARKET

As explained later in this report, the wider is a market, the better convergence in price can be obtained, and the more diluted are any situation, such as suden unavailability of a generation unit, increasing injected volume of intermittent energies. The regulations are set over the two market areas, clarifying how to enter the market, actually the various markets (day-ahead, intraday, capacity, dispatchable demand), and which entity is responsible for clearing all the transactions. Once the two frames of policies would be aligned, the extension of market place would bring additional commercial actors, increasing the fluidity of such market. At a time where it is garanteed the power costs will raise drastically, the seek for any price convergence becomes critical.

3. ABOUT INVOLVED TECHNOLOGY

3.1. INTRODUCTION

Development of electrical power supplies began more than one hundred years ago. At once, there were only small DC networks within narrow local boundaries, which were able to cover the direct needs of industrial plants. With an increasing demand on energy and the construction of large generation units, typically built at remote locations from the load centers, power to be transmitted, voltage levels and transmission distances increased: the technology changed from DC to AC.

The development of Electric Power Industry follows closely the increase of the demand on electrical energy. In the early years of power system developments, this increase was extremely fast, also in industrialized countries: energy consumption doubled every 10 years for many decades. It has been followed by the development of new technologies in the field of high voltages, and by innovations in design and manufacturing of the equipment. Increasingly higher voltages have been used, first at 110 and 220 kV levels in Europe, then 287 kV in USA and 380 kV in Europe. Finally, the 735 kV level in Canada and corresponding 765 kV level in other countries have been established. A transmission project with 1,150 kV level has been built-up in the Soviet Union.

In industrialized countries extensive interconnected systems were built in the past to gain the well known advantages, e.g. an ability to use larger and more economical power plants, reduction of reserve capacity in the systems, utilization of the most efficient energy resources, and to achieve an increase in system reliability. As the regional networks have been built to supply energy from power stations relatively close to the load centers, the voltage levels have been chosen according to these initial conditions. However, due to the demand for interconnection to other systems, which rose from massive introduction of renewable energy in developed counties, and for exchange of power between them, these conditions have been changed. Power has now to be transmitted over longer distances by insufficient voltage levels and systems are in general not well developed at the system borders. This can produce technical problems leading to bottlenecks when power has to be exchanged between the systems.

Interconnection of separated grids can solve some of these problems, however, when the interconnections are heavily loaded due to an increasing power exchange, the reliability and availability of the transmission is reduced.

Germany, for instance, plans to build wind farms with up to 30GW of capacity in the northern part of the country between now and 2020. But most of its energy consumption is in the south. So the real question for Germany is how to get its renewably generated electricity from the north to the south. Existing power lines can't do the job; already, clean electricity from the north often has to be redirected through Germany's eastern and western neighbors in order to get to the south. A huge expansion of the grid therefore appears to be unavoidable. In response to this challenge, Germany's federal government and the country's four power transmission companies presented a grid development plan in May 2012. The plan calls for the construction of 3,800 kilometers of new transmission lines over the next ten years. After it's completed, this colossal project could serve as a model for sustainable energy supply systems in other countries, especially if, as is the case in Germany, a large share of renewable energy sources is situated far from major energy consumption centers, **and power has to be transported over long distance over several countries: Either electricity highways are built**, at an expected tremendous cost[5] **or interconnection between incumbent grids are power up**.

The liberalization in the power industry additionally supports interconnections to enable exchange of power among the regions or countries and to transport cheaper and more ecologically suitable energy over long distances to the load centers. Maximum reasonable distances to transmit power by AC line still economically are in the range of up to 3,000 km. In the future, the situation can, however, change if ecological and political terms or the present cost conditions alternate.

[5] European project e-Highway 2050, as a DC-ring across Europe

3.2. SYNCHRONOUS INTERCONNECTION BETWEEN GRIDS

A wide area synchronous grid is an electrical grid at a regional scale or greater that operates at a **synchronized frequency** and is electrically tied together during normal system conditions.

The benefits of synchronous zones include pooling of generation, resulting in lower generation costs; pooling of load, resulting in significant equalizing effects; common provisioning of reserves, resulting in cheaper primary and secondary reserve power costs; opening of the market, resulting in possibility of long term contracts and short term power exchanges; and mutual assistance in the event of disturbances.

In large AC Systems with long distance transmission and synchronous interconnections, technical problems can be expected, mainly from load flow, system oscillations and inter-area oscillations. If systems have a large geographic extension and have to transmit large power over long distances, additional voltage and stability problems can arise.

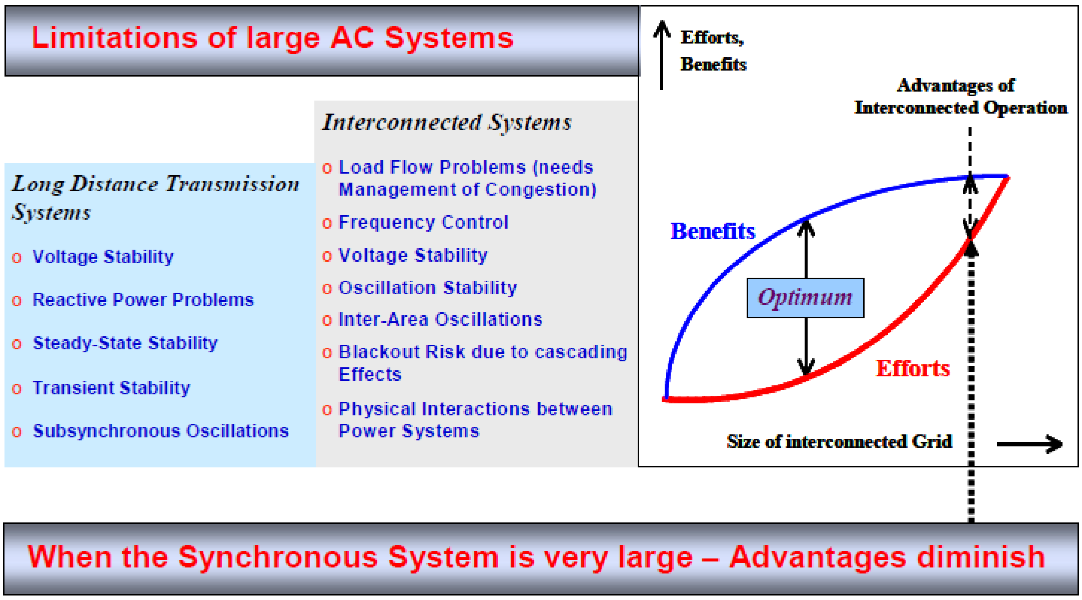

Figure 5 - benefits & drawbacks of large synchronous networks (CIGRE Session B4-106 2004)

The geographical size of the UCTE[6] power grid, from Portugal to the eastern boundary of Poland, amounts to about 3,000 km. **Assuming East-West interconnection project is realized, the distance from the outermost eastern to the utmost western points of the interconnection can reach 9,000 km**, and assuming integration of power systems of North Africa and Middle East (TESIS – through Desertec program), it can exceed 12,000 km. Such interconnected power system will have severe wave characteristics. Most of it is characterized in the wave of frequency, caused by emergence of a large active power imbalance in one part of the power grid, will be moving, at a infinite speed, along the transmission system. Under some conditions, this wave of frequency can give rise to continuous low-frequency oscillations.

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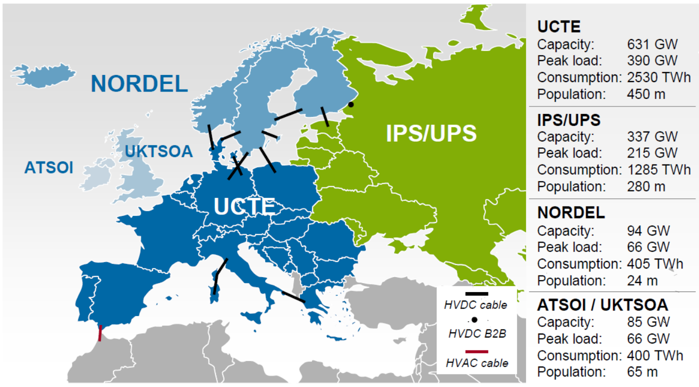
[6] Former ENTSOE

FEASIBILITY STUDY OF SYNCHRONOUS INTERCONNECTION OF THE IPS/UPS WITH THE UCTE.



At the beginning of 2002, the Electric Power Council of the Commonwealth of Independent States (EPC CIS)[7] expressed its interest in a synchronous interconnection with the power systems of the CIS countries and the Baltic States (IPS/UPS) to the power systems of the members of the Union for the Co-ordination of Transmission of Electricity (UCTE). Therefore, the UCTE decided to conduct a preliminary feasibility Study[8] in order to analyze the steady state load-flow. After this was completed in 2003, the UCTE and the EPC CIS's Commission on Operational and Technological Coordination (COTC) agreed to launch a detailed feasibility study[9] on the synchronous interconnection of the power systems concerned. The project was carried out in close cooperation with a UCTE consortium and a group of companies from the IPS/UPS in 2008.

The Feasibility Study's purpose was to answer the following major concern: **Is a synchronous interconnection of the IPS/UPS and the UCTE technically possible?**

Based on the current separate synchronous areas, models for the power system simulations were prepared by the UCTE and the IPS/UPS, respectively. Both parties were responsible for their respective model preparation and for their individual validation procedures. These were carried out by an interactive comparison of real measurements and system simulations. After the setting up of the individual models, they were merged in order to create joint simulation models for evaluating the impact of a possible synchronous coupling. The UCTE and the IPS/UPS focused their analyses on their individual synchronous systems in line with their skills.

In parallel to the modeling and data acquisition process, the installation of a Wide Area Measurement System (WAMS)[10] – similar to the one operating in the UCTE – was initiated in the IPS/UPS synchronous area. This transient measurement system was a prerequisite for the validation of the dynamic simulation models. One was able from early 2007, to observe the dynamic system behavior of the whole synchronous IPS/UPS area and receive measurements, for example, following disturbances in the grid. Some 26-measurement devices had been installed in the IPS/UPS up to April 2008. Around 50 measurement devices was currently installed in the UCTE synchronously operating systems.

The nine tie lines (three of 750 kV, four of 400 kV and two of 220 kV) considered as being available for the coupling itself. Eight links connect Ukraine with its Western neighbors and one 400 kV line links the transmission system of Moldova with Romania. The transmission lines and the "MIR" power system were operated as an integral part of the IPS/UPS up to 1995, prior to Poland, Hungary, Slovakia and the Czech Republic being synchronously interconnected to the UCTE. These lines need to be refurbished and partly reconstructed in order to have a synchronous coupling between the UCTE and the IPS/UPS. Due to their independent development in the past, major differences in the system structure and operation philosophy exist between the UCTE and the IPS/UPS. The UCTE system is developed using the n-1 contingency as the planning criterion (that is, when a single outage of any component of the power system takes place, the grid has to be within limits), whereas in the IPS/UPS, this criterion is met with the support of a set of operational actions mainly comprising of load and generation shedding.

Erreur ! Source du renvoi introuvable. are available in appendix.

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[7] A. A. Grobovoy, A. J. Germond, N. V. Bondareva, B. J. Trémérie, «Full Scale Experiment of the East-West Interconnection»

[8] Union for the Co-ordination of Transmission of Electricity: Pre-Feasibility Study – Load Flow Analysis with Respect to a Possible Synchronous Interconnection of Networks of UCTE and IPS/UPS. Brussels, April 2003.

[9] Feasibility Study: Synchronous Interconnection of the IPS/UPS with the UCTE. Brussels, November 2008.

[10] Ayuev, B., Erokhine, P., Kulikov, Y.: IPS/UPS Wide Area Measuring System. CIGRE, 41st Session, August 2006

RESULTS FROM STEADY STATE ANALYSIS

The models for the steady state and load flow analyses reflect the planning status in 2008 for both synchronous areas. The main economically-impacting outcomes are:

- In most cases, the power transmission is limited due to the internal congested sections in each synchronous zone. Short distance power transfers between the systems in the interface zone reached a secure power transfer in the East West direction of about 1,000 to 3,000 MW. The calculated West-East transfer is limited to 1,000 MW, limiting the access to power exchange in terms of transaction volumes. This is advocating for wider interconnection capacity.
- The simulations clearly proved that in the synchronously coupled system structure, the capacities for long distance power transmissions are rather limited. In about 50% of the simulated long distance transmissions (e.g. Russia/Germany or Russia/Italy) **the transferable capacity across the interface was less than the mandatory transfer capacity for the provision of control reserve**. In order to guarantee system security in the UCTE after a synchronous coupling to the IPS/UPS, the UCTE grid must be improved or the present available capacity for the market in the UCTE needs to be reduced, limiting by as much amount of capacity the access to power exchange markets. A long-term analysis of market developments needs to be initially carried out in view of the requirement for a realistic allocation of the investments involved.

DYNAMIC SYSTEM SIMULATIONS

Analyses showed that the coupling of the IPS/UPS and the UCTE might not ensure reliable support between the systems in such emergency situations. Instead, it could worsen the situation due to severe stability risks. The simulation demonstrated the technical drawbacks of large synchronously interconnected systems when considering the survivability of the systems concerned in the event of major incidents.

Economical benefits that are mainly associated with the extension of power systems are to some extent countervailed by technical drawbacks. Priority has to be given to preventing of propagation of disturbances and their consequences throughout the interconnected system.

POWER SYSTEM CONTROL ANALYSIS

The synchronous coupling of the two transmission systems leads to reduced frequency deviations after a large, sudden loss of power. This is a result of the mutual cooperation, which is automatically activated by primary control within the whole synchronous area. The amount and distance of the related power flows increase in proportion to the capacity of the synchronous area and its geographical extension, respectively.

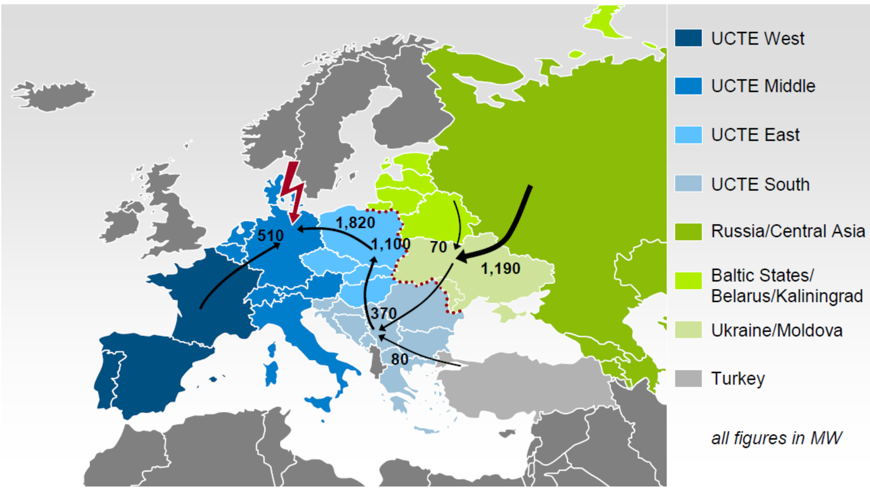

Figure 6 - ***Control power flow after an outage of 3,000MW over UCTE (Synch. Interco. of the IPS/UPS with the UCTE)***

Today the frequency volatility of the CIS grid is comparable to that of the UCTE grid. In 2002, for the first time the frequency volatility of the UPS /IPS System was sustained within the UCTE's acceptable parameters (0.2 Hz) for 100% of the operating hours.

The installed power and the control reserve in both systems are in the same range. **Erreur ! Source du renvoi introuvable.** illustrates the distribution of the control power flow after a loss of 3000MW generation capacity in Germany. In the case of a 3,000 MW outage (which is the dimensioning amount of reserve power in the UCTE system), a ~1,500MW regulating power flow will cross the interface area. This flow has to be managed in a safe manner. Hence, free transfer capacity has to be maintained at any time in order to allow this regulating power to flow through the interface in both directions.

The synchronization scenario between UCTE and IPS/UPS is translated in less capacity made available for trading, hence "missing money" for the market, however, under current circumstances, the introduction of capacity markets over Europe and Russia, is re-instating the value of reserve capacity to ensure the security of supply.

Although the conclusions indicate that a synchronous coupling appears technically viable, it must be considered as a long-term option. The findings underline the overall complexity of a synchronous coupling, in the context of system security and overall reliability.

Therefore, a synchronous coupling of the UCTE and the IPS/UPS would require the consideration of an additional Control Power Flow Margin (CPFM) for determining the Available Transfer Capacities (ATC). The CPFM is not incorporated in the Transmission Reliability Margin (TRM) according to definitions applied in the UCTE at the present time. Thus, in order to respect system security, the required amount of CPFM has to be determined and the ATC has to be reduced correspondingly for the market across the IPS/UPS-UCTE interface.

3.3. ASYNCHRONOUS INTERCONNECTION BETWEEN GRIDS

HVDC TECHNOLOGY

HVDC technology has been successfully proven in various specific applications worldwide. The major difference of a DC solution compared to an AC coupling concerns the decoupling character of the link. **When system disturbances occur, neither a dynamic interaction between the coupled systems, nor the factor of the CPFM (which reduces the installed interface capacity) has to be considered, as is the case with a synchronous coupling. Additionally, DC links allow the control of the power flow, that is used for discharging the grid under overload and emergency situations.** Ultimately, due to their technical features, back-to-back links could result in an "easier to realize" perspective for interconnection between grids.

In the second half of the past century, High Voltage DC Transmission (HVDC) has been introduced, offering new dimensions for long distance transmission. This development started with the transmission of power in an order of magnitude of a few hundred MW and was continuously increased to transmission ratings up to 3 - 4 GW over long distances by just one bipolar line. Now long-distance power transmission (2,000km) at a voltage level of 800 kV - providing power capacities of up to 7GW - has now become technically as well as economically feasible for the first time ever. Both poles of the first 800 kV UHV DC system, ordered by the China Southern Power Grid Co. in Guangzhou, are in commercial operation since June 2010.

In 1956, ABB built the first high voltage DC (HVDC) transmission line in the West (which is still in service, though it has since been upgraded) between Gotland Island and the Swedish mainland, via a subsea cable. The Soviet Union had built an HVDC line earlier than that, between Moscow and Kashira, which was based on technology taken from the Germans after WWII. These early projects were based on mercury arc valves. Since then, HVDC has evolved a lot, and is now the best way to transmit large amounts of power great distances.

By these developments, HVDC became a mature and reliable technology. Almost 50 GW HVDC transmission capacities have been installed worldwide up to now. Transmission distances over 1,000 to 2,000 km or even more are possible with overhead lines. Transmission power of up to 600 - 800 MW over distances of about 300 km has already been realized using submarine cable, and cable transmission lengths of up to about 1,300 km are in the planning stage.

To interconnect systems operating with different frequencies, back-to-back (B2B) schemes have been applied.

The interconnection alternatives with HVDC are schematically shown in Figure 5 - *a) back-to-back solution; b) long-distance solution*. The DC interconnection can be either long distance transmission or a back-to-back link. The back-to-back solution is more suitable for exchange of moderate power, e.g. up to 1200 MW in the areas close to the borders of both systems. If, however, a large amount of power should be exchanged or transmitted over long distances, the HVDC point to point transmission offers more advantages. Power can be brought directly to the spots in the systems where it is required without any risk to overload the AC system in between. A further advantage of such a solution is the control performance of HVDC, which can effectively support the AC system stability and damp inter-area oscillations.

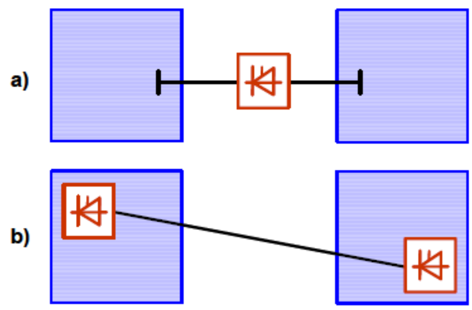

Figure 7 - *a) back-to-back solution; b) long-distance solution*

3.4. COMPARISON BETWEEN AC AND DC TRANSMISSION SYSTEMS IN TERMS OF LOSSES, COSTS, APPLICATION LIMITS.

Electric Power can be transmit in both AC and DC systems. However, there are some advantages and disadvantages of both systems.

Advantages of DC Transmission:

- Investment cost over long distance (Figure 10 - *Investment cost DC vs AC*)
- There are only two conductors used in DC transmission while three conductors required in AC transmission.
- There are no Inductance and Surges (High Voltage waves for very short time) in DC transmission.
- Due to absence of inductance, there are very low voltage drop in DC transmission lines comparing with AC (if both Load and sending end voltage is same)
- There is no concept of Skin effect in DC transmission. Therefore, small cross sectional area conductor required.
- A DC System has a less potential stress over AC system for same voltage level. Therefore, a DC line requires less insulation.
- In DC System, there is no interference with communication system.
- In DC Line, Corona losses are very low.
- In High Voltage DC Transmission lines, there are no Dielectric losses.
- DC system is more efficient than AC, therefore, the rate of price of Towers, Poles, Insulators, and conductor are low so the system is economical.
- In DC System, the speed control range is greater than AC System.
- There is low insulation required in DC system (about 70%).
- The price of DC cables is low (Due to Low insulation)
- In DC Supply System, the Sheath losses in underground cables are low.
- DC system is suitable for High Power Transmission based on High Current transmission.

In DC System, the value of charging current is quite low, therefore, the length DC Transmission lines is greater than AC lines.

Disadvantages of DC transmission systems:

- Due to commutation problem, Electric power cannot be produced at High (DC) Voltage[1]. AC Power has to be produced first then converted into DC. AC/DC converter substations use high voltage power electronic elements and have considerable cost compare with typical AC transmission substation. **The specific investment costs estimated for a back-to-back link are in the region of 12.5M€ / 100 MW.** Typical unit sizes for conventional HVDC back-to-back links vary between 600 and 1,000 MW.
- For High Voltage transmission, DC Voltage can not be step (As Transformer cannot work on DC). That is why AC power won the "war of the currents" in the 1880's, establishing its preference over DC.
- There is a limit of DC Switches and Circuit breakers. Usually there is no circuit breaker along DC transmission line.
- The level of DC Voltage cannot be changed easily. So desired voltage cannot be obtained for Electrical and electronics appliances (such as 5 Volts, 9 Volts 15 Volts, 20 and 22 Volts etc) directly from Transmission system.

Advantages of AC Transmission System:

- AC Circuit breakers are cheaper than DC Circuit breakers. Indeed, it is easy for AC circuit to break current transmission as AC current's instantaneous value crosses over zero-value over every period.
- The maintenance of AC substation is easier and less expensive than for DC Substation[1].
- The Level of AC voltage may be increased or decreased step up and step down transformers.

Disadvantages of AC transmission System:

- In AC line, the size of conductor is greater than DC Line.
- **The Cost of AC Transmission lines are greater than DC Transmission lines.** (Figure 8 - *Advantage of HVDC line*, including reduced transmission losses: Figure 9 - *Losses comparison DC vs AC*)
- In AC Lines, there is Capacity between line and ground, so continuously power loss when no load on lines or Line is open.
- Other line losses are due to inductance.
- More insulation required in AC System
- Corona Losses occur In AC System,
- There is telecommunication interference in AC System. Hence co-localizing power and IT/Teleco cabling along NordStream pipeline could only be performed over DC.

TRANSMISSION CAPACITY COMPARISON: DC VS AC

Voltage for AC transmission lines can readily be taken up to about 765,000 volts. This is the current maximum AC voltage, but beyond that, power dissipation through dielectric loss becomes significant. Dielectric losses are caused when dipoles in matter align with a changing local electric field. As the polar structures turn to follow the field, the movement causes local heating. The dielectric loss during transmission is equal to the total heat that is generated in materials around the power lines due to induced motions of electric dipoles. At high voltage, non-resistive power dissipation via dielectric losses (for AC only) and/or through corona discharge (for both AC and DC) becomes severe. Voltage for DC overhead power lines can be taken up to higher voltage than the maximum practical AC voltage; at present the worldwide maximum is ±800 kV for HVDC lines. Note that the way that voltage is reported for AC vs. DC power lines is different. A ±800 kV DC power line has 1600 kV conductor-to-conductor (800 kV conductor to ground), whereas AC voltage refers to the conductor-to-conductor root mean square, or "rms" voltage; roughly speaking AC rms voltage is comparable to the line-to-line voltage in DC in terms of transmission capacity. In effect, HVDC voltage can go about twice as high as HVAC voltage, which explains most of the advantage of overhead HVDC lines compared to overhead HVAC lines.

Wire diameter is limited for AC transmission lines due to the "skin effect" that prevents an AC current from penetrating to the center of a large wire, whereas a DC line can be arbitrarily thick. At 60 Hz, the skin effect becomes significant for wires greater in diameter than about an inch. Because of the skin effect in part, multiple wires arranged in a circular pattern and separated by polymer spacers are often used in high capacity high voltage AC transmission lines. Thus, overhead HVDC power lines can transport significantly more power for greater distances than AC lines, for two main reasons: the effective voltage can be higher, and the wires can be bigger. But DC lines were not developed initially to be capable of higher voltage, nor to be able to move more power than AC lines, but rather to make it possible to put high capacity power lines underground (for security) or under the ocean (to bring power to islands initially).

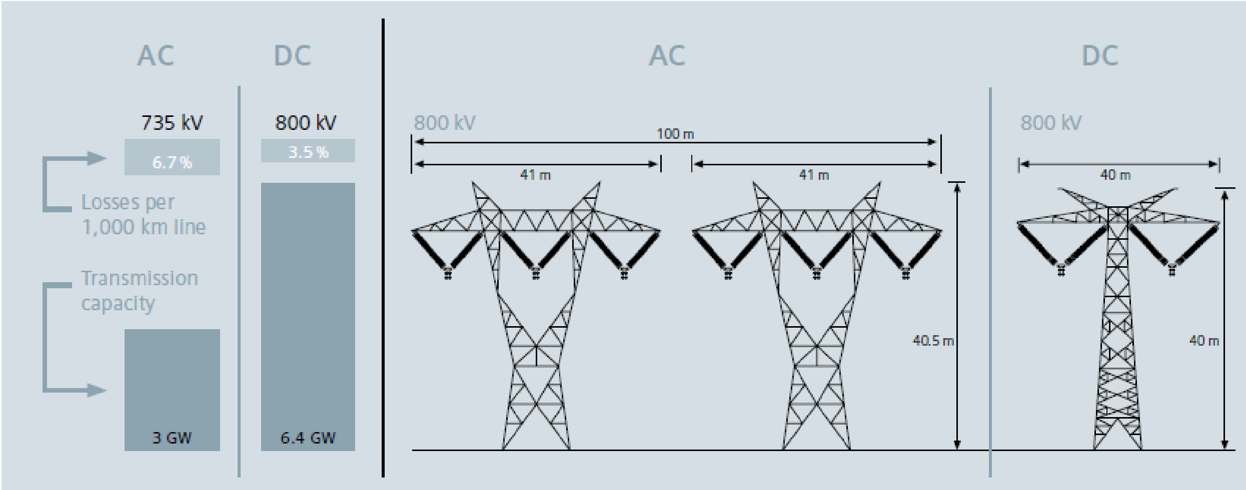

Figure 8 - ***Advantage of HVDC line (Siemens. The Bulk way. 2011)***

HVDC yields enormous transmission capacities and at the same time keeps losses to a minimum. Footprint of an HVDC transmission line is significantly smaller than the footprint of a double-circuit AC transmission system with the same redundancy. (For a n-1 redundancy design, bipolar DC transmission is equivalent to a double-circuit AC system). The need for ROW (Right Of Way), both economically, and environmentally, is much smaller for HVDC than for HVAC, for the same transmitted power.

LOSSES COMPARISON AC VS DC

HVDC transmission losses are lower than AC transmission losses in practically all cases. An optimized HVDC power transmission line has lower losses than AC lines of the same capacity. Losses in the converter stations must also be added and they are about 0.6% for HVDC based on classic technology and below 1% for HVDC based on VSC technology of the transmitted power in each station. Hence, in a side-by-side comparison, total HVDC transmission losses are still lower than the AC losses in practically all cases. HVDC cables also have lower losses than AC cables. The diagram below shows a comparison of the losses in 1,200 MW overhead line transmissions using AC and HVDC. That are close to 30% reduced losses on HVDC.

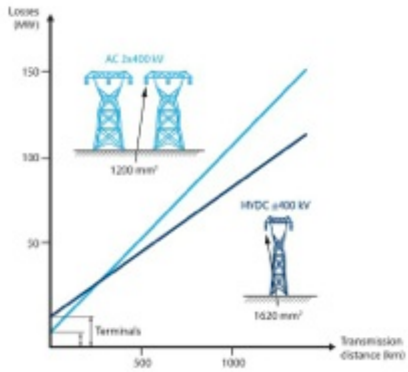

Figure 9 - ***Losses comparison DC vs AC (ABB)***

UNDERGROUND LINES COMPARISON: AC VS DC

To understand why undergrounding HVDC lines for great distances is feasible, while undergrounding HVAC lines for more than about 40 miles is not, it is necessary to consider the capacitance of air-insulated overhead lines versus cables, which are typically surrounded by polymer insulation and soil. Capacitance is a property of every electrical circuit, not just capacitors (which are designed deliberately for high capacitance). A wire suspended in air has much less capacitance (by about a factor of 50-100) compared to a cable, in which the wire is surrounded both by polymeric insulation and soil. The capacitance limits how fast the voltage responds at the far end of a power line when voltage is applied at the near end. Capacitance has only a small transient effect on a DC power transmission line, delaying the voltage rise at the far end of the line by milliseconds at most when voltage is applied at the near end. When capacitance of an AC line is too high though, it has a quite dramatic effect; this is the case because at 50 Hz, the voltage reverses 100 times per second (10 milliseconds for per reversal); each time this happens, the "line capacitor" needs to be charged up before any power can flow through the line. The much higher capacitance of a cable (especially one that is located underground or undersea) means that this limiting line capacitance is reached for a much shorter cable (50 to 100 times shorter) than an overhead line. Thus, at most short bits of an AC power transmission line can be placed underground, whereas there is no problem in terms of power flow with putting a DC power line underground.

INVESTMENT COST COMPARISON DC VS AC

An HVDC transmission line costs less than an AC line for the same transmission capacity. However, it is also true that HVDC terminal stations are more expensive due to the fact that they must perform the conversion from AC to DC, and DC to AC. But over a certain distance, the so-called "break-even distance" (approx. 600 – 800 km), the HVDC alternative will always provide the lowest cost. The break-even-distance is much smaller for subsea cables (typically about 50 km) than for an overhead line transmission. The distance depends on several factors (both for lines and for cables) and an analysis must be made for each individual case. The break-even distance concept is important, but only one of a number of factors, such as controllability, that are important to consider in choosing an AC or HVDC transmission system.

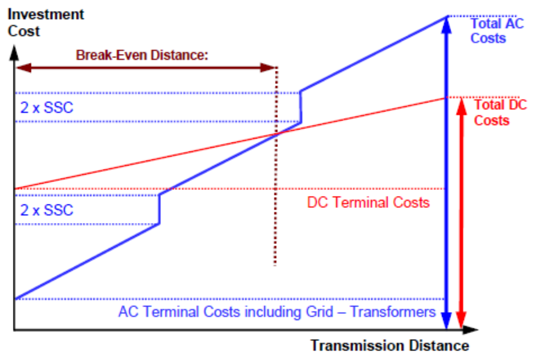

Figure 10 - *Investment cost DC vs AC (Friends of the Supergrid. Roadmap to the Supergrid Technologies. 2014)*

DC/DC TRANSFORMER AND DC CIRCUIT BREAKER. WHY DID AC GRID IS FAVORED?

Nearly all of the above factors would seem to favor DC over AC transmission, so why are most transmission lines, and virtually all power distribution lines AC? Simply put: transformers (which change voltage of electrical power) and circuit breakers are dramatically less expensive for AC than for DC power. At the time that the first long transmission lines were built, there was no such thing as a DC/DC transformer, and that hard technical limitation persisted for a hundred years. Today, electronic DC/DC voltage transformers are found on every computer motherboard, and can be built for high voltage, high power conversion as well, but these devices are a lot more expensive at present than conventional transformers. However, being electronic devices, these DC/DC transformers have been on a steeply declining cost curve for some time now, and it is probable that they will in the future reach cost parity with conventional AC/AC transformers. Meanwhile DC circuit breakers are also a huge problem, especially at high power levels above 1MW. ABB recently announced a breakthrough on HVDC circuit breakers that they say will allow HVDC circuit breakers up to 1GW. Unpublished ABB costs are estimated about 100 times as high as comparable AC circuit breakers.

3.5. FACTS TECHNOLOGY

FACTS DEFINITION AND APPLICATION.

In theory, an AC transmission system should be able to carry power up to its thermal design limits. However, the AC transmission system becomes constrained to ratings which are often well below its thermal limit. These constraints are mostly caused by reactive power, as most loads consume reactive power as well as active (real) power. Simply put: An excess of reactive power will lead to over-voltages, too little reactive power will cause under-voltages – both can lead to a supply voltage at consumers which is not within contractual limits or even line tripping.

Long distance power transmission, which becomes necessary due to replacement of existing power plants in Europe, changes the reactive power flow within the HVAC system and can have unwanted side effects as explained above.

Therefore, a reactive power balance has to be maintained, both statically and dynamically, throughout an AC transmission network for security of supply.

Flexible AC Transmission Systems (FACTS), based on power electronics have been developed to improve the performance of long distance AC transmission, specifically to overcome certain limitations in the static and dynamic transmission capacity of electrical networks. The main purpose of these systems is to supply the network as quickly as possible with inductive or capacitive reactive power that is adapted to its particular requirements, while also improving transmission quality and the efficiency of the network. Later, the technology has been extended to the devices which can also control power flow. Excellent operating experiences are available world-wide and also FACTS technology became mature and reliable.

FACTS provide:

- Fast voltage regulation
- Increased power transfer over long AC lines
- Damping of active power oscillations
- Load flow control in meshed systems

This means that with FACTS, power companies will be able to better use their existing transmission networks, substantially increase the availability and reliability of their line networks, and improve both dynamic and transient network stability while ensuring a better quality of supply.

Technical details are available in appendice.

3.6. CONCLUSIONS ABOUT TECHNOLOGY

Implementing completely new transmission systems and components is a long-term strategy for meeting these challenges. Over the short and medium term, modern transmission technologies can be employed at comparatively little expense to rectify or minimize bottlenecks and substantially improve the quality of supply. Often, this makes it possible to postpone investing in new plants and, as a result, to achieve critical advantages over the competition – especially important in de-regulated energy markets in which power supply companies are subject to extreme pricing pressure.

An expanded European electricity grid will go beyond the existing ENTSO-E (European Network of Transmission System Operators for Electricity) system, and possibly extend all the way to Iceland, Russia, the Middle East, and Africa. In order to explore associated possibilities, the European Commission launched the "e-Highway 2050" study in mid-2012. Up until now, grid planning was carried out by individual countries — but what needs now is a European-wide concept. The Commission's study will define the technical framework and propose appropriate policies for Europe. There are still no binding rules regarding which technologies should be employed to put electricity into the grid and how they might be used.

HVAC equipment and operation has been developed over more than 100 years and highly standardized solutions are available today. This allows short-term competitive supply chains for all network components, such as transformers, switchgear, protection relays etc.

For HVDC technology, however, this is not the case. With very few exceptions, HVDC links are point-to-point connections, each built by one manufacturer. Each manufacturer's technology differs significantly in detail and cannot be easily combined with that of others. This applies both to the relatively mature Line Commutated Converters (LCC) and even more to the new technology based on Voltage Sourced Converters (VSC). When Multi-terminal HVDC networks or HVDC Grids are to be developed, interoperability of the equipment provided by different manufacturers becomes important. In a first step, agreement on some fundamental operating principles of HVDC networks is needed, such as:

1. Fault behaviour including:
2. Power System Protection including:
3. Converter Control and Protection
4. HVDC grid controls

To ensure optimized development of the future integrated grid it is critical to agree such basic principles for the technologies. Work is under way within organisations such as CIGRE and Cenelec to develop the necessary standards and to suggest standard transmission voltage levels for the Supergrid links.

Developing standards takes time and experience. HVDC Grids are new and consequently standardization should be focused on functionality rather than on detailed parameters and technical solutions. This approach will provide the ground for an open market for HVDC Grid technology while at the same time allowing for innovative solutions.

Other standard definitions are required for the performance requirements for the Supergrid including reliability, availability, Loss of Load Expected, Infeed Loss etc. Transmission systems are typically designed based on N-1 criteria and the Supergrid design must address these reliability issues.

Hence HVDC shall be the base for future infrastructure as this is the only technology, which can afford both stability of the grid and expansion of the interconnections, as well as enhanced ROI[11]. HVDC is also the only technology that allows long-distance transportation of electricity. Supergrids, electricity highways[12], as integrated in multiple PCI[13] of the European Commission, are projects financially dependant from the supply of generated energy to extremely remote areas. Beside, as the great portion of renewable energy shall be issued from off-shore farms, it is worth reminding AC cabling can not be implemented over longer distance than 50km. Reviewing the interconnection map over Baltic Sea, this constrain flags critically.

[11] refer to Appendice for ROI/NPV forecasted estimations
[12] e-Highway 2050 is the most critical project of European Commission
[13] potential Projects of Common Interest in energy infrastructure from the prospective of European Commission

4. ISSUES & CHALLENGES: PREVIOUS CASE

ANALOGY WITH DESERTEC

European power demand already triggered the ambition of investors. Keeping in mind, that only 0.5% of the surface of the North African deserts can cover energy, mainly electricity, demand of the entire world, and for this only about 500 square kilometers of surface are needed[14] covered with solar panels. Considered this area to be a full desert, thus the surface is not usable for agriculture or living, the only challenge is to transport the produced electricity to the spots, where it is needed, for example to Europe across the Mediterranean Sea. Various studies were performed on the topic, analyzing technologies and finances, and considering the pros & cons of such plan. Not only studies were produced also the organization DESERTEC was founded in order to promote the idea of Saharan clean energy to Europe. We would like to take a look at the DESERTEC project from the perspective of analogy to the electricity interconnection between Europe and Russia. However, DESERTEC can not be considered as a fully similar or related to the EU/Russia interconnection project, because the reasons for implementation behind these mission are slightly different. From our point of view, DESERTEC should be considered as an experience, for the purpose of lessons learned, in order not to repeat the same mistakes with the future large-scale multinational projects.

The idea of DESERTEC was born in 2009. Its main goal is to provide the Europe with electricity from renewable energy sources. As technologies to implement CSP – Concentrated Solar Power plants, as the technology is proven and has storage possibilities and wind farms were the lead technologies. The electricity, about 100 GW[15] would be generated in the desert of MENA – (Middle East North Africa) region and transferred to Europe and Africa via high-voltage direct current (HVDC) transmission lines. The advantage of HVDC in comparison to conventional AC transmission is less loss: three percent per 1,000 kilometers[14]. All in one it is a concept paper on energy, water and climate security.

Figure 11 - DESERTEC project map

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[14] DESERTEC Foundation, 2010. http://www.desertec.org/en/concept/benefits/
[15] Snieckus, 2014

Structurally the project was initially divided in two components: the DESERTEC Foundation and the DII (DESERTEC Industrial Initiative) GmbH. DESERTEC Foundation being a non-profit organization, focused on developing the DESERTEC concept and vision, and DII GmbH incorporated by a group of over 50 companies, nearly entirely European, working on implementation and financing of the vision[16]. Among others the shareholder in the Foundation are ABB, Abengoa Solar, Deutsche Bank, Enel Green Power, E.ON, First Solar, Red Eléctrica de España, RWE, Avancis, Schott Solar and State Grid Corporation of China. Also more then 16 countries have signed associated contracts with the foundation[17].

The main idea of the project was that European countries could supplement their domestic electricity mix with the clean imported electricity, at the same time strengthen the partnership with MENA region and reduce the dependence on Russian, Algerian and Norwegian gas and Arabian Gulf oil. The CSP being the main technology for DESERTEC can provide renewable controllable electricity from sun and this could compensate for the fluctuations known from PV and wind power plants. For the future it means, that more variable energy from PV and wind sources can be used in the electricity mix. The network extension is one of the mainstays of DESERTEC and the modernized grid could be used more efficient[18]. If implementing according to the initial plan, the project would start to supply Europe with electricity in 2020 and to provide up to 15%-25% of Europe's energy needs by 2050[19].

The difficulties started with the preliminary cost calculation. In the first estimation the cost of project were calculated as about **400 billion euros**[20]. The costs from transmission loss of electricity would also factor in and are not precisely included in the overall calculation. Later on, based on high cost voices against the idea appeared. Some experts do not agree to the "outsourcing" of power production from Europe, and insist on keeping the technologies within EU borders[21].

One more challenge of the project were the drivers to bringing it forward. It was mainly focused on commercial interest, and not too much on modernization, technology development, improvement of local living conditions and energy mix finding for the MENA region[22]. Critics have accused DESERTEC of being "nothing more than a new and expansive form of energy colonialism, where Europeans outsource their energy needs to poor African countries, leaving little else but pollution behind[23]. What's more, MENA region is different from Europe and CIS in its structure. The political uncertainty in the region and change in society, resulting from the Arab Spring, is another complicating dynamic, the most risky factor of which is the uncertainty on the final way of solving the political situation. Now the MENA region, where the concentrated solar power plants would be located, is not fully stable and secure.

The major argument supporting the DESERTEC initiative was the reduction of dependence on Russian gas supply, especially in the context of gas crises in 2006 and 2009. The critics mention that as long as the EU does not have real substitutes to Russian gas, it hardly depends on that supply. From this point of view, the sustainable energy partnership with Russia could only be workable while simultaneous establishment of new pipelines and HVDCs to the MENA region and progress towards technological diversification for solar power generation[21]. Also the enormous potential of the region was crucial. According to DII's figures, RES capacity in MENA increased by 30% compound annual growth rate since 2000 and now it is on track to double to more than 8GW by the end of the year 2015, e.g. only wind is expected to add 20GW by 2020[24].

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[16] Burger, 2012
[17] DII GmbH, 2010
[18] DESERTEC Foundation, 2010
[19] Morrison, 2009 & Paradigma, 2012
[20] Euractiv, 2012
[21] Brix, 2010
[22] Osama, 2011
[23] Euractiv, 2012
[24] Snieckus, 2014

DESERTEC, in contrast to the dependency on Russian gas, split the risk of non-supply, shortages or other troubles across about 50 countries in MENA. Important is also that African countries are politically less stable than Russia, this fact will give the EU a stronger position than in Russian relationship and pursue its interests more easily. In any case, political willingness is crucial for success of the project of the scope like DESERTEC[25].

Trying to analyze and find the analogy with the problematic of the EU/Russia electricity interconnection we may say, that the idea of electricity generation from renewables at places where the sources are is brilliant. The way towards electrification of the MENA region is progressive and future oriented. However, there are some major issues for DESERTEC, which have not been completely solved. One of them is the transfer of this electricity across thousands of kilometers. Although the HVDC technology can provide quite reliable electricity transfer, the losses are acceptable according to engineering experts, the cost of the technology and of the infrastructure needed must me considered. The key stakeholders have stepped out, the foundation and DII continue it's functioning[26]. However the latest publications are optimistic and show the new progress. DII aims to guide the construction of over 30GW of wind and solar in the MENA just as a beginning[27]. The MENA countries have now in opposite to 5 years ago RES in their energy strategies and look for new energy[27]. So we may say, the project is still alive and making efforts on the way to first constriction works.

Coming back to the analogy with EU/Russia, the implementation of DESERTEC on the current planned scale, would definitely redact dependency on current oil and gas and the countries supplying them. Especially in this context, the idea of electricity interconnection between Russia and EU would bring even more dependency on Russia. Not on gas and gas pipelines anymore, but it is the same country and region. The same with DESERETEC, it will create new dependencies. The evaluation of advantages and disadvantages of depending on current energy suppliers versus new partners from the MENA region is needed on the EU level[25].

Concluding all said above, the main reasons for not fulfilling the plan and not implementing the project in the full scope could be listed as follows[28]:

- The project had troubles mainly due to high (400 billion euros) and not transparent project cost and its structure. The fact that infrastructure is missing almost completely: the transmission lines in Europe must be assembled too. Not only the CSP in MENA must be constructed, also the infrastructure on the European side. Recently CEO of Siemens Mr. Loescher in one the interviews rejected suggestions that the DESERTEC project cost was unviable. "Today's electricity highways can be highly efficient, both financially and technologically," the Siemens chief executive said."[29].

- The main technology - concentrated solar plants (CSP), is a proven technology, but not competitive in cost with photovoltaic and wind power plants, in terms of investments (Torresol Spanish commercial project, even though offers best capacity factor (63,1%) over solar energy, requires an average 25€/Watt against 4 to 6€/Wc for PV, that are 11 to 17€/Watt). Probably the economies of scale and synergies will appear, now it is very costly plus the one needing high-qualified personnel.

- The multilateral partnership is always a challenging task, especially in the politically instable region of MENA and the context of Arab Spring. A partnership with over 50 countries, most of them represented by public institution and central authorities, all of them having own interests and main focuses, also the absence of representatives of the local communities make the communication and acceptance by the local people difficult.

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[25] Brix, 2010
[26] Borchardt, 2013
[27] Snieckus, 2014
[28] Jamea, 2013
[29] Eurodialogue, 2012

- The project will use a lot of hectares of land and fresh water, which is already scarce and not sufficient for their consumption. This will cause huge socio-economic impacts on local environment and communities, on ecosystem, even if the region where the project is situated is seen as a full desert.

Coming back to the aim of comparison of the project and EU/Russian electricity interconnection and based on the main reasons for not fulfilling the goals of DESERTEC we can resume following facts :The electricity interconnection of the markets will most probably be very expensive. On the other side, the infrastructure modernization and network extension is needed in any case in Europe and in Russia. For the proper functioning of the Internal Energy Market new transmission capacities within the EU are necessary and for the integration of renewables the stability of the grid at the distribution and transmission level is essential. Although the cost of infrastructure modernization and building up are estimated in the Ten Year Network Development Plan by the European Commission as about 600 billion EUR by the year 2020, out of which 150bn EUR for transmission grids only[30]. The main difference to DESERTEC investment is that, these cost will be applicable in any case, doesn't matter if the EU/Russia interconnection will be improved or not. These network investment is needed to provide security and quality of supply on the European energy market[31].

The main technology for EU/Russia interconnection is the construction of transmission lines. The routes and ways for these lines are not complete clear yet, still the technologies are proven, the HVDC would most probably be the best choice. Here, contrary to DESERTEC, there is only one technology field.

The issues of multilateral partnership stays, but not in the same extend as for the MENA region. For the EU/Russia interconnection the negotiations and working groups are on the level of the European Council and Russian Government. Basically this challenge drops. The political or better to say the geopolitical situation is way more important in the EU/Russia case. The latest developments in the Ukrainian crisis, annexion of Crimea by the Russian Federation etc. cannot be validated and analysed in detail yet, as not enough facts and details are known. What is important, the situation creates new challenges in the relationship between the EU and Russia, these challenges are not advantageous while discussing new large-scale projects, especially in the context of economical sanctions from the both sides. As we have started our research on the topic before the conflict, in Ukraine, we have not considered its impact on our topic, due to missing information and constantly changing situation.

Concluding the comparison and lessons learned, it is important to keep in mind the geopolitical and political situation in the regions. Definitely the cost will play a major role in the development of the pan-European market interconnected with Russia and CIS countries. Last but not least, something being not an issue of DESERTEC, **the regulatory framework is crucial. DESERTEC assumed electricity generation in the MENA region and export if this electricity to Europe. In case of EU/Russia electricity interconnection we are talking about free flows of electricity across the borders. In order to make it possible some rules and standards must be adopted and agreed on the both sides**.

	Desertec	EU/Russia interconnection
Grid Transfer Capacity Increase:	+100GW	+15GW (NW zone)
Socio-Economic Welfare:		
RES Integration:		
Improved Security of Supply:		
Losses Variation:	w/ HVDC	w/ HVDC
CO_2 Emission Mitigation:		
Technical Resilience:		
Flexibility:		
Social & Environmental Impact:		
Project Costs:		

Figure 12 - Relative benefits for Desertec and EU/Russia interconnections, author's creation

[30] EURELECTRIC, 2014, S. 5
[31] ENTSO-E, 2014, S. 10

5. REGULATORY ANALYSIS

5.1. EUROPEAN AMBITIONS

European Union is currently under pressure of reaching the goals of the EU Energy Policy Triangle. Customers must be provided with secure supply at the affordable competitive price. At the same time the climate change goals are paying more important role than for example five years ago: the 20-20-20 EU targets, set in 2007 and enacted in 2009 through the climate and energy package request all Member States to[32]:

- 20% reduction in EU greenhouse gas emissions from 1990 levels
- Increase of the share of EU energy consumption produced from renewable resources (RES) to 20% in the gross final consumption energy mix of Europe, by 2050 even 80%
- 20% improvement in the EU's energy efficiency.

The development of the energy industry with the goal of achievement of these targets will most probably result in increased demand and supply of energy produced from RES. This demonstrates Europe's pioneer role in integration of energy and climate policies[33] and will bring new challenges in terms of RES integration into the electricity system and grid management.

The pressure of energy policy on the electricity prices is also playing an important role in the positioning of the European Union in the energy field[34]. Price pressure made competitiveness and affordability of energy cost together with security of supply to the top priorities of the Energy Policy Triangle[35]. To be able to fulfill the obligations of the Triangle and to enable the development of competitive liberalized energy markets, operating according to market mechanisms and with market-based price formation, it was decided to complete the Internal Energy Market in Europe. For liberalization and harmonization of the internal market, three consecutive legislative packages of measures were adopted starting 1996. Currently the last policy package was the Third Energy Package, which entered into force in 2011 but hasn't been fully implemented yet by all Member States. The legislative measures focus on issues of market access, regulations, consumer protection, transparency of the markets, interconnection extension and efficiency, acceptable levels of supply and last but not least, development of trans-European networks for electricity and gas transport[36] and address the issues of Third Party Access.

Nick Werner, President of ENTSO-E[37] accents in the annual report for 2013, that the Internal Energy Market (IEM) will play the main role in the process of achieving the energy policy objectives of affordability, sustainability and security of supply[38]. In order to make the IEM possible, European regulators associations, such as ACER[39] and CEER[40], network companies and coordinators as ENTSO-E are developing the measures

[32] European Commission, 2014
[33] EGMONT, 2014, S. 1
[34] AskjaEnergy, 2013
[35] EGMONT, 2014, S. 2
[36] Kerebel, 2014
[37] ENTSO-E - The European Network of Transmission System Operators for Electricity represents all electric TSOs in the EU and others connected to their networks, for all regions, and for all their technical and market issues (ENTSO-E 2013).
[38] ENTSO-E, 2013, S. 6
[39] ACER – Agency for Cooperation of Energy Regulators is a formal EU Agency, created by the Third Energy Package to progress on the completion of the internal energy market for electricity and for natural gas (ACER 2011).

and policies for harmonization of technical rules for cross-border electricity exchange first of all whiting European Member States, in the next step also for interconnections with neighboring countries e.g. Baltic interconnection to Russia or Finland-Russia electricity exchange. More details on EU/Russia interconnections are given in the Chapter 5.5.

Coming back to the IEM, at first glance it seems to be on track but today we can say, that the target of the EC of fully functioning IEM by the end of 2014 most probably wont be reached, as currently in the 3rd quarter of 2014 there are some unsolved issues. However the noticeable progress has already been made: consumers have a possibility to switch suppliers for gas and electricity, and suppliers are forced to provide their customers with clear explanations of terms and conditions. The part still in progress includes facilitations of cross-border investment possibilities and alignment of national markets and network operations rules for gas and electricity[41]. Major progress was reached on 4th February 2014, as the pilot project for EU wide electricity trade has started. According to the press release of the EC, network operators and power exchanges from 15 Member States in North-Western Europe (in alphabetical order: Belgium, Denmark, Estonia, Finland, France, Germany, Austria, UK, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland and Sweden), combining 75% of todays electricity consumption of the European Union, will jointly participate in electricity trading at “day-ahead market” on the basis of NordPool power exchange, using the market coupling method for pricing[42]. This project is definitely a very important milestone towards European Electricity Market. EU Energy Commissioner Oettinger said: "The start of the NWE market coupling proves that the Internal Energy Market 2014 is not just lip service. Fragmented European energy markets will soon be history, which is certainly good news for European customers". The European Commission is working on the regulations package, making Market Coupling mechanism for price formation binding in the entire European Union. EC estimates cost saving by the EU-wide market coupling and expects benefits for the European customers[43]. Despite all positive indications there are some struggles and challenges, which must be surmounted and which lead to the delay in the process. Internal Energy Market is already producing benefits for the gas field, trading has taken off and lower wholesale prices are the result[44]. Market coupling is the aimed model for the day-ahead markets in Europe. The European Price Coupling (EPC) ideally simultaneously determines price and volume in all relevant zones, this method is based on the marginal pricing principle. The common government structure is under preparation, in order to meet the aims of the EU and start already 2014 the implementation of the EPC could start under interim governance arrangements and later changed to the adopted finalized guidelines[45]. Currently different Market coupling solutions exist, mainly regional, like CWE region or NWR (North-West Region). The main driver for the mechanism is to boost the total economic advantages for all participants: electricity generation becomes cheaper in one country, meets the demand and reduces prices in another country. The ACER/CEER annual report 2012 shows the price convergence during the past years. One of the best examples is the price in the Netherlands and Germany. The power plant operators in these countries in 2008 received the same hourly price for their electricity in 7% of the time, 2012 this number increased to 57%.

The IEM has already delivered huge benefits for EU consumers and it completion is the clear way to integrate the renewables in the European energy system. An open and well-connected market helps to keep energy prices in check despite the ongoing rise in commodity prices. It is also the best guarantee for securing energy supplies across the EU member states and ensures easy entry of renewable energy into the market. All this is crucial for creating growth and jobs in Europe and to mitigate climate change. The leaders of EU governments are committed to making a fully functioning internal market a reality[46]. Therefore implementation

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[40] CEER - Council of European Energy Regulators established in 2000 as a non-profit cooperation of Europe’s national regulators of electricity and gas for protection of consumer's interests and for facilitation of creation of a single, competitive and sustainable internal market for gas and electricity in Europe (CEER 2000).

[41] European Commission, 2014

[42] EuropeDailyNews, 2014)

[43] EuropeDailyNews, 2014)

[44] Wörsdörfer, 2014

[45] ACER, 2012

[46] Friends of Europe, 2013, S. 2

of harmonization rules for cross-border electricity exchange, coordination of new network development and pan European solutions should be developed further[47].

Moreover, the energy landscape has changed considerably. Since 2000 the electricity generation from renewable sources like wind and solar, mainly PV, has increased by more than 500%. The enormous utilization of renewables is forced by national non-market based supporting mechanisms, like feed-in-tariffs, subsidies and green certificates with a goal of CO2 and greenhouse gas emission reductions. As the expansion of renewable is not market based, result are delayed grid expansions, electricity becomes meaningless at the time when production from these sources at zero-operational-cost exceeds the demand. Just one of numerous examples can be 2012 with an average in Belgium, France, Germany and the Netherlands being below €0.05 per kilowatt hour (kWh) at the wholesale markets, while in Germany prices dipped below zero in 48 cases, due to oversupply from renewables. At the same time retail prices in the Netherlands were at the level of €0.19/kWh and in Germany €0.25/kWh[47]. Electricity prices for residential sector include the VAT, levies and payment for renewables support, network transportation charges, capacity and flexibility that are outside the price formation of the internal market. Basically in current situation the cost of renewables support are broken down to the residential level, whereas at the power exchanges the wholesale prices are often below zero. In this case it means that generator have to pay for produced energy in order to sell it[48]. Considering constantly growing share of renewables in the electricity generation, the need for flexible power generation capacity, for example gas turbines power plants, is increasing.

Member countries of European union are under pressure of fulfillment of 20-20-20 EU Directive, some of the countries are trying to reach the percentage of renewables, other countries like Germany and Spain are in the phase of finding out the best way for grid management with share of renewables of about 60-70% on sunny windy days. All this brings Europe to the new challenges in the energy and electricity sector, market design and structure are questioned one more time, Capacity Market Mechanisms are being discussed. Some other challenges are steady increasing energy costs, especially electricity cost for the end consumers, also uncoordinated national interventions disturb the IEM development and progress.

Most of electricity markets in Europe are or were recently organized as energy-only markets, in theory the market prices should provide sufficient incentives for new investments in production capacity. Current situation on the markets is rather characterized by increasing intermittent capacity, low and decreasing margins on supply and low load factors for thermal plants[49]. These developments lead to the discussions on introduction of Capacity Mechanisms.

ELECTRICITY MARKETS DESIGN ACROSS EUROPE

Member states of the European Union have similar electricity market structures with energy-only markets, there are still significant differences between them and these markets are weakly integrated. There is great potential in improving the use of existing grid infrastructure. The investments in grid bottlenecks are necessary and existing regulation is lacking important points to ensure and coordinate cross-border transmission investments[50]. In addition to this, wholesale electricity markets in Europe are facing challenges and the EC struggles with the transformation to a low carbon economy and increasing share of renewable energies on one side and security of supply and affordability for commercial and residential customers on the other side. Support and back up for security of supply are being discussed among the experts, and is this context the potential establishment of capacity markets is being mentioned. Some of the Member States are pushing the ideas of the appropriate mix of generation and the later consequences for other aspects of the infrastructure[51].

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47 Godfried, 2013
48 Asendorpf, 2009
49 SQ Consult, 2014
50 Meeus & Belmans, 2005, S. 25
51 Mehmet Baha Karan, 2011 & Cerre, 2013

Market design in energy industry consists of at least three different dimensions that are interdepended to each other. These dimensions are shown on the Figure 13 and can be categories as follows:

1. Industry
2. Whole sale market
3. Market place

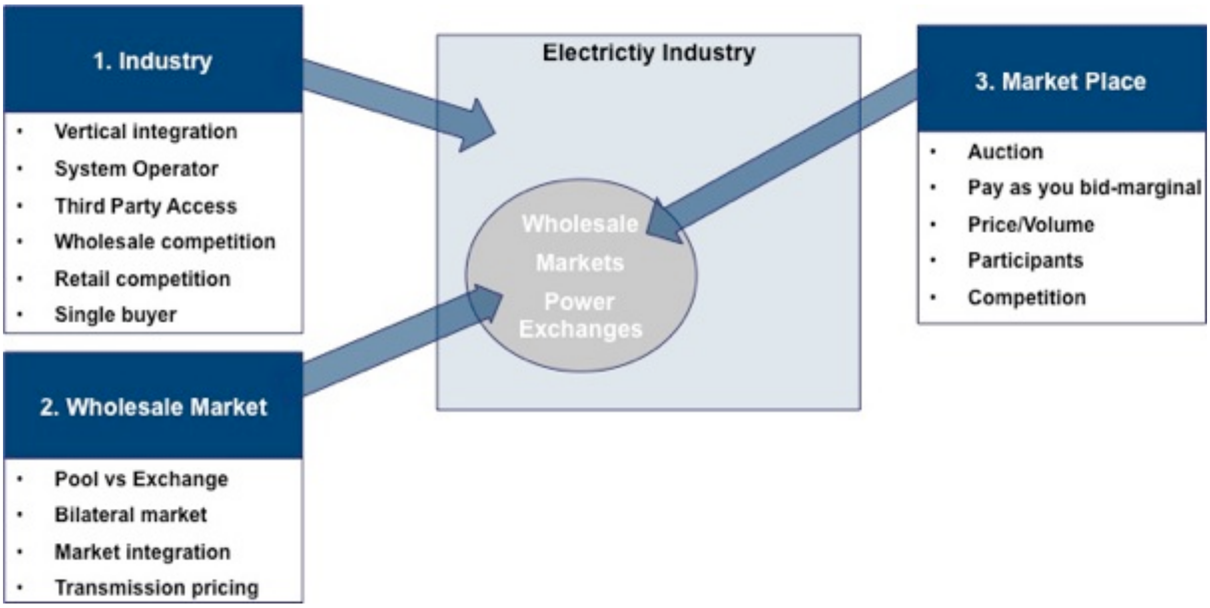

Figure 13 - ***Element of Electricity Market Design (Jaakko Karas, 2013, S.4)***

The industry level is a starting point of electricity market design. At this level the cost structure: natural monopoly functions vs. potential competitiveness, is essential. Definition of a system operator is is decided by the regulatory framework on this level. The second level reflects the design of the wholesale market itself. At this stage must be decided: should the market place be compulsory or voluntary. Also such issues as who will run the marketplace and price definition: zonal prices or locational prices. Technical aspects must be taken into account, the level of governmental involvement into market design. The third level of market deals with the detailed functioning of the market, the rules and regulations of the market place. Examples are prices determination: by a pay-as-bid auctions or by a marginal price auction, design of auctions[52].

From todays perspective the European electricity markets can be observed within 3 regional groups: the UK, Nordic Countries and Continental Europe[53]. The UK market seems to be the most competitive, the Nordic market (Denmark, Sweden, Finland and Norway) is the most harmonized cross-border market in the world. For the Continental Europe, Germany was a driving force in the energy market reform process with the biggest market by number of players and generation capacity and the fastest market to open up, France is the third market in size among all open European markets[54].

Coming to the market structure and design - there are significant differences within EU Member States. It is important to differentiate between wholesale power trading and retail power trading. In this paper we focus on the wholesale trading. The wholesale electricity market is divided into Over The Counter (OTC) and Exchange trading, however the volumes are not equal on the both sides. The principle structure of the European electricity trading is shown in the Figure 14. The amounts are not equally divided among OTC, Exchanges and bilateral contracts in terms of volumes. Each exchange in Europe has different importance on the electricity

[52] Jaakko Karas, 2013, S. 4
[53] Mehmet Baha Karan, 2011, S. 16
[54] OXERA, 2007, S. 24

market. However it comes out, that OTC trading is the main driver for power trading, based on the historical trade, often at 95%, sometimes over 99%[55]. However the importance of power exchanges increased in the last few years. There are two ways of trade arrangements between buyers and sellers: trade bilateral, direct trade or via intermediary, this function can be given to a dealer, exchange or pool[56].

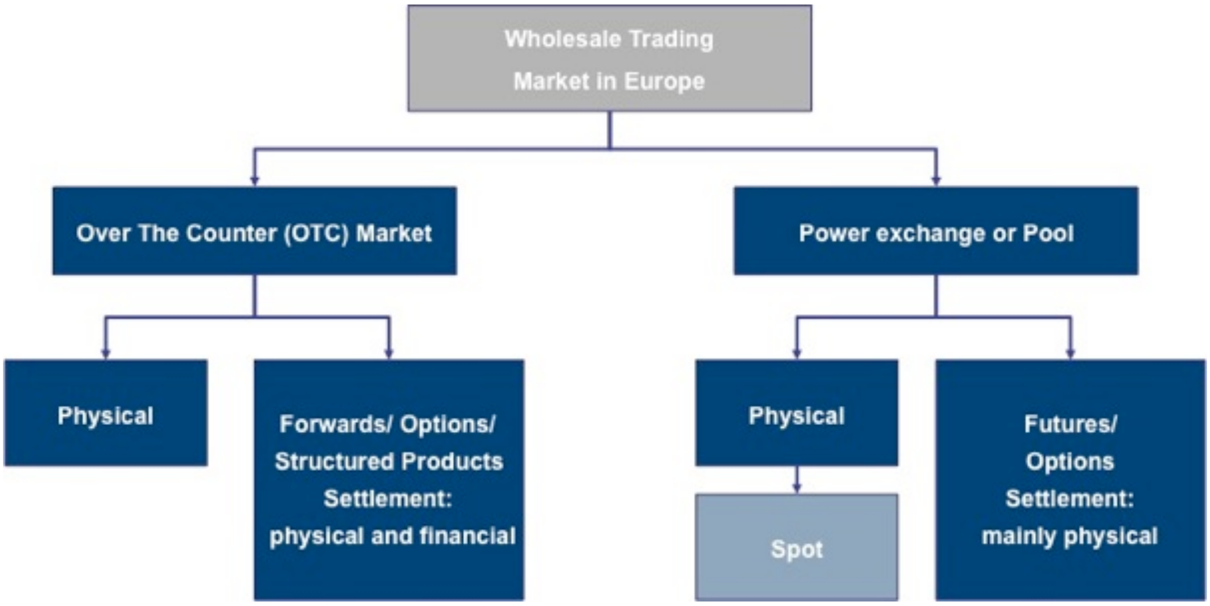

Figure 14 - ***The Structure of Power Trading in Europe (Rademaekers, 2008, S.18)***

TRADING AT THE EXCHANGE IN EUROPE

The EU-27 electricity consumption was 2.7 million GWh in 2009[57]. The biggest portion of electricity trading Europe takes place in the OTC market. As regards electricity trading in 2009, for example, according to the European Commission, 75 per cent of electricity was traded OTC, while only 25 per cent was traded via power exchange[58]. Electricity trading for the EU in the same period accounted to 6.2 million GWh, which is a 27% increase, compared to the previous year[59]. There are several reasons for the increased trading on the exchanges and why demand for such market places as Power Exchanges increases. First market participants look for a market place where buying and selling is possible at any time. Second, a transparent price index benchmarking reference for their bilateral transactions and hedging purpose is needed. Third, Power Exchange is an alternative option for electricity purchasing. Fourth, the anonymity of the market place is an advantage in a competitive market environment. Finally, since all transactions are covered by the exchange's clearinghouse, trading at the exchanges reduce counter-party risk[60]. Currently there are more than twenty different power exchanges operating in Europe. The biggest and the most liquid power exchanges are the Nord Pool Spot / Nasdaq Omx Commodities in Oslo and the European Energy Exchange (EEX) in Leipzig[61].

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[55] Mehmet Baha Karan, 2011, S. 19
[56] Jaakko Karas, 2013, S. 6
[57] Statistics, 2009
[58] Michetti, 2012, S. 5
[59] FSA, 2012
[60] Jaakko Karas, 2013, S. 8
[61] Vattenfall, 2013

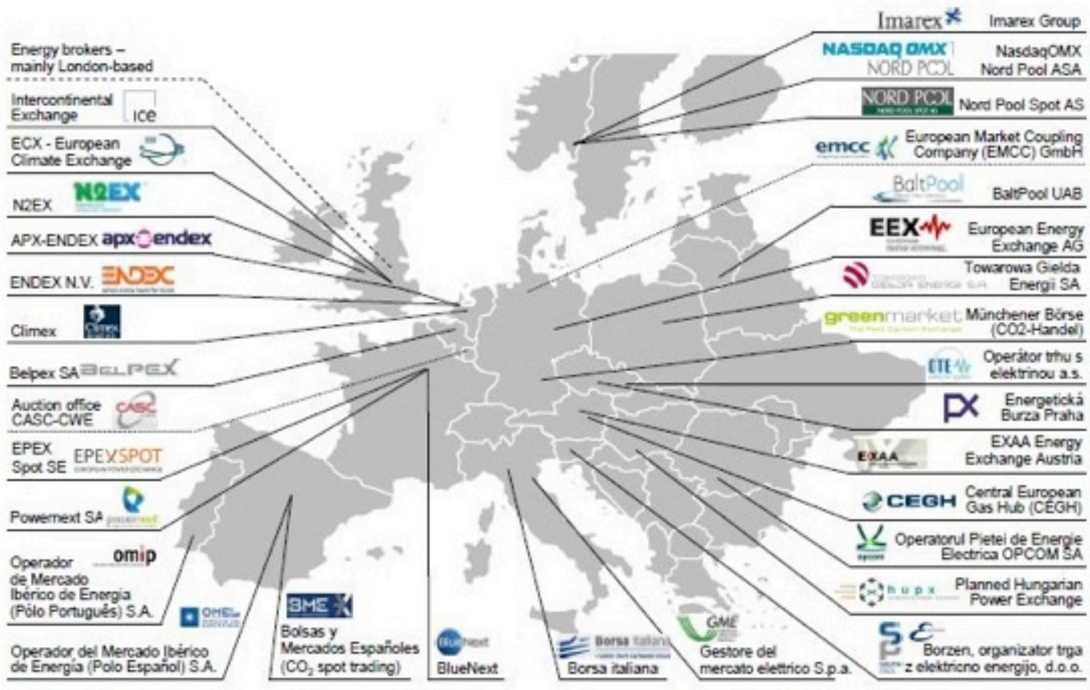

Figure 15 - ***European exchange for power and related products (EEX, 2014)***

OVER-THE-COUNTER (OTC) OR BILATERAL CONTRACTS

Over-the-counter trade, also called bilateral trade, is not listed on the exchange, though some OTC arrangements can be cleared on exchanges. OTC are trade contracts, involving the buyer and the seller, the main difference to the trading at the exchange is that they are typically not anonymous Trade is possible via broker over the phone, per email or fax instead of physical trading floor. For the OTC market there is no central market place. OTC contracts are riskier than exchanges, because they have a nonappearance risk. In the EU bilateral trade on the markets is seen as financial instrument. These contracts can be re-sold after procurement and treated as every other product traded on an exchange. However, there are no standardized form for these contracts and no anonymity[62].

Power Exchanges and the bilateral trading are complementary and reliant to each other. The level of organization (bilateral - low, exchanges – high) and control is different, from the participant's point of view this competition is beneficial. As Power Exchanges are voluntary organized markets, market participants always have a choice to use the OTC trading whenever the costs of trading on the organized market are not acceptable[63]. Typically Power Exchanges are energy-only markets. The power exchange is seen as a hub of the electricity market. Electricity price is determined on the spot market, where the players are generators, retailers, traders and large end users[64].

Under the current EU legislation the Power Exchanges have no nominative role in the regulatory framework, although their increasing importance is highly recognized by the authorities. In the most European countries PXs have the key position in wholesale market in terms of estimating and referencing the fair

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[62] Rademaekers, 2008, S. 25
[63] Jaakko Karas, 2013, S. 6
[64] Vattenfall, 2013

electricity price level. Price relation between wholesale and retail prices is used as an illustration of reliance for the retail market competition and fair pricing[65].

DAY-AHEAD MARKET

The day-ahead market, also called spot market is the typical market at the exchange. On this market the bids are submitted and the market is cleared the day before actual delivery. Trading day is divided into periods e.g. 24 blocks of 1 hour each. Each bidder makes a price bid for every generation unit for the whole day. Sellers must send their sale bids (volumes they are prepared to deliver at various prices during the 24 hours of the following day) to the power exchange by 12 noon on the day before the power is delivered to the grid. Retailers must send their purchase orders (demand analysis for the 24 hours of the following day), and the amount they are willing to pay[66]. Hourly trading gives the possibility to the market players to balance their physical contracts portfolio, whereas block trading, a number of successive hours allows them to bring complete power plant capacities into the auction process[67]. Retail electricity companies use the spot market price for price setting for the end consumers (the "electricity retail price"). Depending on transmission limitations and the generation assets mix of the region, the market price may vary between the regions. Price determination is based on supply and demand, corresponding to the marginal cost of the last production unit needed for generation in order to meet the demand in each hour. In Europe, in regular case this are the cost of electricity production by coal and natural gas power plants[66].

INTRA-DAY MARKET

Due to the time span between the contracts settling on the day-ahead market and physical delivery, exchanges offer the so-called intra-day market. The trading at this market allows purchase and sale of a product within a given trading day. This market closes a few hours before delivery and gives to the market players the possibility to improve their balance of physical contracts in the short term[68].

FUTURES AND FORWARDS

Futures are contractual agreements that allow buying or selling particular commodities or financial instruments at a pre-determined price in the future. These contracts are standardized for facilitation of the trading on a futures exchange. Futures are derivative products, with their help participants secure whose price is dependent upon or derived from one or more underlying assets. Both futures and forwards are similar in the way that they locks the price of a product with delivered at a future date. Difference is that forwards are not standardized, the parties involved in the transaction define their structure, also forward contracts are not traded on an exchange, these are bilateral contracts. On the electricity markets in the EU forward contracts are generally used between large energy sellers and end users[68].

The main difference of electricity trading from other commodities trading is that electricity cannot be stored. Production of the commodity –generation is compelled to the exact moment of demand. Therefore even light influence on supply and demand side has an immediate effect on the electricity price on the spot market[66].

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[65] Jaakko Karas, 2013, S. 10
[66] Vattenfall, 2013
[67] Rademaekers, 2008, S. 24
[68] Rademaekers, 2008, S. 25

NORDIC COUNTRIES

Norway was one of the first European countries to open its electricity market in the early 1990s. Also Sweden, Finland and Denmark started the restructuring processes in the early 1990s. The reorganization and liberalization took place before the legislation of the EC. The Scandinavian markets have built their own regional markets, but decided to integrate these regions into one market area[69].

At present there is only one Power Exchange in the Nordic region - NordPool, which calculates the price all regional markets. The main difference of the Nordic market from the rest of Europe is that the cooperation between countries and their TSO was very close and intense also before the liberalization and privatization processes started and there has always been a sufficient transmission capacity between the countries. This historical connection had an influence on the chosen market model, as illustrated in Figure 16. TSO and power exchange work in close cooperation together: TSOs inform on available cross-border transmission capacity and the exchange is responsible for electricity trading [70] .

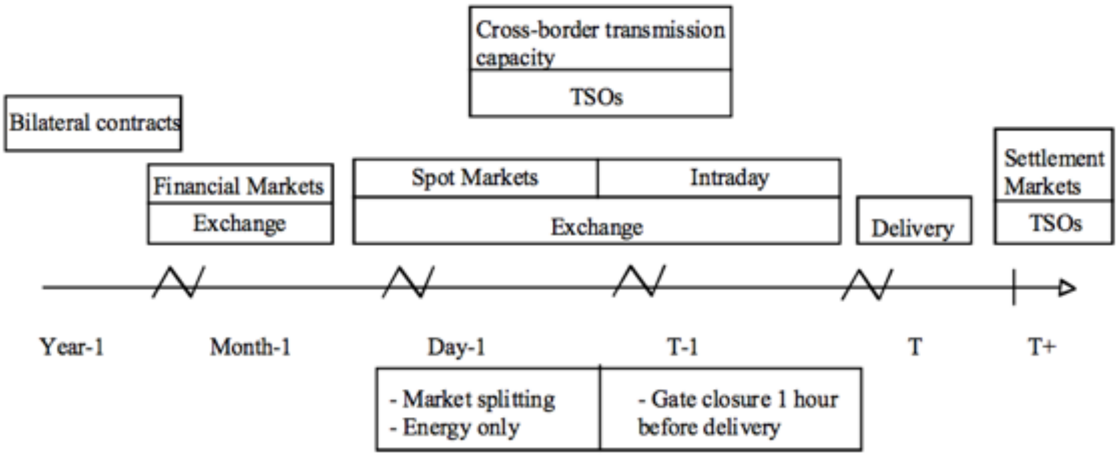

Figure 16 - *Electricity market model in the Nordic Countries (Oksanen M, 2009, S.3)*

TRILATERAL MARKET COUPLING (TLC) AREA – BELGIUM, FRANCE, NETHERLANDS

Other big regional market in Europe is the TMC area. France, Belgium and the Netherlands decided 2006 to merge their electricity markets after the long process of liberalization. The decision was taken, as not enough players were participation at the markets in each country and the competition as a big issue. The expansion of the market area was the key to solve these issues.

Difference from the Nordic region is that there are national exchanges. The markets are treated separately and linked to each other with the uniform system price in the second step, if there is enough transmission capacity available, as it is shown in Figure 16 - *Electricity market model in the Nordic Countries (Oksanen M, 2009, S.3)*[71]. Each of the exchanges is responsible for the price calculation on the national level, TSOs inform about available cross-border transmission capacities within the TLC area. When it is enough

[69] Oksanen M., 2009, S. 3
[70] Oksanen M., 2009, S. 9
[71] Oksanen M., 2009, S. 4

capacity available, the price offers of the exchanges are merged and the area gets one or 2 prices. According to the APX Group[72], in 2008 about 70% of the time France, Belgium and the Netherlands have the same area price.

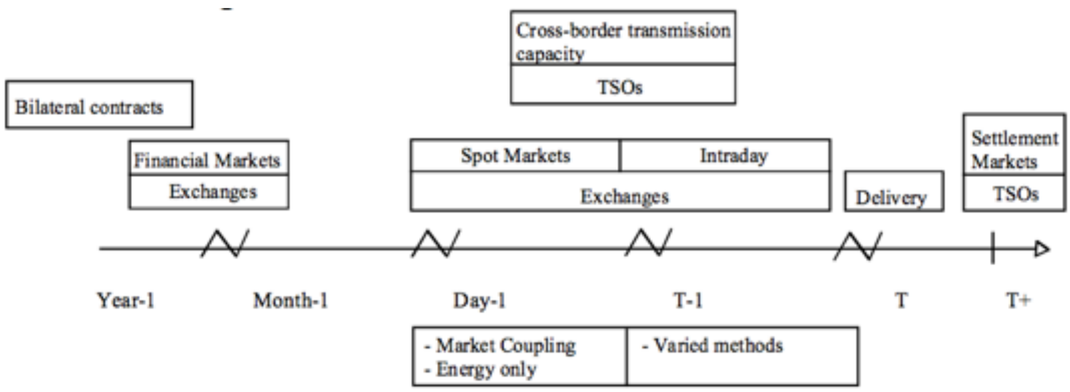

Figure 17 - ***Electricity model of the TLC area (Oksanen M, 2009, S.4)***

REGIONAL REGULATIONS

The way towards market liberalization and setting up of the regional and EU-wide regulators started in 2003 with the set up of the European Regulators' Group for Electricity and Gas. The group was responsible for cooperation between national regulators and application of the internal market directives in the Member States according to the Decision 2003/796/EC. In 2009 The Electricity Directive 2009/72/EC was introduced. The purpose of it is creation of competitive markets for electricity generation and transport, sets up common rules for the IEM in electricity[73]. The deadline for transporting the Directive[74] was set for March 2011 (EC, 2014). A few years later, in 2010 the EC Regulation 713/2009 promoted the establishment of the European Agency for the Cooperation of Energy Regulators (ACER). The Agency acts as a supervisory body with an advisory role. The EC and ACER work in close cooperation regarding market regulation, promoting cooperation between national regulatory authorities at regional and European level. The Regulation 1227/2011 establishes guidelines prohibiting abusive practices, which may have negative impact on the wholesale energy markets (Europedia, 2011). The Regulations 714/2009 and 543/2013 determine rules for improvement of cross-border electricity trade. Main rules are compensation mechanism for cross-border flows, allocation of available transmission capacity between national TSOs and harmonization of transmission charges. Al in one this Regulations contribute to the facilitation of functioning and transparency of the European electricity wholesale market with a high level of security of supply.

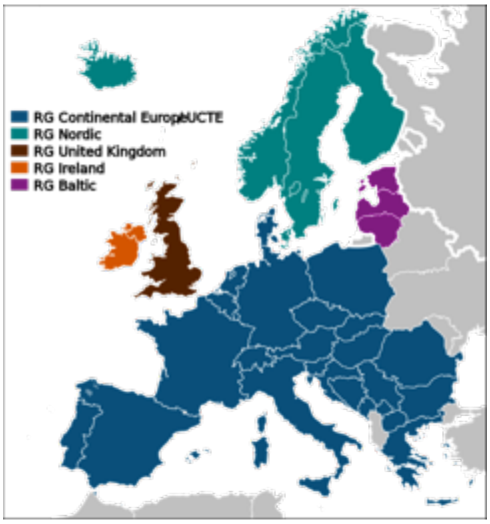

Figure 18 - ***ENTSOE European members, 2013***

[72] APX Group is a power exchange, operating transparent trading platforms in the Netherlands, Belgium and the United Kingdom. Belgium power exchange Belpex SA is a 100% subsidiary of the APX.

[73] Europedia, 2011

[74] This Directive is also called "Third Package" refers to Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 (Gas Directive) and Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 (Electricity Directive), concerning common rules for the internal market in natural gas and electricity respectively

Not only regulations but also technical issues were adapted. After the introduction of European Network Transmission Systems Operators - ENTSOs, one for electricity (EC/714/2009) and one for gas (EC/715/2009), amended by EC Decision 2010/685/EU, the work on networks harmonization were started.

ENTSO-G and ENTSO-E, together with ACER worked on establishment of technical codes and network access rules and on coordination of grid operation through operational information exchange. The 10-year investment plan was also drafted by ENTSOs with a support and revision by ACER. ACER also can „gather, review and share data from wholesale energy markets, monitor markets and trading, investigate cases of market abuse and coordinate the application of appropriate penalties with the Member State, according to EU adopted Regulation (EU) No 1227/2011 on wholesale energy market integrity and transparency (Kerebel, 2014). In November 2013 European Parliament authorized the budget for the Connecting Europe Facility CEF-projects in the field of energy, transportation and infrastructure, with 5.12 billion euros reserved for the development of trans-European energy infrastructure projects (T7-0463/2013). "The Regulation on energy infrastructure guidelines identifies twelve priority corridors and areas covering electricity, gas, oil and carbon dioxide transport networks, and provides measures on streamlining and speeding up permit granting and regulatory procedures for projects of common interest. In 2013 the Commission proposed a list of 248 European projects of common interest in line with the procedure and criteria set out in the regulation. This list will be reviewed every two years. In March 2014, the European Council asked the Commission to put forward by June specific interconnection objectives to be attained by 2030.

The Northern region, on the Figure 14 colored green, is the most advanced in Europe in terms of regional market arrangements. In this region investment for interconnections, transparency, joint intra- day and balancing markets and are the key priorities[75]. The Latvian Public Utilities Commission Energy (PUC) monitors the Baltic region, including Estonia, Latvia and Lithuania. The Latvian Regulator was created in 2001 and took over multi-functional regulatory functions[76]. „The Baltic region represents 21.215 GWh of final electricity consumption, 0,71% of the EU 25 final electricity consumption. The Baltic region is situated between the Central-East and the Northern European regional markets and is a potential bridge between the Central-East and Northern region. For the Baltic electricity system the key priorities are closer co-operation between network operators, grid access, balancing rules and transparency. "Congestion management, transparency, market entry barriers and regulatory competences are the four key priorities of the Central-East (Austria, Czech Republic, Germany, Hungary, Poland Slovakia, Slovenia)"[77].

The Central-West REM (Regional Electricity Market), includes Belgium, France, Germany and Luxemburg, indicates 42% of the EU 25 electricity market and has electricity consumption of 1.1 million GWh, is monitored by the Belgian Energy Regulator (CREG). This REM includes the biggest national market operators in Europe. Key issues for this region are improvement of long-term explicit auction rules, implementation of flow-based market coupling and of cross- border intraday trade and increase of efficiency for cross-border trading[75]. The Central-South electricity REM with Austria, Germany, Greece, Italy and Slovakia, represents 51% of the EU 27 electricity market and has an electricity consumption of about 1.3 millions GWh. For this region harmonization of congestion management methods, of operational and security standards, markets integration on example of intra- day and balancing markets are the key priorities, regulatory monitored by the Italian Energy Regulator (AEEG)[77]. The Spanish Energy Regulator (CNE) monitors the South-west REM, represented by France, Spain and Portugal. This REM has an annual electricity consumption of about 780 TWh, with a share of 30% of the EU 27 electricity market. Spanish and Portuguese markets work very close since the middle of 1990s, the interconnection is constantly growing (Rademaekers, 2008, S. 19). The Ofgem - British Energy Regulator monitors the region of France, UK and Ireland. This REM is working on the topics of interconnectors and compliance with the Congestion Management Guidelines, intra-day trading, and wholesale market transparency[75].

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[75] Rademaekers, 2008, S. 20
[76] ICT Regulation Toolkit, 2004
[77] Rademaekers, 2008, S. 19

MAIN ACHIEVEMENTS AND PROBLEMS OF THE IEM, STATUS JUNE 2014

The development of IEM is essential, also from the economic perspective, as it could lower the cost of decarbonization „because integrated, properly functioning markets and market-based instruments are more cost-efficient than any regulatory measures or political interventions"[78]. One of the main challenges for further development is the nature of regulatory policies. National Regulatory Authorities developed policies with the main focus on problems and benefits on the national market. These leads to closed national markets disrupt strategies of greater cross-border trading and competition. Although the IEM is currently at the turning point: either the Member States change the course and align developed policies and targets with the EU ones or the opposite process of destruction of the achieved progress could start, which would put the goals of European Council at serious risk. One example for national decision is the introduction of Capacity Remuneration Mechanism in some countries[79]. Some experts compare the introduction of the Third Energy Package with Lego, the pieces of Lego are there: policy, framework guidelines, network cods, unfortunately nobody knows what kind of market should be built out of these pieces[80].

Despite big progress reached in 2014 also with the introduction of day-ahead trading using market coupling, there are a lot of challenges on the way to fully integrated European electricity market. One of the biggest problems is market coupling it self. The mechanism has been in use in Central-West Region in place since 2010 and showed good results till 2011. In 2012 price convergence ratio fall down to 46% from 66% previous year and in 2013 it has reached just 15% (McCracken, 2014). One of the explanations for such development could be missing cross-border transmission capacity. And missing transmission infrastructure is the next big issue for further efficient development and progress of the IEM.

Next challenge is the increasing share of renewables. The larger market makes integration of RES smother and easier to manage at the national level, but as all national markets increase the renewables amount in their portfolio the difficulties related to the high concentrations of renewable penetration will return[81]. Other troubles occur due to long time the integration process took. During the last ten years environmental perspectives have changed towards low carbon economies and the market does not look as initially planed. The member stated had their doubts on liberalization processes[82]. The initially elaborated idea of the integrated wholesale market was based on conventional generation, at the time it took EU to move toward integrated market, structure of energy industry has changed a lot and become a mixture of subsidized mechanisms for RES, feed-in-tariffs and high electricity levies[81]. Current price finding, based on merit curve is under pressure. The question is, will the merit curve survive in the context of low to zero operational cost for the renewable generation asset and very high capital investments in RES in comparison to conventional generation. The post probable solution "the Barrel" writes is the capacity market, nobody wants its introduction, but become necessary, despite that it will create additional challenge and weaken the wholesale market[81].

In order to further progress with the development of the IEM the Member States should complete a few steps. Rapid implementation of the EU energy market legislation is needed. "National support schemes for renewables should be aligned, putting an end to costly subsidy wars"[83]. The investment gap resulted from too fast integration and advance of RES must be addressed. In some countries, e.g. Germany or Spain, the preferred network access for the RES has considerably reduced the operating hours of fossil power plant, especially gas. As a consequence, conventional plants become unprofitable to run but their existence is necessary for handling of intermittency of renewables and gas is considered to be the best choice from the technological (short time needed for start-up and shut-down the operations) and environmental (less emissions than coal power plant und less waste than nuclear plants) points of view. And finally, the main infrastructure priority should be the

[78] Friends of Europe, 2013, S. 62
[79] Friends of Europe, 2013, S. 63
[80] Mehmet Baha Karan, 2011, S. 29
[81] McCracken, 2014
[82] Koch, 2014, S. 25
[83] Friends of Europe, 2013, S. 64

improvement of cross-border interconnections. Grid investments are essential for the proper functioning of the IEM. The length of bureaucracy procedures for transmission investments in most EU Member States is among the major barriers for faster network improvement[84].

CAPACITY MARKETS IN EUROPE

Capacity Remuneration Mechanism (CRM) is well known in United States, was introduced in Russia during the energy sector reform and is being developed, but for the European Markets it is a relatively new instrument. However recently this has rapidly changed[85]. European markets are mostly energy-only markets, acting on market rules and electricity price, at least in theory should provide incentives for new investments in generation and transmission infrastructure. In reality increasing share of intermittent renewables generation, decreasing margins, fluctuating overcapacity and decreasing load factors for thermal plants characterize current situation on the electricity markets[85]. These circumstances, especially the fast integration of renewables in the generation, cause uncertainty and growing concern in some participant of Internal Energy Market, that sufficient capacity will not be available at all times, keeping in mind peak times, so the electricity demand will not be covered[86]. Therefore some Member States recently announced intentions to introduce the CRM. A variety of mechanisms have been proposed and analyzed, generally speaking they can be classified in two groups: volume-based and price-based. Five different types are defined and presented on the Figure 19[87].

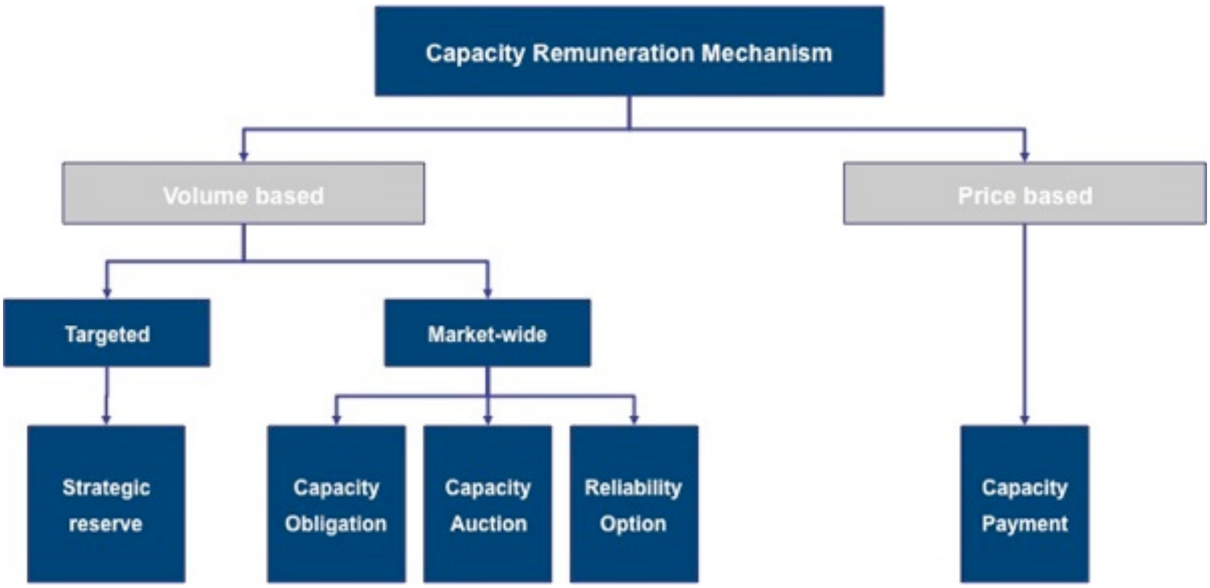

Figure 19 - ***Taxanomy of CRM***

As most promising for the European markets experts see two possibilities: Strategic Reserves (SR) and Reliability Options (RO)[88].

Despite some critical arguments against CRM, for example[88] analysis argues on danger of national arrangements by „distorting cross-border trade or even act as barriers to trade" while being "designed without taking into account their cross-border impact or are not coordinated with neighboring market"[88] the Member States elaborate on the national generation adequacy policies. Figure 20shows the status of CRM development in Europe with regards to generation capacity adequacy in the region. The map shows that some of the

[84] Friends of Europe, 2013, S. 65
[85] SQ Consult, 2014
[86] ACER CRM, 2013, S. 1
[87] ACER CRM, 2013, S. 4
[88] Elforsk, 2014, S. 1

countries, like Finland, Greece, Ireland and Northern Ireland, Italy, Portugal, Spain and Sweden have already implemented capacity mechanisms, other Members including Belgium, Denmark, France, Germany and UK are in the process of elaboration of the policies. The Figure 20 also demonstrates the diversity of approaches within EU. The range is from no CRM via Strategic Reserve to Capacity Payment and market wide schemes[89].

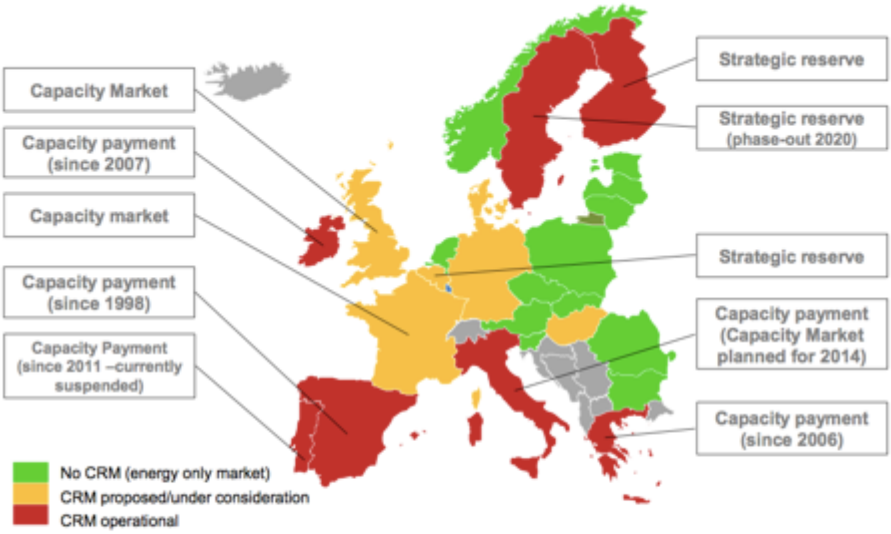

Figure 20 - ***Status of capacity remuneration mechanism in Europe, 2013 (ACER CRM, 2013, S.8)***

Member States introduce CRM to ensure profitability of existing fossil power plants and to support and force investments in new generation facilities "while restoring "missing money" through filling the gap between fixed cost and inframarginal rents plus scarcity rents received on the energy-only market"[90]. Basically these mechanisms are investor oriented and not market based. However, the additional revenues caused by CRM are not stable but also higher than they would be the on an energy-only market[91]. Due to this, such mechanisms could cause even higher electricity cost for energy consumers. The impact of CRM on the Internal Energy Market and cross-border trade is difficult to estimate. The issues of security of supply and IEM are not only national challenges but also regional and pan-European. From this perspective also the issue of resource adequacy should be addressed at the European level in close coordination of the Member States to avoid contrary effects[92]. However the Member States acting nationally with a lack of coordination, this results in a patchwork of CRM in the EU, what may be a disadvantage for the IEM. The impact of those actions and can not be proved to hundred percent as CRM are not implemented in all countries participants of the IEM, what is know, are the results of empirical studies and modeling. The outcome of the studies can be summarized in the following possible impact. CRM definitely has short-term and long-term price impacts on the electricity markets. In the long-term the mechanism could affect investment decisions in terms of plant locations. Finally, additional negative impacts could arise from "incorrect design or implementation of CRMs" after all new policies and measures have been applied[93]. European Commission in 2013 concludes: „such interventions as Capacity Mechanisms are only justified if the need has been clearly identified and should only take place in combination with measures to promote demand response, and building market and transmission infrastructure required by a low carbon emission energy system"[94]. One more important point stressed out by experts, "the implementation of a CRM should not delay the completion of the IEM, and the removal of barriers to the well-

[89] ACER CRM, 2013, S. 8)
[90] Elforsk, 2014, S. 7
[91] ACER CRM, 2013, S. 2
[92] ACER CRM, 2013, S. 15
[93] ACER CRM, 2013, S. 9
[94] THEMA, 2013

functioning of energy markets and to the formation of reliable and efficient price signals across Europe should remain a priority“[95].

All in one, capacity mechanisms have short-term impact on electricity pricies and and in long-term on investments attractiveness[96]. Some emperical studies are against implementation of CRM in Europe. For example, the Norwegian Consulting Group THEMA sees no need for capacity mechanism in Europe in the next future. The thoughts are prelimenar, until 2020, until old coal and nuclear capacity is not phased out there is no danger of capacity inadequacity. What is needed in the next years is mainly balancing and reserve capacity due to increasing shares of variable RES capacity[97]. The difficulty of analysis and elaboration on CRM is cause by the fact, that there are few real-life examples of the interaction of energy-only and capacity-markets. In the United States it is the PJM, Ireland and Great Britain, and Russia and the Nordic market. The observations from the real life examples are inefficient cross-border flows in all the regions. These examples show how challenging the integration of electricity markets with different market designs in one big unified system could be[98]. As our paper and analysis focuses on cross-border effects of such mechanisms we are not describing the CRM in detail. Concerning the integration of CRM in pan-European electricity market we can say, that coordination on the fields of market designing and policies are crucial for future efficient functioning of these markets. The main research outcome is that negative effects of CRM implementation can be only minimized by coordinated implementation by the neighboring countries[99].

BENEFITS OF THE INTERNAL ELECTRICITY MARKET IN EUROPE

Coming back to the IEM, the ideas for its introductions, the benefits and challenges are essential to understand. The idea of internal energy market developed out of two objectives: liberalization of the markets for electricity and natural gas in order to benefit from the competitive prices and accomplishment of a closer relationships between the Member States of the European Union, while completing the single market. The long-term advantages of integrated markets are easily definite: better access for investors, as markets become larger. This point is crucial, as investments in transmission infrastructure are needed already today. Competitiveness will bring stability of electricity prices and significant improvement of security of supply. All these cannot be realized without market integration and the benefits exceed the short-term costs of certain measures by far[100].

Concerning financial and economical benefits some reports can be mentioned, for example[101], and the European Commission Communication paper. Experts have calculated yearly savings expected after introduction of fully integrated European electricity market. The numbers are inspiring, in the range of 12.5-40bn EUR/year in the EU starting 2015, in the first year of IEM “operations”, if the integration proceeds according to EC plan and could be finalized in 2014. This amount of saving is calculated and compared with 2012, states the European Commission. Such saving are possible thanks to lower prices forced by increased competition. In addition to lower prices, end customers would gain better control of energy costs[102].

In order to be able to benefit from all the advantages of the IEM, European Union needs to improve the cross-border electricity trading to ensure the operation of renewable capacity at the most possible level of efficiency. This is one of the topics of EC, according to Mr. Barroso, the President of European Commission: “Europe needs a much stronger transmission and distribution system – 600bn EUR of the 1 trillion EUR of investment needed between 2010 and 2020 must go to this sector”[103]. EU must ensure the best possible

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[95] ACER CRM, 2013, S. 15
[96] Elforsk, 2014, S. 5
[97] THEMA, 2013
[98] Elforsk, 2014, S. 5
[99] Elforsk, 2014, S. 29
[100] Ernst, 2013, S. 44
[101] Friends of Europe, 2013, as well as booz&co, 2013
[102] Friends of Europe, 2013, S. 16
[103] Selleslaghs, 2014

coordination for the infrastructure investments in order to guarantee the EU-wide cost-effective system of connectivity. The investment amount is defined for transmission networks for electricity and gas with 210 billion EU. Out of which 140 billion EUR for electricity infrastructure, smart grids, storage and high-voltage transmission networks, other “70 billion EUR for reverse flow interconnectors, gas infrastructure: storage, gas pipelines and LNG terminals and 2.5 billion EUR for CO2 transporting infrastructure. The total investment needed amounts to around 1 EUR trillion. It is worth stressing that the introduction of smart technologies must not be restricted to automatic meter-reading only but must be completed with dynamic, online grid management”[104].

One more point in favor of interconnection and pan-European electricity market is decarbonization. The low carbon power production assumes reduction of flexible power generation from fossil fuels, and its replacement by non-predictable generation from renewables like wind or sun. With regard to the security of supply, flexible generation, e.g. gas power plants, stronger transmission grids, demand side management and storage technologies are needed. Harmonized policies, which are in progress and were done mainly the “trial and” approach will enable the free cross-border electricity flow across the EU. Internal Energy Market can become a source of greater cooperation between the Member States, as it can provide jobs, is aiming the energy cost reduction and goes along with EU climate targets.

The fundamental problem of the EU Internal Energy Market is the focus of Member States on their national interest and not on European goals. This issue seems unsolvable under current regulatory framework and probably even with the new governance, announced by the European Commission to be launchen in October 2014[105].

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[104] Friends of Europe, 2013, S. 17
[105] EcoLogic, 2014

5.2. RUSSIA POSITIONING

Russia is one of the top producers and consumers of electric power in the world, with about 223 GW of installed generation capacity. In 2011, electric power generation totaled approximately 996 TWh, and Russia consumed about 861 TWh“[106]. One of the main issues of Russian generation is aging. About 90% of installed 220 GW are older than 20 years, currently average age of Russian assets is 30 years[107].

Russian grid concludes in a unified system, called UNEG, and comprises almost 2 million miles of power lines, about 70,000 kilometers of which are high-voltage cables over 220 kilovolts[106]. The United National Electricity Grid (UNEG) is the name for transmission and distribution facilities in Russia. The UNEG is managed by the Federal Grid Company. The law does not require the UNEG facilities to be fully owned by the Federal Grid Company. However, companies that own transmission or distribution facilities that qualify as forming part of the UNEG must lease them to the Federal Grid Company and accept its management with respect to these facilities[108]. Russian Power System called Unified Power System of Russia (UPS) and came into existance in 2001 as a result of the Governmental Decision 526 from July 11th 2001 "On the Restructuring of the Russian Federation United Energy System"[109].

CONGESTION AND LOAD MANAGEMENT OVER RUSSIAN GRID

Russian energy market is characterized by limited accessible information on network congestion. The information is not generally available to market participants. The degree of data transparency on generation and network availability, load and balancing is varying a lot. Russian regulatory authorities and the System Operator and the Market Council all report the date, but the timescales range from daily through to annual reporting, publish information on performance of the wholesale market[110].

On the Russia-Finland interconnection Fingrid is responsible for the availability of transmission capacity on its 400 kV connections from Russia. Fingrid makes 1,300 MW of transmission capacity available to the electricity market with a reserve of 100 MW. Customers who have made an agreement with Fingrid on a fixed transmission right and an agreement on energy purchases with InterRAO, the Russian organization responsible for electricity export, can import electricity from Russia. The customers must report transmission program weekly, and any changes to it on the morning before the day of operation. Fingrid has a right to restrict imports in the event of troubles in the grid. The restrictions must be reported to the importing customers no later than 100 minutes before the beginning of the hour of operation, being subject to the restriction[111].

PRODUCTION COST OF ELECTRICITY ? HOUSEHOLD/INDUSTRY PRICE ?

Russian electricity generation is leaded by gas power plants. For example hard coal production in the country in 2011 was at 248 million tons and lignite at 76 million tons[112], but only 30 million tons 12% were used for power generation. In contrary, gas production was on steady rise in Russia till the economic crisis in the year 2009, since that decreased by 7% in consumption but also increase by 28% in exports[113]. Current domestic gas demand is lower than gas production in the country. Experts resume production growth with rising demand and exports, especially due new pipeline Nord Stream and the construction of South Stream. Gas price for the domestic market is heavily subsidies by the government and thereby much lower than in Europe. In 2011 the domestic price and the price for exports to CIS were at the level of USD 1.5-4/mmBtu[113].

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[106] EIA, 2013
[107] EON Russia, 2012, S. 8
[108] Reuters Practical Law, 2013
[109] RAO UES, 2005
[110] IEA, 2013, S. 54
[111] Fingrid, 2014
[112] Coshet, 2012, S. 5
[113] Coshet, 2012, S. 6

Electricity (Billion Kilowatthours)		History	Russia	Eurasia	World	Rank	Russia
			Previous Year				Latest Year
Net Generation		(1992-2011)	980.90	1,425	20,254	4	996.82
Net Consumption		(1992-2011)	858.52	1,248	18,501	4	869.27
Installed Capacity (GWe)		(1991-2011)	228.12	356	5,086	4	231.65

Figure 21 - ***Electricity consumption and generation in Russia, 2013 (EIA analysis, 2013)***

As mentioned in the beginning of this chapter, Russia's electric power generation was at the level of 996 TWh in 2011, with the net electricity consumption in the same year calculated as 861 TWh, see the Figure 21. The exports in year 2011 were at the level of approximately 22 billion kWh. Main export destinations were Finland, China, and Lithuania. Smaller amounts were exported to Georgia, Ukraine, and Azerbaijan[114].

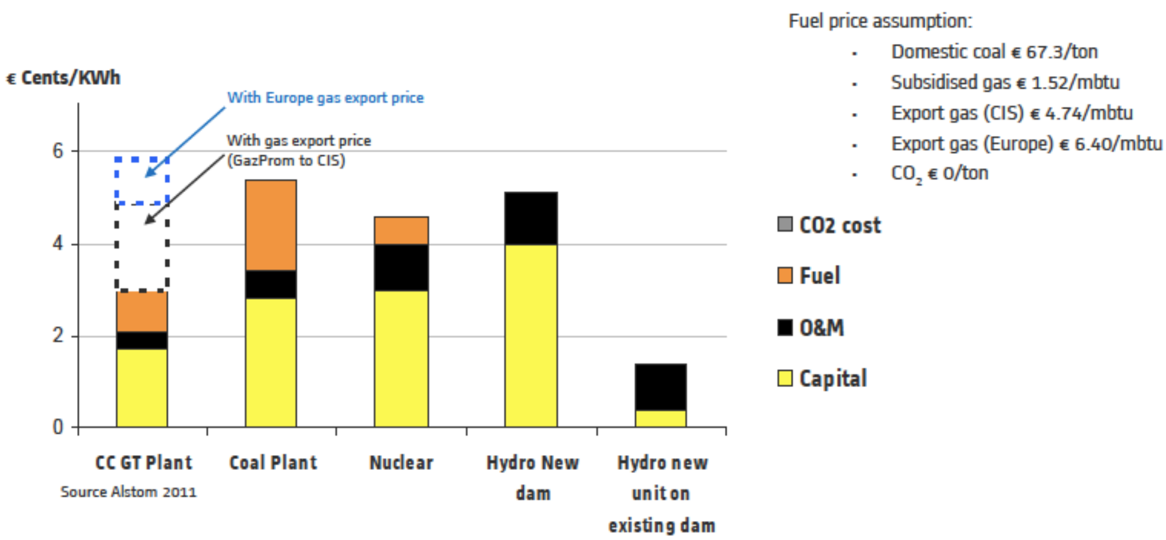

Figure 22 - ***Levelized cost of electricity in Russia new power plants (Coshet, 2012, S.7)***

The Figure 22 shows current levelised cost of electricity generation in Russia for new power plants. The figures show that due to the subsidies for gas price at the domestic market, gas power plants are the most competitive. Gas pricing reform is in discussion by policy makers since a few years, and if the price setting method for gas will be modified, the picture may change completely. With the gas price close to 6.4 EUR/mbtu, which is approximately the export gas price to Europe, levelised cost of electricity produced by Combined Cycle Gas Turbine (CCGT) plants will increase and be higher (5.9 cEUR/kWh) than for coal (5.2 cEUR/kWh), nuclear (4.4 cEUR/kWh) or hydro (4.9 cEUR/kWh) assets[115].

[114] EIA, 2013
[115] Coshet, 2012, S. 7

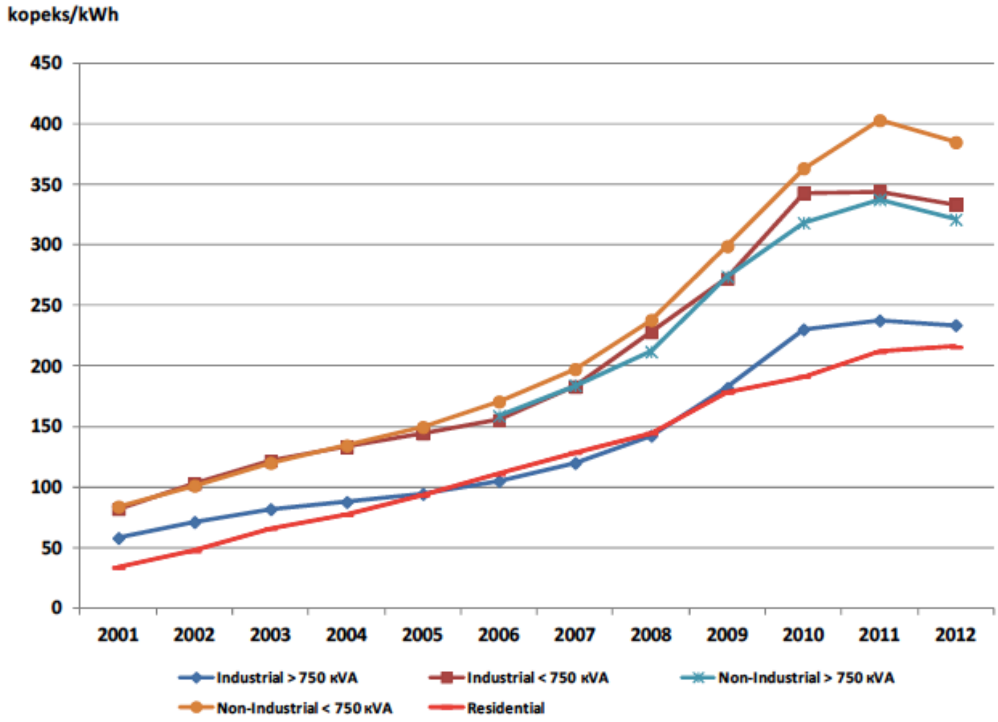

Figure 23 - ***Russia end-user electricity price (incl. taxes and surcharges) by customer class (IEA, 2013, S.79)***

The Figure 23 shows electricity price development in Russia from 2001 to 2012 for the end-user. One fact is steady increase of the price during last 12 years, in average about 12% per year, another issue is the important difference between Russian and European electricity markets. In Russia residential sector has the lowest electricity price, mainly due subsidies and tariff gaps from the government. "Average prices for Russian residential consumers are at USD 66 per MWh, around 27% of the OECD Europe average of nearly USD 245 per MWh in 2011". Figure 24 indicates that Russian industrial electricity prices were similar to the lower level among OECD countries in 2011, with average prices ranging from around USD 75 per MWh for larger volume industrial users to nearly USD 108 per MWh for smaller volume industrial users over the period. "However, the average Russian industrial electricity price remained 10% to 40% below prices for OECD industrial customers at around per USD 123 per MWh, and 25% to 50% below the OECD European average industrial price at around USD 150 per MWh in 2011"[116]. In comparison with Europe, electricity costs as a proportion of household income in Russia stay relatively low, with about 1.2% of average family salary[117]. This makes the tariff adjustment for the residencial sector even more probable.

Regulated electricity prices for retail end-users are typically the sum of the components such as weighted average generation cost, capacity cost in the wholesale market, cost of ancillary and system services, distribution cost, see the Figure 24. The free market prices on the day-ahead market are transferred to end-user prices according to the liberalized market share. Therefore retail market participants with exception of residential sector, partially pay[118].

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[116] IEA, 2013, S. 79
[117] IEA, 2013, S. 82
[118] EBRD, 2009, S. 231

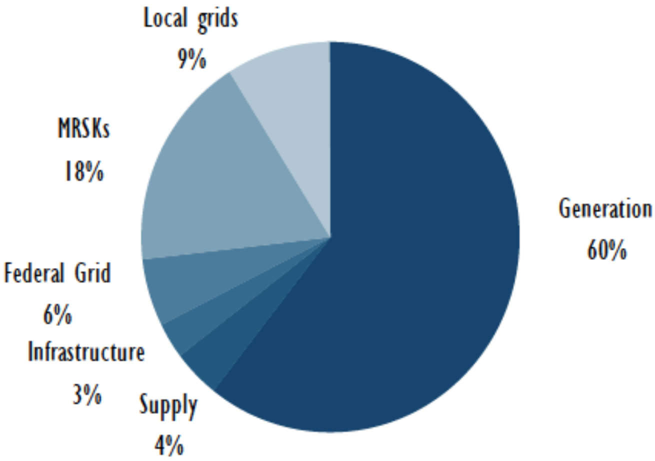

Figure 24 - ***Electricity end price breakdown in Russia (Kotlyearov D, 2011, S.5)***

RUSSIAN ELECTRIC POWER INDUSTRY REFORM

Russian electric power industry is leaded by the thermal power generation. The power market in comparison to the other European markets in relatively young, it has started the way towards liberalization in the year 2003. The current structure is a result of the reforms, which have unbundled the state monopoly and began a formation of competitive power market. Although significant changes have been implemented, certain areas remain stay in transition. Following has been achieved so far: the unbundling and privatization of generation infrastructure; a wholesale spot market for three zones - European Russia, the Urals and Siberia - was created. A progress on more cost-reflective retail pricing by creating critical market and regulatory institutions was reached[119].

Prior to the reform all facilities operation in the power sector were part of a vertically integrated state owned monopoly RAO UES (JSC United Energy System of Russia), during this time period electricity prices were fully regulated by the state, through Federal Tariff Service authority and so called "tariffs" were set for each year, separately for the industry and for residential sector. The reform spitted RAO UES into fields entities and began the formation of a competitive liberalized power market[120]. Reformation of Russian energy system was forced by the national economic crisis in the early 1990 and later by the Asian economic crisis in 1998. The Figure 25 shows electricity industry structure in Russia in 2000 before the reform.

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[119] IEA, 2014
[120] Josefson, 2013, S. 5

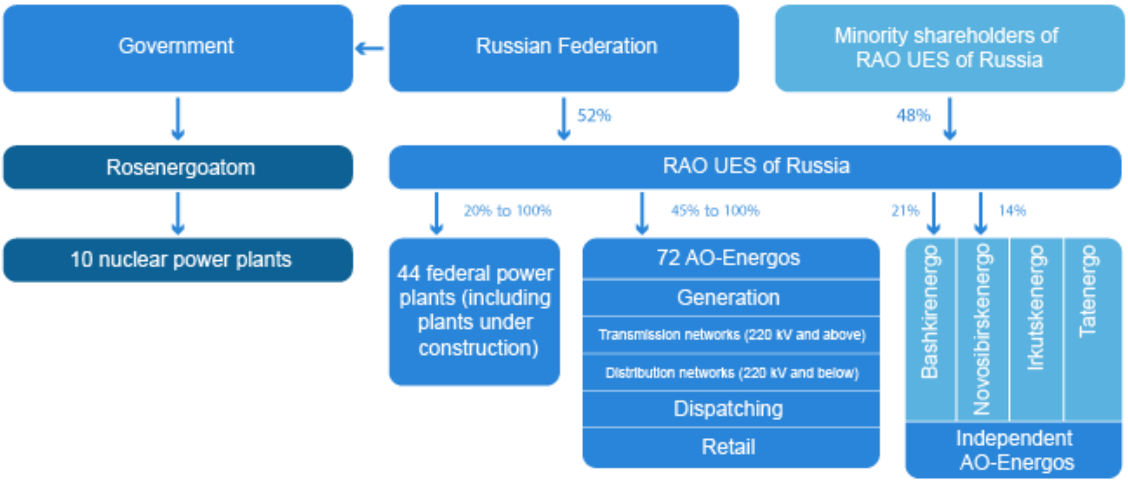

Figure 25 - ***Electricity industry structure in 2000 (Rosseti, 2014)***

The reorganisation was predominantly needed for the efficiency increase of assets and stimulation of investment flow to the industry for assets renewal. Russian electric power sector undertook a fundamental transformation: the government regulation system in the sector was modified, the competitive electricity market was formed, and new companies were set up[121]. With the help of reform, the whole industry structure was transformed as shown in the table on Figure 26. In the year 2008 RAO UES was fully replaced by its former spin-offs.

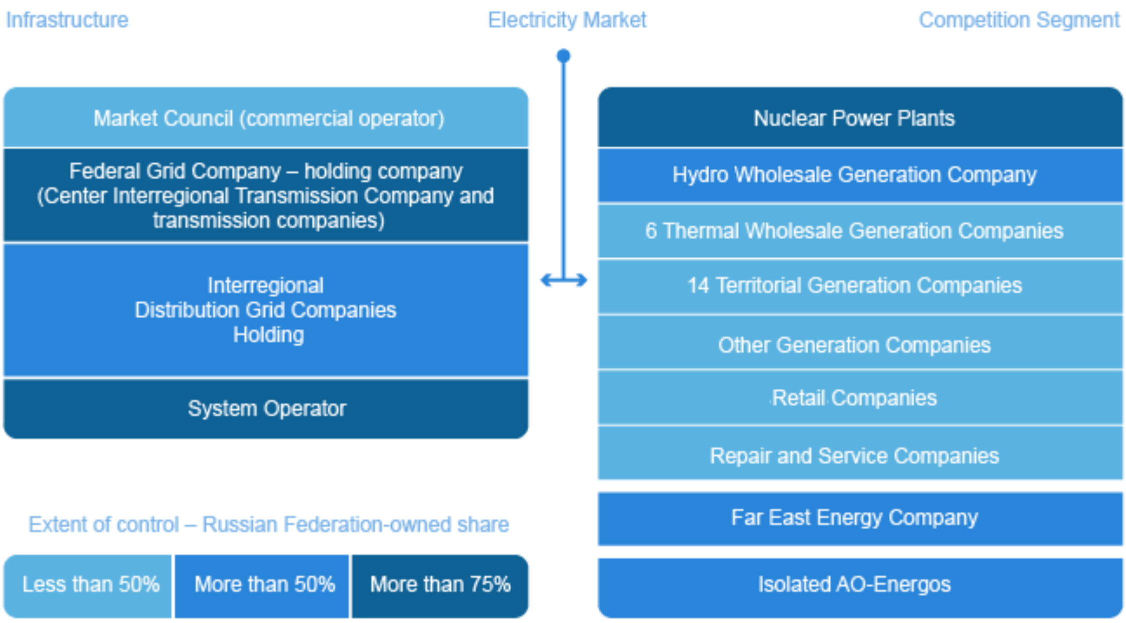

Figure 26 - ***Target structure for the Russia power industry (RAO UES, 2005)***

As result electricity transmission and dispatching fields were separated from potentially competitive operations, like electricity generation, supply and retail, repair and maintenance services were formed in separate entitles in specific business actives[121]. All generation assets were consolidated into interregional

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[121] Rosseti, 2014

companies of two types: the Wholesale Generation Companies (OGKs) and Territorial Generation Companies (TGKs). OGKs consolidate mainly power plats focused on electricity generation, TGKs mainly heat and power cogeneration plant for production of heat and electricity. Seven OGKs operate thermal power plants and one – RusHydro - operates all hydro generation assets in Russia. The generation assets are predominantly privately owned and operate on natural gas[122]. Nuclear plants and hydropower generation assets have over 50% state participation[123]. The grid part of Russian power sector was divided into transmission and distribution grids during the first phase of the reform: high voltage long-distance transmission power lines (220 KV and above, also some of 110 kV lines) were managed by the sole state owned TSO of the country - Federal Grid Company (FGC).

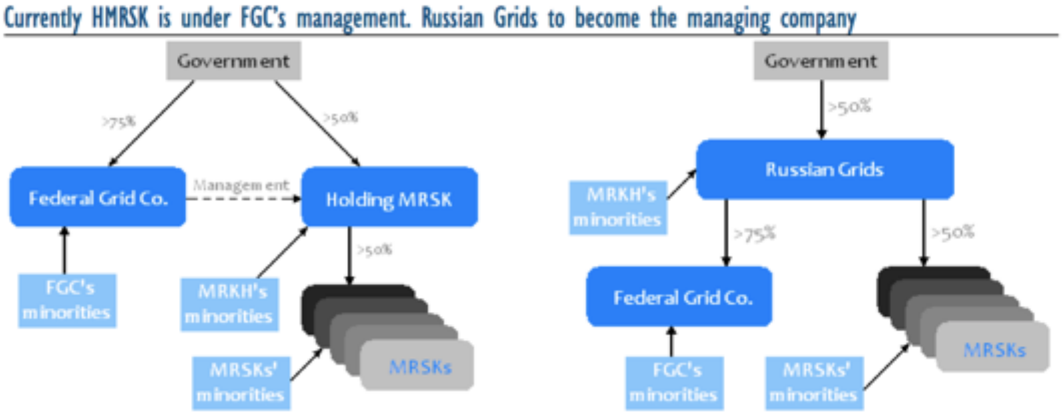

Figure 27 - *Russia grid operators (Kotlyarov G, 2012, S.14)*

MRSK Holding (also known as JSC Interregional Distribution Grid Companies Holding, IDGH) managed Russian distribution network. MRSK Holding consisted of interregional and regional distribution grid companies (IDGCs/RDGCs), research and development institutes, design and construction institutes and construction and sales entities and was under Managemetn of FGC. The MRSK Holding coveres operations of power network of ten voltage types, in the range from 0.4 kV to 220 kV. In the year 2012 the Russian Government decided transfer of grid assets in the sole entity for better coordination and management of the tasks, in order to accellerate the development of the Russian electrictricity network (Rosseti, 2014). The merger between MRSK and FGC has an aim to uniform the approach of technical policy implementation and "the principles of managing Russia's electric grid sector and pursue uniform investment, financial and economic, and personnel policies"[124]. The merger of TSO and DSO in the new entity JSC Russian Grids (Rosseti) was completed in the end of the year 2013. Currently the Russian Grids portfolio consists of interests in 43 joint-stock subsidiaries and affiliates, including interests in 14 interregional and regional distribution grid companies (IDGCs/RDGCs). The controlling shareholder is the Government of Russian Federation with a share of 85.3 %[124].

RUSSIAN ELECTRICITY MARKET: STRUCTURE, DESIGN AND WORKING MECHANISMS

Russia has started the reformation and liberalization process of its electricity market later than the European countries. The process was finished for the wholesale electricity market in 2011, retail part oft he market is still being reformed. The unbundling of services created conditions for the establishment of competitive power market, with price determined by market mechanisms.

[122] Primary energy consumption of gas in Russia was 56% in 2011, Petroleum and coal accounted for 19% and 14%, respectively according to EIA Russia report, March 2014

[123] Josefson, 2013, S. 3

[124] Rosseti, 2014

Thie development of currently existing seven divisions or dispath areas: North- West, Centre, Volga, South, Ural, Siberia and Far East is dedicated by historical development of the United Electricity System in Russian, which was established from the west to the east. Each of seven divisions is so called UES –United Energy System[125]. The first six zones (North-West, including Kalinigrad, Centre, Volga, South, Ural, Siberia are synchronised, the Far East dispatch zone operates nearly autonomously[126]. The UES in the European part of Russia (Nowth-West, Centre, Volga, South and Ural) are well connected to each other and properly connected to the systems outside of the Russian border. The connections between UES Siberia and other UESs are quite weak, which has several implications for system stability and market operations, however there is a so-called "energy bridge", connecting UES Siberia to UES Ural via territory of Kazakhstan[125]. In Siberia itself most of the territory is not covered with the grid, the operations of UES Siberia are only sufficient on the south border of western part of the region. One special electricity zone was established in the north of Siberia – Norilsk electricity zone. The Far-East UES operates almost autonomously as already mentioned above and has only one weak connection to Siberian UES[127].

The electricity market model in Russia is different from European, it is based on nodal pricing. "Nodal pricing or sometimes also called Locational Marginal Pricing (LMP) refers to a centrally dispatched electricity market, where the system operator (SO) is responsible for the optimal use of the electricity system, including the optimal dispatching of the power plants and the efficient use of the transmission networks. In a centrally dispatched system, a node is defined as the entry or exit point of the main grid, and the nodal prices encompass the price of energy, losses and congestion fees at a specific location of the electricity system."[128]. According to the Russian Energy Ministry Russian wholesale power market is divided into 5 zones.

Figure 28 - ***Electricity market zones in Russia***

The first two zones, marked with the numbers 1 (European part of Russia and Ural) and 2 (Siberia) on the map shown in Figure 28 are the non-regulated price areas. Within these market zones electricity can be traded, purchased and sold at non-regulated price, based on supply and demand mechanism. Generating

[125] Belobrov, 2010
[126] Chernenko, 2013, S. 17
[127] RAO UES, 2005
[128] Fingrid Oyj , 2013

companies can buy and sell capacity in the same zones, also at non-regulated price (capacity market). Further zones are zones where trading at non-regulated price is not possible. Zone 5 is so called isolated Far-East zone, due to small number of customers and generators the concurrence is not foreseen for this region and electricity is sold at state regulated tariff price. Zones 3 and 4 non-pricing sectors and are excluded from the wholesale electricity market. The dashd areas on the map are specific areas. Two administrative regions in the North-West dispatch area are excluded from the market and price zone 1 due to weak transmission links, are combined into the non-pricing zone 3, which is regulated by the government[129].

Very important element of the market is price mechanism. The price setting takes place in appliance with so called „zones of free power flow", defined by the technical restrictions of the network[130]. The Russian Federal Antimonopoly Service sets the number of the zones of free power flow yearly. The map on the Figure 29 shows the geographical location of the zones of free power flow for the year 2014[131]. Directly after the reform number of zones was 29, the goal is to decrease the number with the simultaneous extention of the scope of the free-flow zones at the end to have two free-flow zones in the European price area, marked with the number 1 on the Figure 29 and two free-flow-zones in the price area Siberia, zone 2 on the previous chart[132].

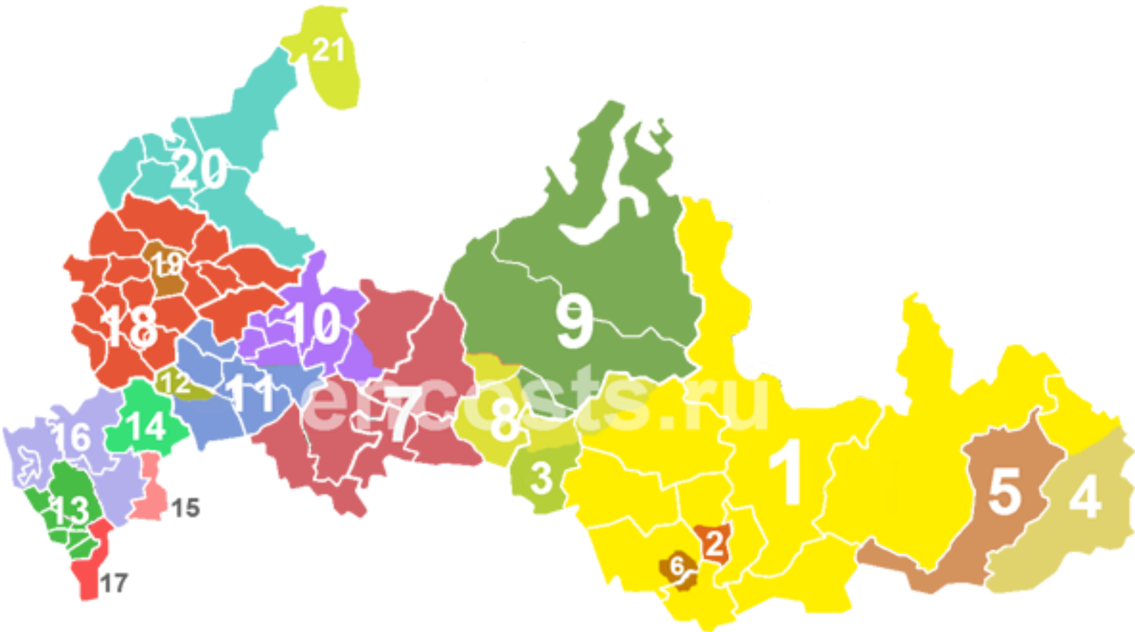

Figure 29 - ***Zones of free power flow for 2014 (Encost, 2014)***

It is important to differentiate between United National Electrical Grid (UNEG), zones of free power flow and the pricing areas. Structurally Russian power market is divided into wholesale market and retail market (not the focus of this report and have not been fully liberalized yet, mostly regulated tariff pricing, set by the government). The main participants in the retail market are consumers of electricity, suppliers, distribution companies and generators that do not have the right to participate on the wholesale market, because the volume of their power generation or consumption is not high enough to be eligible for the wholesale power market"[133]. The wholesale markets incorporate separate day-ahead market and balancing market and capacity market[134].

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[129] Chernenko, 2013, S. 22
[130] EnergoConsultant
[131] Encost, 2014
[132] Prime, 2013
[133] Reuters Practical Law, 2013
[134] IEA, 2013

SPECIFICITIES OF ISOLATED AREAS LIKE KALININGRAD ? GRID, PRODUCTION, CONSUMPTION

The Kaliningrad Region has experienced steady growth in electricity consumption since 2007 till now, by 2.5% yearly. This is almost twice as high as an average electricity consumption growth rate, which is 1.5[135]. In numbers the consumption 2011 was at the level of 4.1 GWh and is expected to reach 5.6 GWh in 2020.[136]. According to the data of NGO Ecodefense the electricity demand is not only covered by two gas power plant with total capacity of 900 MW, but also exceeded its consumption by almost 50%[137]. The challenge for generation is that the region is dependent on a single generating asset without any backup or reserve capacity in place. Russia has no legally binding agreements with the TSOs in the neighboring states securing power supplies to Kaliningrad Region in case of shortages or as back up for the gas power plant Kaliningradskaya TPP 2[138].

In 2012 the plan was to build a nuclear power plant close to Kaliningrad not only for domestic use but also for export to BRELL (Belarus-Russia-Estonia-Lithuania-Latvia) countries, but in the end of 2013 Rosatom froze the construction of the project due to economic reasons[139]. The hope was to attract European investors with the project. Generation assets in the Baltic Region could secure Russia's position as main energy supplier in this region. European investors were not too optimistic about the project and clients are missing too the chances are high, that the Baltic NPP will never be built[137].

The network in the Kaliningrad region has the worst transmission losses among all Russian regions: up to 22 % is lost during transmission and distribution work, world average is at 4 to 9%[138]. The transmission capacity is very limited, underdeveloped network infrastructure of various voltage classes, and a lack of powerful and reliable transmission connections within the grid – while the high degree of reactive power in the network results in increased transmission losses. On the distribution level not enough substations exist in the region. The access to the grid for the new customers is not clearly determined by the legislation and thereby difficult to manage[140].

RUSSIAN WHOLESALE ELECTRICITY MARKET

Russian wholesale electricity market consists of two separate markets for energy and capacity. The liberalization was fulfilled in January 2011. Since the liberalization most electricity has been bought and sold through the centralised wholesale spot market[154]. According to the International Association for Energy Economics, at the end of 2011 about 50% of the electricity was traded at unregulated prices. The aim is to increase this percentage up to 90%, with the exception of residential sector consumption[141]. "Wholesale prices, volumes and counterparties supplying regulated residential customers are regulated by the Federal Tariff Service (FTS)"[134]. For technological reasons, the wholesale power and capacity market is divided into three independent geographic zones:

- The first pricing zone – zone 1 on the Figure 29
- The second pricing zone – zone 2 on the Figure 29
- The non-pricing zone – zone 5 on the Figure 29
  -
  -

[135] Nigmatulin, 2011
[136] Ecodefense, 2012, S. 2
[137] EastBook, 2013
[138] Ecodefense, 2012, S. 7
[139] Menkiszak, 2013
[140] Ecodefense, 2012, S. 9
[141] Kristiansen, 2011, S. 27

- This split is crucial, as power can be traded at free prices only among participants within the same pricing zone.

RUSSIAN POWER EXCHANGE –ATS

- Currently on the Russian market only one Power Exchange is active: ATS – Administrator of the trading System. Cost of services are regulated by the state. Main functions of the ATS are:
- Organization of wholesale power trading
- Developing market rules, ensuring implementation
- Granting market access, maintaining market participants database
- Settlement of financial transactions for the energy traded
- Power production/consumption metering system control
- Market monitoring and analysis
- Providing alternative dispute resolution
- Control over System Operator
-

Traded volume in the two price zones reached approximately 1,000 TWh in the time period from September 2006 to July 2007[142].

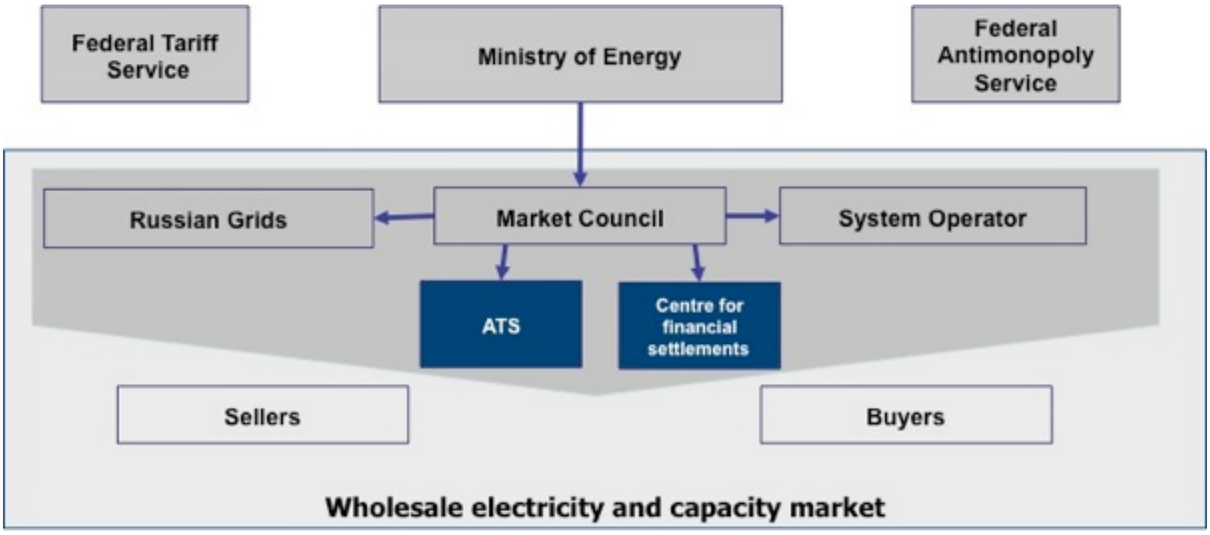

Figure 30 - ***Russian power exchange ATS positioning in the power sector (ATS, 2014, S.6)***

In the year 2013 the volume of 1.1 million GWh of electricity was traded at ATS in the two price zones Europe and Siberia[143]. For comparison, in the EU in 2009 Electricity trading accounted to 6.2 million GWh. The portion of contracts traded on the day-ahead market for relatively big with 0.8 million GWh in both trading zones.

There are four principal mechanisms for trading on the Russian wholesale electricity market[144]:

- **Regulated bilateral agreements** – are seen as a temporary measure to ensure the smooth transition to free-market pricing, currently about 20% of electricity continues to be sold at regulated prices.). Market participants, trading in the competitive wholesale market can enter into bilateral supply contracts, which must be registered with Trade System Administrator (ATS) and are treated as price taker volumes for the purposes of spot market settlement (IEA, 2013). The entry into regulated agreements for a defined volume of power is compulsory for

[142] ATS, 2014
[143] ATS, 2014, S. 53
[144] Reuters Practical Law, 2013

wholesale market participants. The tariffs are set by the Federal Tariffs Service (FTS). The term of regulated agreements varies from one to three years, depending on the generation capacity.

- **Unregulated bilateral agreements** may be concluded between the participants within the same pricing zone. They must contain certain key terms and be registered according to the prescribed procedure.
- **The day-ahead market** is based on a competitive selection of bids, submitted by suppliers and purchasers for the following day. The price is an equilibrium point, determined by the market infrastructure bodies on the basis of submitted bids, taking into account line lossea and system constraints. The day-ahead market is managed by the Trade System Administrator (ATS) and is settled hourly on the basis of the marginal pricing system, determined by the marginal generator offer or consumer bid that clears the spot market[145]. „Spot prices are not subject to pre-determined price caps or floors, but are closely monitored by FAS which has the authority to intervene to regulate wholesale prices where competition is considered insufficient to deliver an efficient pricing outcome"[146]. Russian market is a nodal market with nodal marginal pricing at 6400 nodes with centralized financial settlement.
- **The balancing market** starts working in case of an imbalance between actual generation/consumption and the scheduled one. In this case each market participant of the market must sell/purchase power at the balancing market for the correctinon of the differences. "The amount payable or receivable by the participant as a result of trading at the balancing market, with respect to its deviations occurring in each billing period, is calculated as the sum of the value of deviations occurring in each hour of that billing period"[147]. The balancing market is managed by the System Operator of the United Power System (SO UPS).“[146]

The acces to the market can be granted to each generator, supplier or large end-consumers after fulfilling of the minimum requirements[147]. ATS is resonsible for granting acces to the new market players. List of requerment is below:

1. "Demonstrate that the volume of planned electricity generation or consumption is high enough to be eligible for the wholesale market.
2. Enter into an agreement on accession to the trading system of the wholesale market and complete certain conditions in the agreement (the conditions usually include connecting to the closest transmission facilities and installing special metering equipment).
3. Enter into a number of other agreements required for the functioning of the wholesale market, including agreements for transmission and dispatch services.
4. Become a member of the market council"[147].

Capacity trading mechanism in Russia

Significant in Russian energy industry plays the capacity mechanism, introduced in 2008 as one of incentives for new investments in generation assets[148]. The introduction was announced to the market in form of Capacity Delivery Agreements (CDA). The main goal of these Agreements is to ensure the electricity supply for the periods of peak demand and the promotion of new investments in generation. Under CDAs generation companies are granted with a higher rate for the recuperation of the capital cost for the new generation assets. The mechanism would cover about 15% of the total demand for new capacity through 2030[149].

The main features of Russian capacity mechanism are[150]:

- Selection of the generators for 4 years ahead, starting form 2016
- Guaranteed payments to the generator during construction time of new assets

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145 Lappeenranta University of Technology , 2013
146 IEA, 2013
147 Reuters Practical Law, 2013
148 Oksanen M., 2009, S. 6
149 Larisa Makeeva, 2013
150 EURELECTRIC CIS-EPC, 2012, S. 6

- Capacity supply contracts, as funding for further investments

The CDAs are a part of Competitive Capacity Auctions, where old (launched before 2007) and new (launched after 2007) generation assets, chosen by System Operator (SO) to be reserved capacity, compete to be selected for the coverage of peak demand, the generators get guaranteed remuneration, so called capacity payments. The payments and participation vary for old and new assets, they don't compete with each other. New generators are prioritized in the auctions and receive guaranteed fixed capacity payment, covering the investment and maintenance cost of the assets, units the fixed capacity payment covers only the maintenance cost of the units[151].

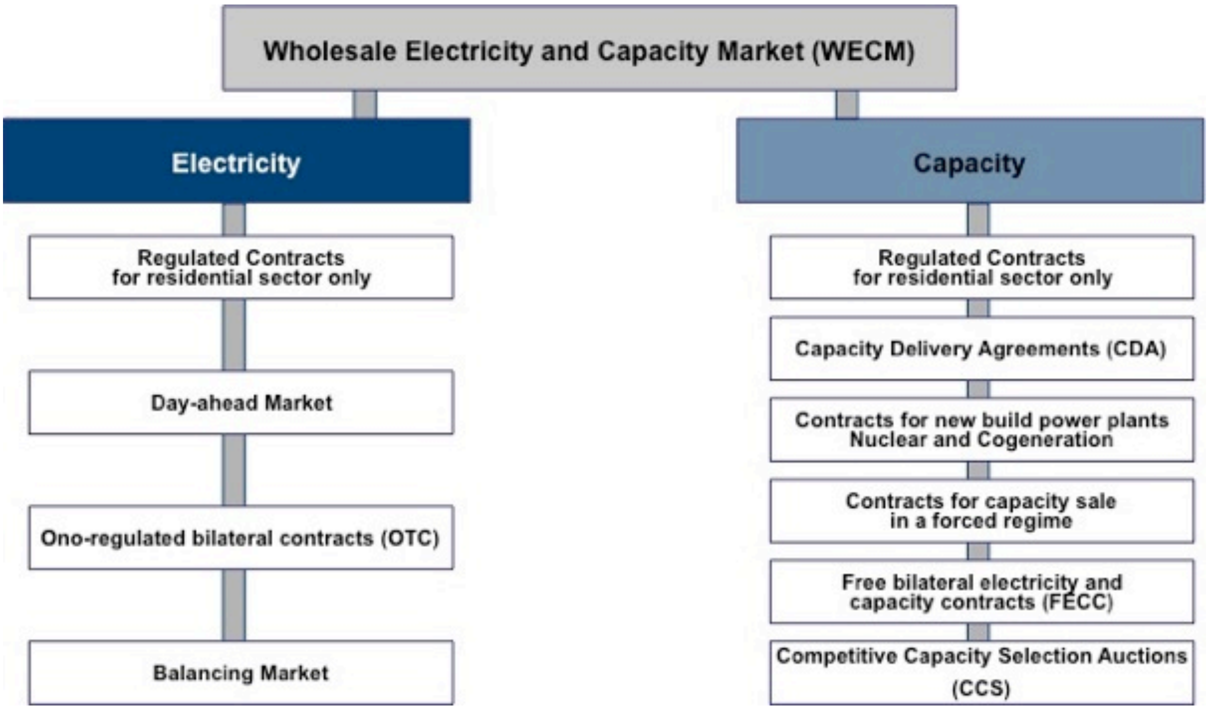

Figure 31 - ***Structure of Russian wholesale and capacity electricity markets (RussHydro, 2013)***

The liberalization of the Russian wholesale electrictiy market was finished in 2010 and since January 2011 power is delivered to the wholesale electricity (capacity) market at non-regulated price. The exceptions are made only for the isolated regions and for the residential sector and some special areas (in the North Caucasus, Republics of Tuva and Buryatia) are subject to regulation. Electric power volumes not covered by regulated contracts are sold at non-regulated prices under free bilateral contracts , on the day-ahead market and on the balancing market, as Figure 31 shows[152].

Capacity volumes not covered by regulated contracts are sold under Free Electricity and Capacity supply Contracts (FECCs), including the commodity market and contracts for capacity sales as the result of competitive capacity selection (CCS) conducted by the system operator.

In addition, the long-term capacity market includes: capacity provision/ delivery/supply agreements (CPAs), for new generation assets. In December 2010, the first campaign to sign capacity provision agreements (CPAs) ended. The thermal generating facility, commissioned under a capacity provision agreement, guarantees capacity payments for 10 years (20 years for contracts similar to CPAs signed with NPPs and HPPs), which provide returns on CAPEX and operating expenses as specified. Capacity supply contracts were signed with heat power industry generating companies, spun-off from RAO UES of Russia. The list includes constructing

[151] Fingrid Oyj , 2013, S. 12
[152] RusHydro, 2013

energy facilities with a total capacity of 28 GW to 2015. A total of 6,840 CPAs were signed with generating companies of the heat power industry and 3,616 CPAs were signed with HPPs/NPPs[152].

Price formation in Russia

Russian electricity market is an 'energy + capacity' market

- – Electric energy price is formed in the day-ahead spot market using the nodal pricing model (app. 8000 nodes in Russia)
- – System Operator (SO) provides the information for the price calculation
- – Forecasted demand
- – Technical parameters of the network
- – Generation units that are needed to satisfy the demand
- ATS (Administrator of the Trading System) calculates the nodal prices[153]
- Capacity price depends on the peak demand, the type of available
- generation, the reserve ratio and the possible imports and exports
- – Capacity prices are formed for the zones of free power flow
- – 29 zones in total, 26 classify as concentrated markets àà price caps
- – Market concentration is checked annually

CDA = Capacity Delivery Agreement, contract between government and thermal generators

LTA = Long-- - term Agreement, contract between government and nuclear and hydro generators

System operator selects on monthly basis the generators that are needed to satisfy the peak demand

- – For new capacity the price can be e.g.15000 Euro/MW/Month
- – The price cap for old generation can be e.g. 3000 Euro/MW/Month
- – The regulated tariff can be e.g. 4000 Euro/MW/Month ("forced" generation)

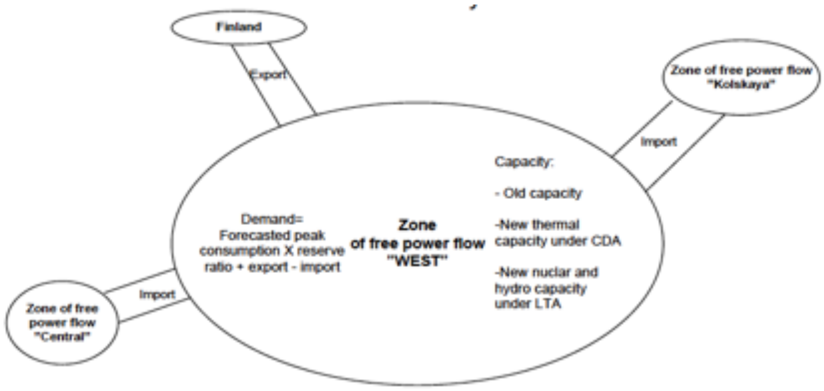

Figure 32 - ***Capacity price formation in Russia (Viljainen, 2012, S.7)***

RUSSIAN REGULATORY ENTITIES AND POLICY FOR ELECTRICITY TRADING

After the restructuring and liberalization the main actors on the Russian electricity market become Territorial Generating Companies (TGCs), the Wholesale Generating Companies (WGCs), the Federal Grid Company (FGC) and Distribution Grid Companies (DGCs)[154], System operator (SO), The Administrator of the

[153] Viljainen, 2012, S. 5
154 FGC and DGCs have merged in 2013 under the name Russian Grids

Trade System (ATS) – Russian Power Exchange, the Federal Antimonopoly Service (FAS) and the Federal Tariff Service (FTS)[155].

Federal Grid Company (FGC) owns the transmission grid and is responsible for its operations and maintenance. SO plays a very important role on the Russian electricity market. The main goal of the Russian System Operator is provision of stability and quality of electricity supply. SO is responsible for technical regalements and dispatch actions, it optimizes the use of the network and report to the Administrator of the Trade System. ATS organizes the trade process on the wholesale market, is in charge for the operations in the balancing markets, as illustrated on the Figure 33 and for bilateral contracts. ATS basically acts as a regulatory agency in very close cooperation with SO. The tariffs for the regulated parts of the market are carried out and determined by FTS, FAS is the surveillance mechanism on the Russian electricity market[156]. FTS is also responsible for tariffs on the non-regulated part of the market: for transmission, trading fees etc.

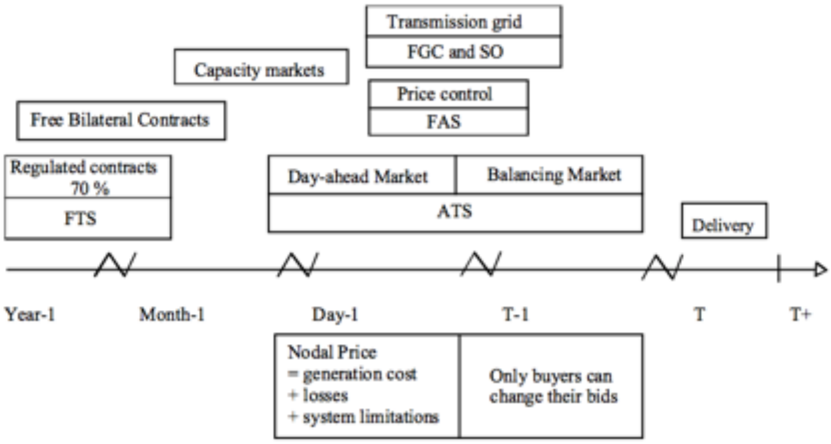

Figure 33 - ***Electricity market model in Russia (Oksanen M, 2009, S.5)***

The legislation in Russian energy sector is based on 2 Federal Laws: 26.03.2003 35-FZ "On Electric Power" and 14.04.1995 41-FZ "On State Regulation of Electric Power"; diverse Governmental decrees, covering the topics of market rules for wholesale and retail, non-discriminatory access to infrastructural services and network, pricing rules, technical connection to networks and regulatory methodology orders from Federal Tariff service[157]. Main goals of the electric Industry are:

- Development of highly integrated transmission and distribution networks of new generation (Smart Grids) in the Russia's Unified energy system
- Developmnet of ultra-high voltage alternating and direct current electric transit lines the Siberia – Urals – European part of Russia (Institute of Energy Strategy, 2009). These line s are needed for better connection between the price zone and easier capacity allocation for cross-zonal electrictiy trading.

Under the Russian Energy legislation it is prohibited for a single company to combine generation, transmission and dispatch activities. For this reason, generating companies that own transmission (or distribution) facilities areforced to rent these facilities to local transmission and distribution companies.

Regulatory functions in the energy sector in Russian are distributed among several authorities: the Ministry of Energy (ME), the Federal Tariff Service (FTS), the Federal Anti-Monopoly Service (FAS), and the Ministry of Economic Development (MED). The Ministry of Energy and the Ministry of Economic Development have primary responsibility for the energy sector. ME is in charge for investment programs

155 RAO UES, 2005

156 FAS, 2014

157 FTS, 2011

development and authorization of energy infrastructure projects and MED is responsible for the general energy regulation issues with regards to the economic planning and development[158]. The Federal Tariff Service (FTS) was established in 2004 (Decree 332, 2004) with an aim of improvement of the regulatory mechanism in Russia. The FTS is a federal executive body, responsible for the regulation of tariffs for natural monopolies, in particular for the sectors: electricity, oil and gas and infrastructure. The FTS is responsible for setting tariffs (tariff limits) and settling disputes concerning regulated services[158], in particular, it approves and amends tariffs for[159]:

- electricity transmission service
- for heat energy produced by cogeneration electric power stations
- electric energy (power) sold by producers at the wholesale market of electric energy (power) at regulated prices or their marginal levels
- services and organized trade operations in the wholesale market
- operational-dispatch supervision in electricity sector
- services ensuring system reliability in electricity sector
- organized operations and development of the indicative prices for residential customers in order to shape regulated contracts
- services of electric power transmission through power distribution networks within the territorial entities
- technical connection to the grid

The FTS reports directly to the Russian Government and does not have regional offices. On the regional level the Regional Energy Commissions or RECs are regulatory governmental agencies representing the FTS, that are responsible for the implementation of procedures and methodology guidelines issued by FTS. The Federal Antimonopoly Service (FAS) is a federal-level executive governmental body supervises the execution of competition laws and compliance with anti-monopoly regulations, e.g. access to transmission services, pricing etc. But also FTS has the right to execute penalties for violation of law on natural monopolies concerning tariff and price regulation. The Federal Service for Ecological, Technological and Nuclear Supervision (Rostekhnadzor) is the regulatory body responsible for implementation of and monitoring of rules and standards concerning the health, safety and environment requirements[160].

A non-commercial organization, called Market Council was established to control the execution of Wholesale Electricity Market Rules and to monitor the pricing situation on the market. The schematic presentation of the functional spread on the electricity market in Russian is shown on the Figure 34.

[158] EBRD, 2009, S. 229
[159] EBRD, 2009, S. 231
[160] Reuters Practical Law, 2013

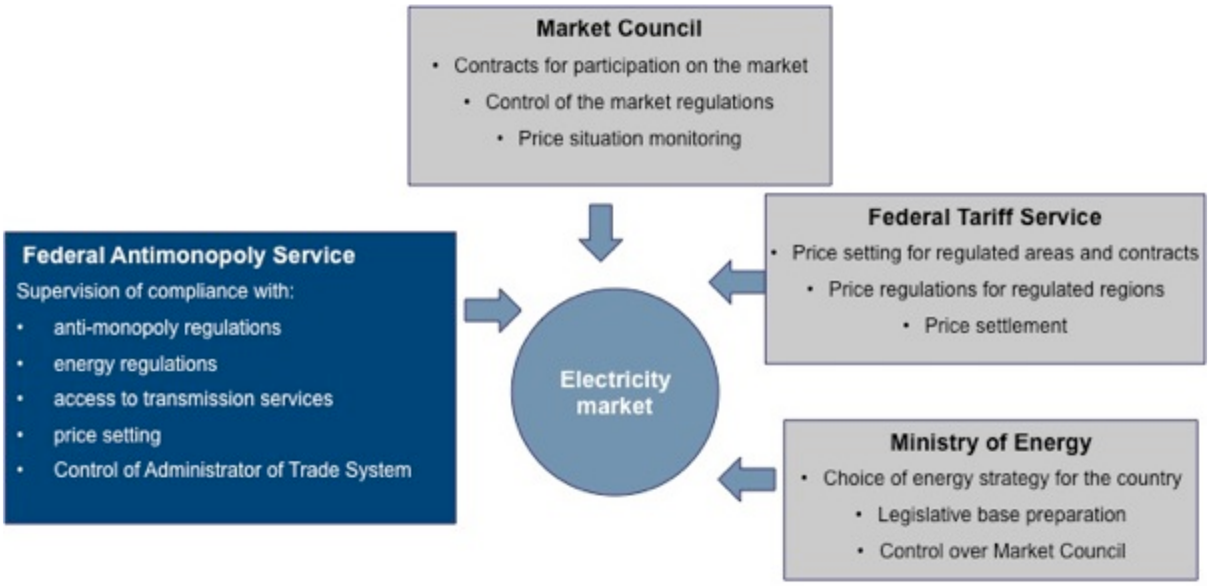

Figure 34 - ***Russian Regulatory Organizations***

While the overall regulations of the Russian power market is endorsed by the authorities described above, the physical functioning and operation of the wholesale market for electricity and capacity is managed and supervised by the following market infrastructure bodies.

Market Council (MC) was already mentioned, it is a non-commercial partnership of wholesale market participants with the overall aim of market supervision and preparation of standard documents and agreements for the market. Another one non-profit company is the Administrator of the Trading System (ATS). ATS is fully subsidized to Market Council and its duty is the administration of the trade on the market and its facilitation by bringing together sellers and buyers. ATS has access to daily aggregated data on the spot market and traded volumes[161]. Centre for Financial Settlements (CFS) is a fully owned subsidiary of Administrator of the Trading System (ATS) and acts as an intermediate for payments on the wholesale market.“ (Reuters Practical Law, 2013). The System Operator (SO) is responsible for dispatching and the stable functioning of the transmission grid, the company is fully state-owned (Reuters Practical Law, 2013). The Market Council together with the ATS and the SO elaborate the rules and procedures for electricity and capacity markets. Trading is currently possible on Moscow Energy Exchange on the one-day-ahead and balancing (or real-time) market. Capacity market is separated form the electricity, capacity is traded in annual auctions with monthly prices[162].

Russian Government updates the long-term projections for the development of the energy sector in the coutrly every three to five years and publishes a social-economic outlook each year[163]. In accordance with the updated Energy Strategy to 2030, 4.5 per cent of all electricity produced and consumed in 2020 should be generated from Renewable energy sources, excluding large-scale hydropower plants above 25 MW from the calculation[164]. This is a big step for Russian but a very low target, in international comparison, especially with the 20/20/20 ambitions and targets of the EU.

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[161] IEA, 2013, S. 54
[162] Chernenko, 2013, S. 42
[163] IEA, 2013, S. 54
[164] Institute of Energy Strategy, 2009, S. 25

IMPORT AND EXPORT OF RUSSIAN ELECTRICITY

The available import/export capacities depend on the transmission grid architecture and domestic demand/supply curve at the certain point of time. In Russia the company InterRAO export is responsible for export and import of electricity. According to the latest report of InterRAO the exports of electricity in 2013 decreased by 4% in comparison to 2012 and were at the level of 17.5 TWh, the imports in contrary increased by 75% during the same time period at were calculated in 2013 as 4.6 TWh[165]. The export decreased because Finland stopped the imports in March 2013 due to high prices for Russian electricity and decreasing prices at Nord Pool. High water levels can explain the price decrease in Scandinavia, what have created excess supplies of cheap hydropower on the Nord Pool Spot market. The trade between Russia and Finland existed since 1981 through a 1,400 MW high-voltage line[166].

The main reason for surplus on the import side comes from increased volumes in trading with Kazakhstan. The geographical location for main cross-border trading directions in shown on the Figure 35. Almost 80% of exports were sold to Finland, Belarus, Lithuania and China.

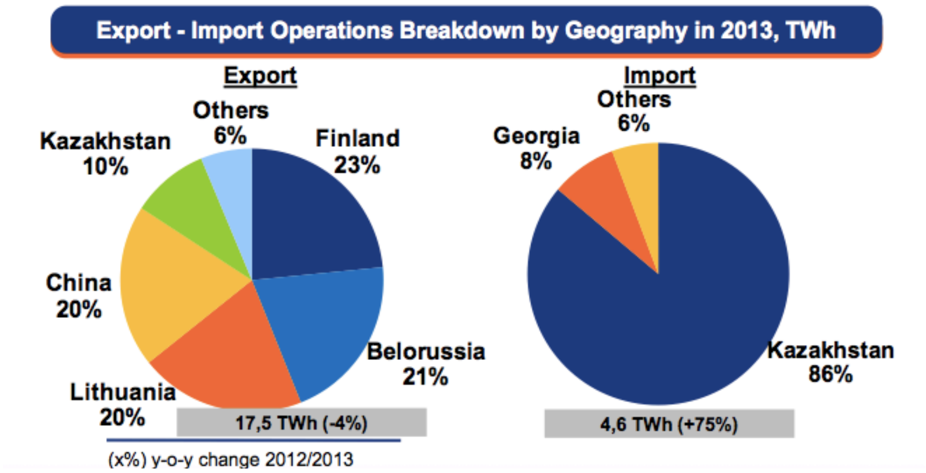

Figure 35 - ***Russian electricity exports and imports by geographical region 2013 (InterRAO Export, 2014)***

165 InterRAO Export, 2014
166 Pettersen, 2014

5.3. INTERCONNECTION EU/RUSSIA

The interconnection and synchronization of the European and Russian/CIS electric power systems and markets is seen by the both sides as a way for increase of security of supply. In the European Union security of electric supply was and stay the key policy area. In 2012 on the CIS Power Council conference in Brussels, EU Commissioner for Energy Mr. Oettinger stressed out the importance of ensuring the secure and steady electric supply and the global importance of this topic one more time[167]. Another challenge and ambition of the European Union and Commission is the fair price of electricity for the end-consumers: reflection of the wholesale price at the end price. In order to achieve this goal it is important to have strong coordination and cooperation not only within Member States but also with the neighbor countries. The negotiation and establishment of common rules and standards between EU and Russia/CIS in the eyes of EU Commissioners will enlarge the benefits of internal integrated European electricity market, electricity ahs a potential to become a new key component of the relationships between EU and Russia. Around 140 billions EUR[167] will be invested according to the Ten Year Plan, edition 2011, in transmission networks, smart grids and electricity storage facilities. There are expectations from both sides to increase electricity exchanges over the next years. For the European Union electricity imports can be one of solutions for increasing security and reliability of supply, while increasing the share of renewables in EU and buying additional capacities from neighboring countries.

Due to the nature of the infrastructure for electricity networks, transmission and distribution system operators are natural monopolies. A move towards incentive-based regulation for natural monopolies implies important consequences for quality of supply. In order to ensure that quality is not compromised at the expense of company cost reduction measures, regulators include quality factors in their regulatory framework. In this context, the evolution of network regulation has seen the development of regulatory frameworks aiming to strike a balance between cost efficiency and quality of supply. In order to advance the understanding and experience in this area, CEER regulators regularly exchange good practices on how to manage this delicate balance, keeping in mind regulators' core objective to find solutions benefiting society as a whole including taking into account all public and private interests.

On the Russian Market the Ministry of Energy (more details on Russian energy sector and regulatory could be found in the 5.2) is the entity responsible for regulatory regime. Federal Anti-monopoly Service is also involved in this issues as a supervisor on the market, Federal Tariff Service is responsible for pricing on the regulated part of the market: the long-term tariffs and regulatory asset-base RAB, which are not the same in Russia, which makes a big difference in comparison to European Union and other countries. „Federal Tariff Service is an executive body authorized to exercise legal control in price and tariff regulation for goods and services in compliance with the Russian Federation legislative acts as well as the control over their implementation except price and tariff regulation that is within jurisdiction of other federal executive bodies. Also Federal Tariff Service is a federal executive body that regulates natural monopolies in which case its functions encompass price (tariff) determination (setting) and control over issues related to price (tariff) determination (setting) and application in the business of natural monopoly agents."

CEER – Council of European Energy Regulators is involved in the information exchange with the eastern countries. Since 2009 CEER have regular meeting with Russian Federal Tariff Service (CEER, FTS and CEER first Meeting, 2009). Since 2012 the Eastern Partnership Platform exist and enables regular exchange on regulatory experiences and practices across European borders between the regulators of the Eastern Partnership (CEER, First workshop, 2012). One of the last joint meetings between CEER and FTS was in July 2013, at the meeting the Kazan Statement[168] of Energy Regulators statement on regulation and promoting investments in energy infrastructure was published and the main focuses in electricity regulations for Europe and Russia were fixed. The statement points out the main fields for electricity regulations direction. The independent role of National Regulatory Authorities (NRA) is stressed as one the most important to achieve the regulatory goals.

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[167] Oettinger, 2012
[168] Russia G20, 2013

5.4. CASE OF BALTIC ELECTRICITY EXCHANGE AREA

INTRODUCTION

NordPoolSpot (NPS) price area was fully opened in Estonia on January, 1st 2013. NPS price area was also extended to Lithuania at the beginning of 2012 and Latvia in June 2013.

From the other side Estonian, Latvian and Lithuanian electricity systems belong to the larger synchronised united system - BRELL, which controls the AC power lines connecting Estonia, Latvia, Lithuania, Belarus and Russia. BRELL is responsible for coordinating operational planning (year-ahead until day-ahead) and real-time operation (including disturbance management).

Nordic-Baltic electricity Balance is shown in Figure 36. The size of electricity market in Baltic countries is significantly less compared with Northern Europe and, globally, is energy-dependent.

Electricity Balance 2012, TWh	Consumption	Production	Balance
Estonia	8,1	10,5	2,4
Latvia	7,2	5,5	-1,7
Lithuania	10,3	3,7	-6,6
Baltic Total	**25,6**	**19,7**	**-5,9**
Norway	128	146	18
Sweden	142	162	20
Finland	83	66	-17
Denmark	34	29	-5
Nordic Total	**387**	**403**	**16**

Figure 36 - Nordic/Baltic electricity balance (NordPoolSpot)

ESTONIA, LATVIA, LITHUANIA - ENERGY MIX OVERVIEW

Total installed capacity and breakdown by type of energy source are depicted in Figure 37. However, real possible net generation is considerably lower, as it depends on maintenance of equipment and emergencies and on the available production from wind and hydro-powered generation.

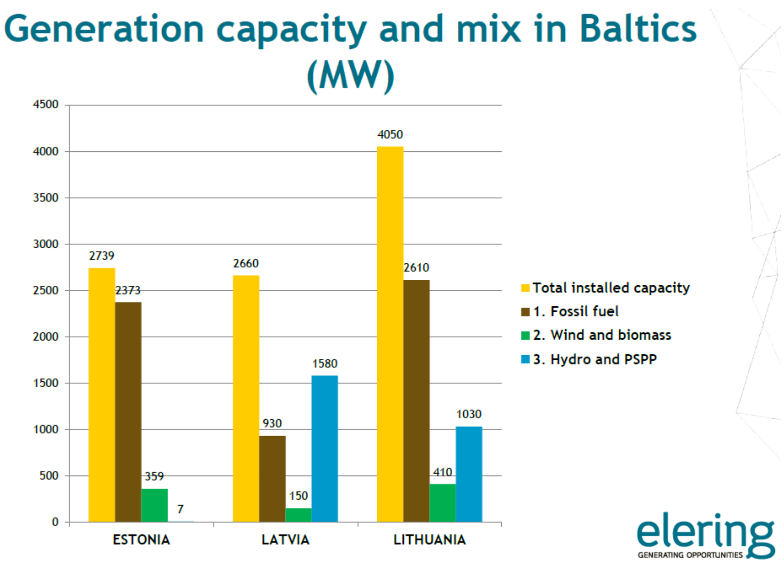

Figure 37 - generation capacity in Baltics

In fact only Estonia energy system has electricity surplus over a 12-month period. Elering – Estonian TSO, also uses own electrical grid for the purpose of electricity transit from Northern Europe to Latvia, and to Latvia through Russian network. Estonia, indeed, foresaw very soon the opportunity of positioning themselves as a power transit place and designed their network for that purpose.

As per Figure 38, electricity transit from Northern Europe amounts almost 40% of Estonian internal consumption, and whole electricity export amounts 75% of Estonian internal consumption. Latvia and Lithuania energy systems are dependent from electricity import. Latvia produces electricity, which amounts 73% of state internal consumption. Even worse for Lithuania, own electricity production is only 33% of internal consumption. Augstsprieguma tīkls – Latvian TSO, transmits 65% of imported electricity from Estonia and Russia to Lithuania. Lithuanian TSO – Litgrid has developed cross border electricity connections, and imports electricity from Latvia, Kaliningrad region and Belarus to cover lack of own production. Considerable lack of electricity production in Lithuania and Latvia was caused by decommissioning Ignalinskaya NPS nuclear power station and not competitive local generation.

Period	Parameter	Estonia	Latvia	Lithuania
July2013-june2014	Electricity production, GWh	10 762	5 258	3 191
July2013-june2014	Electricity consumption, GWh	7 724	7 137	9 574
July2013-june2014	Electricity internal balance, GWh	3 038	-1 879	-6 384
July2013-june2014	Electricity import, GWh	2 866	5 617	7 145
July2013-june2014	Electricity export, GWh	5 844	3 703	0

Figure 38 - Baltic countries electricity balance (NordPoolSpot)

Estonia, Russia, Latvia

EstLink 1, a DC undersea cable between Estonia and Finland, has also been in operation since the end of 2006, and bears great symbolic significance for the connection of the electricity systems of the Baltic and Nordic states. EstLink 1 has nominal transmission power of 350 MW. Construction work on the second interconnection between Estonia and Finland, the EstLink 2, started in early 2011. The EstLink 2 undersea cable is 170 km long, with around 140 km of the cable lying at the bottom of the Gulf of Finland. The new connection became operational in 2014. The completion of EstLink 2 in 2014 has added 650 MW of transmission capacity between Finland and Estonia, allowing for a total of 1,000 MW of electricity to move between the Baltics and the Nordics. EstLink 1 and 2 transmission capacity ensures that Estonia is strongly connected to the Nordic electricity system and the effective functioning of the electricity market, without being synchronized. Risks are hence mitigated whereas market benefits happen.

Three 330 kV lines connect Estonia with Russia, two running from Narva to St Petersburg and Kingissepp, and one linking Tartu and Pskov. Elering is connected to the Latvian system by two 330 kV lines, one between Tartu and Valmiera, and one between Tsirguliina and Valmiera. All Baltic electricity systems interconnections are depicted in Figure 35.

Figure 39 - Baltic cross-border interconnections (Augstsprieguma tīkls)

Latvia, Lithuania, Russia

Electricity transit from Estonia to Latvia is splitted in a three lines: two existing 330kV lines between Estonia and Latvia and one existing 330kV line from Kingisepp to Pskov in Russian territory passing along Estonia-Russia border. Cross border electricity transmissions for Estonia are depicted on Figure 40.

Period, 12months		Estonia
	Electricity Import	
July2013-june2014	Import from Finland through DC links EstLink 1 & 2	2 866 GWh (average per year per hour – 327 MW/h)
	Electricity Export	
July2013-june2014	To Russia (transit to Latvia)	1 745 GWh (average per year per hour – 199 MW/h)
July2013-june2014	Directly To Latvia (two existing 330kV lines)	4 099 GWh (average per year per hour – 468 MW/h)

Figure 40 - Cross-border electricity transmissions for Estonia (NordPoolSpot)

Latvian transmission network, which managed by Latvian TSO - Augstsprieguma tīkls AS, consists of 330 kV and 110kV AC overhead lines. Latvia transmission network has two 330 kV AC lines connection with Estonia, one 330kV AC line connection with Russia (Pskov) and four 330 kV AC lines connection with Lithuania. Cross border electricity transmissions for Latvia are shown on Tab.3.

Period, 12months		Latvia
	Electricity Import	
July2013-june2014	Import from Estonia through 2*330 kV AC links	4 099 GWh (average per year per hour – 468 MW/h)
July2013-june2014	Import from Russia through 330 kV AC link (Pskov-Rezekne)	1 518 GWh (average per year per hour – 173 MW/h)
	Electricity Export	
July2013-june2014	To Lithuania through 4*330kV AC lines	3 703 GWh (average per year per hour – 422 MW/h)

Figure 41 - Cross-border electricity transmission for Latvia (NordPoolSpot)

Lithuania, Latvia, Russia (Kaliningrad region), Belarus.

Lithuanian transmission network, which managed by Lithuanian TSO - LitGrid, consists of 330 kV and 110kV AC overhead lines. The transmission grid of Lithuania is well connected with some of the neighboring power systems: by four 330 kV lines and three 110 kV lines with Latvia, five 330 kV lines and seven 110 kV lines with Belarus, and three 330 kV and three 110 kV lines with the Kaliningrad Region. 50% of Lithuanian electricity import coming from Latvia (Figure 42). Almost 30% coming from Russian enclave – Kaliningrad region and the rest amount of electricity coming from Belarus.

12months		Lithuania
	Electricity Import	
July2013-june2014	Import from Latvia through 4*330 kV AC links	3 703 GWh (average per year per hour – 422 MW/h)
July2013-june2014	Import from Russia (Kaliningrad region) through 3*330 kV AC links	2 065 GWh (average per year per hour – 235 MW/h)
July2013-june2014	Import from Belorus through 4*330 kV AC links and 1*750kV AC line	1 376 GWh (average per year per hour – 157 MW/h)

Figure 42 - Cross-border electricity transmissions for Lithuania (NordPoolSpot)

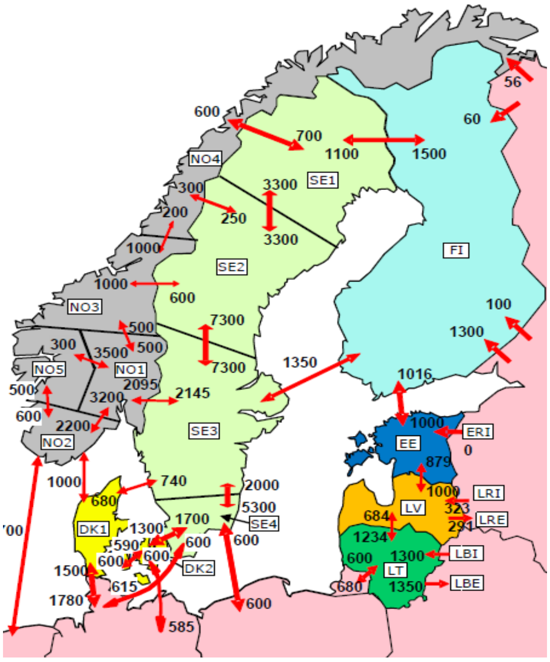

Figure 43 - NTC of NordPoolSpot area (Organization for Nordic Transmission System Operators)

Net Transmission Capacity (NTC) is the capacity that is given for market participants to use in cross-border energy trading. NTC of Nord pool spot area is shown on Figure 39.

Estonia: Est Link 2 increased the transmission capacity between Estonia and Finland (or between Nordic area and Baltics) by 650 MW. The obligation of Estonia TSO -Elering is to be ready for the tripping of the biggest generator or DC link in Estonian Power System (the biggest unit is Est Link 2 when it is in full power from Finland to Estonia – 650 MW). Restrictions (by 140 MW) were until summer 2014 when second emergency reserve power plant (140 MW) in Kiisa were commissioned. 3rd July 2014: restriction from Finland to Estonia removed due to commissioning of Kiisa ERPP 2. Net Transmission Capacity of FI-EE/EE-FI now is 1000 MW/1016 MW.

After installation of Est Link 2 Energy price in Estonia and Finland is most of the time identical.

Latvia: Currently the most restricting bottleneck in the power systems of Baltic countries is located on the two-line interconnection between Latvia and Estonia. Looking at Figure 35, Both existing interconnection lines are concentrated on a small geographical area and are connected to one substation in Latvia - Valmiera substation. Security of supply for the whole Baltic region is endangered in case of trip of large generating units in Latvia and Lithuania. To mitigate that situation, TSOs are forced to decrease interconnection transfer capacities for this chain available for the market. NTC of this interconnection now is 879 MW/1000 MW. Planned third interconnection between Latvia and Estonia will help to eliminate this bottleneck and will provide more interconnection transfer capacity for the electricity market. Current transfer capacity in the Estonia-Latvia interconnection is insufficient for the energy trade in the Baltic region. These market restrictions are especially tight during the summer period. NPS price in different Baltic countries are shown on Figure 45. NPS price for Finland and Estonia – blue line, NPS price for Latvia and Lithuania – yellow line.

The network capacities of Kurzeme region (Figure 40) in Latvia are insufficient, as the existing 110 kV network is overloaded and therefore no more permissions for constructing new wind power plants can be issued, unless the 330 kV ring is constructed. This insufficiency was evidenced in 2005, when a large part of Kurzeme population was left without electricity as a result of the fierce storms.

Figure 44 - Kurzeme region grid design (Augstsprieguma tīkls)

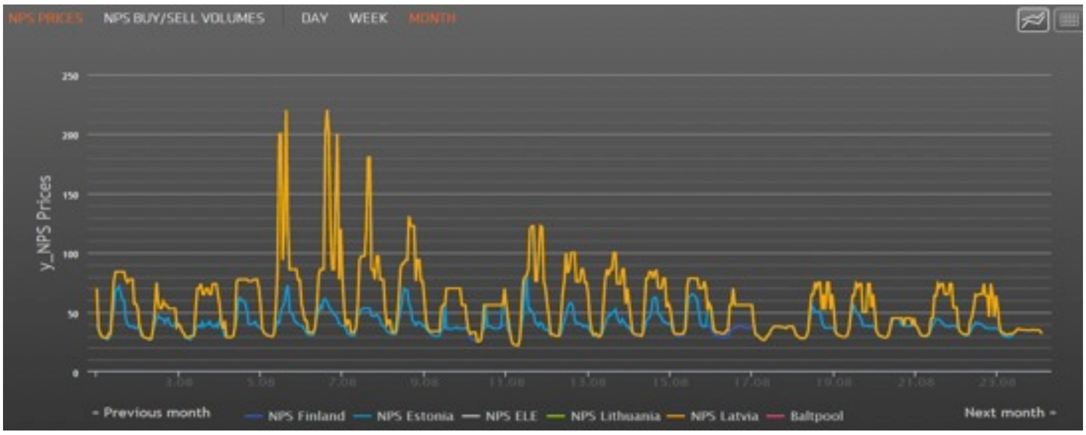

Figure 45 - NordPoolSpot price deviation in different Baltic countries (Elering)

Lithuania: The transmission grid of Lithuania is well connected with neighbouring power systems: Latvia, Belarus, Kaliningrad region of Russia. Net Transmission Capacity of Belarus-Lithuania/Lithuania-Belarus now is 1350 MW/1300 MW, Latvia-Lithuania/Lithuania-Latvia is 1234 MW/ 684 MW, Kaliningrad-Lithuania/Lithuania-Kaliningrad is 600 MW/ 680 MW.

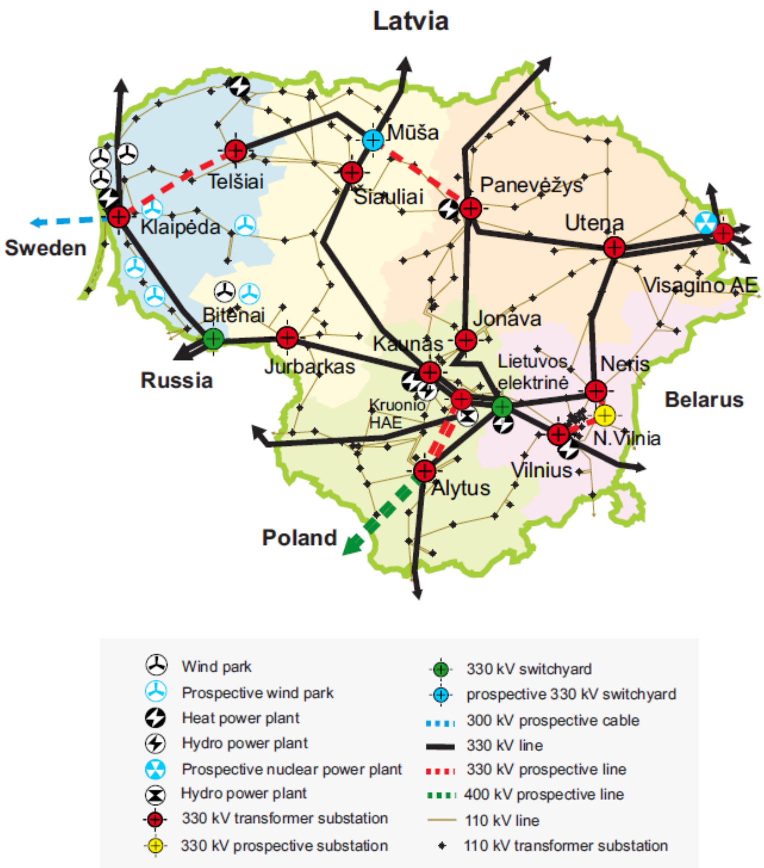

Figure 46 - Lithuania strategic network development (TYNDP)

Lithuania, like the other two Baltic States, seeks to join the decentralized European power system. As part of implementation of the most important objective in the area of energy independence – the connection of the Lithuanian power system with the European system, Litgrid is implementing the following strategic power system projects:

- construction of the intersystem power links with Poland (LitPol link – HVDC b2b) and Sweden (Nordbalt link – HVDC cable), which create conditions to increase competitiveness of electricity market;
- preparation for integration of the Lithuanian power system into the grids of Continental Europe (synchronous operation Lithuania power system with CE).

In order to make full use of the NordBalt Link it is crucial to realize next main network development projects: The 330 kV electricity transmission line Klaipėda-Telšiai, which will be used for the transmission of electricity supplied from the Nordic countries and Panevezys-Musa 330 kV overhead power line to ensure maximum use of the NordBalt power link, both in importing electricity from northern Europe and in exporting it from Lithuania. Refering to Figure 42, the Kurzeme Ring project is an energy infrastructure project involving the construction of a 330kV high voltage overhead line in the western part of Latvia to ensure the possibility of connecting the increased capacities in Kurzeme, impossible up to now. Kurzeme Ring constitutes a part of the NordBalt project too and create conditions for better utilization of energy coming from Nordic countries. The Kruonis HPSP–Alytus 330 kV overhead power line (2010–2016): the line is necessary for full utilization of the LitPol Link interconnection.

POSSIBLE SYNCHRONOUS INTERCONNECTION BALTIC COUNTRIES AND CONTINENTAL EUROPE. FEASIBILITY STUDY.

A thorough Feasibility study on the interconnection variants for the integration of the Baltic States to the EU internal electricity market for the target year 2020 has been performed by the Baltic States TSOs together with the Swedish consultancy company Gothia Power AB. It is concluded from the study that synchronous operation with the Continental Europe synchronized power system (CE) is feasible, from a technical point of view, i.e. with respect to power flow, control and stability. However, reinforcements are needed in the present power system of the Baltic States, in Poland, and in Kaliningrad (when synchronous with CE), control and reserves have to be upgraded, and a number of back-to-back converters towards Russia and Belarus have to be installed. Special attention has to be paid to the size and design parameters for the planned Visaginas nuclear power plant, since it would be the limit-setting unit in many operational situations, especially in island operation. The large size of the planned Visaginas unit also requires quite large reserves.

No major legal or regulatory obstacles against a synchronization has been identified, but a number of issues have to be negotiated, resolved and agreed on. The investment costs and annual costs for a change of synchronous operation are high, compared to the market benefits. Although, a change of synchronization from the present IPS/UPS system to the CE system cannot be based on traditional technical or economic analysis as presented in the study, there might be other driving forces for such a change.

Three main interconnection variants, and variations thereof, have been investigated:

- Baltic States synchronous with IPS/UPS,
- Baltic States and Kaliningrad synchronous with Continental Europe,
- Baltic States synchronous with Continental Europe, but asynchronous with Kaliningrad.

*From the **load flow study** it is concluded that*:

- Synchronous operation of the Baltic States power system with the CE system is feasible from a load flow contingency point of view.
- Some new transmission lines should be established to overcome identified bottlenecks within the Baltic States. Reinforcements of the Polish system close to Lithuania are also presumed and specified.
- The proposed connections and reinforcements are designed with respect to the present and planned system capacities in the affected areas, resulting in import/export restrictions only for extreme operational conditions.
- As the existing IPS/UPS transmission system ring will be broken, it is found that the western part of the Russia/Belarus transmission grid has to be strengthened.
- If Kaliningrad joins the Baltic States in synchronous operation with CE, LitPol Link 1 converted to AC and a double circuit 400kV AC connection between Kaliningrad and Poland is recommended.
- If Kaliningrad will be asynchronous with the Baltic States, LitPol Link 2, double circuit 400kV AC connection between Lithuania and Poland, is necessary to provide sufficient operational security.

To enable power exchange with IPS/UPS, HVDC back-to-back links should be established: Lithuania-Belarus, Estonia-Russia, Latvia-Russia.

The ***regional stability analysis*** has shown that the necessary primary reserve can be transmitted through Poland. No major obstacles against synchronous operation of the Baltic States with CE, with respect to transient stability, have been identified. The transient stability of Visaginas NPP might be an exception that has to be addressed in the design phase of the nuclear power plant.

Wide area stability. The inclusion of the Baltic States dynamic power system model to the dynamic model of the CE system and Poland does not introduce more modes in the frequency range 2-6 rad/s (0.3 – 1 Hz). The damping of the oscillations identified is found to be acceptable.

The ***Gap analysis*** is part of the socio-economic analysis. It reviews the operational differences between the current situation in the Baltic States and the CE system requirements. Moreover, the changes that the Baltic States, as ENTSOE members, must implement according to the upcoming network codes are identified. The main difference between the current situation in the Baltic States and in CE, is found to be the issue of reserves. If the Baltic States would join the CE system, they have to deliver their share of about 25 MW to the total Primary Control Reserve and to ensure enough transfer capacity to transmit Primary Reserve, in case of trip of the largest unit. Also the issue of secondary and tertiary reserves might be considerably costly, especially if Visaginas NPP will be built at 1350 MW. Finally data sharing might be an obstacle in some situations, e.g. if ENTSO-E will require sharing of confidential BRELL data in scenario A of TYNDP – Figure 47.

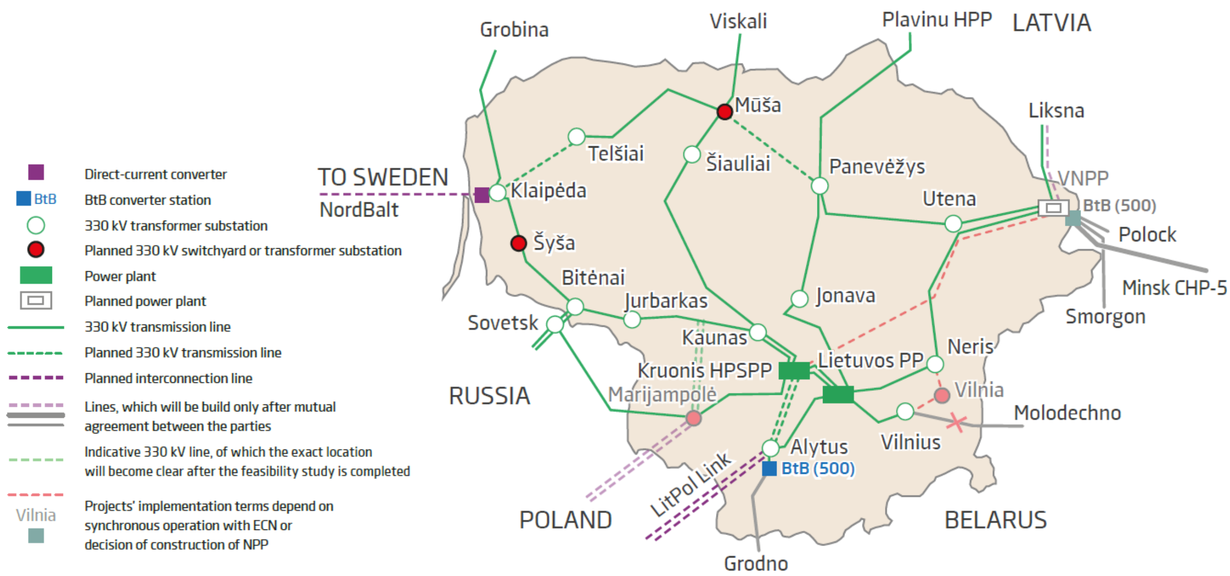

Figure 47 - Scenario A of TYNDP : Synchronous operation between EU system and Visaginos NPP

The ***Socio-economic*** analysis comprises associated investment costs and an electric energy market model for the different interconnection variants to derive the corresponding benefits. ***It should be noted that from an electric energy market point of view, it is irrelevant if an interconnection is synchronous or asynchronous***. Furthermore, other costs than investments, such as costs for operation, reserves, control, administration, etc., as well as costs related to socioeconomic risks, are included in the cost-benefit analysis. Sensitivity analyses with respect to eastward trading capacity for the scenarios with synchronous operation with CE, as well as with respect to synchronous operation with Kaliningrad and LitPol Link 2, have been included in the study. Furthermore the sensitivity of increased asynchronous capacity towards Poland and Europe has been investigated for the synchronous operation with IPS/UPS. Based on a traditional cost-benefit evaluation of the different scenarios, synchronization with CE might be hard to motivate.

BALTIC COUNTRIES ELECTRICITY MARKET DEVELOPMENT

The Baltic electricity markets are too small to operate efficiently on their own. They have to be connected to the neighboring markets, and through them, to the rest of Europe.

Predicted electricity price depends on the choice of assumptions on forecasted electricity demand, fuel prices, the price of carbon permits, subsidies for RES power plants, the production technologies, volumes and prices of electricity import from third-parties (Russia, Belarus), the interconnections and developed scenarios. Start of operation of „NordBalt“ and „LitPol Link“ interconnections will have a significant impact and change the current price of electricity in Lithuania. The results of electricity market analysis in Lithuania and Baltic States show that in the base-case scenario in 2016 electric energy deficit in Lithuanian may rise to 6.7 TWh (Figure 48). Cheaper electricity production in the Nordic countries will determine the flow of electricity in North-South direction. Partly electricity demand in Lithuania will be met by imports from Russia and Belarus.

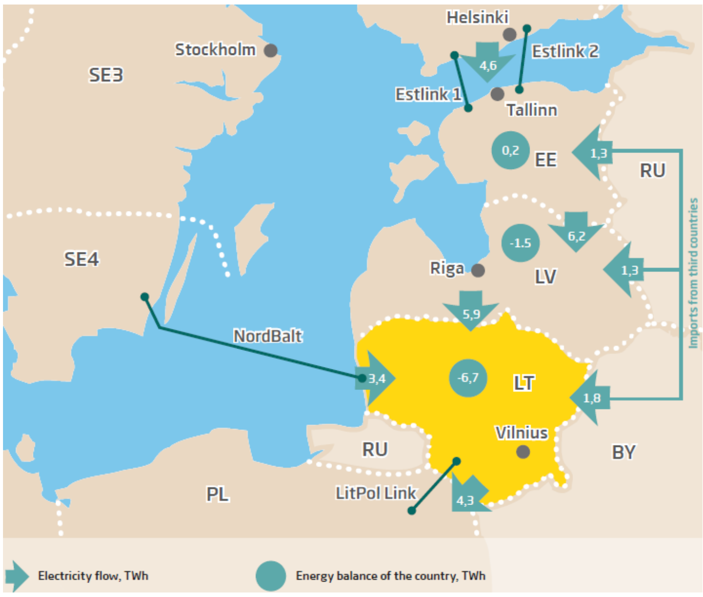

Figure 48 - Energy balance and flows in base-case scenario for 2016 (TYNDP LitGrid)

In 2022, with the launch of Visaginas NPP in Lithuania, the situation would change – Lithuania will become an exporting country (2.6 TWh in net exports) (Figure 49). Due to higher electric energy prices in Poland, electricity exports to this country could reach 6.5 TWh per year. In case of reduction of the difference in electricity prices in Sweden and Lithuania, a decreased imported electricity flow from Scandinavia is foreseen in 2022.

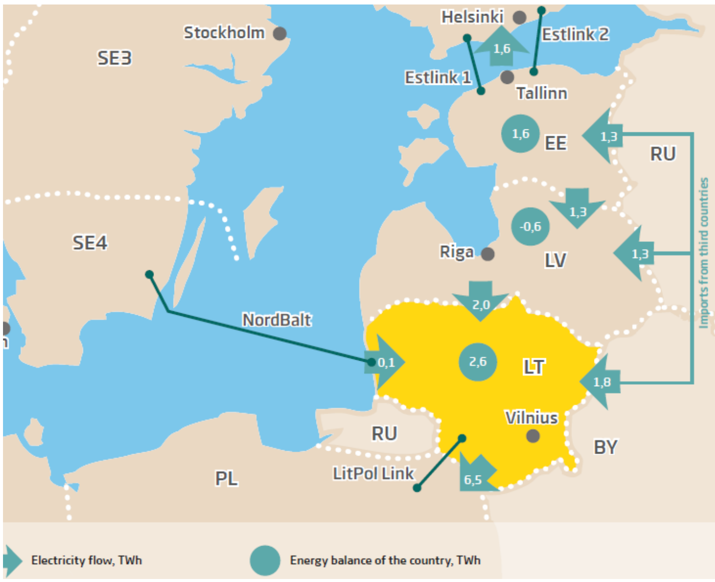

Figure 49 - Energy balance and flows in base-case scenario for 2022 (TYNDP LitGrid)

The electricity networks of Estonia and Finland are connected by interconnections EstLink 1 and EstLink 2 with respective capacities of 350 MW and 650 MW. Elering and the Finnish transmission system operator Fingrid have contracted Nord Pool Spot (NPS) to allocate the capacities of both interconnections. NPS uses the implicit auction method for transmission capacity allocation between Estonia and Finland, meaning that electricity always flows from the lower priced area to the area with higher price.

This is important, because since the opening of the elecricity market, the owners of the marine cables - TSOs receive bottleneck income during the hours when the Estonian and Finnish price areas have different prices. The owners are responsible for the cable's reliability, as well as covering any losses. After the purchase of the EstLink 1 interconnection by TSOs, the bottleneck income is collected by the transmission system operators, who in turn invest it into the creation of additional interconnections. The transmission system operators also took over the responsibility for ensuring the reliability of EstLink 1, and for covering the losses.

In Estonia, Elering and Latvian Augstsprieguma tīkls (AST) reached a bilateral agreement on the rules of cross-border capacity calculation and allocation as from 1 January 2014. In the agreement, the calculations of the capacity given to the market's disposal are based on rules in force today. In addition, calculations for giving free capacity on the Estonian-Latvian border for intra-day trade and allocation on the NPS Elbas market platform, have been added also by Elering. The temporary contract between Elering and AST will be in force until new bilaterally agreed on rules have been approved by the Estonian and Latvian regulators.

On March 15th, 2013, the transmission system operators of the three Baltic states reached an agreement on the calculation and allocation of cross-border transmission capacities both on the intra-Baltic borders and on the borders with Russia and Belarus.

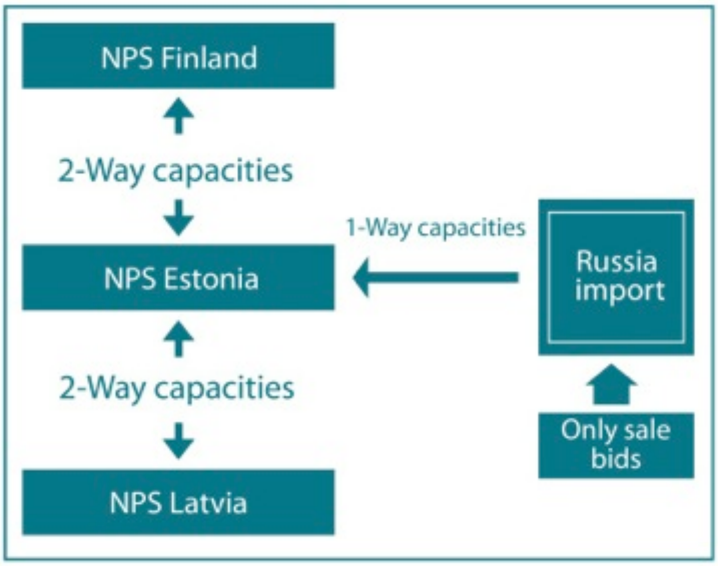

Figure 50 – *Cross-border electricity trade Estonia/Russia (Elering)*

According to the agreement, electricity sellers from Russia and Belarus who are selling electricity to the Baltic states will be able to trade on the Estonia-Russia, Latvia-Russia, Lithuania-Belarus and Lithuania-Kaliningrad interconnections only via the Nord Pool Spot (NPS) power exchange.

According to the methodology agreed upon by the Baltic transmission system operators, NPS will be routing all electricity coming from third states to the NPS price area on the Lithuanian-Belarusian border. No commercial capacity will be given to the borders between Estonia and Russia or between Latvia and Russia.

5.5. REGULATORY FRAME COMPARATIVE

Methodic comparisson of the regulations blocks is only possible with an understanding of electricity markets design. An energy-only market allow revenues only when producing electricity, whereas a capacity market becomes money from two streams: energy generation and for being available to generate. European market is mainly energy-only, however current policy trends go to the direction of introduction of an alternative capacity market by 2017 over several EU members to answer the need for investments on capacity reserves.

EU and Russia have reached a significant progress in cooperation in energy field and in establishing of open and competitive electricity markets since the year 2007, when Joint Task Force on the common electricity cross-border trading was established. Although several examples of cross-border trading between the parties exist, e.g. Baltic interconnection (ref. Chapter 5.3), Finland connection, the efficiency of cross-border interconnection can be improved and current access barriers must be minimized.[169]. Russian Ministry of Energy, CIS Electricity Power Council and EUROLECTRIC[170] are working on the coordinated actions in defined five key areas: increase of compatibility of electricity markets, easy and fair market access, closer regional TSO cooperation, increase of transparency, reconciliation of deviations of actual net electricity flows from planned flows. In 2013 the focus of joint operations was preparation of proposals on harmonization of rules, network codes and regulations in the key areas.

Russian electricity market offers opportunities for the mutual benefits from the cooperation between EU and Russia, for the most efficient realization it is crucial to recognize current trends and challenges of the both markets. The key for understanding the situation in detail is the comparison and evaluation of differences in the key focused areas, like grid operators and power exchanges functioning, market models, the fact that European markets are currently energy-only and Russian energy and capacity market, provision of the network access, division of responsibility between balancing and trading and risks hedging. The market structure is described in the Chapter 7.

Experts see electricity prices in Russia to increase in the mid-term, for industry and residential sector, and probably to reach the EU levels in 2015–2016. At the same time, the increase of transmission fees in electricity prices in Russia will hopefully boost the development of decentralized generation, which tends to be cheaper than centralized generation[171].

Befor ecoming to the direct copmrarison of the refulatory frameworks of the EU and Russia, some overall differencies in market structure must be mentioned. The main challenge in Russian-European cross-border trading is the difference in the market structure. Some examples: different market rules and procedures, such as gate closure time, balancing rules. Also when exporting electricity from Russia according to the regulations capacity purchase is obligatory, corresponding to the volumes of exports. In case of electricity import to Russia – there is no payment for capacity, which results in reduced revenues[172]. The regimes of importing and exporting electricity is unlike, the EU has rechen the free access to cross-border capacity, in Russia InterRAO is the only one importer/ exporter, de facto this field is a state monopoly. “The exporter’s capacity payment depends on the forecasted exports during the peak hours − Capacity has to be reserved in advance on monthly basis − The exporter has to pay for the reserved capacity regardless of whether it uses the capacity or not[173]. These differences result in technical constraints, and thus during the parallel operation of the power systems, like Russia-Baltics interconnection, the trading decisions on the cross-border interconnection are leaded by the restrictions and not market based one the one side and on the other side electricity trading decisions become more and more price-driven. The price sensitivity leads to the export from Russia only in

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[169] EURELECTRIC News, 2012

[170] EURELECTIC is The Union of the Electricity Industry association, representing interests of the electricity industry and its affiliates at pan-European level

[171] Gusev, 2013

[172] Artemiev, 2012, S. 3

[173] Viljainen, 2012, S. 14

certain hours, not as full-time base-load exports[174]. The good example for such behavior is import stop in Finland in spring 2013 due to higher electricity prices in Russia and low prices at the NordPool. Even more important is different spread of roles between market participants and operators. In the EU TSOs are responsible for rules setting and facilitation of the market functioning, in Russia the System Operator is responsible for technical issues of the export, for example balancing, commersial rules are set by the Market Council and in addition to this a package of complex administrative procedures due to customs authorities are used. And the main challenge for economicaly interessting collobaration of the markets is Russian capacity market, which is "killing" cross-border trade with energy-only market[175].

Due to all the fact above competitiveness of Russian power on already existing and functioning interconections is declining, the best example for such development is the Baltic electricity market. The cost of Russian generation are risning and efficiency is not increasing, therefore also power price is increasing. On the Nordic market prices astay moderate, sometimes even decreasing because of competition. The only way to normalize the trade reletionship is direct bidirectional trading like on Finland interconnection with the access of more players to the market.

Now coming to the comperison, the first topic would be functions of the network operators on each electricity market. On the European side the actors are TSOs, who are not responsible for power dispatch, Power Exchanges and t System Operators (SO). In Russia in this process participate the Federal Grid Company (FGC), Administrator of the Trading System (ATS), System Operator (SO), who exercise dispatch functions, and the Centre of Financial Settlements (CFS). In the European Union TSOs are responsible for cross-border capacity calculation and allocation and for cross-border balancing. All market participants have balancing responsibility, meaning that they must economically cover their electricity use and deliveries, while TSOs are responsible for physical flows. Such split of functions makes access to cross-border transmission capacities open and simultaneously possible for more than one trader at the same grid point[176]. On the Russian market situation is different: the company InterRAO, not the Transmission Operator or System Operator, is responsible for all cross-border operations it balances both, physical and financial flows. The SO is responsible for management of cross-border flows only in emergency situation or if normal operation is disturbed. According to the Russian legislation the border trade is treated as consumption (for export) and generation (for import) points, where deviations belong to a group of delivery points, registered to each particular wholesale market participant and must be settled by that market participant. The combined role of InterRAO as balancing responsible and exporter is slowing down the access of traders to cross-border interconnections and to trade for new participants on the Russian side.[176]. For further development of cross-border electricity trading, harmonization of the market rules in terms of balancing responsibility is important. However the split of balancing responsibility and capacity allocation mechanism will support the facilitation of EU/Russia electricity interconnection (Holmberg, 2012, S. 6). Also the balancing intervals in EU and Russia are different, but this is not the major challenge to cross-border trade[176].

Russian DSOs are regional companies mainly responsible for the network maintenance, reliable and uninterrupted power supply to the customer and distribution grid management. Also access for the new players must be applied via DSOs. Due to non-existing support for RES in Russia nor economically, nor regulatory the questions of market access for decentralized generation is not really urgent. Mostly, decentralized generation is used for own needs and is not connected to the grid of FGC or Regional Distribution Company.

The main differences from the regulatory point of view are the structure and the price mechanisms on the markets. At the European market, regarded as an energy-only market, pricing occurs at marginal cost: the fixed cost of the generator must be covered by the bidding price. Russian market includes capacity market also for export and pricing follows the nodal method and the SO regulates the capacity selection. The structural difference between electricity only and markets for two products, electricity and capacity, is not necessary a

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[174] Artemiev, 2012, S. 6
[175] Kekkonen, 2012, S. 6
[176] EURELECTRIC CIS-EPC, 2012, S. 7

barrier for cross-border trading. What this structure definitely causes are so called “dead zones” – areas with no trade in any direction and the high price, can be about 30 EUR/MWh, like Russia - Finland interconnection in the case of peak hours[177].

Other very sensitive topic is the network access. In Europe the Third Party Access (TPA) is regulated by the legislation and guarantees to every market participant opportunity to bid for the cross-border grid and transfer electricity across the border. Within the EU the transit between the countries functions automatically, but each market in responsible for its un-balance on the border[178]. The spot markets of neighboring countries arrange the transfer by implicit auctioning or by explicit auctioning. The transit concept is not needed anymore, the cost of transit are cleared between the TSOs under so called inter TSO compensation mechanism. These amounts (positive or negative) are included into national transmission grid tariffs[179]. On some borders, e.g. with Finland where 3 parties are involved additional fees can be applicable for imported electricity. In contrary, Baltic States allocate import cross-border capacity for free. The payments calculation done by TSOs and is fixed to the lowest capacity value at every border. The case of Baltic interconnection with Russia/Belarus is regulated by agreements between Belarus, Russia, Lithuania, however there are some indicators, that these agreement will be changed[180].

Third Party Access to the grid in Russia is not regulated by legislation. Financial responsibility for all cross-border activities is executed to InterRAO, as already mentioned before, the company is also fully responsible for the un-balance at all borders and act like “open supplier to the border[181]. Such situation makes the free access to cross-border capacity not available. Participation of other players on the Russian side is difficult in terms of differentiation of actual physical flows and deliveries. From the regulatory point of view in order to enable the barrier free cross-border interconnection new rules and standard must be applied for the cross-border trade. Also the Belarus power system has no inter-country compensation mechanism, like in EU, therefore annual bilateral contracts are needed, flow calculations are done on the monthly basis and the transit price is regulated by the contract[180].

The establishment of open and competitive electricity markets is making a good progress between the European Union and Russia. Results of diverse reports and researches show that variances in wholesale market models had not an obstacle in the development of trade relations across EU and Russia. Nevertheless, to improve the cooperation and to expand the welfare across the regions, optimization and harmonization of cross-border interconnections should be continued. Current access barriers should be reduced and this will increase the efficiency of cross-border trading. In order to achieve these goals, coordinated action on the following challenging issues are needed[182]:

- Compatible technical rules for the market access: The Third Party Access is a crucial topic for the acceleration of cross-border trading and interconnections. Moreover, clear and transparent regulations, creating equal opportunities to all market participants, need to be created, and cross-border capacity allocation must provide the information and allow electricity to flow at the borders, where it is economically relevant.
- Regional TSOs cooperation for accurate calculations of electricity flows and improvement of network stability. TSOs should carry the unbalance cost of their actions on the border and not impose this cost to the traders183.
- Replacement of cross-border tariffs and capacity payments with bottleneck income. The allocation of the cross-border capacity should be market based (implicit/explicit auctions)184.

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[177] EURELECTRIC CIS-EPC, 2012, S. 6
[178] Holmberg, 2012, S. 6
[179] EURELECTRIC CIS-EPC, 2012
[180] EURELECTRIC CIS-EPC, 2012, S. 8
[181] Holmberg, 2012, S. 6
[182] EURELECTRIC CIS-EPC, 2012, S. 11
[183] Holmberg, 2012, S. 6
[184] Holmberg, 2012, S. 7

- Definition of clear rules for the deviations calculation in actual cross-border flows from the planned flows, reasons for these differences and clear procedure of deviation settling
- Individual balancing responsibility on the EU/Russia border for each trader

By suggesting the development of cooperation the way it went during last several years, we could assume that the overall goal for the electricity interconnection between EU and Russia is market coupling for pricing. Such collaboration and cooperation is only possible between highly efficient and competitive markets, with totally unbundled structure in the electricity sector and completely market based pricing setting. Today the situation is not advanced enough. First of all Russian retail market is not fully liberalized yet. Secondly the establishment of Internal Energy Market in Europe has some challenges to solve. Despite there are some promising examples of trading between 15 countries on the Nord Pool and interconnection, Spain-Portugal, Belgium-France-Netherlands, still the market coupling mechanism was not truly successful in the last 3 years, price conjunction accrued quite rare. This issue is not fully researched and understood by the experts.

NETWORK INVESTMENT REGULATIONS: RAB WITH THE EXAMPLES OF SCANDINAVIAN COUNTRIES, UK AND RUSSIA

Tariff setting and price regulation schemes are highly complex and different from country to country, even within the EU, therefore direct comparison of certain constraints such as capital costs or depreciations is difficult and is only possible with regards to the entire regulatory framework of the country or region[185]. Also the regulatory frameworks and systems are different, there are various methods of natural monopolies regulations. In the EU the "ex ante regulations" were implemented. The ex-ante regulation method means the way of economical regulation of prices or revenues by the regulator and this constrains is known in the regulated industry before the regulatory period begins. Ex ante regulation is usually not fully fixe and can be designed differently. Some parameters can be updated during the regulatory period, it could be for instance the rate of return, prices on power, inflation rate etc. The aim of this regulation is control over the variables like prices or revenues of the utilities. The main challenge of the economic regulation is mainly the absence of detailed information on the real level of production, operational costs and quality of produced electricity for each market participant, therefore the asymmetry of information appears. The intervention of the regulator directly is also possible by setting the caps for the profit levels or the return on capital[186]. Regulations methods used for infrastructural services are diverse: rate of return, cost-of-service, price cap, revenue cap, yardstick regulation, performance standards, earnings- sharing (sliding scale) etc. All methods have their advantages and disadvantages and typically a regulation is never only one method, it is designed with features from different methodologies. Very common are the combinations of revenue cap regulation with inflation index and yardstick analysis accompanied by bottom (minimum) and ceiling (maximum) rules on rate of return[187].

Regulatory frameworks include a variety of components, which form a coherent package. These elements are[188]:

- the determination of the RAB (including, for example, the evaluation of efficient costs of assets, working capital, assets under construction etc.);
- the cost of capital (e.g. WACC);
- the depreciation rates;
- the application of benchmarking results;
- the inclusion of contribution from third parties;
- the treatment of under-recovery; and
- the pass-through of CAPEX for new investments
- technical requirements, standards, compensations and incentives for quality of service.

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[185] CEER, 2013, S. 3
[186] NordREG, 2011, S. 11
[187] NordREG, 2011, S. 12
[188] CEER, 2013, S. 2)

The major elements of a regulatory regime are the determination of the regulatory asset base (RAB), the calculation of an adequate rate of return and the rules for depreciation of assets. Regulatory Asset Base is a system of long-term tariff regulation, with the main goal in attraction of new investments into for modernization of the infrastructure[189]. The RAB was developed by Ofwat, the economic regulator of the water industry in England and Wales, and introduces with the purpose of setting five-year price limits to provide investors in privatized network utilities such as electricity, gas, transport, railways and water with securities[190]. Regulatory Asset Base is commonly used for infrastructure industry monopoly networks. There is no explicit definition of RABs in UK and other EU countries primary legislation or in regulatory licenses. The countries use different approaches for the RAB calculation.

However the key concept behind the RAB is financial capital maintenance (FCM). Hence, FCM and the RAB address the issue of whether the financial capability of the company is being maintained intact. The value of the RAB can be expressed as follows[191]:

gross current cost of assets + depreciation = net book value = RAB

This is a general formulation applied across infrastructure industries. For the UK infrastructure privatized after 1980: net book value – privatization discount = RAB

In Denmark the value is a mix of standard units and book values, norm costs, applied before year 2000, and actual book values for the modern assets. In Norway the calculation of RAB equals to the book value. In Finland the age-adjusted replacement value is calculated with the help of standard unit costs. In Sweden replacement value is used based on standard unit costs[192]. In the other Member States the RAB is linked to the historic-cost of net book value with an inflation adjustment. Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands and Spain have RABs for electricity and gas networks. For example the electricity network RABs in Belgium and France include working capital. The RABs have been accepted as a useful tool by infrastructure regulators in the EU, however, the realization of this method depends predominantly on the security and stability of the regulatory package within which the method is amended. This includes the transparency and consistency of regulatory decisions from the legal frameworks and informal practice perspectives[193].

In Russia the RAB methodology was introduces much later than in Europe, in 2009 as a part of energy sector reform. This methodology is also known and called in Russia tariff regulation with the use of return on invested capital method[194]. The assets of the Federal Grid Company (transmission) were transferred to the RAB in 2010 and the regulation was extended in 2011 for high-voltage distribution networks[195]. The new tariff design system has shown itself as viable and useful in the pilot projects and it was proved by increased construction and lending for distribution networks. Also the international examples have shown several advantages for network sector investors and customers in comparison to the cost-plus pricing system. The RAB methodology provides a secure payback and return on investment sufficient to service loans and generate profits. Additionally, the companies are stimulated to reduce their costs because the RAB regulation allows them to recollect the funds stemming from cost cutting. From the customer perspective the RAB system provides with the more reliable power supply and better services. The Russian Government and Federal Tariff Service amended the legal framework for electricity and heat pricing in Russia and made the new tariff design method the one to be used in Russia at least till 2014[196]. Legal framework for RAB in Russia foresees the setting

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[189] E.A. Milovanova, 2011, S. 287)
[190] Stern, 2014, S. 15
[191] Stern, 2014, S. 20
[192] ordREG, 2011, S. 33
[193] Stern, 2014, S. 27)
[194] FTS, 2008, S. 1
[195] IEA, 2012, S. 11
[196] ROSSETI, 2014

of tariffs for 5 years. Key principal for tariff setting is that the invested capital should generate enough return on investment to attract new investments. Tariffs setting process using RAB regulation includes[197]:

- declaration of operating expenses
- determination of investment amount
- fixed rate of return on investment

Out of pilot projects the Federal Grid Company see direct correlation of profits with the reliability of the electricity supply and the customer service level. IN the table on the Figure 51 you can see the approved RAB tariffs for Russian network companies for the time period from 2012-2014.

Year	Return on initial invested capital	Return on new invested capital
2010	3.9%	11%
2011	5.2%	11%
2012	6.5%	11%
2013	7.8%	10%
2014	10%	10%

Figure 51 - ***Russia Federal Tariff Service approved tariffs under RAB for 2012/2014 (FGC, 2012)***

Despite significant results, which the RAB method shows in Russia, the key rate-of-return (known as RAB in Russian) regulation is to be scrapped and redrafted by 2014, the Government decided. The RAB rules were supposed to change the previous cost-plus formula and provide investing power companies with advantages benefits. However, the administration and some regional utilities have been unsatisfied with the RAB regulations. The framework was revised in 2012 in order to attract and motivate new investors for capital expenditure in the grids and since that time it seems to perform better[198].

The direct comparison of RABs on the Russian and European markets is not reliable, due to different methodology of application. The traditional EV/RAB ratio is not applicable in Russia. Gazprombank Utilities Research Branch in convinced, that the traditional multiples, such as P/E and EV/EBITDA would be better indicator for the evaluation of Russian grid companies[199]. The reasons for this are the following. First, not all regional branches switched RAB. Secondly, as the rates of return can differ across the country and are in the hands of the local regulators, the difference between the companies' cost of capital and effective rate of return is even more significant. Third, the performance of entities depends on a numerous factors, not only on the asset base and return, and accordingly the net financial results are not always including the allowed returns in the meaning of RAB[200].

In the EU the regulations for DSO and TSO apply the same principles as far as possible. The difference is due to the different responsibilities. The TSO is responsible for the functioning of electricity transmission system on national level and in the most countries there is only one TSO (exception is Germany with 4 TSOs) but many DSOs in each country, this has an influence to the design of regulation[201].

In the years 2006 to 2008 a Feasibility Study "Synchronous Interconnection of the IPS/UPS with the UCTE"[202] came to the general conclusion saying that a synchronous coupling between the UCTE and the IPS/UPS is feasible. This can be achieved but only after implementing a number of technical, operational and organizational measures and by establishing the fundamental legal framework. Resuming this, the most

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[197] FGC, 2012
[198] Aris, 2012
[199] Kotlyarov G. D., 2012, S. 7)
[200] Kotlyarov G. D., 2012
[201] NordREG, 2011, S. 42
[202] UCTE, 2008

economically and currently technically feasible solution of power trade development between IPS/UPS and European markets are asynchronous interconnections[203].

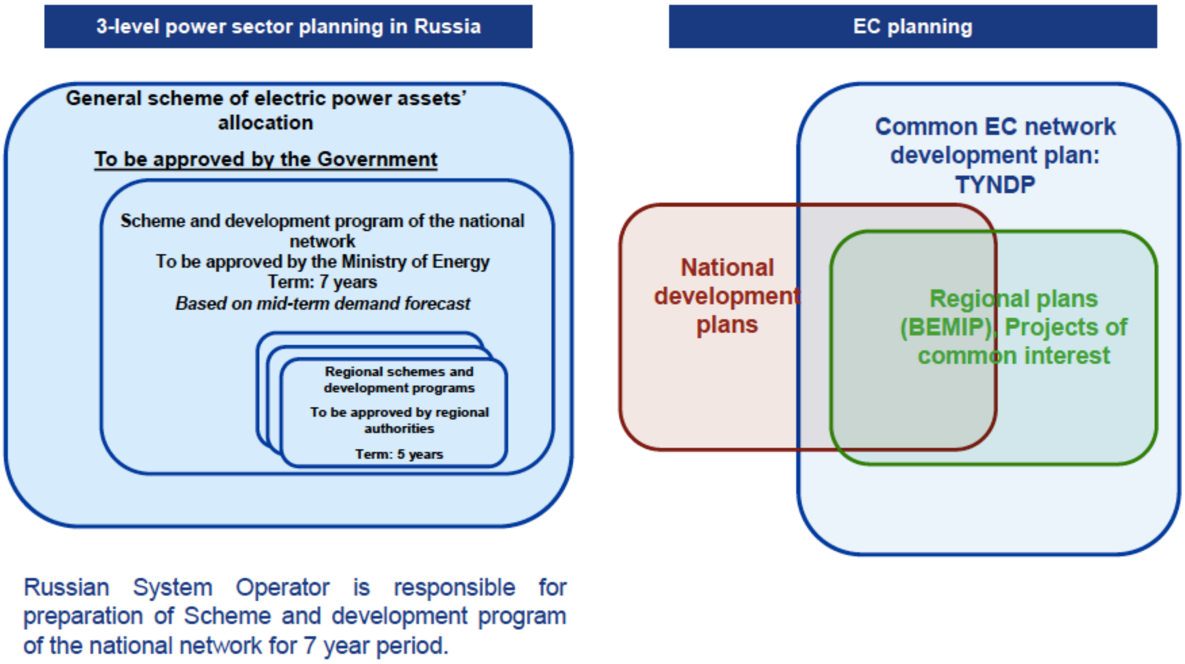

Figure 52 - ***Energy sector planning (InterRAO, 2012, S.13)***

The Figure 52 shows principle difference in the policy and sector planning in energy between Russia and the EU. The all schemes and regulatory frameworks in Russia are to be approved by the Government. Even the documents prepared on the regional and national levels need a long bureaucracy approval process avery 5-7 years. In Europe the development of the energy sector is decided on the EU level and adapted on the national levels in the Member States.

Active cooperation of System Operators of Russia with Poland, Germany and Baltic states is needed in order to accelerate the development of cross-border trade between Russia and EU. The supporting factors would be the approval from both sides for joint development. Coordination of legal actions between system operators, system agreement rules for road-flow planning, dispatch and control rules of operation etc. Another very important topic is the joint preparation and execution of technical and organizational actions for cross-border links commissioning, including site tests, 24-hours load tests, emergency training etc. Acknowledgment by the EC entities and ENTSO-E is needed for the inclusion of the interconnection projects into the Agenda of Energy Dialogue EU-Russia, integration of the projects into the Ten Year Network Development Plan TYNDP 2014. Form the Russian side there are some proposals for the integration mechanism. The start could be made by the special procedure with a guidance document for network development projects between EU and Russia. In the next step representatives of Russian entities will be integrated into ENTSO-E System Development Committee and analysis of the projects in Kaliningrad to interconnect the region to Poland and Latvia for possible integration into TYNDP-2014[204].

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[203] InterRAO, 2012, S. 9
[204] InterRAO, 2012, S. 14

Exporter is InterRAO with 1300 MW, first importer RAO Nordic – subsidiary of InterRAO, having 980 MW and the second one Inter Green Renewables and trading AB with 320 MW. Additional 100 MW is available for direct trading at NordPool Spot market.

Bilateral trade on Russia-Finland interconnection, between the seller and buyer, as shown on the Figure 53 was taking place before the adaption of so-called Direct Trade Scheme between the countries launched in 2011[205]. The Direct Trade Scheme enables player engaged in direct exchange between electricity market players. The electricity is bought on the electricity exchange in Russia and sold directly to Nord Pool Spot. Also trade in the secondary market is possible, in Nord Pool Spot's or the Russian intra-day market. Daily volumes for the bilateral trade were not defined on the basis of the market situation, but they were specified in advance before exchange trading. Direct trade is a development towards market-based rules and a strong intensive for the market mechanisms. This scheme made trading more dependent on the market prices, and increased the transparency of trading. Very important was the introduction of this Scheme also for the interconnection discussion between the EU and Russia if two different electricity markets can work together. The Direct Trade scheme was the first step for the bidirectional trade between Russia and Finland[206].

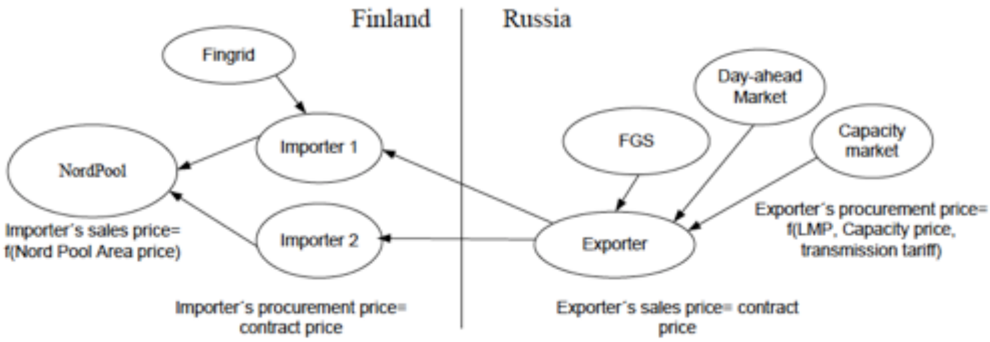

Figure 53 - *Bilateral trade on Russia Finland interconnection (Viljainen, 2012, S.11)*

After the introduction of the Direct Scheme diverse talks and working groups were involved into adaptation of technical infrastructure for the bidirectional trade Finland-Russia. Very recently, on July 4th 2014 Russian Federal Grid Company and Fingrid Oyi have signed the agreement on accounting arrangements for cross-border power flows on 400 kV Russia-Finland interconnection. This document sets out the procedure of co-operation and information exchange including technical and regulatory support of power flow accounting electric power amounts transmitted across the Russia – Finland border[207]. "Today's agreement has brought us closer to the final stage when electric power supplies from Finland to Russia will begin. For its part, FGC UES has taken every possible effort to ensure bidirectional electric power supplies in a reliable and uninterrupted manner. Electric power import from Finland will be cost-effective for the Russian counterpart in certain periods of a year. Besides, it will help cut the likelihood of disconnection of large consumers in case of accidents at Russian power generating plants", – stated Andrey Murov, Chairman of the Management Board of FGC UES while signing the agreement. All technical adjustments on the converter station were made, and it can operate bidirectional, test and first successful electricity exports from Finland to Russia followed during reverse testing phase in September 2013[208].

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[205] InterRAO, 2014, S. 11
[206] Lusaker, 2011
[207] FGC, 2014
[208] FGC, 2014

However the main market trends are now going towards price convergence between Russian Market and Nord Pool. Exports are becoming economically feasible in less and less hours this is the impact of new generation assets in Russian and increase of capacity price. Other trend is that during these hours the spread between the market prices becomes smaller, and in some cases Russian market prices exceed NordPool prices. The development perspectives for the cooperation of the markets could be the following[209]

- More cooperation projects in technical aspects, for example provision of emergency assistance in special cases. Projects for such mutually beneficial international cooperation are Estlink-2 ±650 MW, NordBalt ±700 MW and LitPol ±500-1000 MW
- Development of derivatives market will open new perspectives to hedge commercial supplies and to minimize the risks
- Start of electricity imports from Finland after modernization of Vyborg converter station. This will provide opportunities for electricity import from Nordic countries, allowing flexible management of commercial cross-border power exchanges according to the changing price conditions and technical states of power systems, will make trading more flexible and market-based
- Improvement of non-synchronous Pechnega bridge interconnection from Russia to Norway. The Project will provide "green" energy exchanges between the countries. Share of RES in the total annual generation in the Murmansk region where the project is located is about 40% at present (RES include in this case mainly hydro power plants of installed capacity more than 25 MW) and it is expected to grow significantly due to the development of hydro generation and implementation of renewables supporting measures by the government in the nearest future. Bidirectional reversible converter station (back-to-back station), 200 MW transmission capacity with the yearly volumes of exchange of about 1.5 billion kW is planned to commissioning in 2016-2017[210].
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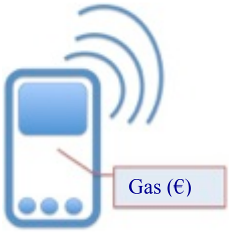
[209] Tsurkan, 2014, S. 9
[210] Tsurkan, 2014, S. 10

6. MARKET ANALYSIS

ZONAL VS NODAL

The consideration of trading electricity over Europe and Russia cross-border is by definition a challenge. Indeed, their designs are by essence different as one is an « energy-only » market with zonal price, and the other is a capacity-based market (Russia) relying on nodal price mechanism. In addition, subsidy policies are inequally transposed and would require first political arbitrage to compensate distributional effects and ensure necessary transparence and equity over both markets, as that has been investigated in previous chapter.



Question is not to say whether the current status is suitable for such interconnection today, which is obivously not the case, but to identify which signposts to be watched in the future to foresee an interest of business investment. As reminded by Lappeenranta University of Technology[211], deeply involved in this sector from Finland prospective, « market designs are not the only thing affecting the trade but the price difference between the two markets is what creates incentives for trade in the first place ». Gas price is essential in fixing electricity price as gas-fire power plants constitute up to 65% of the total installed generation capacity. Lappeenranta study estimates that, should gas price increase by annual 15% on average as expected by central plannification, the Russia power price could increase by 10-15€/MWh in the North-West region by 2016. **Gas is an obvious signpost**.

Another obvious element of influence is the quantity and capacity of any interconnection binding both zones. The more total capacity implemented would go with the sense of having a more liquid market. Additionally, there will be direct effect to the whole areas or indirect effect by capillarity depending on the exchange organization over each interconnection : A full-level of market coupling, associated with a large exchange capacity will allow effective commercial trades all over the geographical Europe and lead to wider price convergence. A single link, with reduced capacity toward one member of the Community, and the majority of exchanges being set through bilateral contracts, will barely generate any incidence over the wide picture, but for the immediate neighboring countries. It is worth investigating various interconnection schemes, such as

- re-inforcement and 2-way set up of current Russia/Finland link
- re-inforcement and 2-way set up of current Russia/Baltic interconnections
- implementation of HVDC link with Germany, in parallel of the NordStream gas pipeline
- implementation of HVDC link with Eastern Community, in parallel of the Southtream gas pipeline

Costs of HVDC and interconnectors is then another signpost.

[211] « Cross-border electricity trade between the Nordic 'energy-only' market and the Russian capacity-based market », Lappeenranta University of Technology, Department of Electrical Engineering, December 20th, 2013, by Satu Viljainen, Mari Makkonen, Olga Gore, Dmitry Kuleshov, Evgeniia Vasileva.

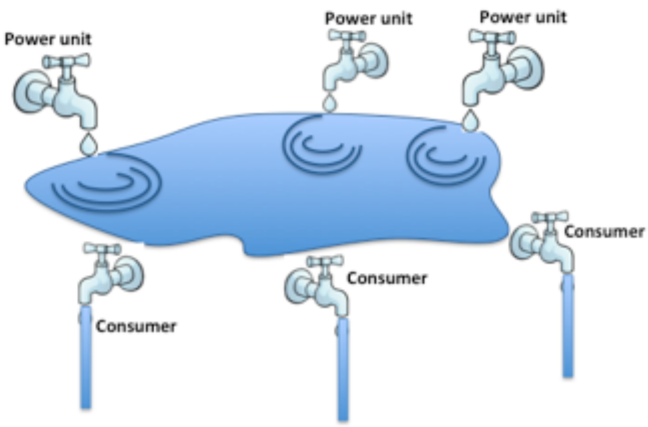
7. MARKET MODELIZATION

7.1. MARKET COUPLING

Prior to perform market modelization and conclusive analysis, it is worth reminding some definitions and behavioral specificities of the electricity markets.

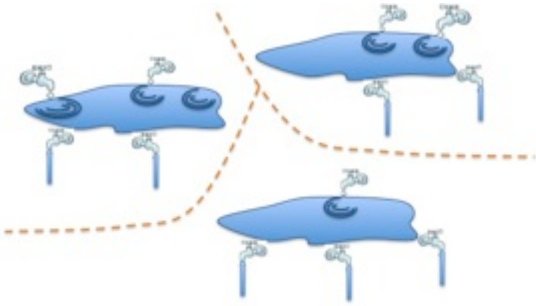
Electricity, not being a commodity that can be stored, is a matter of flows of electrons spreading all over the meshed grids. This is impossible for anyone to know exactly which path the electricity is going to take, should it have the opportunity of multiple ways. That is why all matters is how much is injected (production), how much is withdrawed (consumption), as well as location of congestion points.

A meshed grid can be seen as one water dam – which water level is per definition unique all over the dam surface – with each power plant pouring its production and each consumer collecting the needed energy from the collective tank. As such, even though the supplier/purchaser binômes are binded by commercial transactions, a consumer can not determine from which producer he collects its power, and to the opposite, a producer can not select the consumer to whom he is supplying the electricity. It is said the physical transactions are not directly correlated with commercial transactions.

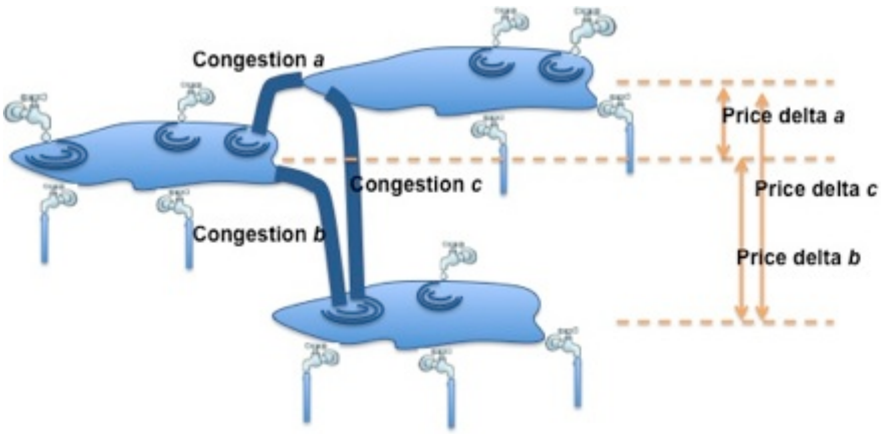


Over the market, the TSO (Transmission System Operator) ensures the respective amounts of injection and withdrawals are continuously aligned, and acts as a clearing chamber with regards to all commercial transactions. Consumers can directly purchase their energy from the TSO, but usually perform their purchase through the DSO (Distribution System Operator). Such grid management authorises the dilution of every price of production ending in a unique price for the consumer and ensuring equity of supply. Another indirect effect of this mechanism is the dilution of any disturbance (overflow from one unit, or unplanned disruption of production), reducing, even anihilating consequences over the consumer, thus ensuring security of supply. For such purpose of equity and security of supply, the wider is the market, the better it is. From economical prospective, it is said the market is liquid. To our concern of investigating the opportunity of extending the market to Russia, it is ad minima beneficial for both parties to improve the liquidity of the markets, by bringing additional actors into the market. Now it is to be determined by how much.

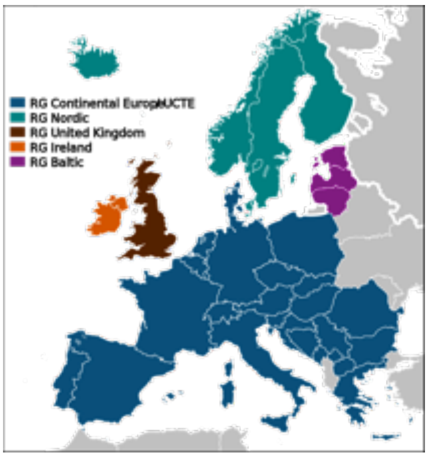
The above description fits with the power market of every European country, which quite rapidly in History seeked for interconnection with its neighbor, either to sell surplus or to compensate with lack of power. Should such interconnections provide enough exchange capacity, the European market would be a unique and wide transaction place, with one price of kWh. However, interconnections being the result of long political negociations as well as huge volume of investment, their capacity are limited and act as bottlenecks. European market, which initially used to be a collection of independant market places, is now a meshed network with congestion points.



Each of the congestion point, physically reflected by an « inefficient », or more adequately « sub-optimal » interconnection (meaning whom capacity is not designed to allow the full alignement of water level on both sides), can be schematically represented by a waterfall where the flow of electron wishes to drop from an area where they are in excess, and affordable (meaning relatively low price) toward an adjacent area where they lack (meaning relatively higher price). As such, during an instant *t*, the interconnection tends to a partial re-alignement of the two areas, and possible convergence of the electricity prices.



Demand/Supply curve over every area fluctuating, this instanteneous situation is expected to evolve all over the period of investigation. Areas is excess can see their status move to an area in need, and conversely. The cross-border wholesale markets are composed of the volume of capacities which are traded over the interconnections.



Starting 2010, European market started various steps of integration. Purpose was to optimize the full capacity of cross-border interconnections, and authorize convergence of the prices. The first initiative was the price coupling between CWE (Central West Europe) including Belgium, France, Germany, Luxembourg and Netherland. Cross-border exchange capacities were calculated by respective TSO and a coordonated price was set by power exchange places. The second initiative was a temporary volume coupling based on existing EMCC model (European Maket Coupling Company). It linked German borders, thus CWE, to Nordic Countries market, via interconnections between Germany, Denmark and SWeden. Indeed, on November 9th, 2010, spot prices converged completely all over the periods and interconnections were used at full capacity for 23 hours.

EU directives target that no single country remains outside the perimeter of market coupling beyond 2015. From then, it can be considered that wholesale power spot prices converge all over the Community.

Hence, the matter of extending the European market coupling to neighboring third parties is natural. Already, Agency for Cooperation of Energy Regulators (ACER) and National Regulatory Authorities (NRAs) suggested unofficially to benefit from the current connection of Polish day ahead electricity market to the future NWE region via the Sweden/Poland DC cable. The idea of ACER and the NRAs is to connect the extended Czech, Slovakia, Hungaria market coupling already successfully in place, with the Polish and Romanian markets, to CWE/NWE markets using the Sweden/Poland DC cable. Moving forward, and consider the coupling of EU power market with Russia power market is also rational, for both re-inforcement of security of supply, and price convergence, keeping in mind there is

already a 1,400MW interconnection capacity in place between North-West region of Russia and Finland. The question is to determine whether the price convergence would be economically beneficial to both parties, and increase welfare over both markets.

7.2. PRELIMINARY ANALYSIS OF NORDIC / RUSSIA MARKET

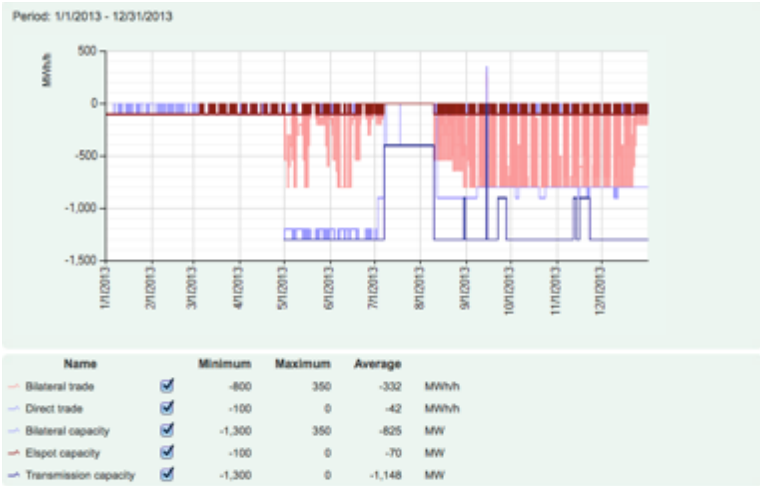


Figure 54 - ***Cross-border Finland/Russia exchange, 2013, NordPoolSpot***

Observing the most recent completed year of data (2013), it is worth highlighting Finland is an importing country. Except for the 50MW connexion toward North Norway (to cover North Cape area), Finland imports from Sweden, and Russia, and starting 2007 from Estonia. The import from Russia had been going on for 32 years through a 1,400 MW high-voltage line that was built in 1981. The line brought a substantial amount of nuclear generated electricity into Finland and later the Nordic power system traded at Nord Pool Spot electricity exchange market. The flow is no more a constant, marking the importance of market information and the need for transparence increase. More and more the trades happen over the power exchange (to the opposite of bilateral OTC transactions) and the picture is moving from a import-only trade to import/export trade. The reflects the current situation : at date Jan 1st, 2013, the total 1,4GW transmission capacity was mainly occupied by bilateral trade, leaving less than 10% of it to power exchange market. It is also to be noted this is a one-way possible trade. Allowing reversion of the transmission, and move forward to exchange market would remove this congestion point. More than the capacity itself of the interconnection, this is the **Elspot capacity over the cumulated interconnections between Nordic region and Russia which is to be watched out.**

Following extraction of the baltic market place demonstrate the opportunity of aligning spot power prices over the nordic regions, with Finland or Baltic countries as a point of entry : Even though NordPool Elspot price that day is 30,50€/MWh, Finland spot price jumped to 43,41€/MWh, Baltic countries culminating at 52,55€/MWh, whereas Russia West zone nodal spot price was 20,62€[212]. A transparent market, coupled with relevant interconnection capacity, would have turned down the area spot price over the exchanged energy that day.

[212] Refer to appendix **Erreur ! Source du renvoi introuvable.** for assumptions and calculations

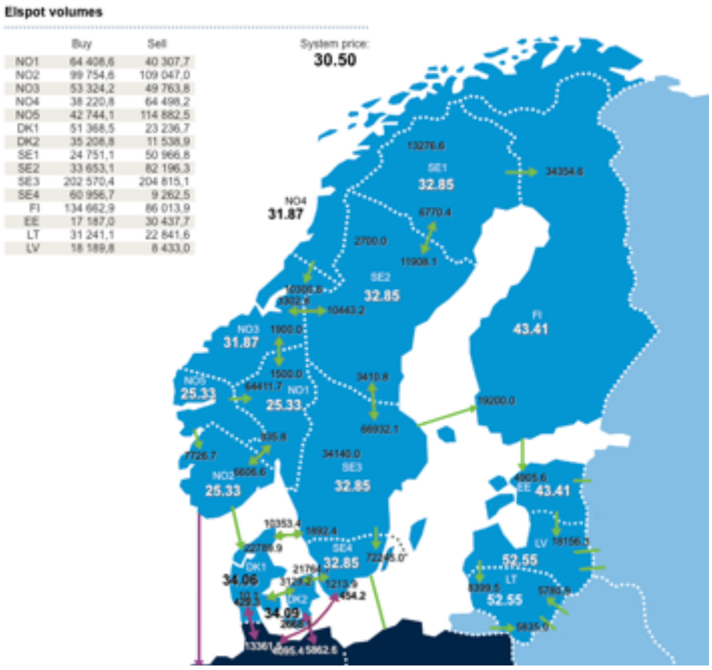


Figure 55 - Elspot volumes July 2013, NordPoolSpot

Blunt comparative analysis of the spot price in Finland over 2013 with Russia spot price of West region (FZSOE27) concludes Finnish price are above Russian price 41% in average (98% of the time period). Enlarging to NordPool spot price over the same period, we conclude Nordpool price are above Russian price by 36% in average (98% of the time period). When concentrating to peak hours (from 8am to 8pm every day, weekends excluded), the spread between spot prices is less important but still remarkable, respectively 39% and 31%, and it happens in every single peak hour in Finland, and 99% of the peak time over NordPool.

7.3. ASSUMPTIONS FOR MARKET MODELLING

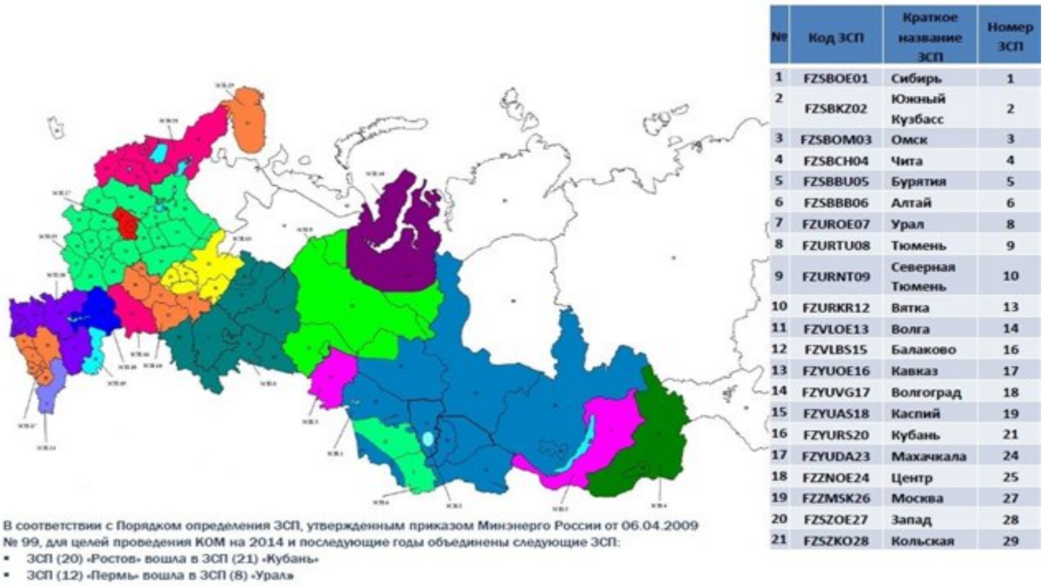
The right way would be to set on one side the exhaustive modelization of European integrated market, taking into account the portion to be driven by long-term OTC contracts, and the one to be exchanged through every domestic day-ahead market, compilated together at the level of each market coupling areas. Performing the same over zonal Russia market, and simulate the hourly price and volume coupling should be the most exhaustive model base to start analysing the effect of forthcoming primary cost evolution, as well as policy set up. However, such model would require fixing the intrinsic inadequation between zonal and nodal market (for instance, how to integrate transmission losses over the interconnection), in addition to high volume of computations that we definitely don't have the capacity nor time for this first analysis. The study being run to evaluate the opportunity potential of this business, thus reading the trends, shortcuts are to be drafted :

- Assuming that what is good for one EU state member, in terms of welfare optimization, due to the integrated power market soon to be completed, market analysis shall be limited to Finland price behavior under the influence of interconnection with Russia. Should it be concluded any price reduction over a relevant period, it is expected the EU integrated market to benefit from it by extension. In the same way, Russia, being a nodal market, only the neighboring region with Finland will be considered, hence the nodal price of North/West cluster.
- Too few information is publically available with regards to Long-Term bilateral contracts, and the analysis will focus on spot markets only. For this purpose, both NordPoolSpot (EU Nordic Countries market) and ATSEnergie (Russia power market) release publically the volume of transactions and prices.
- In order to rely on relevant analysis, a one-year investigation is performed (4 seasons, weekdays/weekends, all day long). Hence the hourly spot price is under study over past 2013.

The model is an Excel-based simulation tool set up by the team, remodeling the spot price of domestic Finnish power price, on an hourly rate basis, over 2013. The tool allows the re-building of the Finnish power spot price, with or without interconnection with Russia. The strong support of Dr Philippe Vassilopoulos, head of product design with EpexSpot in France, PhD Economics from Dauphine University, has been well appreciated.

The building blocs of the simulation tool are as following :

- A re-collection of each Finland-based power generation unit is set, and distributed depending of the type of generation. The list is available in appendix **Erreur ! Source du renvoi introuvable.**.
- Every conventional power plant is identified clearly with its location and capacity.
- Solar-based generation units are neglictable, and are excluded from the scenario.
- Wind farms are not registered with similar precision, and are embedded in a sole virtual generation unit of 288MW, wich is one fourth capacity of the currently biggest installed nuclear plant.
- Olkiluoto 3 nuclear EPR (new generation), which is scheduled to be commissioned by 2016, has been integrated in the scheme, as it would be a major generation node and would impact consequently domestic market with its 1,6GW capacity.
- Merit-order classification has been assumed to determine the ranking of integration of every unit in every hourly offer to sell. As such, marginal cost of every generation unit being confidential, reconstruction of a standard marginal cost for every type of production plant has been run. A unique marginal cost being considered for all units of similar type213, the first generators in the list, type after type as per the merit-order classification, are integrated in the offer till the need for energy is covered. Calculation for every type of marginal cost is described afterward.
- The unavailability of the unit for maintenance, unexpected shutdown or meteorological event can not be exhaustively confirmed all over the 8,760 hourly slots of the year. Hence, a random probability of availability of each unit, over each hourly timeslot, weighted by its capacity factor, has been set up for the purpose of this scenario.
- Once the domestic hourly spot price is calculated, a check is performed to compare Finland price with respective Russia price. Should Finland price is below Russia price, the interconnection is deemed closed and Finland domestic price remains unchanged. If Finland price is higher than Russian price, the interconnection is deemed open and saturated, is integrated primarily in the offer to sell of Finnish power market, and domestic price is re-calculated. The Russian power is thus assumed to be always available for export as per interconnection capacity (which assumption can only be made till a reasonable size of the interconnection capacity compared to the volume of energy spreading over Russia market currently, and the will of Russia to build up additional generation units dedicated to export). Russia grid model being a nodal market, the price of exporting node to Finland is taken into account : zone FZSZOE27 (West) covering the Republic of Karelia, Novgorod region, Pskov region, Leningrad region and St. Petersburg.



№	Код ЗСП	Краткое название ЗСП	Номер ЗСП
1	FZSBOE01	Сибирь	1
2	FZSBKZ02	Южный Кузбасс	2
3	FZSBOM03	Омск	3
4	FZSBCH04	Чита	4
5	FZSBBU05	Бурятия	5
6	FZSBBB06	Алтай	6
7	FZUROE07	Урал	8
8	FZURTU08	Тюмень	9
9	FZURNT09	Северная Тюмень	10
10	FZURKR12	Вятка	13
11	FZVLOE13	Волга	14
12	FZVLBS15	Балаково	16
13	FZYUOE16	Кавказ	17
14	FZYUVG17	Волгоград	18
15	FZYUAS18	Каспий	19
16	FZYURS20	Кубань	21
17	FZYUDA23	Махачкала	24
18	FZZNOE24	Центр	25
19	FZZMSK26	Москва	27
20	FZSZOE27	Запад	28
21	FZSZKO28	Кольская	29

[213] It is assumed that we have unique rankings for all thermal generators, but this is not necessarily the case in real applications; see Førsund (2007).

The simulation tool runs over 3 steps of spot price elaboration :

- pure domestic-based spot price building : The price of each hour's MWh is built following merit-order mecanism embedding only generation units, pending their availability, which are installed within Finland territory.

For rough simplification of the simulation, Finland has been considered solely importer, and spot price of Sweden and Estonia invariant from cross-border exchanges. Shouldn't it be the case, the tool should check the opportunity of selling domestic power production to neighbors, and coupled markets which are SE and EE would see the wholesale price revised, as systems are interlinked. As such, should a perfect simulator be targeted, the tool should analyse the price of all areas in Europe and Russia together as the purpose is to verify the opportunity of an Eurasian coupled market.

- The domestic spot price is compared to power price, during same time, across the borders of Sweden and Estonia. Should it be higher, there is an opportunity for importation, and the spot price is recalculated following same mecanism by integrating both SE and EE available capacity at borders, their rank being determined from their respective spot price among the list of domestic marginal costs of production.
- Should the recalculated spot price be found above Russia spot nodal price for region FZSZOE27, the tool is run again by positioning the Russia available capacity at Vyborg interconnector within the list of marginal costs and import from SE and EE. A transmission fee is added to the resulting spot price, according to the frame agreement between Fingrid and Federal Grid Company of Russia, as following : Transmission fees for bilateral trade for the period 2013 is the sum of

- the unit price for the unit price for the Cross-border fee (0.35 €/MWh)
- the unit price for the Main grid service fee (2.2 €/MWh)
- the unit price for the ITC/Perimeter fee (0.8 €/MWh)

That is a total of 3,35€/MWh, to which are added the new capacity reservation (100 €/MW per reserved MW per month).

Marginal Costs elaboration :

Each of the power generator of the same type is considered within the same portfolio renewable, nuclear (3 types of nuclear plant, especially since new generation EPR is deployed in Finland), coal (assuming hard coal instead of lignite, to stick with what rules in Finland), gas and fioul. It is worth reming the building principle of Marginal costs: These are more explicitely the shor-term variable costs to produce one extra unit of kWh, that is fuel plus operating assets, with the inclusion of CO_2-related costs.

- **Renewable** : Finland rely on wind and hydro, solar being neglictable. Wind is a fatal resource, meaning « not used at instant t » equals « lost at such instant t » (free resource with no storage possible), hence wind marginal cost equals zero. Hydropower comes from Run-of-the-river hydroelectric stations, meaning with small or no reservoir capacity, so that the water coming from upstream must be used for generation at that moment, or must be allowed to bypass the dam. Should it relies on dam, it can retain/regulate the water flow to get close to optimal usage (optimal usage is considered when the production is set once this is the most economically interesting, that is in replacement of a generator with higher cost of production – nuclear in the case of Finland). By design, these 3 units are given very few opportunity for the water to bypass the turbines (even considering the touristic sightseeing of Imatra daily water release), and disconnect the generators from the grid. Hydro-generated power is Finland is thus considered close to fatal, leading its marginal cost to epsilon (ε) (The fixed costs are neglected since new investments are not looked at, but only the problem of optimal management of existing capacities).

- **Biomass** : Nearly one quarter of Finland's total energy consumption is covered by wood fuels since forest are generous and well-maintained. Cost of supply is limited to transportation nearly neglictable since production sites are close to primary resources. Marginal cost is assumed to be epsilon (ε).

- **Nuclear** : Cost of fuel is the cost of uranium, including treatment and transportation (obviously safe and secure, thus expensive, part) and storage, to which should be included the future costs of refurbishment. Cost data for nuclear park in Finland are not knowed at the time of this report, and estimations have been performed from France inputs. Indeed, France nuclear park is most important over Europe, coming 3rd-generation nuclear facility (EPR) in Finland (Olkiluoto 3) is built by AREVA, and French data are reliable as EDF costs for exploitation, and AREVA bills as supplier of the primary ressource and manufacturer/recycler of the mox (nuclear combustible) are validated by the highest accounting chamber of the Republique (Cour des Comptes). In its latest 2012 report214, the Cour des Comptes estimate the 2010 costs of nuclear fuel as following :

Euro (€$_{2010}$)	**2010**
Cost of nuclear combustible (M€) *(a)*	1,503
Annual power production (TWh)	407,9
Cost per MWh	3,68
Transportation cost (M€) *(b)*	632
Total cost *(a)+(b)*	2,135

[214] Les coûts de la filière électro nucléaire, Cour des Comptes, Jan 2012

Annual power production (TWh)	407,9
Total cost per MWh	**5,23**

OECD analysis about the nuclear combustible cycle[215] reported a delta of 1,02% between France and Finland, which would lead to 5,28€/MWh.

From the same source, the operational variable cost associated to extra MWh production is estimated at 0,28€/MWh for France. Employee costs are excluded for short-term marginal cost as no additional staff are to be recruited for that matter. However, various advantages are granted to all personnel as preferred energy rate and is to be considered as missing money for the operator. This was a total of 116M€ in 2010 for 407,9TWh produced for EDF, that is 28Eurocent/MWh. Without confirmation of similar agreement in Finland, these are not taken into account.

Maintenance, to the exclusion of the subcontracted staff (which is not fluctuating over the production), was reaching a total of 773M€ for 407,9TWh. These are additional 1,89€/MWh.

- Carbon costs can be calculated by different approach (CO_2 captation, Stern economical estimation) but it is commonly efficient to catch the price per ton as per CO_2 European market, whom 2013 average was 4,36€/ton. Electronuclear park in France is issuing 15g/kWh[216], that ends up with 6,54Eurocent/MWh. Obviously, as CO_2 price per ton is assumed to highly fluctuate in the future, going above 100€/ton, this would affect consequently the MWh price and should be watched out as a signpost.

Other externalities could be considered but are not yet valuated, and might be integrated in future calculations :

- recycling costs which are assumed in the supply cost of AREVA might need to be added up with weighted costs of storage as the conditioning of the nuclear wasted is a sensitive social case.
- Cooling systems are highly consumming water, whom scarcity is more and more a concern. A cost of water could be added to the unit MWh price.
- Fukushima, added to Tchernoby and 3-Mile Island raised the concern of risk of damages. Even though accident probability is close to zero (10^{-6} for current technology, down to 10^{-8} for next EPR), the 3 main world-known accident demonstrate there is still an uncertainty, which is, from an economical prospective, potentially valuated as an insurance risk, affecting the MWh cost.

That is a total of 7,24€/MWh that are considered as marginal cost for nuclear facilities. 2 types of reactors are deployed in Finland, VVER and BWR. The last one being more complex technology, its marginal cost is arbitrarily penalized by one eurocent, at 8,07€/MWh. EPR being a new technology not yet operational, there is a 10% learning weight applied to base assumption, raising its marginal cost at 8,86€/MWh (Such learning penalization should be cancelled at some point in the future. Indeed EPR is supposed to bring additional efficiency to the system and reduce cost of production.

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[215] Coûts prévisionnels de production de l'électricité, OCDE, actualisation rate at 5%
[216] Strategic energy review of the European Commission

- **Coal** : There are 2 types of coal : lignite and hardcoal. Lignite, which is the cheapest, is typically the resource used in generation units in Germany (the affordability of this resource explains the economical precedence of coal against gas in this country). Power boiler plants in Finland relies on hardcoal, as in UK. The most efficient way of determining the marginal cost for hardcoal is to deduct it from historical spot price and darkspread as these two values are usually publically recorded, and they are binded with marginal cost as following :

darkspread = power price – cost of coal

Dark spreads are reported as indicative prices giving the average difference between the cost of coal delivered ex-ship and the power price. As such, they do not include operation, maintenance or transport costs. Platts recorded on July, 16th 2013, a UK darkspread of 30,00€/MWh (month-ahead). On same day spot price in UK was 56,13£/MWh[217] for peak day-ahead market, that is 64,57$€_{2013}$/MWh, leading to cost of coal at 34,57€/MWh.

Carbon costs are injected as per above calculation for nuclear at 4,36€/ton, assuming 943,47kgCO_2/MWh, leading **the marginal cost for hardcoal generators at 38,68€/MWh**.

Alternatively the fuel costs of gas turbines and coal plants are determined by their heat rates (btu's burned to produce 1 kWh). Some typical heat rates are for a modern coal plant : 12,000 btu's/kWh[218], and it is assumed Coal = 19,336,000 btu's per short ton (that is 0.90718474 metric ton, thus Coal = 21,314,291 btu's per metric ton, meaning 563kg of coal are required to produce one MWh). Cost of fuel in being in 2013, \$81,69 per ton in Europe (that are 63,15$€_{2013}$/ton), these are 35,55€ of coal per MWh. The above provides a marginal fuel cost which is pretty close to the previous calculated one.

As short-term marginal costs are considered, there is no consideration of variable operations and maintenance costs.

Carbon costs are injected as per above calculation for nuclear at 4,36€/ton, assuming 943,47kgCO_2/MWh, leading **the marginal cost for hardcoal generators at 39,66€/MWh**.

Hence, Platts organisation provides their own calculated indicators, which for the same period were reported for North West Europe at **28,33€/MWh**, including carbon tax.

Methodology	Heat rate	Dark spread	Platts
MC hardcoal (€/MWh)	39,66	38,68	28,33

- **Gas** : Gasum, natural gas operator for Finland confirmed last november 2013 that the contract signed in 2005 with Gasprom (sole supplier for the country) was an LTC lasting till 2026 and is favored by the specific condition of being indexed only by 50% to oil. However price level is not declared competitive by Gasum CEO Antero Jannes. Appart from oil, Finnish gas price is indexed mainly to coal, which is currently cheap but could expect to see its value increasing over the period of the contract. Furthermore, this indexation with coal will maintain the low affordability of gas compared to coal, even though this last one shall occur a price increase. In that sense, coal-based power generation shall always be more incentivized than gas-fire units.

[217] NG2EX, Nord Pool Spot, NASDAQ OMS Commodities
[218] www.eia.gov

Gasum data showed that Finland was paying less than 30 euros219 a MWh during the first half of 2013, comparable to gas prices in Britain's competitive spot market. That are 8,79€/mmBtu.

A new simple cycle gas turbine consumes 9,000 to 11,000 btu's/kWh, a modern combined cycle gas turbine plant burns roughly 7,000 btu's/kWh. For instance, Finnish generators, if not already done, are under upgrading program to turn them into combined cycle types, and assuming natural gas at 8,79€/mmbtu, the cost per MWh will be 8,79€ times 7,000/1000 = 61,54$€_{2013}$/MWh. The addition of carbon tax (420gCO_2eq/kWh for gas[220], at 4,36€/ton, that is 1,83€/MWh) determine a **marginal cost for gas at 63,37€/MWh**.

Alternatively, the marginal cost for gas can be deducted from historical spot price and sparkspread as these two values are usually publically recorded, and they are binded with marginal cost as following :

sparkspread = power price – cost of gas

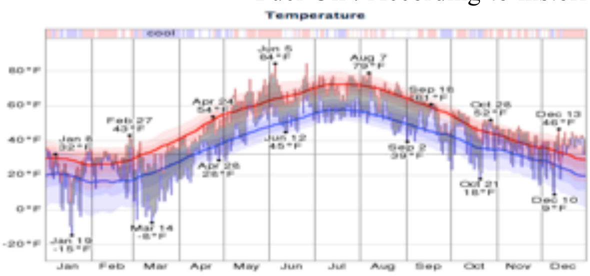
Platts recorded on July, 16th 2013, a UK sparkspread of 14,32€/MWh (day-ahead). On same day spot price in UK was 56,13£/MWh (peak spot day-ahead market), that is 64,57$€_{2013}$/MWh, leading to cost of gas at 50,25€/MWh. Adding 1,83€/MWh for carbon tax, it ends to **52,08€/MWh**.

Hence, Platts organisation provides their own calculated indicators, which for the same period were reported for North West Europe at **49,44€/MWh**, including carbon tax

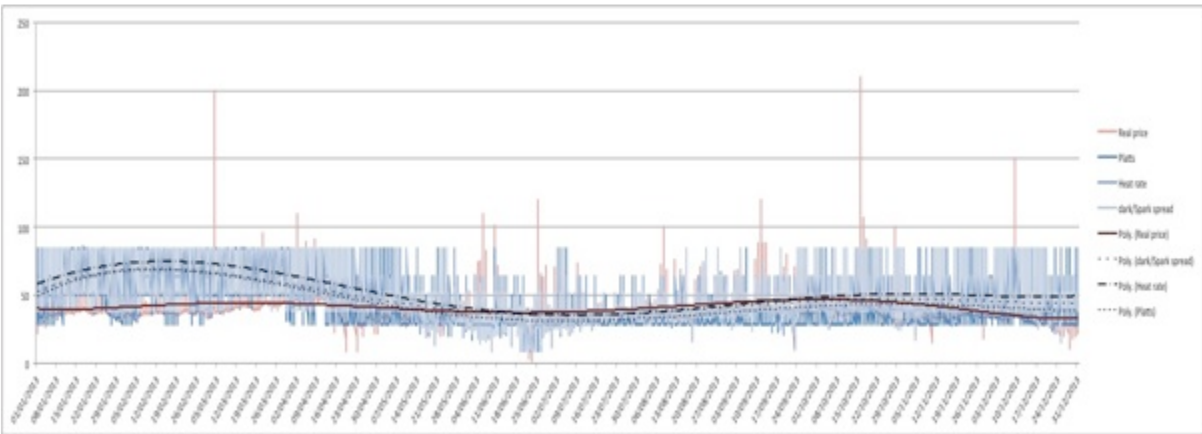
Methodology	Heat rate	SparkSpread	Platts
MC gas (€/MWh)	63,37	52,08	49,44

[219] UK Reuters, November 2013
[220] Les coûts de la filière électro nucléaire, Cour des Comptes, Jan 2012

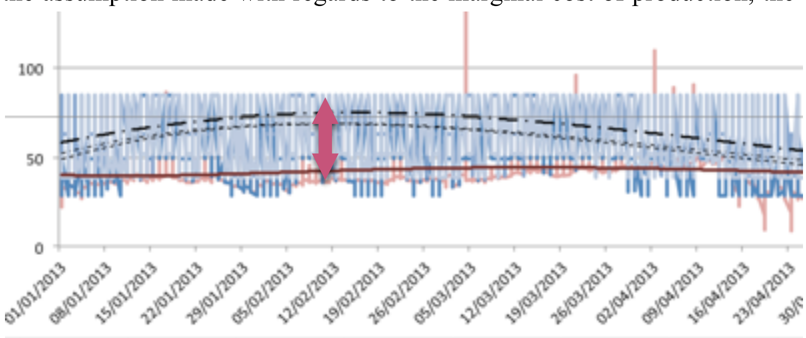
- Fuel Oil : According to historical data analysis from NordPool, the winter peak consumption happened in March for the year 2013. The spot price at that time, since calculated from merit-order principle, should be close to the marginal cost of peak reserve generation units. Looking at the graph, the first 2 weeks were the coldest time of the season. The maximum spot price recorded from NordPool historical database during that period was **84,41€/MWh**.



Running all the various above mentioned calculation methods, the « Platts » methode shall be retained for the following of this report. Indeed, reminding the average spot price in Finland in 2013 was 41,16€/MWh, the information issued by Platts organization based on factual recorded data is averaging 45,09€/MWh (that is a delta of 9% compared to true prices, lowest spread of all scenarii).

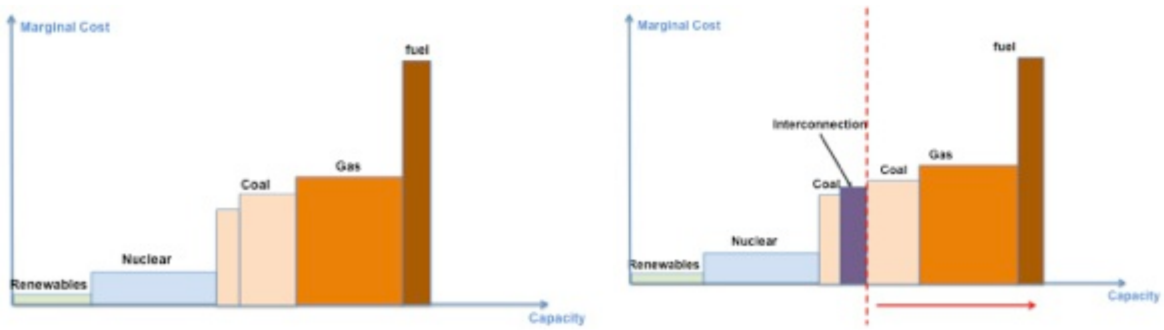


It might be interesting to notice the larger delta of all methodologies' results from « true » data during first quarter of the year : Whatever is the assumption made with regards to the marginal cost of production, the calculated spot prices rise during winter as it would be expected by calling reserve capacity. Recorded data show a relatively flat curve for this period. Rational behind this fact might come from the usage of hydro reservoir in Finland, whom existence is set as reserve power capacity (detailed analysis is available in appendix **Erreur ! Source du renvoi introuvable.**). That reserve power is indeed not taken into account in the simulation scenarii, but **it is worth mentioning, from deeper analysis, that this is contributing to close to half a billion euro socal benefit to Finnish consumers**.



7.4. OUTCOMES

Using the power capacity of the interconnections is a distorsion of merit order principle that applies all over Europe. Indeed, this mechanism is set to compell renewable energies being injected first into the grid. Integrating an interconnection as an additional source into the power exchange excludes the knowledge of the source origine, focusing only on the price. Should the electricity price coming out of the interconnection being cheaper than the most expensive instantly price-qualified domestic generators, it will pre-empt their place up to its capacity. The interconnection pushes the most expensive available domestic capacities aside to the right of the merit-order curve.



The pricing simulation tool embeds a critical uncertainty : Marginal costs are the one recalculated based on theoretical data, and extrapolation of the few certified and experienced data that is publically shared. This is clearly a matter of confidentiality for each power producer and they shall not easily share such sensitive information. Closest average resulting price among Finland integrating domestic generators' estimated offers to sell and import from Sweden and Estonia is about 45,09€/MWh whereas the reported Nordpool 2013 price was averaging 41,16€/MWh. Marginal costs can indeed not be simply taken for granted as unique in type and time, in addition to the unavailability assumption of each generation unit which has been randomly evaluated based on its capacity factor instead on relying on respective historical unpublished data (especially the availability of wind resource has been equally spread over the year, where it should certainly follow seasonal periodicity). Olkiluoto 3 EPR nuclear plant has also be injected into the scenario : it would indeed have been unreasonable to exclude the 1,600MW of this nuclear facility in future scenarii (at 90% of capacity factor, it would have represented 15% of 2013 Finland consumption, and still 12% of SO&AF[221] forecasted consumption for Finland in 2020), However the simulation reflects the relative added value of the interconnection, failing absolute value, which actually is our concern.

Figure 36 represents the 8,760 hourly timeslots of recalculated spot price for Finland, in 2013, based on domestic power production including available import from Sweden and Estonia (red dots), versus calculated spot price for Finland, same year, based on identical domestic power production and import from Sweden and

Figure 56 - ***Spot price FI domestic_importSE/EE(dotted) vs estimated price DI domestic_import SE/EE/RU (plain)***

[221] Scenario Outlook & Adequacy Forecast (SO&AF 2012) from ENTSOE

Estonia, plus available power import from Russian zone FZSZOE27. The trend curve for each data serie has been added (polynomiale curve grade 6).

Vertical axe are the wholesale spot prices, in euros, and horizontal axe is characterized by the 8,760 hourly timeslots for year 2013. The dotted line is the recalculated Finnish spot price, with access to Swedish and Estonian power, whereas plain line is the estimated outcome with Russia power in addition. It is to be noted the relative placement of the curves is always the same all over the year, which demonstrates the permanent benefit of opening the access to Russian power over Finland. The gap is however wider during winter, whereas summer time shows little benefit. **The global average benefit over the 365 days of interconnection have been 9% of spot price decrease (beneficial 28% of the time)**, keeping the actual net exchange capacity to where it is currently (1,400MW). This is however to be compared with the 18% optimization that combined Swedish/Estonian interconnections already bring to Finland domestic market.

When concentrating to peak hours (from 8am to 8pm every day, weekends excluded) the interest is lower with a 4% price optimization over 518 hours (meaning 17% of the peak load time).

Thus, to the initial question of evaluating the interest of interconnection between Europe and Russia, the answer is

- From Finnish prospective, positive as it brings economical value to consumer. However where it was assumed the benefit would be positioned around the peak load management, the answer is not as radical as it coult be. Indeed, as a general statement, biggest added value happen during winter time, hence when the peak are expected most, however it is to be determined whether a 4% optimization rules out the following constraints occured by Russia capacity market (subject to a following chapter).
- Interconnections within European community is already bringing twice added value (18% price optimization, versus 9%) to Finnish power market. Investigation should be performed wheather investments should be decided on these « internal » interconnections rather than toward Russia. To that matter, the enormous hydro reserve capacity of Sweden (10,000MW), beside being carbon-free, are playing a better referee role upon Finnish spot market.
- Should the interconnection with Russia be emphasized, would an annual 4% improvement be sufficient to allow a reasonable ROI over infrastructure cost ?

7.5. CAPACITY MARKET EFFECT

An additional factor has to be embedded again in the calculations, that was voluntarily forgotten for simplification reasons : Starting end of 2010, Russia launched the new capacity market (KOM)[222]. New generators (scheduled to be 40GW from 2010 to 2015) get regulated fixed capacity payments, while the old generators compete in Competitive Capacity Auctions (CCA). For newly built units, the capacity payment varies between 12,500 and 30,000 €/MW/month, whereas over CCA, the market experiences 3,000 to 4,000€/MW/month. Even considering actual generation units, a importer of electricity in Finland (case would be similar from anywhere inside Europe) over the Russia market shall have to pay the minimum 3,000€/MW every month. Knowing the maximum imported energy is constrained by the capacity of the 1,400MW interconnection, these are 4,200,000€ every month to be provisioned, thus a minimum of 5,41€/MWh to be re-injected in spot Finnish price. The spot price optimization happens only 21% of the time over 2013 (to be compared with previous 28%). Since the capacity fee is cumulated over every month, the cumulated monthly/annually spot price must be considered : This last criteria is rendered higher than the spot price without the Russian interconnection, leading this one inefficient.

	Capacity fee	average spot price w/o import (€/MWh)	average spot price w/SE&EE w/o RU (€/MWh)	average spot price w/SE&EE w/RU (€/MWh)	periodicity over 8,760 hourly timeslots
without capacity fee		64,82	53,09	48,20	28%
with capacity fee (over CCA)					
min	3 000			58,28	21%
max	4 000			61,64	19%
with capacity fee (new infra)					
min	12 500			90,20	8%
max	30 000			149,00	0%

Various European analyst including European regulator CEER or Finnish Lapperaanta University believe this capacity market is a dealbreaker for any opportunity of investment as it is representing an entry barrier upon this market. It is said that Russia currently run discussion about a general review and modernization of wholesale market model and regulatory framework with the final aim of the abolishment of capacity market and the introduction of an Energy-Only Market.

For the rest of this report, the assumption of the cancellation of capacity fee would be considered granted by Russian government.

7.6. LIMITATIONS

Should Nordpool market, hence European market open the door to Russia with regards to day-ahead and intraday power market, technical pre-conditions would be mandatory to garantee that Russia power generation capacity, as a whole, complies with requirements of European 3rd-package Energy, that is

- 20% of reduction of the greenhouse gas emission from 1990's level
- 20% of power generation being provided by renewable sources

This is obviously the major frontier for such market integration since, according to governemental russian decree 449 "Renewable Energy Source Development Measures" which aims to develop and support usage of renewable energy, Russia shall introduce 6.2 GW of generating capacities from renewable energy sources until 2020, which will increase the share of these sources in the energy mix from 0.8% to 2.5%, way below European criteria. Integration of electricity markets would require

- either an ambitious program from Russian government in terms of renewable energy generation. The new Competitive Capacity Auctions (CCA), equivalent of European merit-order mecanism, focuses on favorizing new hydro, nuclear and gas-fired generators, against dismantling of old ones (that have been launched before 2007). This is going in the right

[222] Government decree N89 on 24.02.2010 "On organization of long-tem capacity market"

direction with estimated 1,170MW commissioning of nuclear-based electricity over installed 16,086MW in neighboring nodal zone FZSZOE27 by 2016 in North-West region, (hydro and other renewables targets are unknowned), but that would require still an upgrade from 7% in 2016 to required 20% four years after223.

- or a exception being offered by European commission, favoring the importation of power against the 3rd-package Energy. would happen only should EU grid management being critically under stress, and close to consequent and reproductible black-out, and that is not yet forecasted even in worst scenario224.
- Alternatively a parcelized region of the grid, which would easier reach required minimum amount of renewable, could fit with the preconditions and being integrated. North West russian region being an oversupplied area with 30% higher capacity than the capacity needed to meet forecasted peak demand (taking into account hydro power constitutes about 46% of the installed electrical capacity) it is not a fantasy to believe russian decision-makers would opt to de-synchronize this node, should they foresee an economical interest in commercializing extra capacity. Another enclave is already in place with Kaliningrad region, eager to feed neighboring Baltic countries with its energy (A nuclear plant project was cancelled due to lack of interconnection and related long-term contract with Poland and Lithuania.

7.7. PUSHING THE LIMIT : BUSINESS AS USUAL & RUSSIAN SHIFT

A rapid review of the expressed signposts over the first parts of this report reflect the sensitivity of them with the geopolitics. Russian market design, embedding capacity market, gas price over Europe, weight of renewables in Russian power production are all highly dependant of the will of leaders and their decision to invest their global economy one way or another. For the sake of bordering the path of future opportunities, it is worth considering several scenarii. For the purpose of this report, two have been selected :

- Business-as-usual is the pursue of current statu-quo between Europe and Russia. Both parties pragmatically realize the dependance of their economies, tied by the energy supply/demand connection, and they work hard in keeping partnerships as demonstrated by the EU-Russia Energy Roadmap 2050. However both work also hard in minimizing this energy burden, Europe seeking for energy efficiency and alternative of supply, Russia willing to unty their economy from Europe gas/currency transactions. Governmental rules and regulations are set without respect of any impact over other party nor research of homogeneity to reinforce the trading schemes. Business-as-usual scenario sticks to what is currently acted, and this only :
- Both Europe and Russia dream of LNG, but none are close to have the infrastructure. Roadmaps are designed, but no funds are yet garanteed. Thus Russia shall remain supplier of Europe for gas for more than 120 billions cubic meters. Including the newly 400 billions € frame agreement signed with China, it is expected Russia strengh will authorize the gas spot price to remain at current level, and newly-signed long-term contracts will not gain any benefit as it can be seen with Ukraine, till Siberian pipeline is useable. From then, Russia will even be stronger as offered a real diversified demand, and gas price are expected to occur a certain degree of convergence between Europe and Asia. Its price shall remain high sustained by an increasing worldwide demand of primary energy. It is to be kept in mind that Southern European corridor remains of interest by involved parties. However Ukraine crisis highlighted the dependancy of Europe energy from Russian gas, and additional LNG infrastructure or pipelines will only allow the price to be kept at

Figure 57 - Natural Gas Price w/ IAE New Policies

223 Detailed figures of Russian targets as part of CCA program available in appendices

current level, sticking to what is written in long-term agreements. Lapperaanta University estimates the Russian gas price to raise in close future, including for domestic purpose and will reach +15% in average during next few years.

- Climate change conclusions make realistic the melting of snow reserve over Finland. According to climate models, there will be a change in the seasonal distribution of annual cycle of precipitation, snowmelt and inflow to hydro reservoirs. Climate change shortens winter, which leads to a thinner snow cover and decreased amount of melting snow in spring. It has been identified when modelizing the spot price over this country that hydro reservoir allowed for the mitigation of peak demand during winter, to the size of half a billion euro. Should this reserve be reduced, the loss is linearly calling for import at the worst time : Sweden and Estonia are reaching capacity threshold upon their interconnectors, and Russia apply their capacity fee. As identified by ENTSOE, over their SO&AF model, Finland’s Remaining Capacity (to face seasonal exceptional peak demand) shall be under stress.
- Russian shift reflects a radical reform of the governmental vision from relying upon the CIS trade market only, and clearly open the gate to larger economical integration with Europe. Currently, it is understood Russia are building an Economy whom they ensure the primary pilar. Trade agreement are set with former USSR republics and with strategical countries which are banned from OMC, such as Iran. Any trade with external countries outside this circle is a way for the Russian economy to inject foreign currencies. Russia could go beyond this mechanism by looking after a diversification of commercial exchange patterns. Russia might not have the most sustainable economy, but similarly to Brasil, whom economy initially relied upon the sole fossil fuel reserves, is magnetizing huge volume of investments from US, China and Europe with the target of boosting the transport and energy transformation infrastructure. Russia could benefit from stronger investment from foreign contributors.
- Power can be part of this diversification, and an immediate project of densifying the Finland/Russia interconnection is realistic. Supplementary connections are easily contemplated along the current gas grid pattern as well as the ones to come. Customers are indeed the same, and following same corridors for underground or aerial HVDC would avoid, or at least minimize, the administrative process of collecting favorable report and authorizations. The replacement of gas by power would not necessarily impact the gas price as this one is protected by long-term contracts, and would better push for the dismantling of fioul-fire generation units whom marginal cost are most superior to any other technology.

Figure 58 - Gas grid patterns (SIA-Energy)

- Production can also benefit from this vision : Wind and biomass are the most promising renewable technologies in Russia. By densifying this supply, and by getting closer to Europe conditions of 3rd Energy Package, the opportunity of an integrated market is no more a fantasy.

Already by assuming a larger interconnection with Finland, the social benefit is ensured. By simulating the spot price of electricity in function of the capacity of interconnection with Finland, the conclusion is clear the fluctuation of price depending on gas price (from -15% to +20% over Europe, or from an increase up to +15% within Russia, independantly from each other), carbon price (from 3€/ton to 40€ /ton) or coal price (from current level to maximum experienced in the past ten years), is better mitigated the wider is the interconnection with Russia.

Figure 59 - MonteCarlo sim of Finland spot price (€), function of Russia interconnection capacity (MW)

8. CONCLUSIONS

8.1. DISCUSSION OF THE METHODS AND RESULTS

This report is obviously a first analysis focusing over the economical impact of only one country of EU28 in order to draw the trend of plausible futures. This needs to be extended to European community as a whole, potentially leveraging the integration of Energy Community with Eastern Countries, and Ukraine. EEC is indeed a meshed network, already close to full market coupling, and any drop of modification is spreading all over the region. The reactions, current and to be, of all members must be agregrated into a larger study. The reaction, current and to be, of Russia is also to be deeper integrated. The tool should embed the 28 European wholesale areas, as well as the 21 nodal zones of Russian grid.

Methodology as it has been set is limited as well since marginal costs have been unified per type of generation. Every single power plant gets its own efficiency, and roadmap for improvement. The more an individualistic approach is performed, the closer to the reality the results would be.

Analysing from zonal mode approach is also a limitation by itself. Russia is not zonal. Building or using a simulation tool based on nodal approach should be forecasted, and synchronise the 2 of them to evaluate the potential of interconnection. To that, assumptions will have to be made upon how to distribute the transmission costs (to the purchaser, to the consumer, equally to both ?).

Hence, the simulation is not integrating the evolution to come in a very close future : European members are setting their own capacity markets, which is necessarily going to impact the wholesale pricing model. Folowing the same philosophy, dispatchable demand should as well be embedded in the analysis. Large consumers, or group of consumers, shall have the opportunity of entering the market as « negative » producers, or « negative » consumers. That is going to complete the list of influencing criteria.

8.2. CONSOLIDATION OF SIGNPOSTS

It is worth reminding the signposts that must be surveied in the future to identify when and how the interconnection between Europe and Russia shall become a valuable concern :

Technology outbreaks :

- HVDC being assumed the next base technology for the matter of interconnection, this is mandatory to watch out the cost of production of Circuit-Breakers, commercially available and down to equivalent profitability as for AC technology. ABB seems to be pioneering on this matter.
- Regulators, hence ACER at first, should initiate the standardization of HVDC technology, and the work of ENTSOE to render homogeneous the policies around grid management, that are Network Codes negotiations lead in Lubjiana, should be under scope to detect the integration of DC technology.

Economical indexes :

- Gas price over European hub is the most critical element of decision. Should Russian gas reach the expected inflation over coming years, as planned by the government, the increase of +15% of the spot price would alterate the profitability of current Finland/Russia interconnection. Other potential interconnection to be built would occur the same sanction. However, a stabilized gas price, when nuclear is inflating due to newly established safety regulations and need for decommissioning of old units, is re-inforcing the position of gas-fire power plant as an alternative to uranium. Outbreaks of LNG markets will be the trigger, if long-term gas contracts embed less oil-index terms and Europe hub succeed in setting itself against Henry hub and Japan exchange place.
- Carbon tax is also a critical influencer : Should it increase sufficiently to render gas as equivalent to coal in the merit-order ranking for power wholesale market, coal would suffer

and gas would become the prefered alternative. As Russia power generation is mainly relying on gas-fire plant, the economical interest of electrical interconnection would raise. However should the CO_2 tax raise the expected 30€/ton and above, gas would be pushed again forward in the merit-order effect, leaving greater room to implementation of renewable energy units. Current Russian investment plan for renewable does not allow the thinking of greater portion of it in close future.

Political surge :

- Russia, as centralized as it is, and focused over the will of few decision makers, can also be the subject of rapid turnover over Energy planification. Either due to reviewed ROI in the head of current governing team, or alternative ambition of next team, Russia could very fast order a energy transition, with larger renewable integration. As this would match the requirement of EU28 in terms of Climate management, Energy Roadmap 2050 negotiations would be relaunched at the most efficient pace.

8.3. LOCATION OF COOPERATION OPPORTUNITIES

Following the path of the incumbent gas pipeline is the most intuitive move : Where the tubes are installed means the regulation is already set in favor of correlated power cabling. In addition, from an economical prospective, the logistic routes are in place and synergies would definitely be confirmed.

Figure 60 - ***Main Russian gas pipelines over Europe (Le Monde)***

NordStream, Yamal, Blue Stream are already active, BrotherHood will highly depend on the outcome of current Russia/Ukraine crisis, and South Stream still receives strong supports from contributors.

Pushing for the extension of the current power grid is the other natural move : Finland/Russia are already interconnected, and over this summer, happened the conclusions of the test proving the feasibility of reversing the flow of electricity. 2-way trading is now possible over the 2 countries. Baltic countries are definitely the most favorable places, where historical economical, technological and political relationships with Russia smooth the negociations, and the 3 states are part of EU28. Kaliningrad, in the middle, is as well inducing in favor of more interconnection over the area. Should an investment be initiated, these are the preferred locations to focus on.

8.4. FUTURE WORK

As it has been elaborated in previous chapter, widening the scope of the analysis is mandatory to stick to the reality of incumbent market coupling. It will require the better investigation over Marginal Cost definition. This extension should also be performed over Russian market, by integrating a nodal-base simulation tool. A specific task will have to be run over the definition of LMP (Local Marginal Price) for that matter. This is an opportunity to use the ACEWEM model from the Research Center of Energy Management (RCEM).

There is actually no limit to such investigation since interconnectors can be build over several countries. Germany is a good candidate by following the path made by NorthStream pipeline to open an interconnection toward Europe : Using a cable under the sea is usually following simplier regulation than over mainland. However, South Germany is more in need of power than wind-equiped Northern regions, and still the NIMBY concern is acting against the Nord-South corridor.

It would also be worth analysing further the work made over Desertec as, even though this is incentivized by the need for more renewable energy, which can not be solved by Russia, the problematics of interconnections are similar, both from regulatory and market prospective. However economical and financing studies of Desertec might not be as easy to compare since a 7% discount rate was assumed for the WACC, whereas experts on the field would favor a 11% instead. Truely, this discount rate was chosen based on scientific studies, and this represents an EUMENA-wide discount rate, not the specific discount rate a specific investor would base its own investment decisions on (which often is higher). The issue would then to approach such investors to collaborate over their own analysis.

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Mr Evgeny Y. Abramov, former CEO of WGC 4 „Quadra“ Energy generation in Russia, June, 30th 2014

Mr Oleg V. Samarenko Director Energy Division JSC“ Sibur“ Energy Efficiency topics in Russia, June, 30th 2014

INTERVIEWS RELATED TO THE ECONOMICAL AND FINANCIAL UNDERSTANDING OF THE POWER MARKET

Mr Emanuele Colombo, Director European Market Integration, RTE, April, 22nd 2014

Mr David Assaad, Head of European Market Integration & Coupling, EPEX Spot, March, 19th 2014

Mr Philippe Vassilopoulos, Head of Product Design, EPEX Spot, May, 2nd 2014 & May, 23rd 2014

Mr Jean-Baptiste Bart, Responsable du groupe « Economie des Systèmes Electriques », R&D EDF, Jan, 28th 2014

Mr Damien Folliot, Ingénieur R&D, Département EFESE (Économie, Fonctionnement et Étude sur les Systèmes Électriques), EDF, Jan, 28th 2014

Mr Bruno Prestat, Resident Researcher / Smart Grids / Electric Power Research Institute - EPRI Palo Alto, EDF, Jan, 7th 2014

Mr Michel Bena, SmartGrids Director, Réseau de Transport d'Électricité (RTE), March, 18th 2014

INTERVIEWS RELATED TO THE REGULATORY UNDERSTANDING OF THE POWER MARKET

Mr Axel Strang, Chargé de Mission Filière Verte, Direction Générale de l’Energie et du Climat, Ministère de l'Ecologie, du Développement Durable et de l'Energie, Jan, 27th, 2014

Mme Sidonie Blanchard, Chargée de mission réseaux de transport d'électricité, Direction générale de l'énergie et du climat, Ministère de l'Ecologie, du Développement Durable et de l'Energie, Jan, 27th, 2014

Mr Sebastien Lepy, Head of grid development studies department, RTE, March, 6th 2014

Mr Erik Füßgen, Geschäftsführer, Stadtwerke Oberkirch, June, 24th 2014

INTERVIEWS RELATED TO THE TECHNOLOGICAL UNDERSTANDING OF THE POWER MARKET

Mr Frolov Oleg Valeryevich, PhD. tech., General Director of the Scientific and Technical Center of Unified Power System (STC UPS)

APPENDICES