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The perspectives and risks of electricity supply in the Czech Republic by 2030

Master's Thesis

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Abstract

The thesis will focus on outlooks of the Czech energy system, especially with respect to supply-demand balance and generation adequacy. The current situation in the electricity market will be used as a starting point for projections of future scenarios. The scenarios will look at possible issues and challenges as well as further developments that the Czech energy system will be facing in the near future. These problems and challenges can be defined as the mid-term and long-term ability to balance supply and demand for electricity in the Czech Republic. The increase in production of electricity from renewable resources and the subsequent loss of flexibility of power sources go hand in hand with adverse economic conditions, together worsening the overall risk in the electricity system. At the same time we must take into account changes in EU energy policy and its effect on member countries, such as the planned shutdown of nuclear power plants in Germany, increased taxation of carbon dioxide production, supported production of electricity from renewable resources, and integration of energy markets. We must consider the harmonization of methods that are used to evaluate the adequacy and security of a production portfolio, known as a generation adequacy, while meeting the requirements of the given system and development of technologies.

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Declaration of Authorship

I hereby declare that I compiled this thesis independently under guidance of my supervisor, using only the listed resources and literature.

I declare that this thesis was not used to obtain another degree.

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Prague, 5 January, 2015 Bc. Tereza Vinklerová

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Master Thesis Proposal

Master Thesis Proposal

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Topic Characteristics:
The thesis will focus on outlooks of the Czech energy system, especially with respect to supply-demand balance and generation adequacy. The current status in the electricity market will be used as a starting point for projections of future scenarios of issues and challenges together with further developments that the Czech energy system will face in recent future. These problems and challenges can be defined as the mid-term and long-term ability to balance supply and demand for electricity in the Czech Republic). The increase in production of electricity from renewable resources and the subsequent loss of flexibility of power sources go hand in hand with adverse economic conditions, together worsening the overall risk of the electricity system. At the same time we have to take into account the changes in energy policy in EU member countries, such as the planned shut down of nuclear power in Germany, increased taxation of carbon dioxide, supported production of electricity from renewable resources and integration of energy markets. We have to consider the harmonization of methods that are used for evaluation of adequacy and security of production portfolio, that is known as a generation adequacy, meeting the requirements of the given system and development of technologies.

Working hypotheses:
1. Hypothesis #1: Did Czech Republic fully exploit the potential of investments into traditional power sources (i.e. coal, natural gas, nuclear,...)?
2. Hypothesis #2: Does Czech Republic have in place conditions to ensure an efficient structure of the production mix?
3. Hypothesis #3: Does Czech Republic have in place a sufficiently flexible structure of the power generation mix?

Methodology:
Concerning the relevant literature that will provide the outline of power system in Czech Republic, institutions and their regulatory rules, I have to firstly concentrate on energy policy requirements that are presented in the state energy conception (ASEK), also in the NAP SG and other corresponding documents from European Union. The aim of this thesis is to evaluate the trends and opportunities on the Czech energy market and concentrate on the mid-term and long-term balance of supply and consumption. I will consider the given approaches, both deterministic and probability approach, the deterministic approach will be focused on calculation of balance in each time section, this analysis will consider the reliably available capacity, remaining capacity and adequacy reference margin and probability approach will be focused on modeling of the transmission system balance in supply and demand, in this probability analysis will be used for better risk assessment the calculation of “lole” (loss of load expectation), price risk will be tested through calculation of VAR indicator. Thanks to this

methodology we can analyze the mid-term and long-term balance of supply and consumption, level of construction of power sources and renewal of conventional sources, throughput of international connections and the share of renewable resources according to balance of the power system in Czech Republic.

Outline:

1. Introduction
2. Balance in generation of electricity according to Generation Adequacy
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6. Evaluation of risks of power balance
    a. Evaluation of scenarios in 2030-2040
    b. Optimal conditions for ASEK scenario (conclusion)
7. Conclusion
8. References / Bibliography

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Author   Supervisor

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Abbreviations and Acronyms

ACER	Agency for Cooperation of Energy Regulators
ARM	Adequacy Reference Margin
AS	Ancillary Services
ASEK	Actualization of State Energy Concept
BRP	Balance Responsible Party
CCGT	Combined Cycle Gas Turbine
CEE	Central-Eastern Europe
CEESEG AG	Central and Eastern Europe Stock Exchange Group
CEPS	Czech Transmission System Operator
CfD	Contracts for Differences
CZ	Czech Republic
DAM	Day Ahead Market
EEX	The European Energy Exchange
EFET	European Federation of Energy Traders
ELSPOT	Day-ahead auction where power is traded for delivery during the next day
ENTSO-E	European Network of Transmission System Operators for Electricity
EPEX	European Power Energy Exchange
ERU	Czech Energy Regulatory Office
EU	European Union
GCC	Grid Control Cooperation
IDM	Intraday Market
LOLE	Loss of load expectation

LNG	Liquefied Natural Gas
MIT	Ministry of Industry and Trade
NAP SG	National Action Plan of Secured Generation
NREAP	National Renewable Energy Action Plans
OPEX	Operating Expenditures
OTE	Energy Market Operator
PECD	Pan European Client Database
PVE	Photovoltaic power plant
PXE	The Power Exchange Central Europe
RAC	Reliable Available Capacity
RC	Remaining Capacity
RES	Renewable Energy Sources
RMP	Registered Market Participant
R&D	Research and Development
SEI	State energetic inspection
SOAF	Scenario Outlook and Adequacy Forecast
SyS	System Services
TSO	Transmission System Operator
TYNDP	Ten Years Net Development Plan
V2G	Vehicle to Grid
VaR	Value at Risk

Introduction

Events of the last century, post-war Europe, and the strengthening of the economic role of the USA and BRIC led to creation of a strong, integrated Europe. The integrated common European market established in the past decades enabled the free movement of capital, goods, and people as well as the integration of legislative procedures in several sectors. Special emphasis is placed on creating efficient, integrated electricity market activities. Simultaneously, the role of unbundling, independence of regulation in prices of net activities, coordination of regulatory politics, benchmarking of regulated supplementary charges, and funding of political goals outside of energy prices and protection of consumers were increased.

The price activity on the European market decreased; this is at least the third year of uncertainty about the development of energy prices.

There are many kinds of forecasts and opinions about the further development of the market, as the market itself is very sensitive; this is truer in the case of political events, such as crisis in Ukraine and the new energy goals of EU approved on October 24, 2014, than to economic events. According to these geopolitical issues some European politicians introduced various alternative solutions of the future of European energy policy. In April 2014 Polish Prime Minister Donald Tusk proposed a creation of Energy Union, which will be able to face successfully the threats of external influences.

The historical development of energy prices also should not be ignored and the particular national approaches to energy policy should not be underestimated, meaning what is technically and economically possible and what is socially and politically feasible must be taken into account. Currently the impact of the so-called Energiewende, the German transition to an energy portfolio driven by renewable energy, energy efficiency, and sustainable development, is being discussed. This is strongly influencing energy policies of the other member states and attitudes towards strategic decisions related to security of supply, which is often discussed among experts during the creation of national energy policy framework. The EU is currently solving the issue of if there is a sufficient amount of power installed for covering the consumption in rush hours. The further development of energy market and energy policy will influence the merit order curve. One of the biggest constraints of market integration is the limited possibility of energy exchanges between neighbouring systems. To be coherent with new energy goals while also enhancing the integrated market, there must be plans proposing for the further development of the electricity grid and consequently proposing an efficient plan for energy security and efficiency.

The implementation of a smart grids in EU states also comes into question; where the smart metering is already implemented, the consumer is motivated to use smart metering in order to save the variable components of electricity price and also to save money on taxes. The system of smart metering is currently most developed in Italy and other states are discussing the further development of this approach.

The electricity market of the Czech Republic is facing many challenges today due to upcoming further developments and changes. The issue currently being discussed is the mid-and long-term ability to balance supply and demand for electricity in the Czech Republic. The increase in production of electricity from renewable resources and the subsequent loss of flexibility of power sources go hand in hand with adverse economic conditions, together worsening the overall risk in the electricity system. At the same time, we must consider the changes in EU energy policy and its effect on member countries, such as the planned nuclear power plant shutdown in Germany, increased taxation of carbon dioxide production, subsidized production of electricity from renewable resources, and integration of energy markets. The harmonization of methods used to evaluate the adequacy and security of production portfolio, known as generation adequacy, meet the requirements of the given system; the development of technologies will have to be considered as well. This thesis focuses primarily on supply-demand balance and generation adequacy. The current status will be used as a starting point for future scenario projections of issues and challenges including developments that the Czech energy system will go through in the near future. Concerning the relevant literature, an outline of the power system in the Czech Republic, institutions and their regulatory rules will be discussed, including Energy policy requirements presented in the state energy conception (ASEK) and also in the National Action Plan for Secured Generation (NAP SG) and other corresponding documents from EU. The ultimate goal of this thesis is to evaluate the trends and opportunities on the Czech energy market and concentrate on the mid-term and long-term balance of supply and demand.

The application of a deterministic and probabilistic approach will be explained for the needed projection. The deterministic approach will be based on calculation of balance in each time section; this analysis will consider the reliable available capacity, remaining capacity, and adequacy reference margin. The probabilistic approach will be focused on modelling the transmission system balance of supply and demand; this means that the probabilistic approach will be better suited for risk assessment based on LOLE (loss of load expectation) calculation. The price-risk analysis will be based on standard methods such as VaR (Value at Risk) and other relevant calculations. As a result of the aforementioned methodology, the mid-and long-term balance of supply and consumption, level of needed construction of power sources and renewal of existing conventional sources, throughput of international connections and the share of renewable resources according to balance of the power system in the Czech Republic will be analysed.

The principal aim of energy policy in the EU is to provide secure, sustainable, and competitive energy for society and the economy; therefore, it is very important to enable the sufficient development of a functional, integrated energy market.

Chapter 1

Power system in the Czech Republic and role of the EU

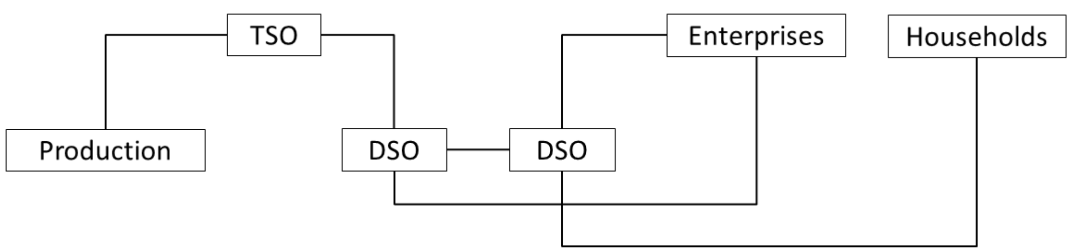
The first chapter gives an overview of the main characteristics of the Czech power system. The whole system went through two important transitions in the past decades. The first was energy market liberalization after the massive restructuring of the national economy. The second was the integration with other European markets. To better understand these processes and their implications, important participants, institutions, and the whole energy trading process are identified.

1.1 The power system in the Czech Republic

The specific features of electricity must be taken into account: it is a traded commodity that is immaterial in nature and cannot be stored. The organization of the energy market includes a very sophisticated process. Despite of the conditions of the Czech market two decades ago and the complicated transition process into the liberalized market, this market can be considered as a place with high standards, comparing to other European states, due to the economical compatibility of economic conditions of the Czech market. The energy market and its participants are regulated by specific norms and standards. In the Czech Republic, the main document determining the role of ministries and market participants is the Energy Act No. 458/2000.

The organization of the energy system has the same scope and infrastructure as in all European countries to ensure the maximum compatibility of the standards and the traded products. Picture 1 below describes the electricity flow and trade in the unbundled system.

Picture 1: Organization of energy market



Source: Author's analysis

The electricity is first generated in the power plant. Next, the transmission system operator (hereinafter TSO) becomes involved, the transmission system in the Czech Republic is under the responsibility of the Czech TSO, ČEPS. Then, the generated electricity is distributed to the end consumers, including both companies and households. Before the particular distribution, the electricity is traded by the energy companies, and then finally distributed to the end consumer (Chemišinec I., 2010). This distribution is ensured by the distribution services through particular distribution system operators (DSO). The processes of energy market are specifically discussed in following subchapters.

1.1.1 Energy market liberalization

Before the liberalization of the European energy market, the power system was vertically integrated and included power production, transmission and distribution. A major part of all energy operations was managed by one integrated company in the position of the single buyer. Non-existent competition, common price policy, and centrally organized structure were the main characteristics of the vertically integrated system. A milestone of this period was the connection of the electricity grid in the Czech Republic, Slovakia, and Hungary, firstly as a synchronized connection to network Union for the Co-ordination of Transmission of Electricity (hereinafter UCTE) and consequently to ENTSO-E. Gradually more and more competition appeared with the establishment of new companies that became important players on the market (Chemišinec I., 2010).

Liberalization of the market ran through the European continent in 1990s. Together with the liberalization of the energy business, new requirements were created that influenced political, ecological, energy, and investment conditions. The liberalization and deregulation process in the Czech Republic was finished in 2006 (Šolc, P., Flášar, P. and Benček, K., 2011). In the Czech Republic, several institutions are responsible for monitoring, regulating, and ensuring the operations of the functioning system. Therefore the system institution plays a key role as in the other systems. Political influence, monitoring, and regulation are divided between particular ministries and their specialized institutions because energy production has significant impact on the environment and on everyday life. The Ministry of the Environment is responsible for monitoring the environmental quality of the production process. This ministry cooperates with the other ministries and institutions of the EU; together they create specific regulatory rules. Another ministry responsible primarily for the system development is the Ministry of Industry and Trade (MIT). The MIT manages the basic functions of the energy market and plays a very important role from the international point of view. Under the European standards, this ministry monitors and regulates the energy legislation, the production of electricity from conventional and alternative resources, the resulting environmental effects, and trading with CO_2 emissions. Every year, the MIT publishes an updated version of state energy conception (hereinafter ASEK); this document also tackles the generation adequacy issues (Šolc, P., Flášar, P. and Benček, K., 2011).

As mentioned above, specific institutions that are subunits of the ministries control the system. The State Energetic Inspection (SEI) is an institution subordinated to MIT; it controls the fulfilment of the Energetic Act, fulfilment of the Act that supports the renewable resources, and also supports the Act of economical completion in energy market (Energy Act No. 459/2000). The energy market has its own regulator as well. The Czech energy regulator (ERÚ) was established in January 2001. This regulator monitors the activities of the companies that provide the distribution and trade of electricity; they also monitor fair competition on the market. ERÚ also supports and monitors of the use of alternative resources for electricity production (Energy Act No. 459/2000).

Electricity trading is organized by special agency, the company OTE a.s. (hereinafter OTE). This company is owned 100 % by the state. Its activities include the organization of the electricity market, and together with the Czech TSO, balances the market where the regulation energy is traded, OTE is also responsible for system deviation settlement and organizes gas trading. All of this will be explained in further detail in the following chapters.

1.1.2 Organization of the energy market in the Czech Republic

For the relevant development of energy portfolio, it is important to set the roles of the market participants. The market participants are called registered market participants (hereinafter RMP). RMPs can be registered to the TSO, trading companies, distribution companies, producers, and some customers, except for small companies and households. Producers technologically ensure the generation of electricity, this process is influenced by market demand, optimize production costs, which ensure to minimize the operational risks. Power traders are responsible for intermediating power delivery. Their main goal is to meet the consumers' needs and react on market offer in generation side. Simultaneously, they fully bear the market risk. Customers are the final receivers of power delivery; they must know their demand requirements to avoid possible losses caused by short position on delivery (Vinkler, K., 2012). The market operator is responsible for the physical settlement of the contract obligations between the market participants and spot market organization. Forward and future products are cleared, at the power exchange. The market place is where the supply and demand are cleared; exchange is possible to close a deal through central counterparty on standards conditions (Vinkler, K., 2012).

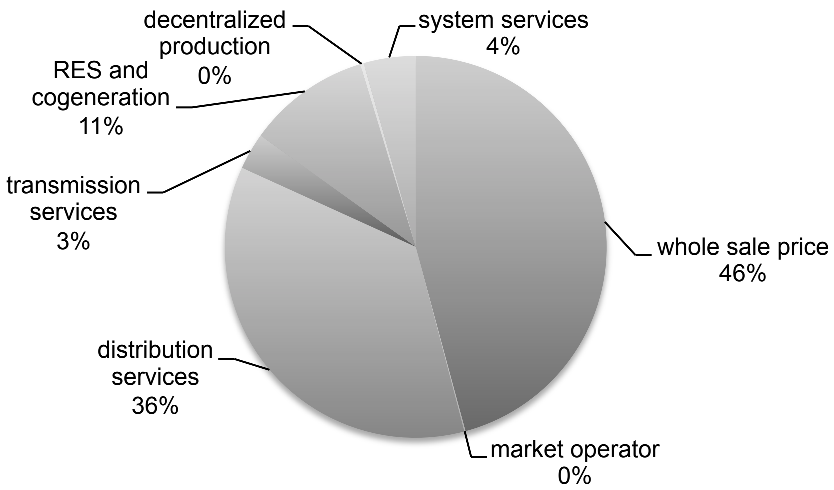
In the Czech Republic the energy mix consist of coal, nuclear resources, gas, water, wind, and solar energy resources, where coal and nuclear resources constitute the main part of the generation mix. A more detailed analysis of energy generation is discussed in Chapter 2.

(i) Transmission and distribution of energy in the Czech Republic are two different and independent systems. The transmission grid is utilized for long distance electricity transmission from the production side to areas with concentrated higher amount of consumption in industrial areas. For the distribution grid is characteristic its character, this grid comes out from places connected to transmission grid. Prior to activation of ancillary services (the role of ancillary services is explained in the next subchapter), the balancing market plays an important role in order to cover inequalities of the electricity grid (ČEPS Summer School, 2013). This method of balancing services procurement will play a more important role in the future. The balancing market is organized by OTE; the trading begins with the announcement on the OTE portal, where the RMPs are logged in. During the trading, RMPs register demands or react on free supplies of the TSO. Both positive and negative regulation energy can be traded on the balancing market, as it depends if the RMP purchases or delivers the electricity. The trading interval is 1 hour and the trading unit is MWh (Chemišinec I., 2010). The balancing market opens one hour before the delivery and is closed and settled 30 minutes before the delivery. The market is opened daily. The demand for regulation energy is based on predictions of the system deviation. The price is regulated by the Act 541/2005. Regulation of energy traded on the balancing market can be completed by the energy regulation purchase from abroad based on the agreement of neighbouring TSOs (Šolc, P., Flášar, P. and Benček, K., 2011).

Electricity is delivered through the transmission grid based on the internal and external transactions and balanced on the balancing market and is further distributed to the end consumers. This process is ensured by the licensed distributor according to Czech law, in which there are three main distribution companies and also local distributors with specific conditions for electricity deliveries. The distributors are responsible for the electricity distribution to the end customer and also act as a supplier of the last instance, which is important when the original delivery is in default.

(ii) To better understand the relationship between the market participant during delivery and behaviour of the power system, the role of the imbalance during the delivery must be described. From the point of view of the particular market participant, it can be determined as a difference between measured and nominated amount. System deviation is understood as a cumulated imbalance between the real and nominated amount; it is covered by the system service to keep the balance of the power system. For this purpose, the difference between market participant, who is not responsible to balance its deviation and balance responsible party (hereinafter BRP), which is charged by market operator in case of its participation in system imbalance, must be distinguished. BRP can collect several market participants, both producers and consumers. A sufficient availability of the whole system is very important to the energy portfolio. Services that ensure the quality and reliability of electricity delivery in the transmission grid, together with the acceptation of international requirements and European integration framework, are System Services (hereinafter SyS). SyS are provided by the TSO. Quality is determined by the parameters of frequency and voltage of the electrification grid. System services price is included in the energy price of each consumer. Financing flows through distribution companies directly to TSO. To ensure SyS requirements, the particular TSO utilizes various technical and commercial measures such as Ancillary Services (hereinafter AS). AS can be considered as a tool for the provision of SyS, as AS allows for any imbalance between generation and consumption to be corrected by means of demand's and supply's side changes. Entities connected to the electrification network have a possibility to provide and offer the AS. Prices of AS are created on the simple market mechanism; the selection of AS Providers is based on public tendering requirements. The AS is purchased on free AS day ahead market or the services are purchased through direct contract with a Provider of AS. AS are technically considered as a part of the output capacity on certified generation facility and as an obligation of the balancing subject to regulate its power in request from dispatching control centre (Šolc, P., Flášar, P. and Benček, K., 2011). The Chart 1 below describes the price structure in the Czech Republic. It is evident that the main elements are the wholesale price and distribution services; the next important part are the renewable energy systems (hereinafter RES) and cogeneration and then system and transmission services.

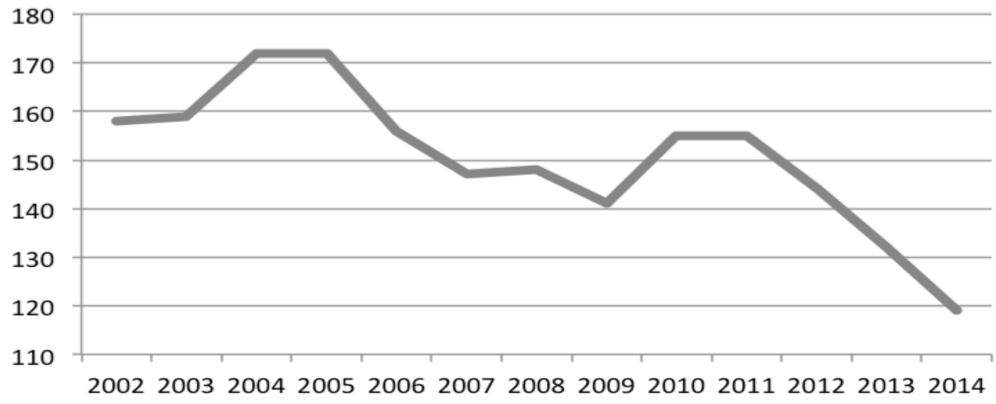
Chart 1: System service charge structure of the electricity price



Source: ERÚ, 2013

After determining the structure of electricity price, focus should be placed on the System Services Price development. Chart 2 shows the development of the System Services Price during 2002 to 2014. The biggest changes occurred between 2006 and 2009 and then again from 2011 and 2014. The system price was influenced by the decrease of the wholesale prices in the power market. The reason of decreased wholesale price is the situation on the commodity market after the crisis in 2008 coupled with lower consumption. These aspects resulted in a surplus of energy capacities that pushed the prices down. Considering the situation in the Czech Republic, which is not part of the Euro Zone, is the influence of currency risk is expected.

Chart 2: Development of the system services price



Source: Author's analysis, data based on information from ČEPS dataroom

AS Market is an integral part of power market and these services are essentially proposed for effective procurement of System Services. Considering technical aspects that are necessary for providing Ancillary Services, several specific conditions should be taken into consideration. TSO's position is accepted as a single buyer and long-term products are prevalent – hedging purposes, products can be substituted and easily differentiated, and competitive opportunity for the wholesale power market, sufficient traded volumes, technical barriers for new entrants, which ensures a high quality standard. The main goals of the procurement of AS are to ensure the quality and reliability of the power system in real time operation in accordance with the ENTSO-E standards, fulfilling the regulatory framework, minimizing the procurement costs, and the cost of optimization of the market participants related with the deviation settlement.

The last point is the scope of intraday balancing market. The purpose of the intraday balancing market is to allow direct online purchases of regulation power with the delivery in the next hour. This market can be combined by participants of the intraday market which gives flexibility for both AS providers and the TSO. These participants are simultaneously responsible for balancing the electricity and minimizing the risk from deviation. Therefore, TSO is able more effectively to react on the actual system imbalance.

(iii) Electricity trading is sophisticated process with different types of actors and rules. Before the distribution of the electricity to end consumers, the electricity has to be traded on specific electricity markets. Electricity trading is divided into two types of market, retail and wholesale market; each has specific features and differences. Firstly, customers are divided into two basic groups:

(a) Companies, which act as a registered market participant with the continuous metering of their consumption diagram; and

(b) Small companies and households, customers, who have small consumption with non-continuous metering using the standardized diagram of consumption.

The retail market is focused on the end consumers, who are mostly households and small companies. The behaviour of each customer influences the overall demand for the electricity. In the wholesale market, the electricity is considered as a trading commodity and the market participants are mostly traders. Traders can trade on two specific wholesale markets, organized markets and unorganized markets.

Organized markets belong to wholesale markets. The electricity can be traded on a long-term or short-term market. Usually contracts in long-term market are longer than one day; monthly contracts are most frequently traded. The length of a particular contract is not limited, but it is not recommended to close contracts longer than three years because of many external elements which influence the price. This market can be also compared to financial markets: the commodity is traded on the power exchange and contracts are the derivatives, such as futures, forward, options, or for example, contracts for differences (CfD) (Vinkler, 2012).

Contracts closed before the hour h and the day D are on short-term organized markets; in this hour h and day D the supply of electricity is realized. This market is divided into two sub-markets: day ahead market (DAM) and intraday market (IDM). On the DAM, contracts are closed during the working day before the supply, terminology use expression D-1. Traders are placing a demand or an offer on the web portal, provided by OTE. Then, the placing and settling is realized between the market operator and organizers of short-tem markets abroad. The TSOs provide OTE the accessible transmission capacity; organized short-term market allocates the transmission capacity through implicit auction (OTE, 2014). OTC markets have standardized rules and specific features and requirements.

Traders use mostly bilateral contracts registered at OTE. For any physical contract traded on bilateral base including OTC trading is recommended to use the EFET requirements, which are suitable for bilateral trading. The European Federation of Energy Traders created the framework of these EFET contracts. Particular contracts are negotiated between two traders (Šolc, P., Flášar, P. and Benček, K., 2011).

1.1.3 Influence of Power Exchange

Electricity is considered also as a traded commodity and influence of power exchange is very important. On the Picture 2 below this text you can see all market places in the European Union.

Picture 2: European market places

Source: Author’s analysis

In Europe, the three most important market places are Nord Pool, EEX, and APX-Endex. Table 1 shows the list of market places in Europe divided by the volume (MWh) traded in 2014. Table 1, shows the biggest traded volumes were in EPEX Germany and ELSPOT market place (Kučera, D., 2012).

Table 1: List of European Market places by Volume (MWh) traded in 2014

Power Exchange	2014 Volume (MWh)
CZ	9 955 744,60
SK	1 362 823,40
EPEX-GE	192 569 626,20
EPEX-FR	48 394 978,20
Belpex	14 493 619,20
ELSPOT	250 058 835,30
PolPX	13 144 510,30
HUPX	9 118 836,30
EXAA	5 736 592,70
Southpool	4 410 149,58

Source: Author's analysis

Considering the central and eastern European region, the Central and Eastern Europe Stock Exchange Group (CEESEG AG) plays a central role. This organization was created in January 2010. CEESEEG AG is constituted by:

(i) Wiener Borse (Wiener Börse),
(ii) Budapest Stock Exchange (Budapesti Értéktőzsde),
(iii) Ljubljana Stock Exchange (Ljubljanska borza),
(iv) Prague Stock Exchange (Burza cenných papírů Praha).

The CEESEG AG is responsible for strategic and financial management and administration of the subsidiary companies. The trading operations are in the competence of four above mention stock exchanges. The aim of this organization is to strengthen and develop investments (Kučera, D., 2012).

1.2 Role of the European Union

The European Union influences the development of the energy market in each European country. The European Union created two important organizations in past years, which coordinate the main activities and interests of states, the Commission, the Council, and the Parliament of the EU. For better coordination of state participation, each EU member state has to follow article number 6, Electricity Directive, which specifically explains the need of reciprocal cooperation during the integration of national markets. The European Commission has the main role in the process of integration and responsible for the creation of the integration strategy. Agency ACER and ENTSO-E can also act as an assisting authority. ENTSO-E is a Brussels-based international non-profit organization founded on December 19, 2008. The Association is established without capital contributions. The members shall contribute annually to the budget of the Association by payment of Membership subscriptions determined by their voting power (ENTSOE, 2014).

ENTSO-E assists other organizations with the improvement of integration and European environment. The creation of TYNDP – Ten years net development plan- serves as a pillar of activities. All member states are recommended to uphold the requirements mentioned in this plan. The main activities and requirements of ENTSO-E are specified in the Regulation No. 714/2009 of the European Parliament and of the Council. There are also specific grid codes and rules to ensure the security and reliability of the grid. ACER, the Agency for Cooperation of Energy Regulators, is located in Ljubljana. All activities are fully subordinated to the European Commission in line with the Regulation No. 713/2009. The Agency controls and regulates the ENTSO-E activities and monitors the energy market and informs the European Commission and the Parliament. The Czech Republic is represented in this Agency by its Energy regulator (ERÚ).

The development of national markets in the EU influences mostly cross-border trading. The implementation of new methods allows customers to choose distributor from different countries, not only from the home country. The integration of markets is based on reciprocal harmonization of rules in each country and is organized by special system called market coupling (Geron, A., 2010).

Market coupling is an initiative to connect national energy markets under the motto "one step, one place, one moment." The supply and demand in market coupling is compared through a central algorithm respecting the transmission capacities. Subsequently, the evaluation of the optimal distribution is performed on the basis of maximization of economical utility. Considering the situation in the CEE region, market coupling in the Czech Republic and Slovakia was successfully finalized in September 2009, and in 2012, these two countries were coupled with Hungary (Geron, A, 2010).

Chapter 2

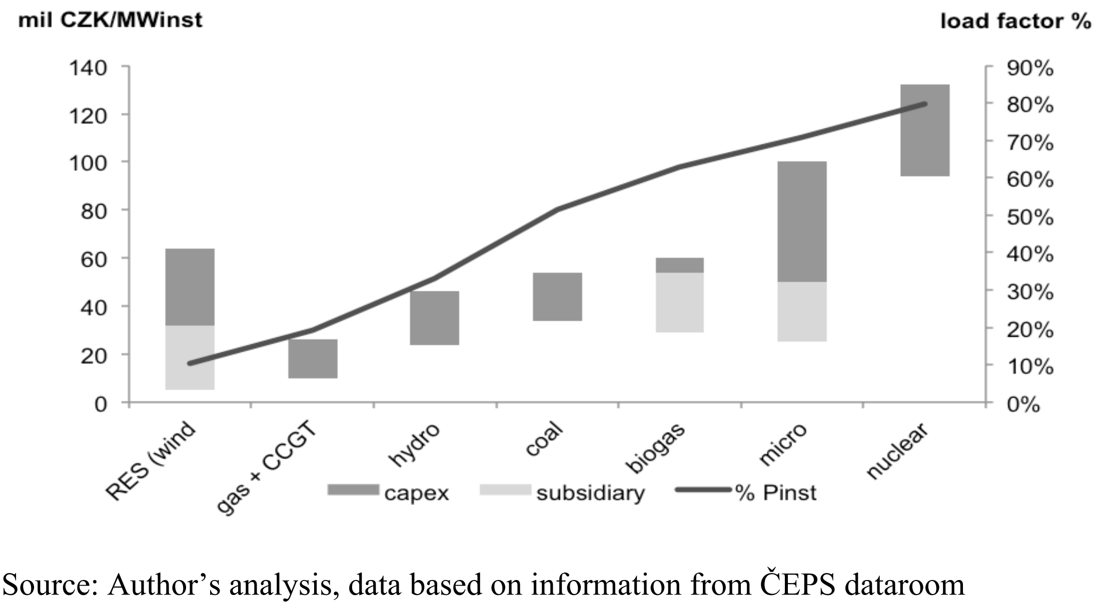
Approaches and criterions

The last chapter defined the organization of the energy market and most importantly the behaviour of the energy portfolio. The factors, which drove the energy portfolio can be considered as key parameters in determining generation adequacy for setting proper energy goals and state energy policy, including the analysis of investment costs and utilization of installed capacity, generation portfolio structure, influence of CO_2 allowances on marginal costs, marginal costs of production of renewable resources (hereinafter RES), and lastly influences of imbalances in the generation of energy from intermittent resources. The last part of this chapter will define the term Generation Adequacy and analyse the important measures that influence its development in the Czech Republic.

2.1 Investment costs and utilization of installed capacity

Investment costs are influenced by a combination of capital expenditures and state subsidies. Chart 3 illustrates, where the highest amount of subsidies is invested. Most state subsidies are applied for the renewable resources, biogas, and micro cogeneration.

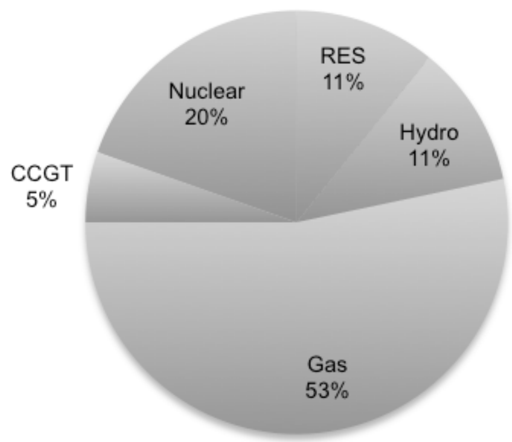
Chart 3: Investment costs and utilization of installed capacity in the CZ



Source: Author’s analysis, data based on information from ČEPS dataroom

The utilization and usage of all energy resources is influenced by the generation portfolio structure. As can be seen on the Chart 4, the generation portfolio structure includes mostly gas (50 %), nuclear power resources (20 %), RES together with hydro (22 %) and CCGT (5 %).

Chart 4: Generation portfolio structure



Source: Author's analysis based on data from ČEPS dataroom

The Table 2 below illustrates the situation in the Czech Republic, considering the total installed power. The total installed power is 20 250 MW; the System Services are covering totally 1 250 MW.

Table 2: Total installed power in CZ

Total installed	**20 250 MW**		**System services total (equal to procured ancillary services)**	**1 250 MW**
Nuclear	~ 40 MW	SR	**Ancillary services total**	**1250 MW**
Hydro	~ 100 MW	TR	PR (Primary regulation)	85
	~ 40 MW	SR	SR (Secondary regulation) day/night	335/290
Pump (CCGT)	~ 500 MW	MZ5	MZ5 (5 min activation)	500
Thermal unit (GAS)	major part		MZ15+ (replacing TR) day/night	330/240
			MZ15- working/non-working days	240/270

Source: Annual report 2013 of ČEPS

The generation portfolio structure is influenced by the CO2 allowances and by the marginal costs and the influences of renewable resources. The next parts of this chapter will discuss these issues.

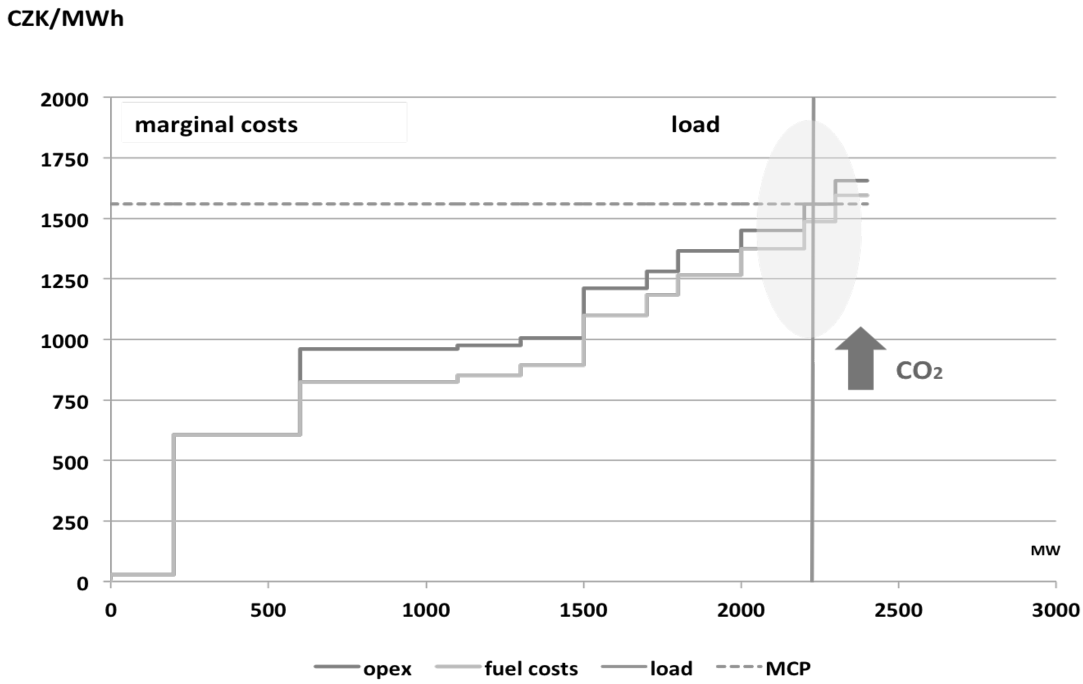
2.1.1 Influence of CO2 allowances on marginal costs

The model of a simplified portfolio was chosen to present the influence of different factors on the behaviour of the energy portfolio, for example for example the price of CO2 allowances and generation of RES. This portfolio is made of basic conventional and renewable sources. By having a look on the Chart 5 below, the light grey curve represents the fuel operational costs for each category of resources, and costs are based on the price of utilized fuel and generation unit efficiency, transport, and other additives used to decrease emissions. In the case of fossil fuels, standardized unit efficiencies are used for brown and hard coal and standardized parameters are used for gas. The returns over fuel costs of coal fired generation are measured by dark spreads, which is difference between the price received from generator for produced electricity and the cost of coal that is needed to produce that electricity (EIA, 2013). Dark spread calculation in following:

$$\begin{aligned} &\textit{dark spread}(\textit{CZK/MWh}) = \textit{power price (CZK/MWh)} - [\textit{coal cost (CZK/ton)} + \\ &\qquad + \textit{transport cost(CZK/ton)}] * \frac{\textit{heat rate (MMBtu/MWh)}}{\textit{heat content (MMBtu/ton)}} \end{aligned} \tag{2.1}$$

For nuclear resources, price for one fuelling cycle is used, which is divided by the standard utilization of generation. For water resources, the operation costs include payment to river cascade providers. Standardized carbon indexes are used for fossil fuels, which show the amount of greenhouse gas emitted in tons into the atmosphere during the generation of one MWh; emission allowances are traded for EUR/ton. Taking into account the fact that each type of fuel has a different price of unit efficiency and current differences of carbon indexed dependency on emission allowances, the final curve (including the emission allowances) is represented by the dark grey curve. The final price corresponds to the value of curve of costs in spot (MW) on the horizontal axis that correspond to consumption. The changes in consumption influence the change in price, for example on the short-term market. The model was programmed through MS Excel and is available in the Appendix 5. The parameters of the chosen sources correspond with current parameters. The overall installed output of the portfolio is 3000 MW; approximately 20 % of the portfolio is covered by renewable resources, 7 % hydro, 13 % nuclear, 30 % lignite, 17 % hard coal, and 13 % gas power. The generation from the renewable resources is balancing between 3 and 17 % of the installed output. The load of the portfolio is 2250 MW, which is approximately 75 % of the installed output of the portfolio. The sources are in merit order by the increasing amount of opex. The marginal costs results when the cost curve intersects with the load. In the given example, the marginal costs determine the market price that motivates operators to commit or to shut down the generation unit. This model is further analysed more in depth, concretely in relation to influences of CO2 and intermittent resources.

Chart 5: Marginal cost of production portfolio influenced by CO2



Source: Author’s analysis, data based on information from ČEPS dataroom

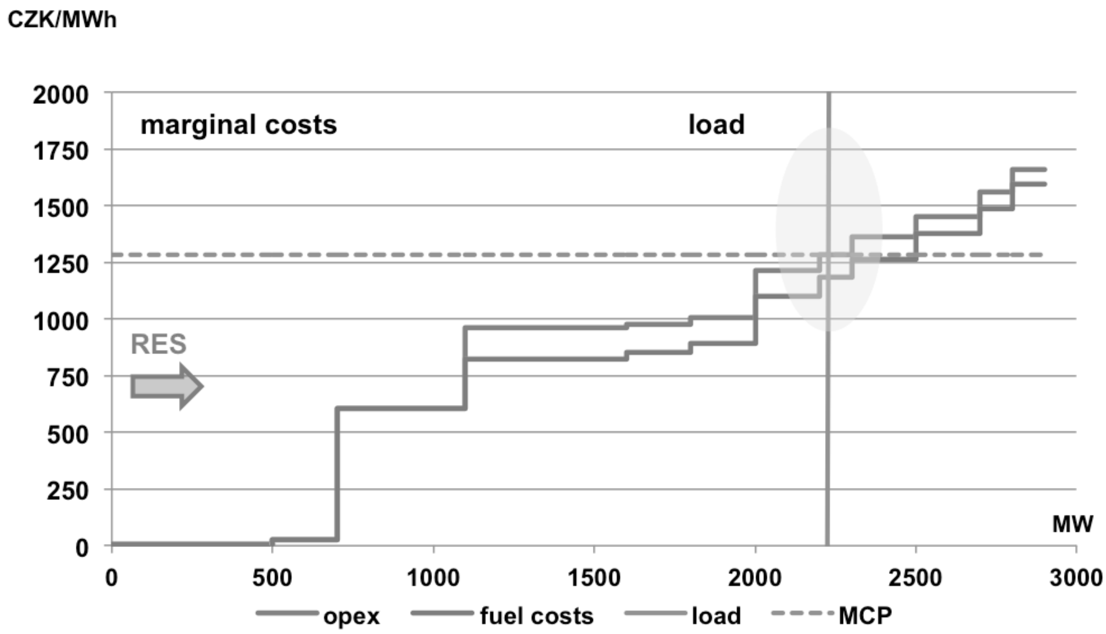
2.1.2 Influence of alternative resources

Electricity production from alternative resources depends on the actual climatic conditions during the year. Due to different climatic and geographic conditions, such as the occurrence of sunny or windy days, the production from wind power plants is more stochastic and lower in summer in comparison to solar resources. Production from solar power plants correlates with the sun radiation during the year and the temperature influences the effectiveness of solar panels.

2.1.3 Influence of alternative resources on putting the resources on operation

In accordance with the corporate strategy of energy companies, a gradual production decline is expected. The main investment programs were finished in 2012; they focused on the power plant renewal and the construction of gas plants. These factors are closely related to the utilization reduction that can result in better opportunities for production in rush hours and consequently lead to higher sale prices. Furthermore, these factors put pressure on the flexibility of the power output, specifically in the most profitable hours of daily deliveries, and the cost arbitrage can be pushed to lower market prices.

Chart 6: Marginal costs of production portfolio by RES



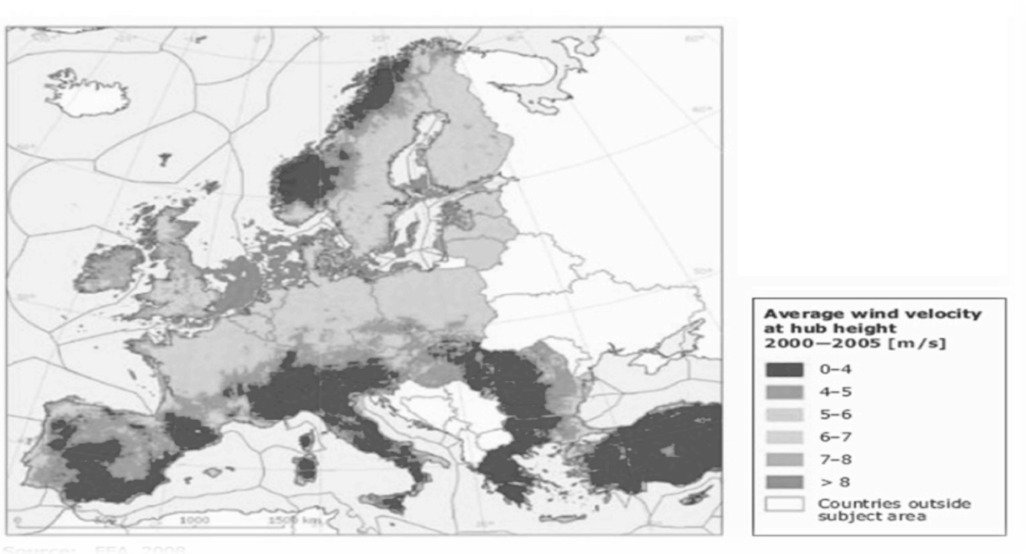
Source: Author’s analysis, data based on information from ČEPS dataroom

Considering the utilization of production capacities used by energy companies, this utilization is related to real availability of the particular power plants. It is more efficient for energy companies to invest into the renewal of the generation capacity and invest less in power plants with higher maintenance requirements and lower efficiency. The production difference should be purchased in the short-term market; as a result, it would be possible to cover the short-term outage and the prophylactic maintenance would be replaced by the corrective maintenance, the Chart 6 illustrates the described situation.

2.1.4 Imbalance in using of alternative resources

On the Picture 3 below this text is shown the imbalance in using of alternative resources in EU.

Picture 3: Imbalance in using of alternative resources in EU



Source: Discussed with Ing. Martin Palkovský from ČEPS in May 2014

The utilization of alternative resources depends on the geographical conditions of a country. For global usage of alternative resources, there is lack of transmission capacity, which is why different areas have different prices.

2.1.5 System deviation

The deviation of the power system in the Czech Republic equals the difference between the production and consumption, including the import and export.

(i) Positive system deviation: Positive system deviation shows the relation between production and consumption, where consumption is lower than production; this situation causes a surplus in the power system (Vinkler, K., 2012).

(ii) Negative system deviation: Negative system deviation shows the relation between production and consumption, where consumption is higher than production; this situation causes a deficit in the power system (Vinkler, K., 2012).

According to system deviation, ČEPS is responsible for balancing the system deviation through the activation of AS, which provides regulation energy. The control room of ČEPS has to take into account the changes in several technical requirements, such as reliability of resources and changes in structure of production capacities, an increase of alternative resources in production and changes in dynamics of behaviour of system deviation, and market integration and its development towards to real time. The continuous development of business tools is based on the pressure in sharing of system reserves and cross-border cooperation, continual trading, adapting to operative demand, participation of traders without physical production, and a higher share of unwarranted regulation energy on balancing of system deviation.

2.1.6 Generation Adequacy

There are many debates about the precise and clear definition of generation adequacy. Generally, generation adequacy is described as a basic mechanism to measure the sufficient amount of sources of electricity in system by meeting the specific requirements and the demand. This particular definition is presented in the member states' electricity power systems. The increase of alternative resources, the loss in flexibility of resources, and market and economic conditions are causing an increase in the system risk (CEER, 2014).

The purpose of the European integration process was to harmonize the markets and create a unified method of evaluation of effectiveness and security of the production portfolio. Every EU member state should propose an efficient plan for the functioning of the system, including legislative procedure that clearly specifies the given requirements and approaches. ENTSO – E develops common methodologies based on long-term experience and analyses. During its establishment, support, and improvement of methodologies, it is necessary to discuss all approaches with every stakeholder.

Generation adequacy is defined as mid-term and long-term ability to balance supply and demand, including the reaction of sufficient flexibility of production portfolio on sudden capacity changes. This means that the short-term balancing should not be included in this process (CEER, 2014). These processes are ensured through various legal and technical standards approved by the regulator. Generation adequacy can be considered to be an analysis of the system risks according to its reliability of capacity balance in the power system for different time periods, scenarios of consumption, and as well as for different level of construction and renewal of conventional resources. Generation adequacy is also utilized by a very diverse range of end-users. This approach is used by TSOs, regulators, policy makers, and investors to cooperate internationally and ensure a stable environment for the use of alternative resources, the balance of power net, and establish a common energy strategy.

What is important for national decision makers is to retain the right of setting the relevant adequacy methodologies and particular standards. This point *"includes the setting appropriate indicators and thresholds to measure the security and supply. However a common set or menu of indicators could be devised and utilised across the Member States. It is necessary that these criteria are defined locally to take into account local circumstances and national specificities, expectations and the unique characteristics of the electric system in question"* (SOAF, 2014).

Considering the methodologies, it should be mentioned at first that there is no accepted unified methodology for data processing and treating at the EU level. The methodologies employed to produce necessary assessment are divided into two philosophies. The first is the stochastic reliability and the second is the reliability or capacity margin. The stochastic reliability attempts to process statistically the loss of the load or energy probability in a given time period. The reliability or as well capacity margin methodology attempts to follow a pre-determined level of excess generation at all times.

2.1.7 A deterministic approach

The deterministic approach is based on the calculation of the balance for single time sections and areas for evaluation of following indicators (SOAF, 2014):

(i) Reliable Available Capacity (RAC):

$$RAC = Net\ generating\ Capacity - Unavailable\ Capacity \tag{2.2}$$

(ii) Remaining Capacity (RC):

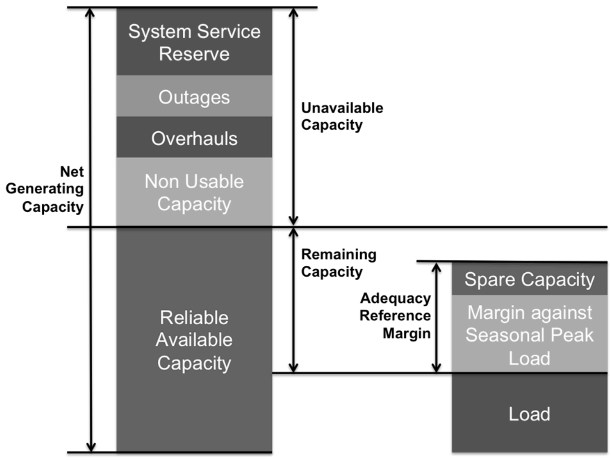
$$RC = RAC - (Load - Load\ management) \tag{2.3}$$

(iii) Adequacy Reference Margin (ARM):

$$ARM = Spare\ Capacity + Margin\ against\ Seasonal\ Peak \tag{2.4}$$

To ensure the reliable supply is valid, the following relation ARM < RC is used. Spare Capacity is capacity for unpredictable situations which guarantees the 99 % of coverage according to fluctuation of production (approximately 5-10 % Net Generating Capacity). The margin against the Seasonal Peakload is used as a specification of the difference between the load in reference to the time section and real seasonal maximum of load (SOAF, 2014). The Picture 4 illustrates the described relations.

Picture 4: A deterministic approach



Source: Discussed with Adam Szekely from ENTSO-E in August, 2014

2.1.8 A probability approach

Considering the general definitions, *"time series is a vector consisting from set of 8760 consecutive values describing the behaviour of selected input during simulation run."* [1] One year is used for the time frame and one hour is used for the resolution. By using a relative form of time series, it is possible to link aggregated values, such as installed power, yearly maximum or yearly consumption. These time series can be either static or dynamic. Static series are stable, and with the exception of simple correction of initial values, they do not vary during simulation.

The process of generation during the specific time period can be divided in standardization and normalization of historical data, for the random fluctuation from historical data and provide conversion of time series on normal conditions – year average must be excluded from simulation. During this part of the analysis,

[1] Discussed with Adam Szekely from ENTSO-E in August 2014

[2] Discussed with Adam Szekely from ENTSO-E in August 2014

the sensitivity parameters are obtained. Consequently, the scenario recalculation uses the aggregated values received before the simulation run.

Lastly, the simulations of the fluctuations modelling based on the sensitivity on changing variables or statistical distribution must be analysed. During this simulation run, the cross correlation between time series can influence load or RES output, as well as the meteorological values by adding in the meteorological simulator and generating a set of corrected climate variables.

The ENTSO-E regional groups use this approach based on detailed simulation of operation of connected grid hour by hour. This method is applicable for the evaluation of complex phenomenon of interconnected electricity network. Except for the standard description of production unit, the probabilistic models (year diagrams) for load (depending on temperature) are used – including the possibility of more profiles. It is important to determine the geographic location, alternative resources (wind and solar resources) – geographically determined, which includes a possibility of more profiles, cogeneration and decentralized together with the maintenance plan, static time series, and climate and its parameters and profiles depending on price. Another factor that influences the analysis is the SyS through the static time series and other important issues[2].

As inputs of this analysis can be used multiple scenarios with hypotheses regarding demand profile, generator characteristics, other generation profile, wind and solar profiles, transfer capacities, reserve, exchanges to rest of world profile, fuel and CO2 prices. During modelling, there can be considered the chronological unit commitment economic dispatch model, hourly model, each country is a single market node, minimise the system cost (fuel bill/operating costs) subject to constraints such as must-run, reserve, power of generator. The national balances, market node marginal costs, hourly generation pattern for each generator, system/fuel cost, fuel consumption by fuel type, CO2 emissions, and wind curtailment are results of an output[3].

[2] Discussed with Adam Szekely from ENTSO-E in August 2014

[3] Discussed with Adam Szekely from ENTSO-E in August 2014

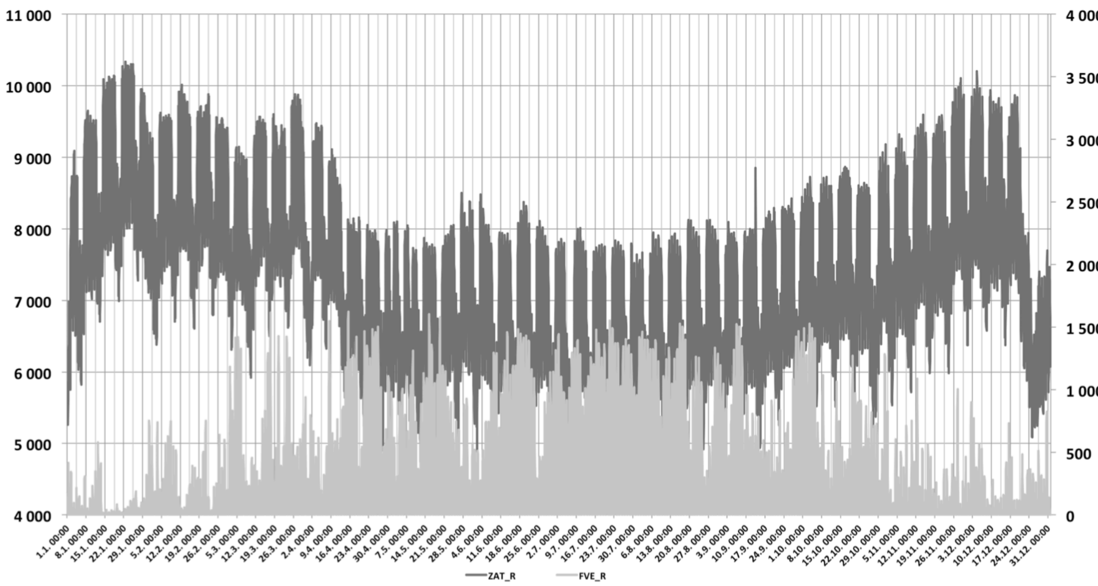
2.2 Changes in electricity production from renewable resources

This part is focused primarily on the volatility of RES production in the Czech Republic. Germany was chosen as a comparison, as it represents the most important partner of the Czech Republic on the energy market.

2.2.1 Volatility of RES production in the Czech Republic

Data of production of wind power plants in the Czech Republic was used for this analysis. These outputs, compared to other countries in the EU, are relatively low, approx. 250 MW. This is because the geographical conditions of the Czech Republic and the continental character of weather. Therefore, the Czech Republic has on installation of photovoltaic power plants in recent years. To date, the total installed power is 2 136 MW, ten times higher than wind.

Chart 7: Volatility of photovoltaic energy production in the CZ



Source: Author’s analysis, data based on information from ČEPS dataroom

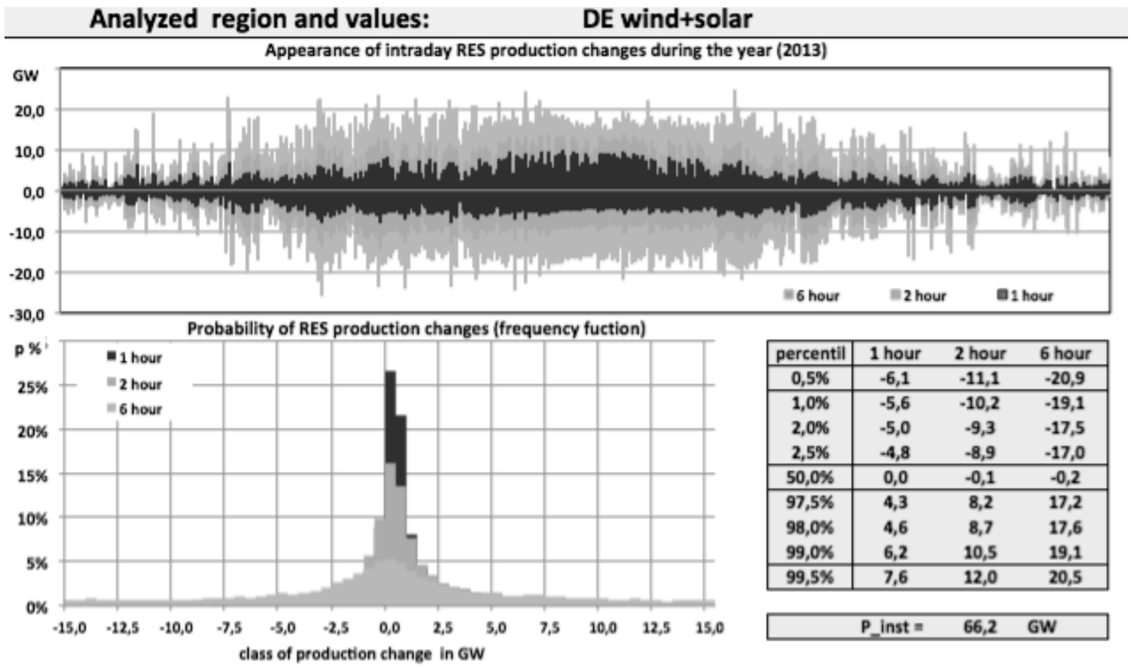
The Chart 7 above illustrates the differences in behaviour of load in every hour, specific to the situation in the Czech Republic. The dark grey part represents the hour shape of load in the Czech Republic in a particular year and the light yellow part represents the generation from RES based on the historical metering together with using the standardized conversion of installed capacity. Throughout the year, this load is very volatile; during the summer period, the load is on minimum, but the level of energy production from photovoltaic power plants reaches the maximum intensity in summer.

Consequently, it is noticeable that the volatility in hour production from RES is higher, which is why networks with a high dependency on RES electricity production have to have a sufficient back up load.

2.2.2 Situation in Germany

Data was provided from ENTSO-E database PECD (Pan European client database), which includes historical hour generation for solar and wind resources based on the simulation of irradiation wind speed. Values are presented in relative figures and the real generation is calculated by installed generation. The values of generation maps were calculated by subtraction of neighbouring values (derivation). Statistical analysis was based on Excel functions – variables, quintiles, and percentiles. The Chart 8 illustrated the outcomes of the analysis; the model was programmed in MS Excel. By using data from the period 2010-2011 in Germany from ENTSO-E database and analysing their values, it is clear that solar in feed has lower utilization (approx. 70% of Pinst) – effective mix is 1:1 (or 1:0,8). Stochastic distribution is wider and a magnitude of 1-2 hour ramping is exceeding 10 GW.

Chart 8: Analysed values of electricity production from wind and solar resources in Germany (2012)



percentil	1 hour	2 hour	6 hour
0,5%	-6,1	-11,1	-20,9
1,0%	-5,6	-10,2	-19,1
2,0%	-5,0	-9,3	-17,5
2,5%	-4,8	-8,9	-17,0
50,0%	0,0	-0,1	-0,2
97,5%	4,3	8,2	17,2
98,0%	4,6	8,7	17,6
99,0%	6,2	10,5	19,1
99,5%	7,6	12,0	20,5

Source: Author’s analysis, data based on information from ČEPS dataroom

From a historical point of view, the power system between Member States, where cross border links were limited, was designed to meet the demand for electricity together with the system needs by an effective combination of domestic generation and reserve requirements with the influence of imported electricity. The interconnection of Member States was limited, and while capacities were built between the Member States, a proportion was allocated mostly for the long-term use. For example a surplus of electricity production in country A was used as a balance of a shortfall in production of country B. For an effectively designed pan-European energy market, it is very important to have an interconnection of capacity and available resources in neighbour states. These aspects are an essential part of every strategy implemented for ensuring generation and system adequacy. In a pan-European energy market, the effective utilization among appropriate levels of interconnection capacity is crucial for efficient internal energy market outcomes including the discussed adequacy.

To develop the current level of integration and complete the EU strategy of building a fully integrated internal market, new investment possibilities in domestic networks should be explored. This will facilitate efficient trade, safer operations, and equal access to the grid. From the provided analysis, it is clear that increasing the amount of variable renewable generation will be necessarily coordinated. Problems can appear in such a moment when the dispatch order of various alternative and renewable generation technologies is different in the power system of each EU Member State. These inequalities can have a direct impact on the interconnection of flows between Member States[4].

[4] Discussed with Ing. Martin Palkovský from ČEPS in May 2014

Chapter 3

Visions and Scenarios

This chapter will describe the visions and scenarios of the electricity market. Under EU Regulation Nb. 714/2009, it is required to publish annual reviews of the development of the generation adequacy outlook and an assessment of the resilience of the system. ENTSO-E regularly prepares the annual reviews of Ten Years Net Development Plan (hereinafter TYNDP). The TYNDP analysis is currently based on the exploration of the 2030 horizon. The year 2030 is used as a bridge between the energy targets of EU for 2020 and year 2050. This plan is based on the four Visions for 2030 (TYNDP, 2014).

The creation of each particular vision is supported by its scenario development. The scenario development helps to identify the particular investment needs based on data provided by TSOs and further analysed on a particular level. Consequently, there are defined parameters, under which the generation and load is forecasted. Each vision is based on a particular scenario. A vision covers the four main areas of the possible 2030 horizon and aims to identify the most resilient and flexible structure under the chosen assumptions. First, it is important to define the main aspects that influence the content of each energy portfolio. The definition of the right amount of required output, given by the demand, is key. In this case, the future profit margin should be measured between the generation and the demand, expectation, ranges, standard deviation. The analysis should also cover the loss of load expectation, unsupplied energy, and usage by geographical unit. After determining the mentioned aspects, the scenario can be defined and the overall effectiveness can be examined through a simulation (TYNDP, 2014).

In the long-term perspective, the high level of uncertainty must be taken into account, as well as the fact that to build a new power plant can take several years. The bottom-up generation scenarios have been developed in past years; the proper definition of these scenarios is to evaluate the risk for the security supply and most importantly assess the range of uncertainty. Besides the bottom-up scenarios, there is the scenario EU2020, which is compatible with the already developed objectives of the European

Union. This scenario discusses the generation outlook, specifically the power generation from renewable and conventional generation regarding the 2020 targets of the European Union.

A special principle called National Renewable Energy Action Plan (NREAP) must be built. The monitoring of fossil fuels will be reported under the national documents that reflect the EU2020 targets.

The definition of the analysed production mix is important as it is continually redefined. The assumptions for setting the relevant production mix are based on the evaluation of given scenarios. The aim of the evaluation is to assess the generation adequacy of member countries between the years 2013 and 2030 by providing an overview of the analysis regarding generation adequacy, regional assessment, and describing of the generation adequacy for each individual country based on national data (SOAF, 2014).

3.1 Scenarios

As was mentioned above, the visions are supported by the analysis of the data provided from each country. The data is examined for each particular scenario. There are three scenarios: Scenario A is known as a conservative scenario, Scenario B is the "best estimate" scenario, and Scenario EU2020, which gives an estimation of potential future developments and targets in 2020. Several terms must be defined before analysing these scenarios. Focus should be placed on generating capacity, when the power of a station is in normal operating mode and simultaneously there is a difference between auxiliary equipment loads and losses in the main power stations transformer and the maximum available unit's power.

It is important to analyse the unavailable capacity as a part of the net generating capacity that cannot be used reliably by the operator. Another important aspect is the reliably available capacity and remaining margin. The reliable available capacity is a difference between net generating capacity and the unavailable capacity. Power can be covered by the system's load at the given moment and the remaining margin is a difference between the load and reliable available capacity.

The remaining power is part of the net generating capacity that is able to cover unplanned generator outages and sudden load variation. Other important terms include the margin against peak load, remaining margin, and spare capacity. Margin against peak load is the difference between the researched regime load and the maximal load of given season. The remaining margin is the difference between the margin against peak load and remaining capacity. The spare capacity is a part of the net generating capacity that is activated to ensure the security of the supply to. The adequacy reference margin is a part of the net generating capacity that should be available for ensuring the power supply.

(i) Scenario A, the conservative scenario, discusses the necessary investments in the energy sector that are particularly relevant to the security of supply. Here, only the resources that will be for sure put into operation (or put out of operation) are taken into account. The necessary additional investments in generation that will be confirmed in the future in order to maintain security of supply are discussed. This scenario takes into account the commissioning of new power plant; the load forecast is the best national estimate available to the TSOs, considering normal climatic conditions. Only necessary investments to the energy system that ensure the secured energy supply are considered. In this case, it is important to take into account new resources.

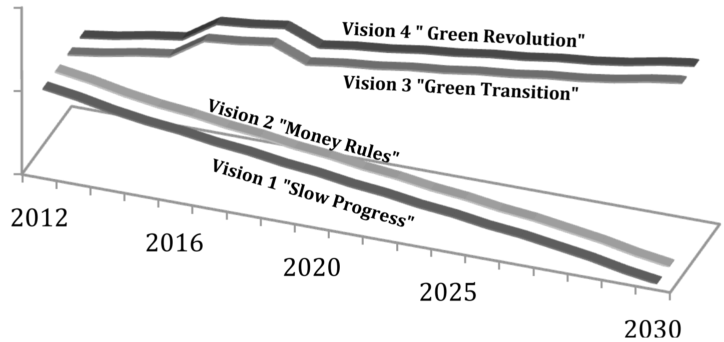
(ii) Scenario B, Best Estimate, the bottom up scenario, takes into account all potential future resources. Also all power plants in commissioning status have to be considered and the adequate incentives for investments are foreseen. This scenario includes the 2014 to 2025 period and takes into account an estimation of potential future developments, an analysis of the situation if market signals give adequate incentives for investments, the generation capacity evolution, and the future of power plants. These are considered to be the adequate incentives for the investment and all new possibilities of resources. Scenario B plays a key role for TYNDP.

(iii) Scenario EU2020 should include the requirements of NAP SG for alternative energy resources and only includes to year 2020. Scenarios A and B are bottom up scenarios based on the political fulfilment of governmental targets for use of alternative energy resources in 2020, whereas Scenario EU2020 is a top down scenario. In this case, the scenario is calculated taking into consideration the accomplishments of RES milestones of the EU 2020 policy. The best national estimation, Scenario B, is taken into account according to consumption (SOAF, 2014).

3.2 Visions

This part is going to describe the four main visions. Figure 1 below this text is showing the particular visions and their forecasted development from 2012 to 2030.

Figure 1: The four Visions for 2030



Source: TYNDP, 2014

The first two visions, Vision 1: Slow Progress and Vision 2: Money Rules are built from the bottom-up on each energy policy of each country. The other two visions, Vision 3: Green Transition and Vision 4: Green Revolution, are built in order to maintain a regular pace from 2012 until 2050.

(i) Vision 1, Slow Progress; this vision takes into account the unfavourable economic situation of the European states. It points out the problem of no development regarding implementation of new technologies. The development of demand is foreseen to grow at slower rate than in Vision 3 and 4. Considering the economy and the market, this vision is understood as less favourable because in this case, the national governments have less money for further development of existing energy policies. There is an absence of strong European framework; this issue is recognized as a barrier to the introduction of a new design of the market that can bring benefits from R&D developments. If there is no reinforcement of existing policies, then for example carbon pricing will remain at such a level that the base load electricity production based on the hard coal will be preferred to gas.

In regards to the demand, there are no significant breakthroughs regarding energy efficiency developments due to very low regulatory push. Another issue is that there are no major developments of the usage of electricity that is to be transported. It has to be taken into account that the electricity demand will grow at a slower rate in this vision. The generation mix is determined by national policy schemes. These schemes are not established in coordination with the EU level. There is a lack of financial resources and delays in construction due to permitting issues. Discussions about the growing public opposition to nuclear power, despite low carbon technology, are occurring. The consequences of the less favourable financial and economic conditions can result in commercial deployments of carbon capture and storage infrastructure. On the distribution grid and transmission systems, the smart communication and the certain amount of price elastic demand enables distributed resources to balance the RES fluctuation. It is generally assumed that this will not fundamentally change the load pattern (SOAF, 2014).

(ii) Vision 2, Money Rules; this vision considers the less favourable economic and financial conditions compared to Visions 3 and 4. Hard coal is in this case preferred to gas and new technologies are proposed as a potential development of the system. Higher consumption is predicted in comparison to Vision 1.

National governments do not have a sufficient amount of money and because of this; the state cannot reinforce existing energy policies. In spite of a strong European framework, the new R&D expenses and market designs focus only on cost-cutting, not on the main goals of the Energy Roadmap. The base load production of electricity in Vision 2 is primarily based on the preference of hard coal over gas; these consequences result from the nonexistence of the reinforcement of policies, carbon pricing, and taxes. Countries with a generation portfolio mainly based on hard coal will be the net exporters (SOAF, 2014).

The energy efficiency development together with the development of the usage of electricity for transport is important. Considering the demand, it is expected that the electricity demand will grow due to the introduction of new uses of electricity and the realization of energy efficiency improvements.

Although the generation mix is determined by the European experts, there are still construction delays and a lack of financial resources due to several issues with permits that cause the overall delay of the energy road map realization. If only the objectives of 2020 are realized, in 2030, there will be need for additional back up capacity. This back up capacity will come from the response of the demand. An effective response to demand is cheaper in this case than building additional gas units or storage.

For this vision, European energy experts predict that: 50 % of the maximum demand response capacity of 10 % is used. It is calculated without preferred technology or market basis competition and with no specific support.

Considering the decarbonisation, it is only driven by the carbon pricing; there are no additional policies (TYNDP, 2014).

Considering the grid, the distribution and transmission systems are connected through advanced control, communication, and monitoring link. According to electric vehicles, it is assumed that these vehicles will be more flexible on the charging side. A partially developed option of potential bidirectional exchange of energy is offered, for example, the V2G, vehicle-to-grid, approach.

(iii) Vision 3 predicts the preference of gas, development of micro cogeneration, and focuses on the development of electro mobility. Also noticeable is the negative public awareness of nuclear energy. In this vision, the consumption is predicted to be higher than in Vision 2 – considering the Scenario A. Economic conditions are predicted to be better than in Visions 1 and 2.

This vision takes into account more favourable financial and economic conditions, in which the national governments have money for development of existing energy policies. Still, the absence of a European framework can be understood as a barrier to the fundamental market design as it can influence the future benefits from R&D developments.

The efforts of the market are to minimize the ecological footprint from heating and cooling and the development of electricity for transport. Generally, the demand response potential is used to shift the daily load regarding the available supply; it allows back-up capacity to be saved, and this process is cheaper than storage. The generation mix is determined together with the national policy schemes. These schemes plan to follow decarbonisation objectives for 2050. In this case, the generation mix will be provided at a higher cost than it is determined in the European Framework. Most of the additional back up capacity set for 2030 would be used from gas units since additional ways of central hydro storage are not generated due to lack of a supportive European framework.

The growing public opposition to nuclear power, despite low-carbon technology, is discussed. The consequences of the less favourable financial and economic conditions can result in commercial deployments of carbon capture and storage infrastructure. The distribution grid and transmission system projections are mostly the same as in Vision 1. The smart communication and the certain amount of price elastic demand enable distributed resources to balance the RES fluctuation. It is generally assumed that this will not fundamentally change the load pattern. The impact of electric vehicles can be used as an augmentation of the load during off-peak hours.

(iv) Vision 4 predicts a favourable economic situation and strong development of electro mobility together with micro cogeneration. A negative public awareness towards nuclear energy exists. The consumption is forecasted higher than in Vision 2 and Scenario B.

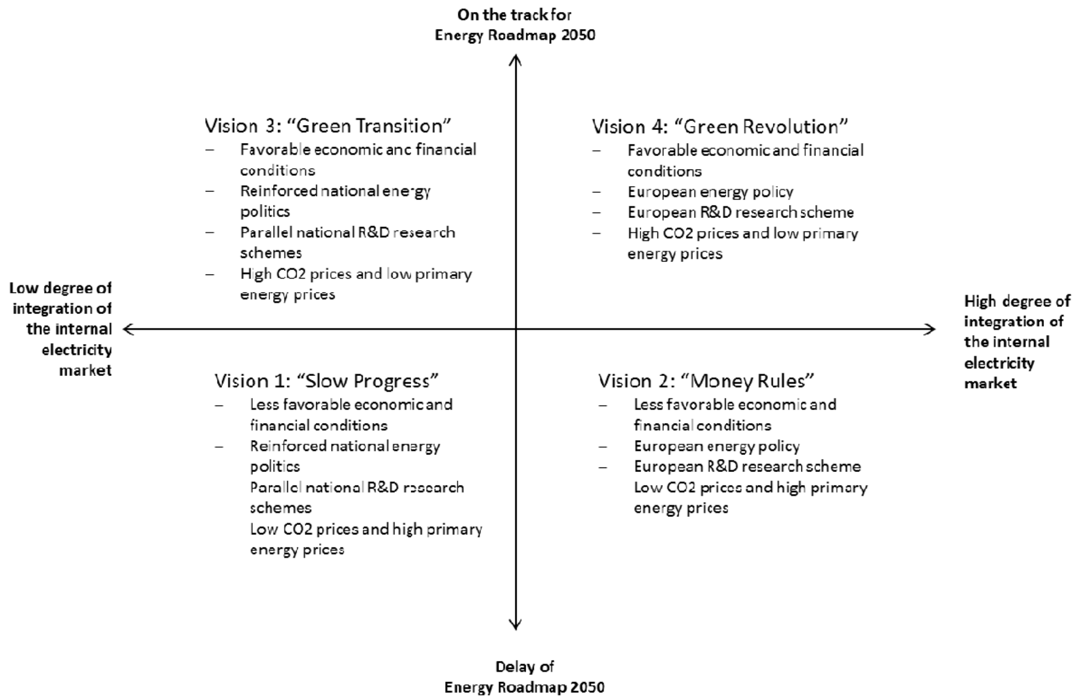
As mentioned above, the economic conditions are in this case predicted to be much more favourable than in Visions 1 and 2. The reason in this case is the better situation of national governments. Investments flow mainly to sustainable energy generation. Consequently, a stronger framework that introduces new market design benefiting from R&D developments is given. Due to the reinforcement of carbon pricing policies, the base load electricity production is based on gas, which is preferred to hard coal. This situation predicts that the countries focused on gas will be the net exporters (SOAF, 2014).

From the point of view of demand, the energy efficiency developments and the developments of electricity for transport and heating and cooling are intensified. In this case, it is possible to combine the highest substation to electricity with the highest energy savings. Electricity demand will grow due to the introduction of new uses of electricity. The strong European vision determines the future generation mix. Vision 4 goes hand in hand with decarbonisation objectives. From this point of view, the back-up capacity will be lower than in Vision 3.

The central additional hydro storage built in the Alps, Scandinavia, and the Pyrenees will be used together with the backup capacity in 2030 from units of gas. Considering the decarbonisation, it is driven by the carbon pricing and negative public awareness of nuclear power plants. Considering the grid, the advanced distribution and transmission systems allow for an increase of environmental sustainability, reduction of CO2 emissions, and ensure the required back-up generation capacity. Through this effective design of the system, it will be possible to accomplish the requirements of the European road map milestones (TYNDP, 2014).

There will be a possibility of bidirectional energy exchange with the grid for electric vehicles. It is assumed that the electric vehicle will be flexible on generation side and charging. Figure 2 provides an overview of the political and economic frameworks of the four visions, considering the low degree of integration of the internal electricity market vs. high degree of integration of the internal electricity market.

Figure 2: Overview of the political and economic frameworks of the four visions



Source: TYNDP 2014

Chapter 4

Risks of power balance in the Czech Republic

This chapter is going to discuss the risk of power balance in the Czech Republic. An analysis of the power balance can be examined by the analysis of balance risks together with the regulation in power trading framework, prediction of consumption, expected decrease, and an increase of conventional energy resources. The expected decrease and increase of alternative resources, upside and downside risks, price risks and finally the impact of integration of energy sector in the Czech Republic must also be analysed.

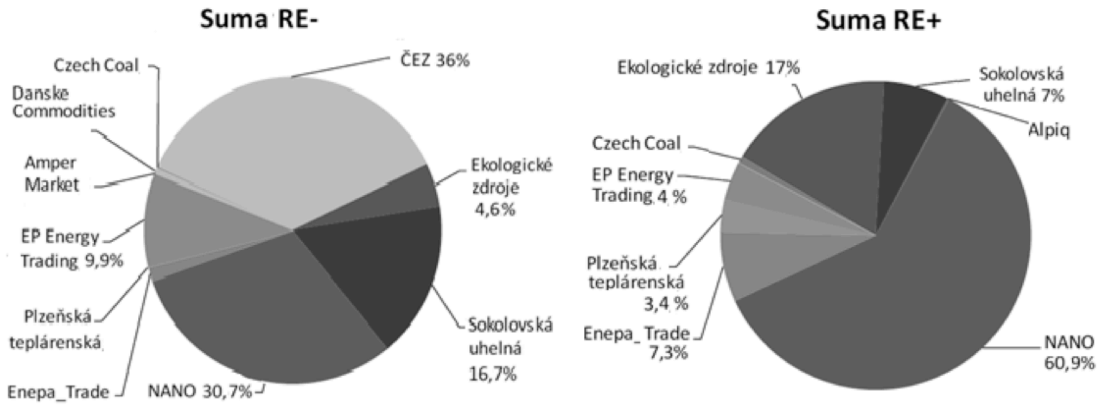
4.1 Analysis of balance risks

The procurement of regulation energy can be ensured through the activation of AS and available contract tools, such as cross-border regulation energy purchases on the external intraday markets through trader with access to the external market. Cross-border Emergency Power Delivery is based on a bilateral TSO agreement. The Grid Control Cooperation (hereinafter GCC) system is based on the system deviation balancing between neighbouring TSOs and internal and external redispatch.

The internal balancing market in the Czech Republic is designed for the intraday direct purchases of the regulation power in the OTE electronic platform in continuous 'hour ahead' sessions (ČEPS Summer School, 2013). This market follows the intraday market; ČEPS is not allowed to participate in intraday market. Ancillary service providers and market participants are allowed to optimize trading positions and minimize the risk from deviation. For ČEPS, there is another alternative market opportunity for regulation energy procurement. Simultaneously, the TSO can react more effectively on the actual system deviation.

Delivery occurs for one hour, liquidity can be maintained with difficulties, and price is sensitive to the actual system balance. As a result, the opportunity for arbitrage and speculation on system deviation appears. Cross border delivery of the regulated energy has a purpose in output changes, power plant cumulated outages, and large demand changes. Considering the pricing, the price of regulated energy is linked to the real price on the local intraday market. The settlement of emergency power delivery is based on the price of the regulated energy in the source system. Then, the contract framework shows the purchase of the regulated energy from cross border delivery and emergency delivery between neighbouring TSOs. The Chart 9 below describes the participation of the trading companies on the balancing market in 2013.

Chart 9: Trading companies´ participation on the balancing market in 2013



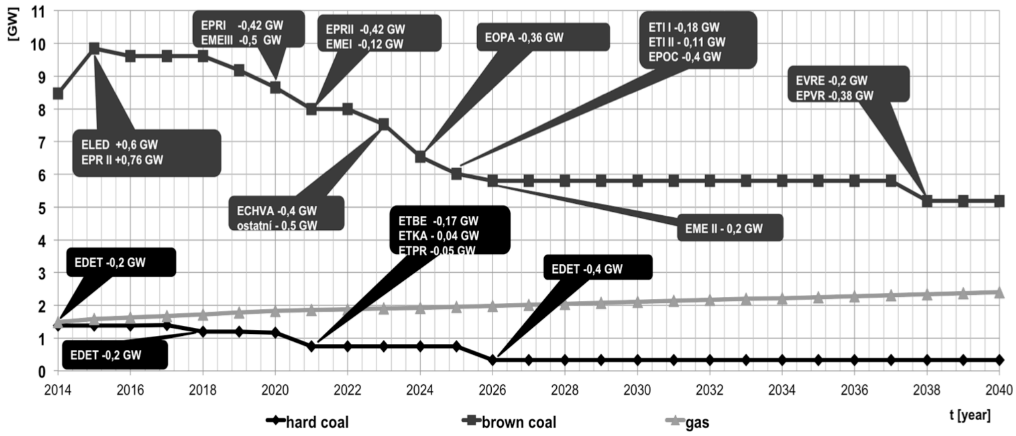
Source: ČEPS summer school, 2013

Considering the delivery specification, the cross border commercial purchase of regulated energy on the external intraday market through trades determines the type of the contract in the frame agreement between ČEPS and the licensed trader who has access to the external market.

The confirmation goes through the each individual delivery; the price settlement includes the negotiated price, the best price bid, and the volume. The delivery period is in hours; the delivery period and volume fixing in a particular hour is up to negotiation.

The counterparties can be divided into groups less than ten, large producers, or local trading companies. The cross border capacity is processed through individual confirmations by each TSO; delivery is at ČEPS borders from the source TSO.

Figure 3: Forecast for installed output from fossil fuels



Source: Author’s analysis, data based on information from ČEPS dataroom

Figure 3 above shows how the installed output coming from the fossil fuels will behave in next 26 years. The prediction takes into consideration generation from the brown coal power plants: Chvaletice, Mělník, Opatovice, Počerady, Ledvice, Prunéřov, Tisová, Vřesová. The hard coal power plants are Dětmarovice, Prunéřov, Třebovice, Teplárna Karviná. Power generation from brown coal power plants will decrease. A significant decline is expected between 2018 and 2022 from 9,5 GW to 8 GW and then between 2022 and 2026 from 8 GW to 5,9 GW. As was mentioned in previous chapters, brown coal one is currently one of the main sources of power generation in the Czech Republic.

The overall situation in the European Union and common approach of EU member states is to decarbonise the generation output and use sources, which are more environmentally friendly. Similar predictions can be made by analysing the power generation from hard coal. Hard coal is not as important of a source of generation output as brown coal, but it still has a significant share of the production. The first decrease is expected between 2018 and 2020 from 1,1 GW to 0,7 GW, than again in 2025 and 2026, from 0,7 GW to 0,3 GW. It is expected that gas will gradually replace the decrease of power generation from brown and hard coal and the production of electricity from gas will steadily grow.

4.2 Expected increase and decrease of conventional energy resources and influence of RES

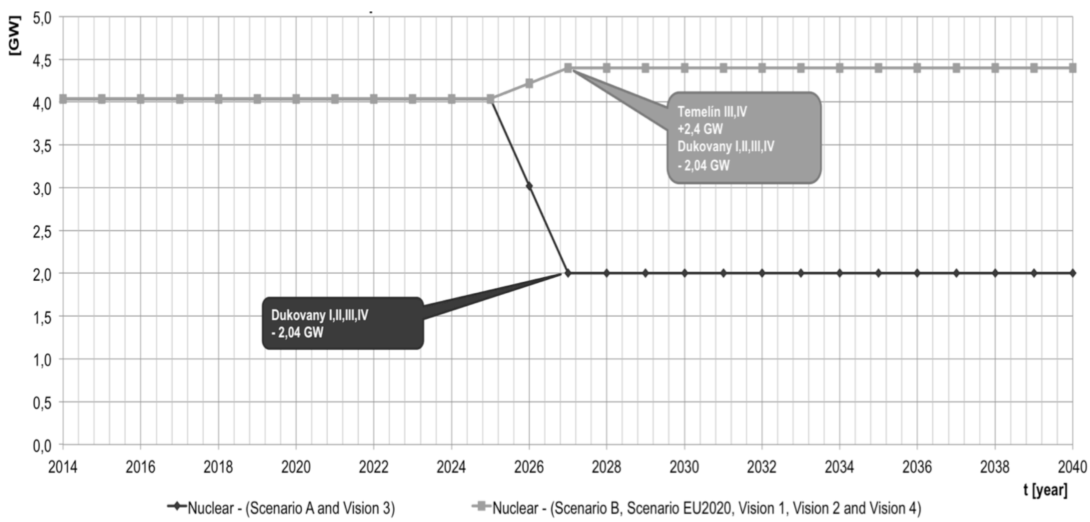
This section explains the increase and decrease of conventional energy recourses compared to the development of energy production of renewable resources. Data used simulates the behaviour of the main Czech nuclear power plants Temelín and Dukovany; the renewable resources used predictions from ASEK provided by the Ministry of Industry and Trade and NAP provided by ČEPS and ENTSO-E.

4.2.1 Nuclear power plants

The scenarios and visions from the previous chapter are compared with the predictions of the installed output from the nuclear resources. The Czech Republic has to calculate power generation from the nuclear power plant Temelín and Dukovany from different views.

This prediction is very important not only from the power generation point of view, but also from the investment prospect. Huge investments into the final project of the new blocks in Temelín nuclear power plant are planned. As depicted in Figure 4, by considering Scenario B, EU 2020, and Visions 1, 2 and 4, the power generation from the nuclear power plants Temelín and Dukovany will significantly increase between 2026 and 2028. By analysing Scenario A and Vision 3, a significant decrease between 2026 and 2028 is apparent.

Figure 4: Forecast for installed output from nuclear power plants



Source: Author’s analysis, data based on information from ČEPS dataroom

Power generation from nuclear power plants is important part of the generation mix in the Czech Republic.

The future behaviour of this electricity source will have a significant influence on the development of other sources that the Czech Republic uses and also has crucial impact on the position of the Czech Republic import and export of electricity.

4.2.2 Expected increase of alternative energy resources

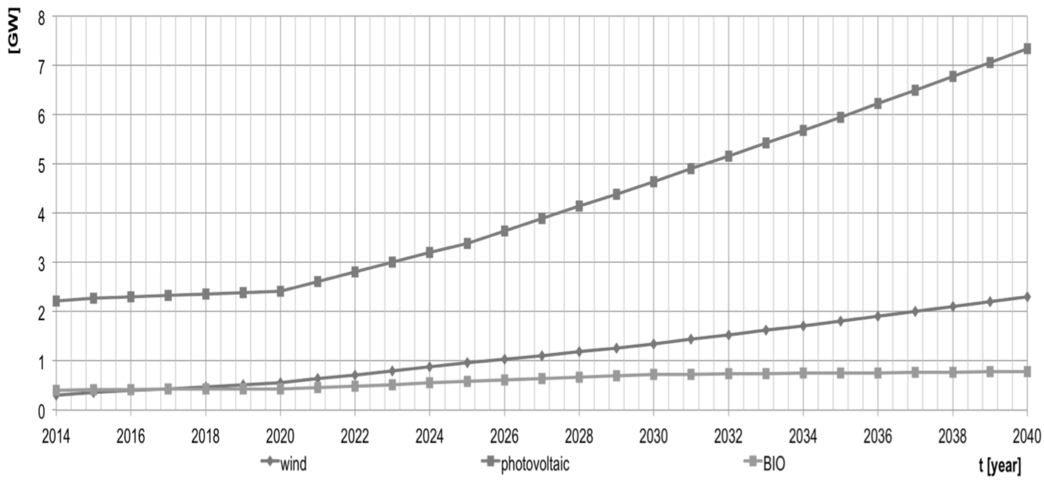
In past years, the Czech Republic has invested in the installation of several alternative energy resources. Considering the importance of the wind power plants and the solar power plants, the weather condition, and geographical localization of the Czech Republic, it can be logically concluded that power generation from these resources is not stable throughout the year.

Generation from solar power plants fluctuates between the winter and summer, while the power generation from wind power plants is more stable. Data provided by ERÚ was used for the analysis; Figure 4 introduces the outcomes from the analysis of the power generation from RES between 2011 and 2014 in the Czech Republic. The scenarios from ENTSOE and Czech Ministry of Industry and Trade give similar predictions.

As shown in Figure 5 below, there is expected significant increase in installed output from RES in the Czech Republic between 2020 and 2030. Three sources are combined here:, the first is solar power plants, the second is wind power plants, and the third is biomass power plants.

The highest usage is predicted to be from the solar power plants, as well as the most significant increase in use of this source for power generation. The increase is expected as well for the wind power plants and at the biomass plants, but still is not remarkable compared to the solar power plants.

Figure 5: Forecast for installed output from nuclear power plants



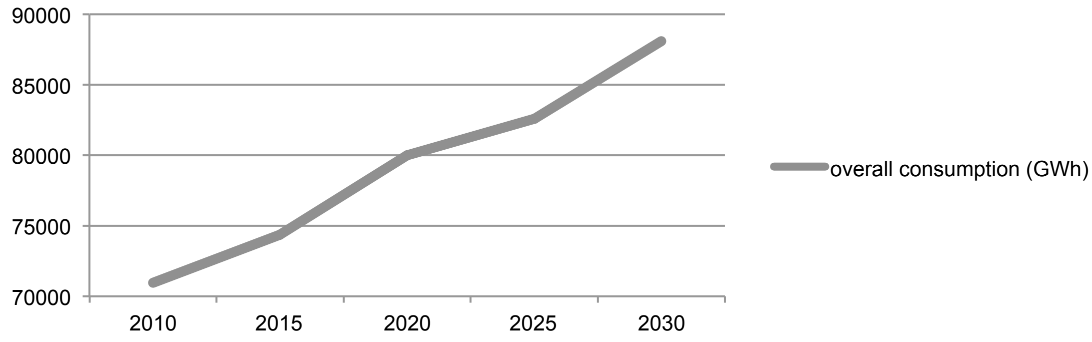
Source: Author's analysis, data based on information from ČEPS dataroom

By comparing the results of the proposed plans provided by the European Union and the Czech Ministry of Industry and Trade, it is noticeable that the future of the power generation becomes more "green". The power generation is only one part of the energy sector efficiency; the second part is the development of the consumption. The next subchapter will concentrate more on this issue.

4.2.3 Development of consumption

Prediction of consumption is an essential indicator used for analysing processes that influence strategy of the energy system in the Czech Republic. The value of annual consumption of the Czech energy system is the factor that most influences the amount of energy transported through the transmission system and it is used as an input for the determination of hour loads of the Czech Energy system in future. It is also necessary to provide information on optimal volume in each category of ancillary services. The values of consumption in the Czech Republic are analysed in the mid-term horizon. Current developments in energy consumption are characterized by the significant decrease in 2009 and relatively slow increase in 2010 and stagnation during 2011-2013. The Figure 6 below shows the described situation.

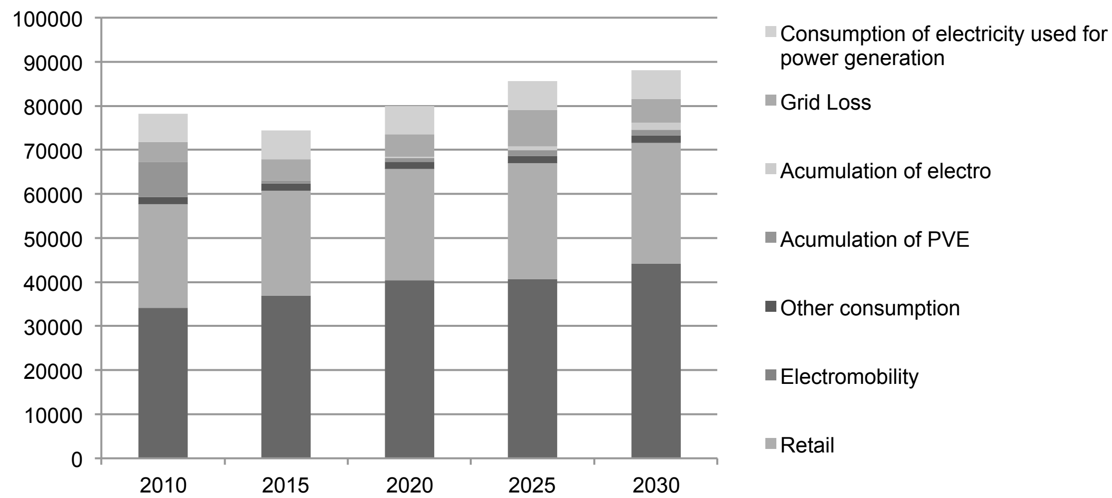
Figure 6: Overall electricity consumption



Source: ASEK 2013

The scenario of consumption until 2020 is based on the data from the end of October 2013. The prognosis for 2014 states that the consumption will also stagnate. A gradual increase is predicted in the next years. The net consumption of electricity has an upward character until 2030.

Figure 7: Consumption drivers



Source: ASEK 2013

The increase of consumption is mostly driven by wholesale and retail consumers, but in the category of grid loss, stagnation is expected, as it is shown on the Figure 7. Importance is placed on the energy efficient electricity appliances, mostly heat or water pumps, and also on the supplement of fossil fuels in the end consumption and utilization of electricity in transportation.

4.3 Upside and downside risks

Finding the balance between generation and consumption is a very important factor of the efficient electrification network. SyS are used on an operational basis (as discussed in Chapter 1.1.2). Considering the long-term basis, it is necessary to accept timely investment decisions, which allows for a portfolio to react effectively on energy needs of a particular economic system and simultaneously to ensure the required comfort to customers (households and enterprises). For efficient planning and evaluation of the investment decisions, it is necessary to ensure stable a economic and political environment, which unfortunately in the past five years, has not been true. The conditions Europe suffered due to several political and economic problems brought instability into the energy system and influenced future development (ECG, 2013). Considering utilization of RES and the geographical location of the Czech Republic, it is not possible to ensure generation from RES during the winter period. The discontinued sources of gas power stations are not able to balance the divergence caused by the cold weather (CEER, 2013). This situation occurred in France in 2012; France was not able to transfer sufficient capacity into the deficit area, while prices increased. Considering the usage of the nuclear blocks with high utilization, high surplus can be generated. This surplus is typical especially for summer period when it is necessary to run nuclear resources on the basic load together with a high production of RES and low consumption. Negative prices and huge unplanned cross border interconnectors are a result of the surplus in the short-term markets. It is necessary to balance a network through redispatching. This is why the generation adequacy is not only considered as the ability of the portfolio which covers supply and demand (energy generation and consumption), but also as the ability to generate electricity during the long term period (CEER, 2013). In this case, the main risk is the sufficiency or lack thereof of flexible capacities.

(i) Upside risk or sufficient upward reserve is risk that evaluates the sufficiency of the system margin, while respecting the basic requirements of ENTSO. In the case of the Czech Republic, the reserve is set up by the possibility of the failure of the biggest block (1070 MW Temelín nuclear power plant) and by the ability to balance this failure for 15 minutes. Another criterion is to cover the critical failure in the network transformer). These failures can be balanced by alternative configurations, the so called criterion N-1. Considering the utilization of RES by the actual installed output of photovoltaic power station, the reserves are influenced by weather changes. In 2014, there was a sudden climatic change that caused a decrease in the utilization of RES by 700 MW. This issue corresponds to a failure of the biggest power block in the network. In the long-term period, the insufficiency of generation capacities can lead to a country's dependency on import; this can cause higher prices and have a possible negative impact on consumers. These negative consequences are why these issues are monitored and analysed in compliance with state legislature from the long-term perspective (approximately 15 years). Through this analysis, it is possible to identify the impacts of all investment decisions regarding ecological actions to ensure the accessibility of resources. The upside risks from the long-term point of view can be compared to the situation on the commodity market that corresponds with backwardation. it then is possible to solve the situation by some hedging operations.

These risks are measured by the loss of load expectation (hereinafter LOLE) parameter, which uses the number of hours during the particular year when there is expected insufficient coverage of load by the generation capacities. The ECG report calculates that the LOLE values are between 4 and 12 hours per year. If the Czech Republic will follow current trends on the EU market, the value of LOLE is higher than 20 hours per year.

Generally, this value represents a country with a low reliability of supplies. In such a case, there is a threat of limited interconnection of network with the other networks. On the local level, this situation can cause high price risk and the loss of liquidity. According to surplus in balance mentioned in Chapter 2, the current value of LOLE is in on the very low level, under 12 hours yearly. This is because there is a sufficient amount of flexible capacities; it is possible to regulate resources including the pumping of water power station; the strategy of ČEPS in the procurement of AS together with the importance of long-term hedging; and integration of the Czech Republic with neighbouring systems. The LOLE values will not change until 2025, at which time the decline of fossil fuel resources and increase of their consumption together with the higher share of RES on generation, the network will not have a sufficient amount of flexible resources. Critical values may be reached around 2035; concretely, these values can reach the value over 24 hours per year if there are no nuclear resources (Vrba, M., 2014).

(ii) Downside risks go together with an insufficiency in the regulation ability of a system to absorb generation surplus. This situation is caused by a lack of coordination in the support of small-decentralized sources. These systems are regulated by different tools than conventional sources; it is expected that technology, meaning the smart grids together with management of consumption, will continue to develop. This is why it is necessary to consider the investment programmes according to RES and micro cogeneration for small households and to consider efficiency of these programmes in combination with other technologies that enable the storage of excess energy generation or the optimization of the consumer's diagram according to the specific needs of network.

In such a situation, the requirement for system services and other requirements for cross border sharing must be redesigned. It is expected that systems with a higher flexibility of capacities will have more favourable conditions. From the long term point of view, these risks can be compared with the situation of the commodity market, contango. The contango situation appears when the future or forward price of a commodity, such as electricity, is higher than the expected spot price. Hedgers or speculators are willing to pay more for a commodity in the future than the actual expected price (Black, B., Hashmizade, N., 2009).

4.4 Price risks

Now, the link between the generation adequacy and the price risk influences by the market will be analysed. Generation adequacy is a technical term that assists in a better understanding of the behaviour of the energy mix. It is generally expected that the generation portfolio will be in an appropriate market balance in a sufficient long interval. The generation adequacy outputs should have economic sense; therefore the scenarios are created which react to market distortions. It is necessary to use the model, which includes the market model, for analytical process.

Looking back to the Chapter 2, the basic conditions that influence the creation of the market-clearing price are mentioned. It has been already been determined that the generation of RES is dependent on weather; therefore, it is not possible to guarantee the share of these resources on power generation. Water resources are limited by the capacities of reservoirs. It is necessary to have sufficient amounts of conventional resources, for example coal; this is dependent on the API index, which takes into account the price of coal and the price of transporting the coal (Kučera, D., 2012). The price of gas resources is dependent on the price of gas, which is currently influenced by a number of factors: the geopolitical situation in Ukraine, the price policy of company Gazprom, and the price of reserved capacity or costs of gas storing in reservoirs. The rising Chinese demand and interest of Chinese companies in the international energy market also affects the price of gas. The situation is further influenced by the discovery of new sources of gas drilling, such as the utilization of shale gas.

The necessity of LNG terminal's utilization appeared during the current situation regarding gas in Ukraine and supplying the Baltic countries, which were fully dependent on supplies from Russia. The current low prices are caused by the oversupply of coal resources and the high price of gas. The gas power station does not generate a sufficient margin and in the long-term, these power stations are excluded from the portfolio. In such a case, the system does not have sufficient capacity for covering the high fluctuation of consumption (upward risk) and prices on market are skyrocketing in the short-term period. High prices from the long-term point of view can negatively influence the main indicators of LOLE because the resources are inaccessible. Other examples of price risk include the surplus of resources and insufficient regulation capacities. In this case, the price of electricity can be negative.

This situation can be used as an opportunity by speculative traders and can simultaneously lead to extreme requirements on transmission capacity because the transfer of surplus energy to neighbouring system must be ensured. Another element that influences the price risk is the price of consumption. Due to long term contango, the consumer has to hedge by using forward and futures only as a part of their supply and settlement is preferred on the short-term market. It is important to note that the liquidity of the short-term market is connected to the physical supply and can be limited by the accessibility of generation or flexible capacities. Taking the commodity market into account, the electricity market is a highly developed market where a sufficient presence of market participants can be found. This market is regulated due to the negative experiences with companies such as TXU and ENRON and as a result of current financial regulation that does not allow for extreme speculative behaviour (Vinkler, K., 2012). Every energy conception should include a long-term strategy that considers resources according to the needs of a particular energy portfolio, as this portfolio should not be dependent on the behaviour of a monopolistic energy supplier.

Chapter 5

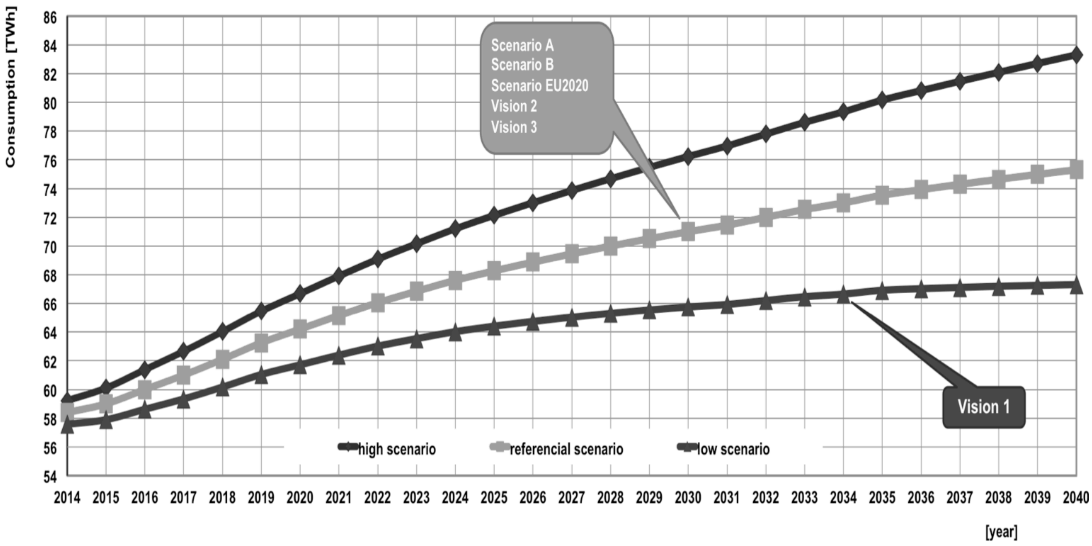
Evaluation of risks of power balance

This chapter describes the evaluation of each scenario, including its consequences and influence on the electricity market. Then, the optimal proposal for ASEK according to situation in the Czech Republic will be analysed.

5.1 Evaluation of scenarios

Before evaluating scenarios, it is first necessary to have a look at first to situation with consumption of electricity; consumption of the Czech Republic was defined in the previous Chapter 4 in the Figure 6. The Figure 8 below illustrates the situation of net consumption of electricity in the Czech Republic forecasted for the period 2014-2040. This is a cumulative analysis of each vision and scenario.

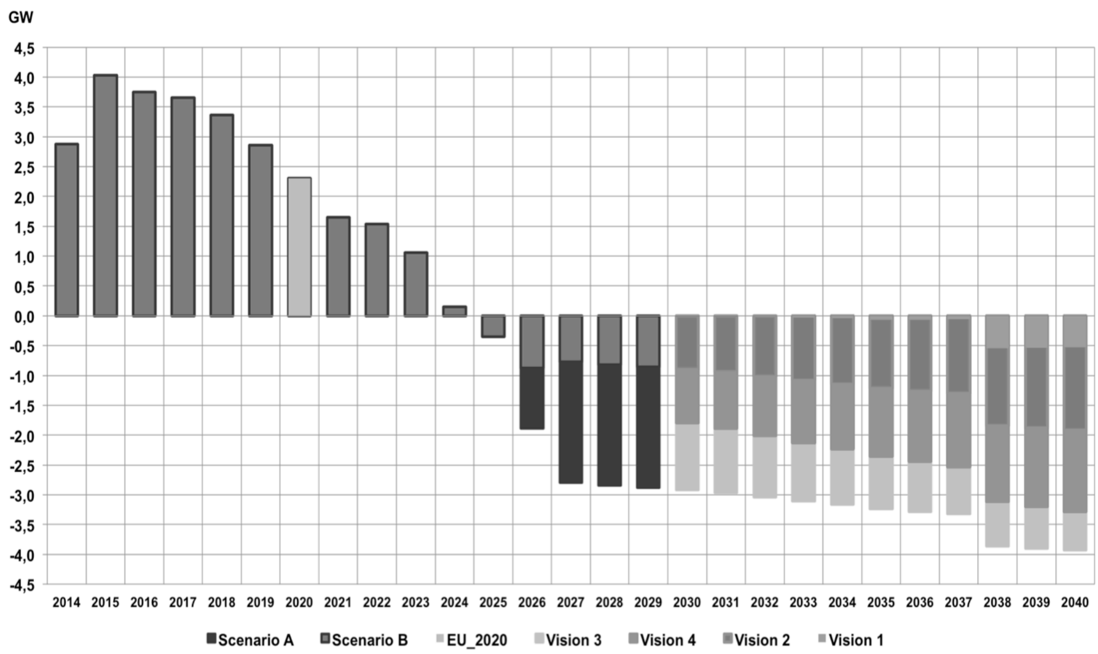
Figure 8: Net consumption of electricity in CZ



Source: Author's analysis, data based on information from ČEPS dataroom

When taking Scenarios A, B, EU 2020 and Vision 1 through 4 into account and using relevant data regarding electricity consumption, it can be concluded that estimates based on Scenarios A and B, EU2020, and Visions 2 and 3 are expected to increase between 2013 and 2030. Both Visions 1 and 4 have completely different behaviour during the period 2013 to 2030. Vision 1 increases very slowly, while on the other hand, Vision 4 increases very fast. The next step in the evaluation of the Scenarios and Visions is to analyse the energy balance of the Czech Republic. Data provided by ČEPS was used in this analysis. There were compared the energy balance of the Czech Republic for the period 2014 to 2040 of Scenarios A, B, EU 2020 and Visions 1 to 4. The Figure 9 below this text shows the outcomes of the energy balance analysis.

Figure 9: CZ balance by SOAF methodology 2014-2040



Source: Author's analysis, data based on information from ČEPS dataroom

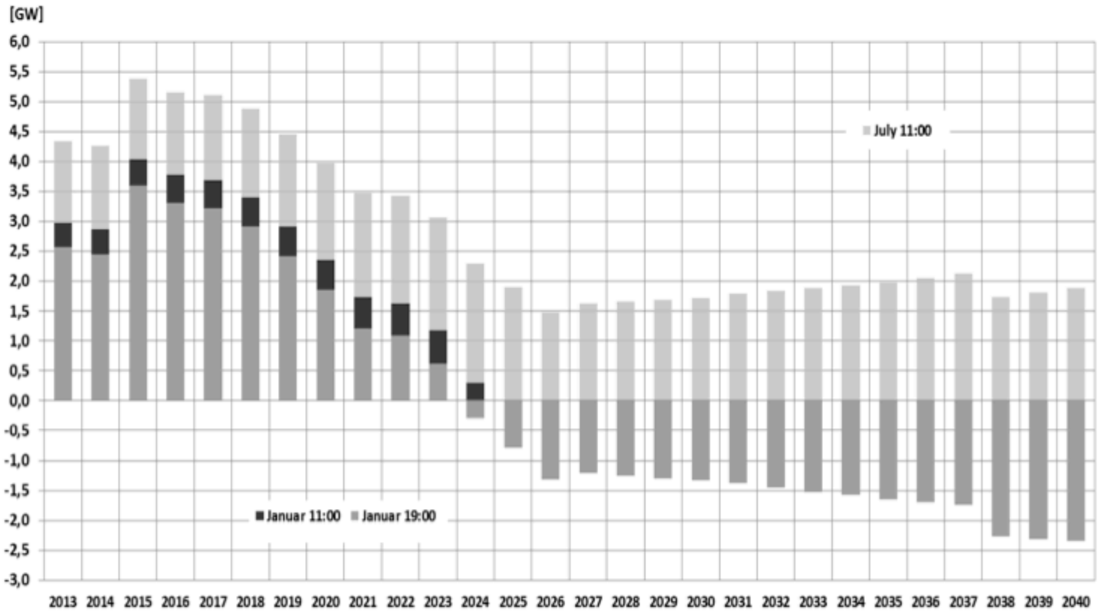
The development of Scenario A is influenced by the necessary investments to the energy sector, which will be confirmed in the future in order to maintain the security of supply. This scenario takes into account the commissioning of new power plants and the load forecast is the best national estimate available to the TSOs, considering normal climatic conditions. Scenario B is influenced by the full utilization of all potential future resources, regarding the fact that the government of the Czech Republic has to consider new nuclear power plant blocks and the adequate incentives for investments are assumed to exist. Scenario 2020, known as the top-down scenario, is based on the political fulfilment of governmental targets for the use of renewable energy resources in 2020. This scenario should include the requirements of NAP SG for alternative energy resources. In regards to Visions 1 to 4, Vision 1 is influenced by the unfavourable economic situation in the European states; it points out the problem of no development regarding the implementation of new technologies. The consumption is predicted low, (such as in) Scenario B. Vision 2 also considers the less favourable economic and financial conditions compared to Visions 3 and 4. In this case, hard coal is preferred to gas and as a result, new technologies are proposed as a potential development of the system. The consumption for this Vision is predicted higher than the consumption in Vision 1. Vision 3 predicts the preference of gas, the development of micro cogeneration, and focuses on the development of electro mobility.

Also, the negative public awareness of the nuclear energy is noticeable. The consumption for this vision is predicted to be higher than in Vision 2 – considering the Scenario A. The economic conditions are predicted better than in Visions 1 and 2. Vision 4 predicts a favourable economic situation and the strong development of electro mobility together with micro cogeneration. There is also a negative public awareness to nuclear energy in this vision. The consumption is forecasted higher than in Vision 2 and Scenario B.

In the above Figure 9, it is important to notice the significant change in 2024, when the Czech Republic is going to change its position from energy exporter as a system surplus of production capacity to a system of energy balance requiring extended cooperation with neighbouring countries to cover balance need during the year.

This situation is described in Figure 10, which depicts negative balance during the winter due to the insufficient capacities to cover high winter demand (upward risk) and a surplus during the summer period based on the high RES production. The excess of the power balance cannot be absorbed by domestic consumption and has to be exported (downward risk). Management of such a system requires sufficient flexible regulation capacities, available capacity for cross border interconnectors, and developed market infrastructure enabling to trade volumes in real time operations. In conclusion, the most acceptable scenario is Scenario B which offers a better position both on the internal and on the external electricity market.

Figure 10: SOAF Balance - Scenario B



Source: Author's analysis, data based on information from ČEPS dataroom

The situation beyond 2030 is an extreme example: it would be necessary to import 2500 MW in the winter and export the same volume in the summer. Compared to the consumption, this volume is equal to ~20% flexible power in the system. Such a range of flexibility is technologically achievable, but will require large scale financing on both the macro and micro level.

Conclusion

The aim of this thesis was to analyse the risks and perspectives of energy supply in the Czech Republic between 2012 and 2030. The first chapter analysed the liberalization process in the Czech Republic, including the role of market participants and the main functionalities of the energy market organization, as well as the role of the European Union and the development of the integration process.

The second chapter described the behaviour of the energy portfolio, which is influenced by market participants. System services, supplemented by ancillary services, are necessary for ensuring the quality and reliability of electricity. The outcome of the analysis shows the situation throughout the year, the load is very volatile, during the summer period, the load is on minimum, but in this period the level of energy production from PVE reaches the maximum. This situation can cause the imbalances in the grid.

In Chapter 3, the strategies and approaches are proposed as possible solutions for the electricity market. These approaches are based on several visions and strategies as defined in the TYNDP published by ENTSO-E. There are four main visions: Vision 1, which considers less favourable economic and financial conditions, reinforced national energy politics, parallel national R&D research schemes, low CO2 prices, and high primary energy prices. Vision 2, considers also less favourable economic and financial conditions, European energy policy together with European R&D research scheme, low CO2 prices, and high primary energy prices. Vision 3, considers favourable economic and financial conditions, reinforced national energy policies, parallel national R&D research scheme high CO2 prices, and low primary energy prices. Vision 4, considers favourable economic and financial conditions, European energy policy and R&D research scheme, high CO2 prices, and low primary energy prices. Visions 1 and 2 were built from the bottom up on the energy policy of each country; while Visions 3 and 4 were built to maintain a regular pace of development from 2012 to 2050. These visions are supported by several scenarios. Scenario A is considered to be the conservative scenario; it includes necessary investments into the energy system and takes into account new resources. Scenario B counts with adequate incentives for the investments and allows for new possibilities of resources. Scenario 2020 attempts to propose a solution that will help to accomplish the RES milestones of the EU 2020 policy. Chapters 4 and 5 analyse the risks of power balance by comparing the RES and conditional energy resources, such as power plant resources as well as the influence of price and other risks.

The EU is still trying to find the most relevant optimum for effective and stable functioning of the European energy market. The relevant solution should bring a new approach to the adjustment of a stable system, which should be in the long-term favourable for technical parameters and is in compliance with financial advantages or specified according to economic profitability. Europe should find a way to manage the central energy system and ensure the quality of supply in such a way that prevents the risk of possible black outs. Every black out can negatively influence the particular area both economically and technically. Europe should ensure the security of supply and every state should consider the adjustment of relevant parameters for the end customers, which should also be effective for the supply.

The European Union must also solve the issue related to the development of deeper integration and the unbundling of distributional system from the big energy companies and according to current geopolitical issues, the single European states cannot succeed in the international environment and they should cooperate and create stable energy union, which will be able to sustain the development and will be able to compete with the external actors. There should be improved contracts with several external states about efficient trades with natural resources, EU should also focus on development of use of its own natural resources and strengthened cooperation in balancing the inequalities in production of electricity between countries.

Evaluating the situation in the Czech Republic, this market can be considered as a place with high standards, comparing to other European States, due to the economical compatibility of economic conditions of the Czech market. A milestone period was the connection of the electricity grid in the Czech Republic, Slovakia and Hungary. Considering the development of electricity consumption, there is expected a gradual increase until 2030. When evaluating Scenarios A, B, EU 2020 and Vision 1 through 4 in can be concluded that estimated based on Scenarios A and B, EU2020, and Vision 2 and 3 are expected to increase between 2013 and 20130. Data provided by ČEPS were used in this analysis, there were compare the energy balance of the Czech Republic for the period 2014 to 2040. Scenario B is influence by the full utilization of all potential future resources, regarding the fact that the government of the Czech Republic has to consider new nuclear power plant blocks and the adequate incentives for investments are assumed to exist. On the other hand, when considering the risks, in case of the Czech Republic, the reserve is set up by the possibility of the failure of the biggest block.

If the Czech Republic will follow current trends on the EU market, the value of LOLE is higher than 20 hours per year, so the Czech Republic will represent country with a low reliability of supplies. In such a case, there is a threat of limited interconnection of network and other networks. This situation can cause high price risk and loss of liquidity. It is expected that the LOLE values will not change until 2025, at which time the decline of fossil fuels and increase of their consumption together with the higher share of RES on generation, the network will not have a sufficient amount of flexible resources.

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List of appendices

Appendices

Appendix 1: Net consumption in the Czech Republic

	2000	2008	2009	2010	2015	2020	2030	2040	2050
low	57602	65642	60872	60118	65559	69349	72095	73548	74757
referential	57602	65642	61640	61316	68719	75077	81033	84197	86796
high	57602	65642	62408	62514	71880	80805	89970	94846	98836

Source: ČEPS data room

Appendix 2: System Services Charge 2013

whole sale price	45,8%
market operator	0,1%
distribution services	35,9%
transmission services	3,1%
RES and cogeneration	10,4%
decentralized production	0,3%
system services	4,4%

Source: ERÚ, 2013

Appendix 3: SyS Price

year	*CZK/MWh*	*EUR/MWh*
2002	158	6,3
2003	159	6,4
2004	172	6,9
2005	172	6,9
2006	156	6,3
2007	147	5,9
2008	148	5,9
2009	141	5,6
2010	155	6,2
2011	155	6,2
2012	144	5,8
2013	132	5,3
2014	119	4,4

Source: ČEPS data room

Appendix 4: Capex, Opex - production portfolio

MW	CZK/MWh	CZK/MWh	MW	CZK/MWh	CZK/MWh
capacity	opex	fuel costs	load	MCP	>=MCP
0	6	6	-9999	1282	9999
500	6	6	-9999	1282	9999
500	6	6	-9999	1282	9999
500	28	28	-9999	1282	9999
700	28	28	-9999	1282	9999
700	28	28	-9999	1282	9999
700	605	605	-9999	1282	9999
1100	605	605	-9999	1282	9999
1100	605	605	-9999	1282	9999
1100	961	825	-9999	1282	9999
1600	961	825	-9999	1282	9999
1600	961	825	-9999	1282	9999
1600	976	853	-9999	1282	9999
1800	976	853	-9999	1282	9999
1800	976	853	-9999	1282	9999
1800	1005	894	-9999	1282	9999
2000	1005	894	-9999	1282	9999
2000	1005	894	-9999	1282	9999
2000	1211	1100	-9999	1282	9999
2200	1211	1100	-9999	1282	9999
2200	1211	1100	-9999	1282	9999
2200	1282	1183	-9999	1282	9999
2250	1282	1183	9999	1282	1282
2300	1282	1183	9999	1282	1282
2300	1364	1265	9999	1282	1364
2300	1364	1265	9999	1282	1364
2500	1364	1265	9999	1282	1364
2500	1449	1375	9999	1282	1449
2500	1449	1375	9999	1282	1449
2700	1449	1375	9999	1282	1449
2700	1559	1485	9999	1282	1559
2700	1559	1485	9999	1282	1559
2800	1559	1485	9999	1282	1559
2800	1657	1595	9999	1282	1657
2800	1657	1595	9999	1282	1657
2900	1657	1595	9999	1282	1657

Source: ČEPS data room

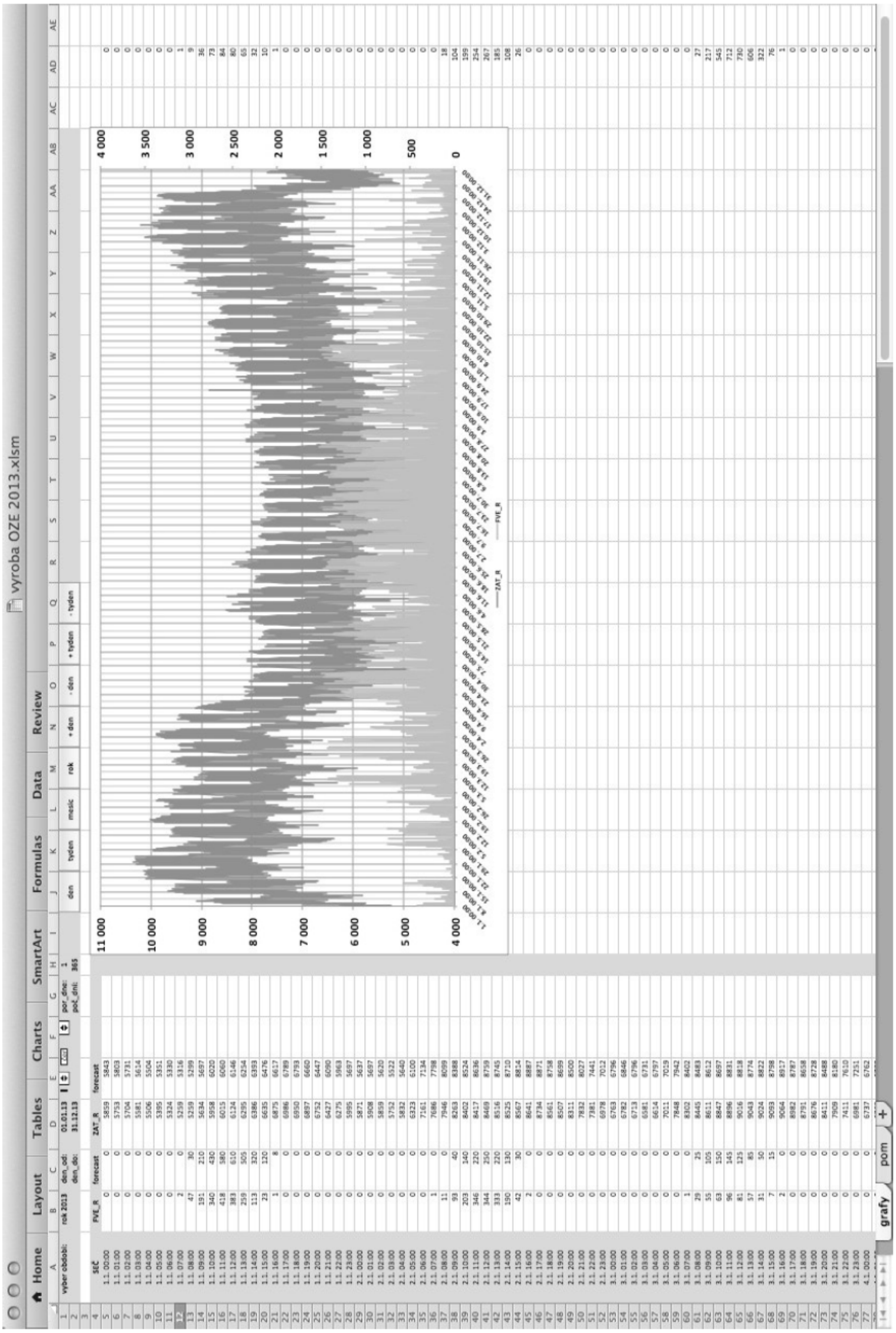
Appendix 5: Capex utilization

		mil CZK/Mwinst	% Pinst	hrs/yrear		
RES	32	64	10%	900	10KW za 1 mil kč	100
biomass	46	70	14%	1200		
micro cogeneration	50	100	14%	1200		
gas + CCGT	10	26	17%	1500	capexy PPC EPC 20 mld CZK za 800 MW	25
hydro	24	46	29%	2500	extimated	
coal	34	54	57%	5000	capexy noveho bloku ELE 40 mld CZK za 660 MW	30,3030303
nuclear	94	132	82%	7200	capexy noveho bloku ETE 300 mld CZK za 1200 MW	104,1666667

	USD/kW	
RES	1600	3200
biomass	2300	3500
micro cogeneration	2500	5000
gas	500	1300
hydro	1200	2300
coal	1700	2700
nuclear	4700	6600
	34	54

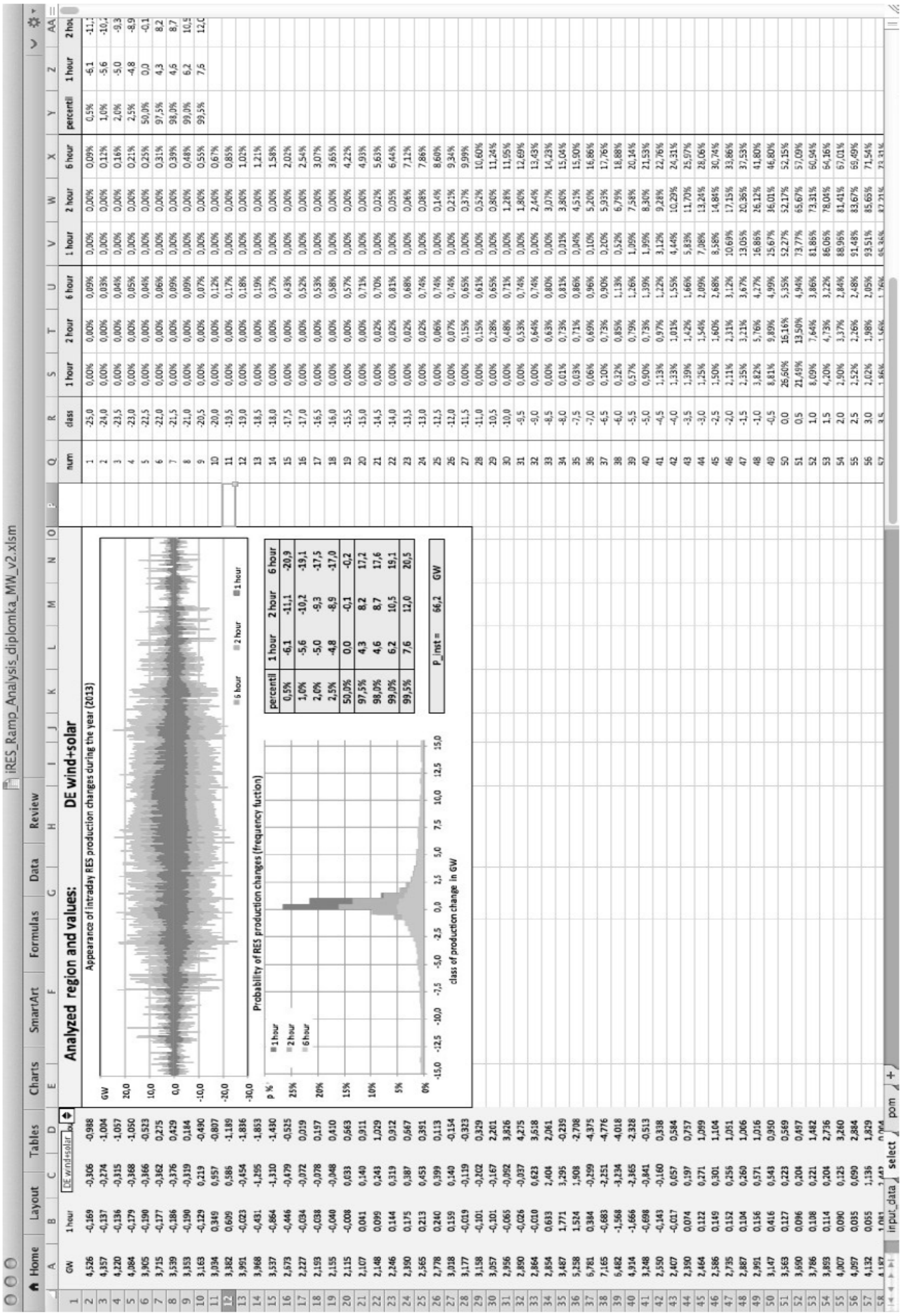
Source: ČEPS data room

Appendix 6: Power generation from RES



Source: ČEPS data room

Appendix 7: Analysed values of electricity production from wind and solar resources in Germany (2012)



Source: ČEPS data room

Appendix 8: Installed outputs in the CZ

rok 2030

Jaderné palivo	MW	GWh
Temelín I,II	2000	14164,5
Temelín III,IV	2400	16997,4
Celkem	4400	31161,9
Hnědé uhlí	MW	GWh
ČEZ – Elektrárna Chvaletice	800	2872
ČEZ – Elektrárna Ledvice III	110	515
ČEZ – Elektrárna Ledvice – nový zdroj	660	3750
ČEZ – Elektrárna Počerady	600	3105
ČEZ – Elektrárna Poříčí II	165	399
ČEZ – Elektrárna Prunéřov II	750	4026
ČEZ – Elektrárna Tušimice II	800	5670
Elektrárna Kladno - Dubská	412,1	791,37
Vřesová – teplárna	220	1492
Vřesová – PPC (zplyňování uhlí)	384	2093
Actherm - Teplárna Na Moráni	26	36
Alpiq Zlín	69,25	74
ČEZ – Teplárna Dvůr Králové	10,4	11
Dalkia – Teplárna Olomouc	49	86
ENERGOTRANS	240	1236
Teplárna Komořany	207	222
Teplárna Trmice (uhlí)	88	94
KA Contracting - Teplárna Náchod	17	25
ENERGETIKA TŘINEC - Teplárna E3	62	227
LOVOCHEMIE	22,6	58
Teplárna ŠKO-ENERGO Mladá Boleslav	88	214
Celkem	5794,15	26996,37
Černé uhlí	MW	GWh
Elektrárna Arcelor Mittal Ostrava	254	800
Biocel Paskov	78	200
Celkem	332	1000
Zemní plyn, technické a důlní plyny	MW	GWh
ČEZ - Počerady PPC	840	1058,4
Elektrárna Kladno - Dubská	66,9	180,63
Elektrárna Kladno II	50,8	137,16
Teplárna Kyjov	23,3	62,91
Teplárna Liberec	7	18,9
Teplárna Brno - provoz Červený mlýn	95	256,5
Teplárna Brno - provoz Špitálka	80,6	217,62
ENERGETIKA TŘINEC - Teplárna E2	25	67,5
Moravskoslezské cukrovary	12	32,4
Teplárna Kaučuk - Tamero Invest Kralupy	89	240,3
Cukrovary TTD	16,5	44,55
Teplárna C-Energy Bohemia	40	108
ostatní malé zdroje (jednotkový výkon do 10MWe)	150	405
mikrokogenerace (souhrn)	606,6	1819,8

Celkem	2102,7	4649,67
Odpad	MW	GWh
Spalovna komunálních odpadů Brno	22,7	47
Zařízení na energetické využití odpadů (Praha)	17,6	37
Závod na energetické využití odpadu (Liberec)	4,5	11,25
nové zdroje (odhad)	167,4	418,5
Celkem	212,2	513,75
Olej/Nafta	MW	GWh
Teplárna Deza	22	67
Celkem	22	67
Obnovitelné zdroje	MW	GWh
bioplyn	574,001	3444,006
biomasa	725	3262,5
VE akumulační	1048,5	2516,4
VE průtočné	74,5	178,8
PVE	1147	-
slunce	3732	3732
vítr	888	1776
Celkem	8189,001	14909,706
Instalovaný výkon/výroba celkem	21030,051	79298,396

Source: ČEPS data room

Appendix 9: Net consumption for Visions and Scenarios

bez vlastní spotřeba a ztrat v traf.		vstupuje do SOAF																
Suma Nové Zdroje	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
uran	4040	4040	4040	4040	4040	4040	4040	4040	4040	4040	4040	4040	4040	4220	4400	4400	4400	4400
hard coal	1599	1390	1378	1381	1399	1199	1199	1173	745	745	745	745	745	332	332	332	332	332
brown coal	8339	8474	9845	9619	9619	9619	9179	8653	7995	7995	7525	6541	6014	5794	5794	5794	5794	5794
gas	1452	1484	1584	1632	1680	1729	1778	1826	1857	1872	1903	1921	1951	1982	2012	2042	2072	2103
oil	43	43	48	48	48	48	48	48	22	22	22	22	22	22	22	22	22	22
mix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
biomas	378	398	418	421	424	427	430	433	462	491	521	550	579	608	637	667	696	725
waste	45	45	45	72	72	72	72	72	72	87	103	119	134	150	165	181	197	212
water	2215	2215	2215	2226	2236	2247	2257	2268	2270	2270	2270	2270	2270	2270	2270	2270	2270	2270
other	397	430	464	478	492	506	520	534	538	542	546	550	554	558	562	566	570	574
VE akumulační	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049
VE průtočné	20	20	20	30	41	51	62	73	75	75	75	75	75	75	75	75	75	75
PVE	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147	1147
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomasa	398	398	418	421	424	427	430	433	462	491	521	550	579	608	637	667	696	725
FVE	2117	2217	2280	2307	2335	2363	2391	2419	2613	2808	3002	3197	3392	3642	3892	4142	4392	4643
VTE	263	309	355	395	436	476	516	556	636	717	797	877	958	1035	1112	1189	1266	1344

Source: ČEPS data room