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Bachelor's Thesis

Introduction of Capacity Mechanisms in European Energy Markets: Implications for Swiss Market Participants

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Acknowledgments

This Bachelor's Thesis has benefited greatly from comments and insights of industry experts. These insights have made it possible to establish a strong linkage of theoretical frameworks and industry practices.

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Management Summary

European energy markets experienced a transition during the start of the millennium and are now faced by new challenges. This transition resulted in increased energy production from renewable sources, market liberalisation and integration. Capacity mechanisms have been introduced or are under discussion in a majority of European countries, in order to ensure the Security of Supply. This complementary market form does however raise questions on how to apply objectives defined by the European Union's energy policy. Cross-border participation is still to be defined and coordinated into more detail.

The aim of this Bachelor's Thesis is to assess implications for Swiss market participants. Fundamental characteristics of capacity mechanisms, status-quo and cross-border participation are assessed in a first step. Concerns and questions resulting from the first part will be discussed in the subsequent chapter. The evaluation combines theoretical concepts, industry feedback and actual actions taken in order to analyse effects for Swiss market participants in a holistic manner.

It was found that Europe faces the challenges of less flexible generation capacity and experiences missing money effects. Efficient energy market should be able to create sufficient investment incentives and create a beneficial satisfying market result. However, current energy-only markets are not capable of doing so and ancillary designs (i.e. capacity mechanisms) need to be implemented.

The paper concludes that no direct threats to the Swiss market exist. However, market participants should develop an environment in which they can adapt to changes in foreign market designs. These are expected occur due to a lack of common European standards and the complexity of the market. Market developments should be monitored closely and participants are encouraged trying to influence market design choices in order to realise arising opportunities from cross-border participation.

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List of Abbreviations

	Description
ACER	Agency for the Cooperation of Energy Regulators
BMWi	Federal Ministry for Economic Affairs and Energy
DECC	Department of Energy & Climate Change
DG ENER	European Directorate-General for Energy
EC	European Commission
EDF	Électricité de France S.A.
ENTSO-E	European Network of Transmission System Operators for Electricity
ERCOT	Electric Reliability Council of Texas
ESO	Electricity Supply Ordinance
EU	European Union
IEA	International Energy Agency
IEM	Internal Electricity Market
LDA	Locational Deliverability Areas
LOLE	Loss of Load Expected
MISO	Midcontinent Independent System Operator
PJM	PJM Interconnection LLC
PLEF	Pentalateral Energy Forum
RES	Renewable Energy Sources
RPM	Reliability Pricing Model
RTE	Réseau de Transport d'Électricité
RTO	Regional Transmission Operator
SFOE	Swiss Federal Office of Energy
SoS	Security of Supply
TSO	Transmission System Operator
UK	United Kingdom
VOLL	Value of Lost Load

1. Introduction

Europe is undergoing a fundamental change in its energy markets. Markets became more integrated over the last two decades and the share of renewable energy production has increased. These changes alter the requirements for today's energy markets in order to achieve the three main objectives established in Europe's energy policy. The policy states that "energy in the European Union should […] be I) affordable and competitively priced, II) environmentally sustainable and III) secure for everybody." (European Commission [EC], 2014a, p. 2) The changes are beneficial for the first two objectives. A more integrated market allows for increased cross-border trading and results in a more economic distribution of produced energy. Increasing production from renewable energy sources (RES) will also contribute towards lower prices since production from these sources includes no or very low primary energy costs. Secondly, climate goals and therefore sustainability objectives can be achieved by this increase in RES. EC (2014a) reports that the share for this generation source amounts to 23.5% of total energy produced in the European Union (EU) and 14% of energy consumed (p. 4). Future targets are set at a share of 27% by 2030 (EC, 2014b, p.6). However, the latter objective of Europe's energy policy does not benefit from these trends under current market design.

RES enlarge potential production capacity. However, they lack flexibility because production depends on non-controllable input (e.g. wind and sun), resulting in a more volatile and less predictable output. Also, existing generators which can only operate economically during peak loads are pushed out of the market since RES reduce price and the need for those generators' capacities. Consequently, investments in new plants are reduced as well due to this effect. This poses a risk towards Security of Supply (SoS) of electricity, standing in contrast to the third objective. SoS defines the ability of a market to supply every connected user with energy to the amounts and period required (International Energy Agency [IEA], 2013a, p. 8). This balance between generation and load is of high importance to the economy since imbalances can lead to blackouts or brownouts (e.g. reduction of voltage). The costs of a blackout in Switzerland are estimated at 8-30 million Swiss Francs per minute (swissgrid, 2011, p. 5). These costs proof the importance of maintaining SoS at all times. Three fundamental requirements are defined by the IEA in order to maintain SoS:

I) Fuel security: Reliable access to fuel supplies and their efficient use ensure reliable operation of generation equipment and enhance predictability for short-term power production.

II) System security: The reliability of generation facilities and network components. This security decreases effects of unexpected shocks (e.g. rapid changes in demand) and sudden interruptions.

III) Adequacy: Adequacy describes the capability of the power system to meet present and future energy demand. Insufficient capacity will lead to black-outs and generate significant economic costs. Adequacy will be discussed in a later chapter into more detail. (IEA, 2013a, p. 8)

Current energy-only markets, which compensate generators for the produced amount of electricity, are no longer able to incentivise new investments which endangers future adequacy. Therefore, alternative solutions were assessed and, in some European countries, already implemented. The United Kingdom (UK) was amongst first European countries to do so and held a first capacity market auction in 2014 (Department of Energy & Climate Change [DECC], 2015). However, not all countries are as advanced as the UK and vary widely from country to country. Status quo of other markets range from discussion to implementation phase.

The aim of this paper is to assess the implications of different forms of capacity mechanisms and their form of cross-border participation in general and for Swiss market participants in particular. Designs of Capacity Markets are discussed in a first part. Cross-border participation in foreign Capacity Markets will therefore be examined into more detail. Not assessed by this paper are technical aspects and analysis of exact design of policies and laws. The regional focus will be placed on Switzerland and its neighbouring countries and extend to Europe as a region. Information from non-European markets is included as well in order to identify potential linking. Findings of this paper will result in recommendations and if possible an action plan for Swiss market participants. Participants include amongst others Swiss market regulator the Federal Electricity Commission (ElCom), Swiss Transmission System Operator (TSO) swissgrid, and others such as the Swiss Federal Office of Energy (SFOE) electricity producers, and swisselectric (organisation of three biggest Swiss generators Alpiq, Axpo and BKW).

The research of this paper was carried out with the use of existing literature as well as conversations with industry experts. Theoretical concepts from economy as well as finance were used to provide a basic understanding of the topic as well as to present underlying models and other market characteristics. Most of the analysed concepts were established between 1990 and 2010, these years correspond to the start of market liberalisation (1990) and the beginning of today’s challenges (2010). Industry feedback was gathered in interviews and conversations with experts. This was used as a source for assessing practical feasibility. The third group of sources consist of policies and guidelines as well as research made by industrial parties. Taking these sources into account allows the paper to draw from industry expertise and integrate latest market developments.

This paper is divided into three sections. The next section compromises the theoretical framework what elaborates on questions regarding status quo in European energy markets and presents Switzerland's current situation with regards to systematic overcapacity and cross-border capacities. Furthermore, the status quo of capacity markets in distinct regions will be discussed. A third chapter approaches open questions and problems with regard to cross-border participation in capacity markets for Swiss participants. The last chapter summarises the findings and gives a recommendation based on the research carried out.

2. Theoretical Framework

Necessary conditions of an energy-only market with optimal outcome are described first as a starting point. This chapter elaborates on the status quo of European energy markets and its problems with regard to supply adequacy. Moreover, the chapter discusses existing capacity mechanisms and their cross-border participation design. Distinct regions are discussed and their solutions presented. The last part of this chapter revises the applied research methods.

2.1. Capacity Mechanisms and Missing Money

What are capacity mechanisms? Capacity mechanisms are a method to incentivise energy producers and investors to not retire plants and invest in new projects. This is done by compensating participants for providing generation capacity for a given time period. Meaning that a generator agrees to hold his plant available to generate electricity if required. His capacity can be called for upon shocks on the supply-side (e.g. lower total production due to a lack of sun or wind) as well as demand-side (e.g. increased demand by consumers). This fee contributes towards the reduction of risks when assessing investments in new plants and creates revenue stream for plants with marginal costs above market prices. Capacities from reliable and more flexible plants can be retained in the market by applying this method, which in turn increases SoS due to the availability of these capacities. There are different types of capacity mechanisms which will be discussed in a later chapter. Also, capacity mechanisms are not a stand-alone market but are in fact complementary to energy spot markets.

De Vries (2003) suggests that "in theory, competitive energy-only electricity markets should provide an optimal level of investment in generating capacity. This optimum, however is easily disturbed […]" (p. 1). A key characteristic to energy-only markets is that prices are defined solely by the market and are not restricted to price caps or other interventions. Investment decisions should therefore be made by market participants and encourage innovation efficiency through this decentralised method (Hogan, 2005, p. 28). An efficient outcome from these markets can be achieved when the conditions such as predictability of market conditions and prices as well as perfect conditions are given. Historical excess generation capacity has reduced the need to assess effects of European electricity market liberalisation for a big part of the process which started in 1990 (Cramton & Ockenfels, 2011, p. 4). However, most European markets recognised the need to take actions ensuring capacity adequacy during the last years.

A first development triggering the need for supplementary solutions to the adequacy problem is the increase in RES. These resources offer their generated energy at very low costs due to very low costs of input. With this new source the overall supply increases and shifts prices to the right of the market's merit-order of power plants. This effect was named Meri-Order Effect by a study of Fraunhofer Institute (Senfuss, Ragwitz & Geoese, 2007, pp. 2-3). Figure 1 illustrates this effect. More generation from RES increase the supply offered at low prices. This pushes conventional power plants, such as gas turbines and pumped-storage hydroelectricity plants out of the market. However, these plants are crucial to the system's capacity adequacy since they provide the flexibility to react to shocks on the demand (e.g. unexpected increase in consumption) and supply side (e.g. outage of power plants).

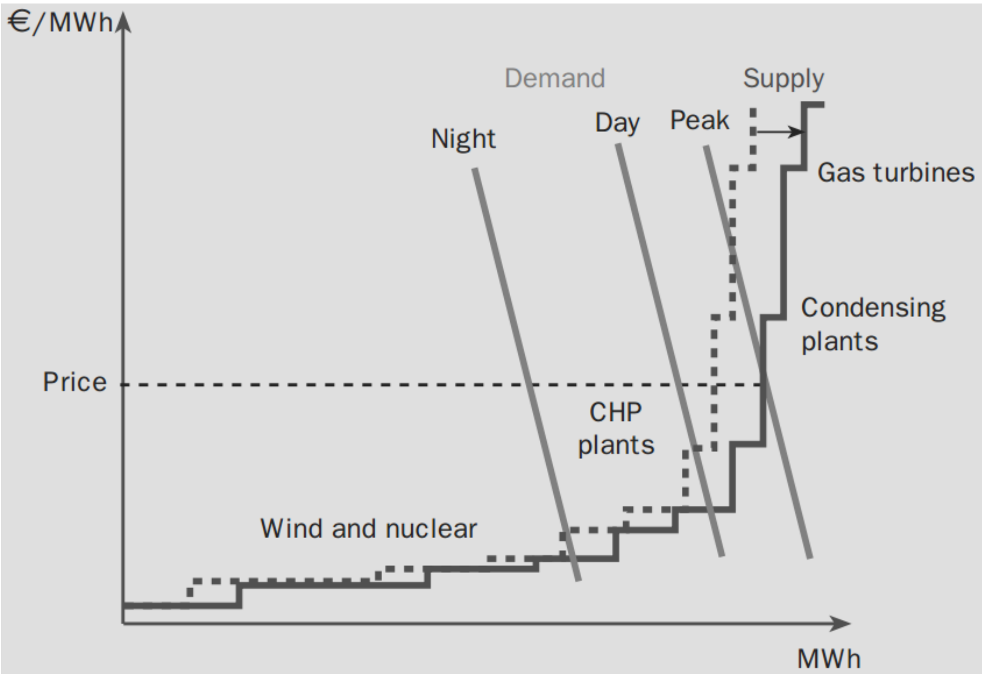

Figure 1: The Merit-Order effect on electricity market prices (Auer, Blanco, Garrad & Morthorst, 2008, p. 244)

The increase of energy production from RES comes from a more sustainable approach what resulted in the introduction of feed-in tariffs for these sources. The increase in the market share of RES also came forth from the decision of a number of countries to exit production from nuclear sources. Switzerland, Germany and Belgium have decided to discontinue this production and retire all nuclear plants by 2034. France, a country with a traditionally high share of nuclear power, aims to reduce its share of total production from 2014's level of 75% to 50% in 2025 (ElCom, 2014, S. 26). This should not influence climate objectives set by governments. However, flaws in the overall market design enable operations of suboptimal fossil plants. Low coal prices and carbon taxes favour the generation from coal fired power plants resulting in a suboptimal outcome for the environment.

Secondly, the market is undergoing the effects described as Missing Money. This problem is created by an administrative limitation of prices (e.g. price caps). Such caps limit the ability of generators to recover their fixed costs with scarcity rents. Scarcity rents describe the higher prices paid on the market due to higher demand in peak hours. The market clears at the intersection of demand and supply curve, if supply on the market is sufficient. Supply is offered at marginal production costs of power plants. The demand curve is defined by the consumers Value of Lost Load (VOLL). VOLL represents the consumers' costs for lost load. Electricity is foregone when VOLL is below marginal costs for suppliers. Certain customers are not able to alter their energy demand in real time and therefore cannot respond to market events. This demand is defined as non-responsive and is placed at the high end of the demand curve (see figure 2). Other consumers will be able to respond and, depending on their appreciation of energy availability, reduce the demanded volume (Midwest Independent System Operator [MISO], 2005, pp. 10-12).

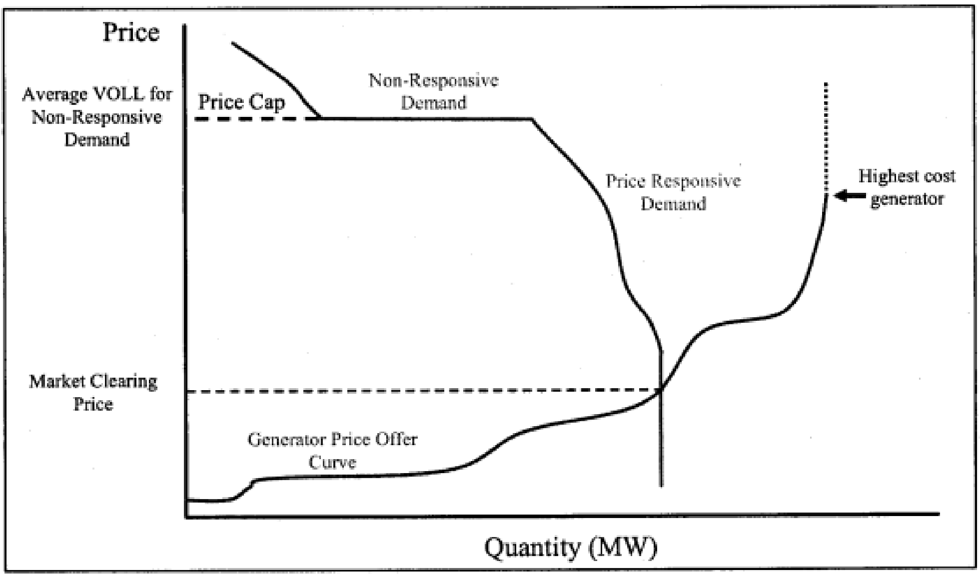

Figure 2: Market clearing in sufficient supply situation (MISO, 2005, p. 11)

However, given the influence of administrative limitations a deficit originates. This deficit is the difference between the upper limit of prices and what the market would be willing to pay. This price difference multiplied by the quantity of traded energy results in the loss of extra revenues for energy producers (i.e. Missing Money). Preventing the flow of these additional returns leads to higher risks for power plant investments and reduces overall attractiveness of peaking plants which serve the market during periods of high demand.

In order for peaking plants to operate profitable they need a certain amount of time during which prices reach a given peak level. This will allow them to recover marginal costs as well as fixed costs (Hogan, 2005, p. 3).

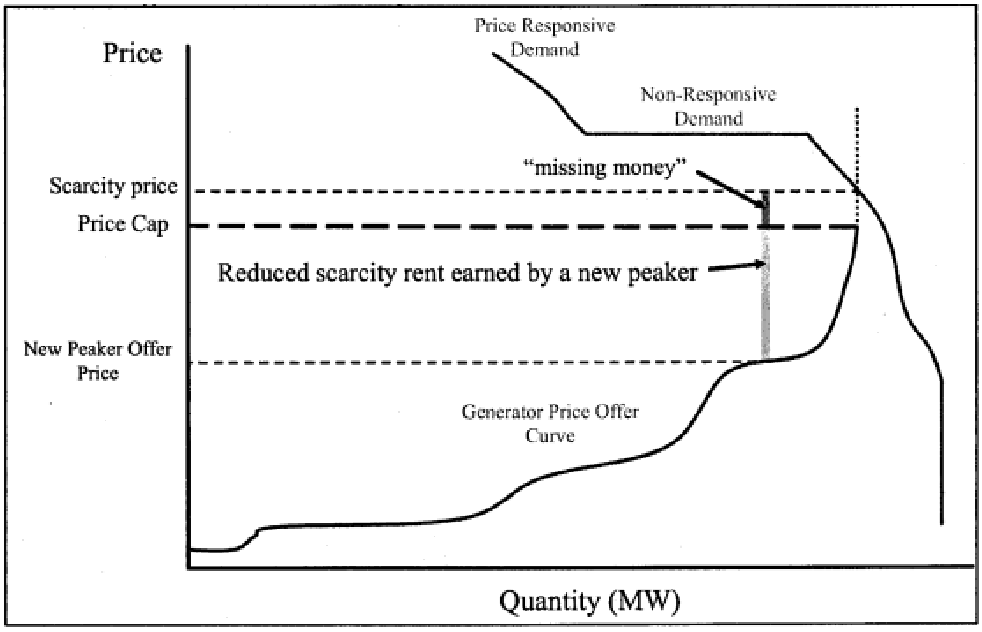

Figure 3: Illustration of Missing Money (MISO, 2005, p. 24)

However, market liberalisation and the introduction of more renewable energy plants distort the planning security for investors and reduce investments in new, reliable generation capacities. A second negative effect, coming forward from these disturbances is the retirement of plants which cannot operate profitable at current low energy prices (linklaters, 2014, p. 2).

The before described effects from current market trends imply a disturbance of optimal market outcome. De Vries (2003) recommends "[…] the market structure should be adjusted to provide more clear and stable investment signal." when optimal market outcome is not realisable (p.7). One possible adjustment to the market design is capacity mechanisms.

2.2. Conditions for an optimal outcome from energy-only markets

Key characteristic of energy-only markets is that no participant is reliable for capacity adequacy on the market. Payments triggered by the market design are expected to generate sufficient investment incentives to ensure sufficient adequacy. Five participants are required for a functioning market:

I) Generators; Energy producers supplying the market with electricity

II) Market Operator; Coordinating of the market and balancing of generation and load

III) Transmission System Operator; Responsible for network and transmission of electricity

IV) Retailers; Purchasers of electricity on the market and supply to consumers

V) Consumers; Consumers of electricity and payers for costs of electricity (HoustonKemp, 2014, p. 2)

The report by HoustonKemp (2014) also suggests following features as key elements for an efficient outcome:

I) Demand reacts to real time prices at any time. This can lead to shortages for consumers who value electricity at below-market prices.

II) Market prices are set at marginal costs of the most expensive, delivering generator. This plant will cover its marginal costs at that price. The price will not contribute towards fixed costs which are considered as sunk costs. However, plants with lower marginal costs are able to recover these costs.

III) No generator holds sufficient market power to influence prices. A lack of competition will lead to no incentives of efficiency improvements. However, groups of generators, setting higher prices due to expected shortages, should be able to have an influence on the price and create scarcity rents with this action.

IV) Generators must have the option of free market entry as well as exit. Optimal outcome is only created if inefficient generators are able to retire when they are no longer required. Also, no or very low barriers should exist for new-entrants.

V) A degree of market predictability is needed to trigger investments in capacity. Investors require recovering at least marginal costs, fixed costs and a risk-adjusted return on capital over the life of the pant. Central to this calculation are reliable, forward looking demand and supply estimates as well as a stable regulatory environment. Liquid hedging products to manage financial risks also contribute towards a reduction of inherent investment risk. (HoustonKemp, 2014, pp. 3-22)

These features theoretically allow for high price levels caused by scarcity situations. The possibility of this price movement is important to create sufficient investment incentives for generation capacity. Administrative measures to limit these movements are likely to prevent an optimal outcome and cause Missing Money as previously discussed (HoustonKemp, 2014, pp. 3-7). Also, prices should be able to find a competitive equilibrium without interferences from regulators. High price levels will cause new entries of capacity what lead to lower prices. Low price levels cause the opposite effect and should push market prices towards economic equilibrium (Jaffe & Felder, 1996, pp. 53-54).

2.3. Capacity Adequacy

"Assessments of generation adequacy are based on a judgement about future patterns of supply and demand, and the strength of the available electricity network (particularly for cross border flows)." (EC Capacity Mechanisms Working Group, 2015, p. 3) Adequacy can be quantified through I) capacity margins, volume difference between peak demand and available supply, II) Loss of Load Expectation (LOLE), duration estimate of time where demand cannot be met, and III) Expected Energy Unserved, volume/time estimate of unmet demand. Assessments will have to be based on following input:

- Expected general development of supply and demand with respect to social, economic and public policy developments.
- Projected generation capacity, accounting for exits and new entries of power plants.
- Projected demand, accounting for impacts from evolving public policy in relation to energy efficiency and smart grids.
- Expected periods of particularly high demand as a result of transient conditions (e.g. weather conditions).
- Expected generation capacity availability, influenced by:
    - Weather conditions;
    - Operation decisions (including decisions by network operators);
    - Availability of primary fuels – in particular the potential impact of gas shortages; and
    - Voluntary response of demand to market conditions or instructions by network operators (in accordance with pre-existing agreements of contracts).

      (EC Capacity Mechanisms Working Group, 2015, p. 3-4).

Capacity adequacy is central to electricity markets. This is due to the resource's unique characteristics. Electricity cannot be stored in a commercially viable way, other than pumped-storage hydroelectricity plants. Also, generation and load always need to be in continuous balance not to cause malfunctions. The short run supply function displays perfectly price inelasticity at its end since no additional capacity can be built to meet short-term demand exceeding current market capacities. And lastly, the demand function for electricity is inelastic. Non-adequate markets, incapable of offering sufficient electricity generation to meet demand, therefore lead to costly market failures (de Vries, 2003, p. 2).

Jaffe and Felder (1996) categorised capacity adequacy as a public good (pp. 53-55). This is due to the fact that "reliability of electricity service is non-excludable and non-rival […]. Because the reliability is the same for everyone on their network, consumers are not able to contract individually for a higher level of reliability." (de Vries, 2003, p. 2) This characteristic is assumed to lead to below optimum levels of available generating capacity (Jaffe & Felder, 1996, p.54-55).

Nevertheless, no capacity shortages were observed in the market so far since the 1990's beginning of market liberalisation in Europe. This is a result of transitions made during times of overcapacities, which were installed before liberalisation. An effect of this is that the market does not create incentives for new investments (IEA, 2005, p. 117-122). This corresponds with findings from Jaffe and Felder (1996). However, new capacity was added during this period. These are mainly in the form of RES which were triggered by subsidy payments (IEA, 2005, p. 122).

Responsibility for adequacy assessment varies from country to country. In Switzerland SFOE is defined by the Swiss Electricity Supply Act as responsible body for control on SoS. In particular its duties include monitoring of national capacity adequacy and infrastructure investments. SFOE is supported by swissgrid which carries out certain SFOE duties itself (e.g. adequacy assessment on both national and regional levels). Responsible for generation and load balancing during the day-ahead market are individual Bilanzgruppen. This responsibility is passed on to swissgrid which oversees the market in real time. TSO have in addition the duty to cooperate with other TSO to which's market they are connected. Other duties include maintaining an appropriate level of technical transmission reserve and ensuring network security (EC Directive 2005 89, 2006, p. 25).

A study released by the European Directorate-General for Energy ([DG ENER], 2013) assessed the need for investments in Europe to compensate for decommissioned capacity and cover peak demand. Figure 4 displays relative investment needs compared to 2010 installed generation capacity. The study assesses moderate needs in the short-run. However, significant investments are needed across Europe until 2030 to meet capacity adequacy (p. 65).

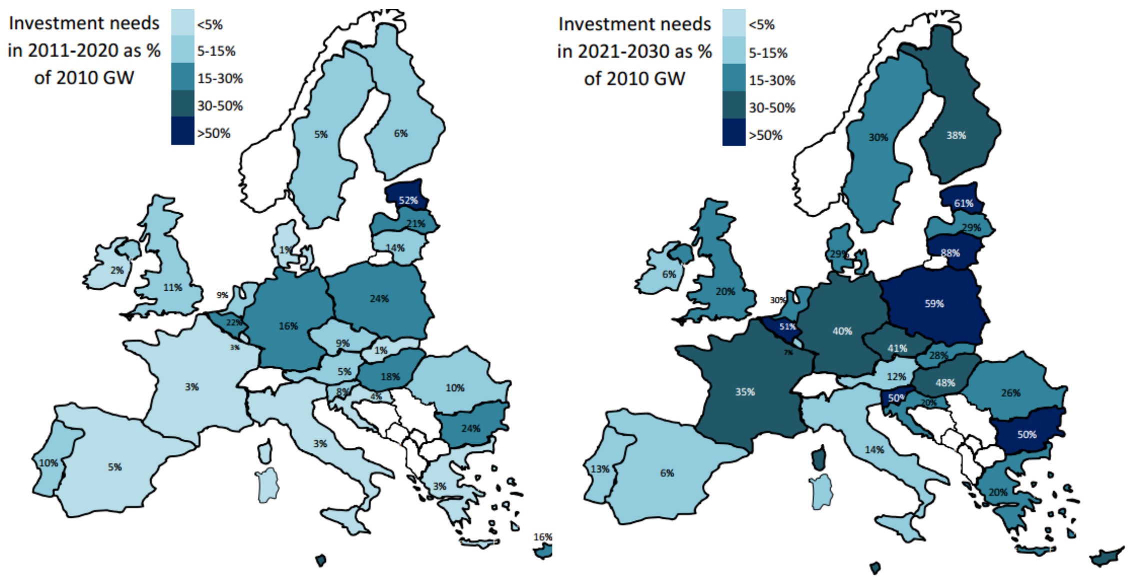

Figure 4: Relative investment needs to 2010 generation (DG ENER, 2013, p. 65)

The Pentalateral Energy Forum ([PLEF], 2015) assessed adequacy within its region (Austria, Belgium, Germany, France, the Netherlands and Switzerland) in more detail. It is based on an advanced probabilistic methodology which is more advanced than approaches used by the European Network of Transmission System Operators for Electricity (ENTSO-E) (p. 2). The study concluded that Belgium and France have to expect scarcity situations in the short-run. In the long-run (2020/21) only France is assumed to be affected. However, France's 2020/21 risk of inadequacy is lower compared to 2015/16 due to commissioning of additional capacity as well as an increase of cross-border exchange capacities (PLEF, 2015, pp. 37-45).

PLEF (2015), Eurelectric (2013) and the EC (2013) suggest broadening the geographical perspective when adequacy is assessed. National assessment should at least include cross-border capacity. Electrical infrastructure does not give systematic reasons to limit these assessments to national levels rather than regions. Where countries make use of synergies coming from cooperation with neighbour states or other network constrains exist, adequacy is increasingly assessed on a regional basis (Eurelectric, 2013, p. 10).

2.4. Adequacy in Switzerland

This subchapter elaborates on the situation in the Swiss electricity market. In Switzerland, the Electricity Supply Ordinance (ESO) defines that swissgrid, SFOE, generators and other market participants are reliable to take actions in order to guarantee secure power supply operations. Standards, recommendations and regulation from recognised organisation (e.g. ENTSO-E) should be considered in addition to mandatory standards. Also, SFOE has the right to introduce technical as well as administrative minimum standards in order to meet objectives (ESO, 2014, p. 3).

2.4.1.Structure of Swiss Energy Market

The absence of a prominent discussion on capacity mechanisms suggests a more comfortable situation for Switzerland's energy market. The market participant nevertheless faces upcoming challenges and follows discussions in other regions. The Swiss electricity market is undergoing a change and is also influenced by decisions made in the EU due to highly interconnected networks.

The Swiss Federal Council decided in May 2011 to exit nuclear energy production. Existing plants are to retire after they reach a defined life span of 50 years of operation (Swiss Federal Council, 2011, p. 3). BKW's nuclear plant in Mühleberg will be the first to shut down in 2019 (BKW, 2015). The last of five plants will reach the end of its live span in 2034 (Swiss Federal Council, 2011, p.3). Figure 5 shows their dominant position amongst Swiss portfolio of hydroelectric and nuclear power plants. The market will have to react to their absence since installed capacity amount to 17% of total market capacity (SFOE, 2015 p.18).

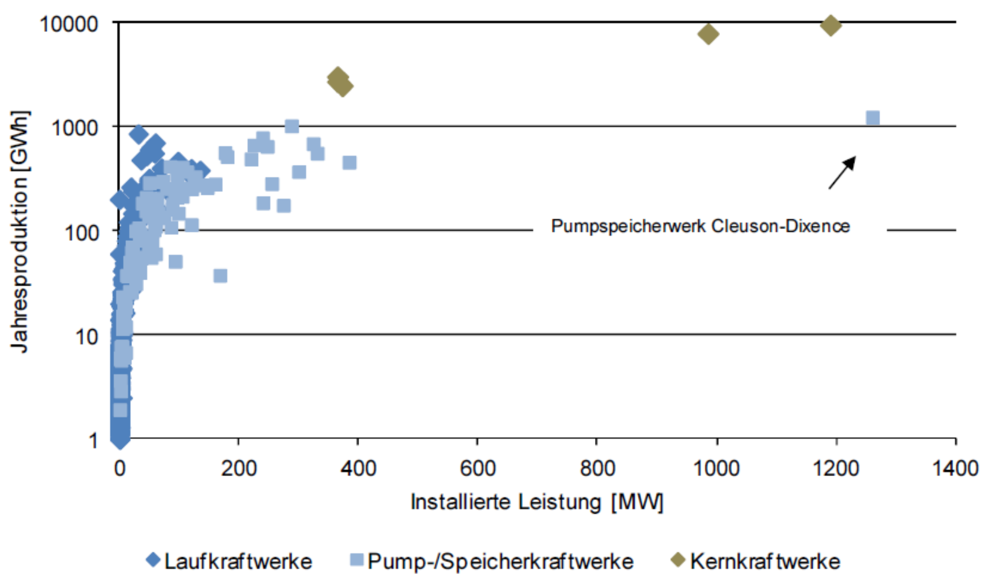

Figure 5: Effective production versus installed capacity for Swiss power plants (SFOE, 2015, p. 20)

Hydroelectric power holds a prominent role in the Swiss generation mix, with 73% of total production. Swiss electricity exports during summer and imports in winter are explained with the availability of more water in summer. Deficits in an isolated scenario, without cross-border trading, would result in 1,086 hours LOLE during winter 2020/21 due to this characteristic (PLEF, 2015, pp. 60-61). These sources provide one of the few methods by which vast volumes of energy can be stored and therefore adds to SoS. Also, hydroelectric plants are very likely to be included in the market due to no marginal costs, with the exception of pumped storage plants (PLEF, 2015, p. 50).

Nevertheless, hydroelectric plants are becoming less economical since their traditional business model is deteriorated. Especially pump-storage plants are no longer able to generate attractive returns by pumping water in basins on higher levels and produce in peak demand situations. The increase in renewable production is reducing price peaks and adds insecurity towards planning. A loss of these reliable capacity providers would pose a threat to the Swiss market security.

Total installed capacity in Switzerland usually exceeds national demand and other electricity consumption (e.g. transmission losses). Higher availability of water during summer results in more reserve capacity than during other periods. Average reserve capacity amounts to 5,000 to 5,400 MW during summer. In the winter term reserves are reduced by approximately 2,500 to 3,000 MW. Figure 6 displays reserve capacity between 2009 and 2012. These levels are, however, low compared to neighbouring countries (see Figure 7). The only country with lower balances is France. The country's negative balance in 2010 negative balance was created by record low temperatures. Significant increases in Italy's capacity reserves resulted from additional generation capacity, mainly from RES. The retirement of German nuclear plants reduced its reserves by 5,000 MW in 2011. Investments in RES resulted in a recovery of reserve levels. In fact 2012 even surpassed 2010 levels (SFOE, 2014, pp. 21-22).

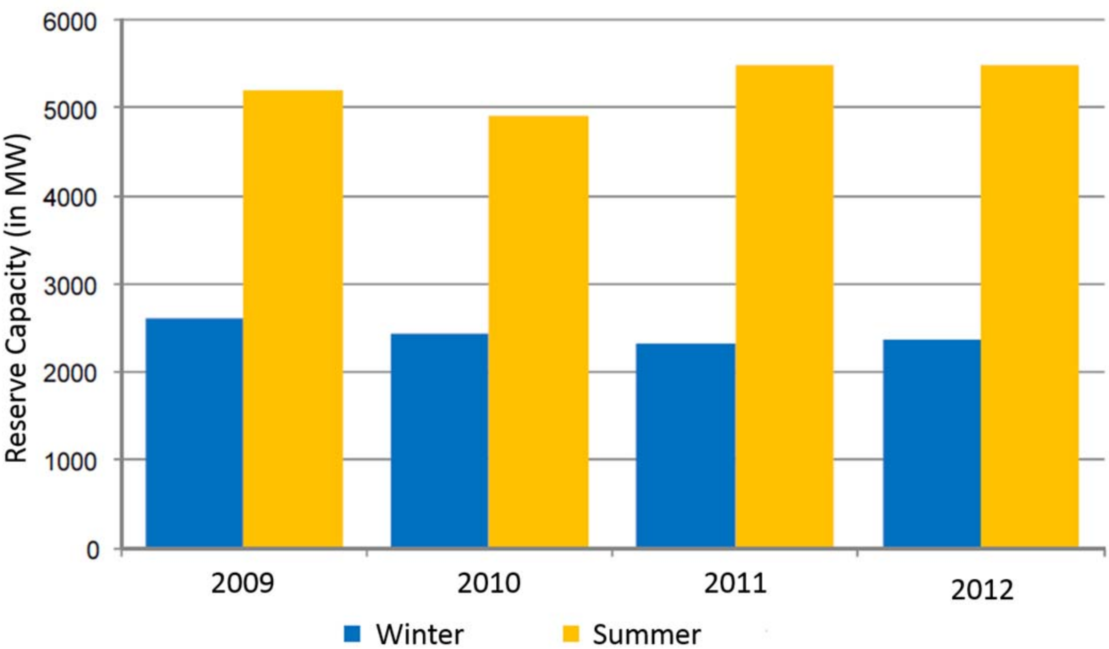

Figure 6: Capacity reserves in Switzerland (SFOE, 2014, p. 21)

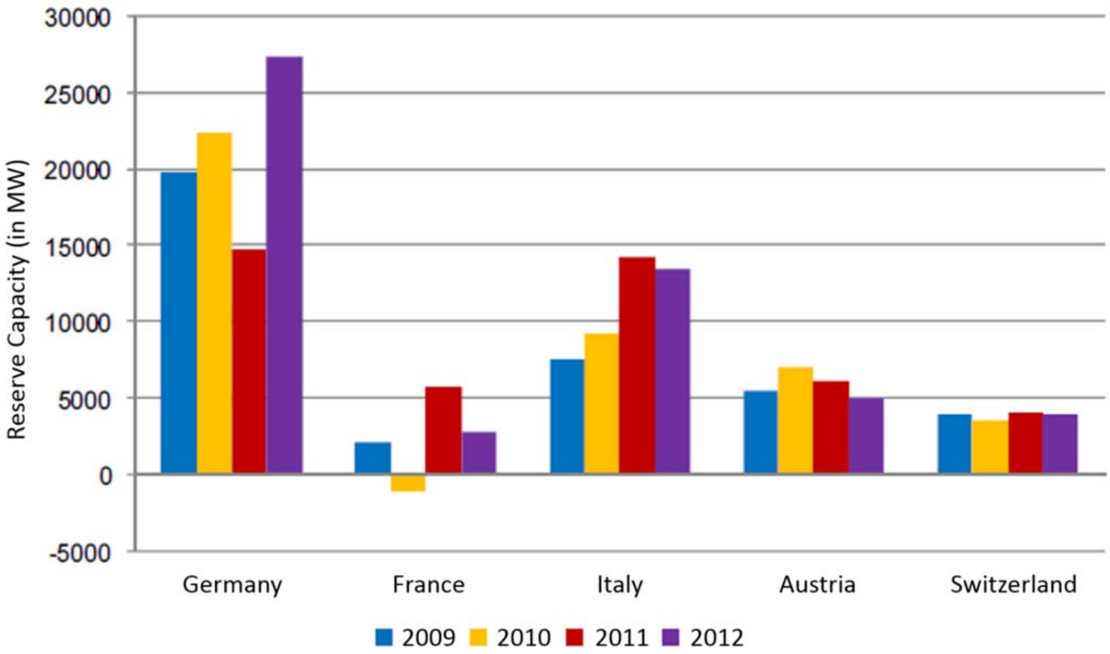

Figure 7: Capacity reserves in Switzerland and neighbouring countries (SFOE, 2014, p. 22)

2.4.2. Cross-border capacities

Switzerland is connected through 38 cross-border links with its neighbouring countries. Additional value create that Switzerland's neighbours are, with the exception of Lichtenstein, Members of the EU and therefore included in EU energy market. Cross-border trading creates a significant added value for Switzerland since flows can be optimised and thereby increase economic market outcome. Interconnectivity is of especial value to peak load generators, which represent a relatively big share of the Swiss generation-mix. More peak loads can be served through access to other countries with varying frequency of peak loads. On the other hand, sufficient base load energy can be imported to refill upper basins of hydro-electricity power plants. Volume of available cross-border capacity is limited and volatile due to constraints such as increased renewable energy production close to borders (SFOE, 2014, p. 13). Cross-border flows at Italian borders are almost always directed towards Italy, despite of high Italian capacity reserves. A reason for this one-directional flow is the addition of high amounts of capacity generators with low marginal costs. Gas fuelled plants, which represent almost two fifth of total national energy production in 2010, are due to lower price levels not dispatched. Non-dispatching of these capacities is compensated by imports of cheaper energy (e.g. Swiss hydroelectricity). This constellation provides additional security for Switzerland as sufficient capacity is available across the Italian border which could serve the Swiss market in case of extreme scarcity. The increase in interconnector capacity in both 2025 scenarios confirms that increased market integration is expected (swissgrid, 2015a, p. 62).

Net Transfer Capacity (in MW)	2013	2025	
		«On Track»	«Slow Progress»
NTC North Import			
Winter	5274	8600	7500
Summer	5074	8600	7500
NTC North Export			
Winter	6300	9740	8640
Summer	6300	9740	8640
NTC Italy Import			
Winter	1810	3110	2010
Summer	1440	2740	1640
NTC Italy Export			
Winter	4240	5540	4440
Summer	3420	4720	3620

Table 1: Net Transfer Capacity at Swiss cross-border regions (swissgrid, 2015a, p. 62)

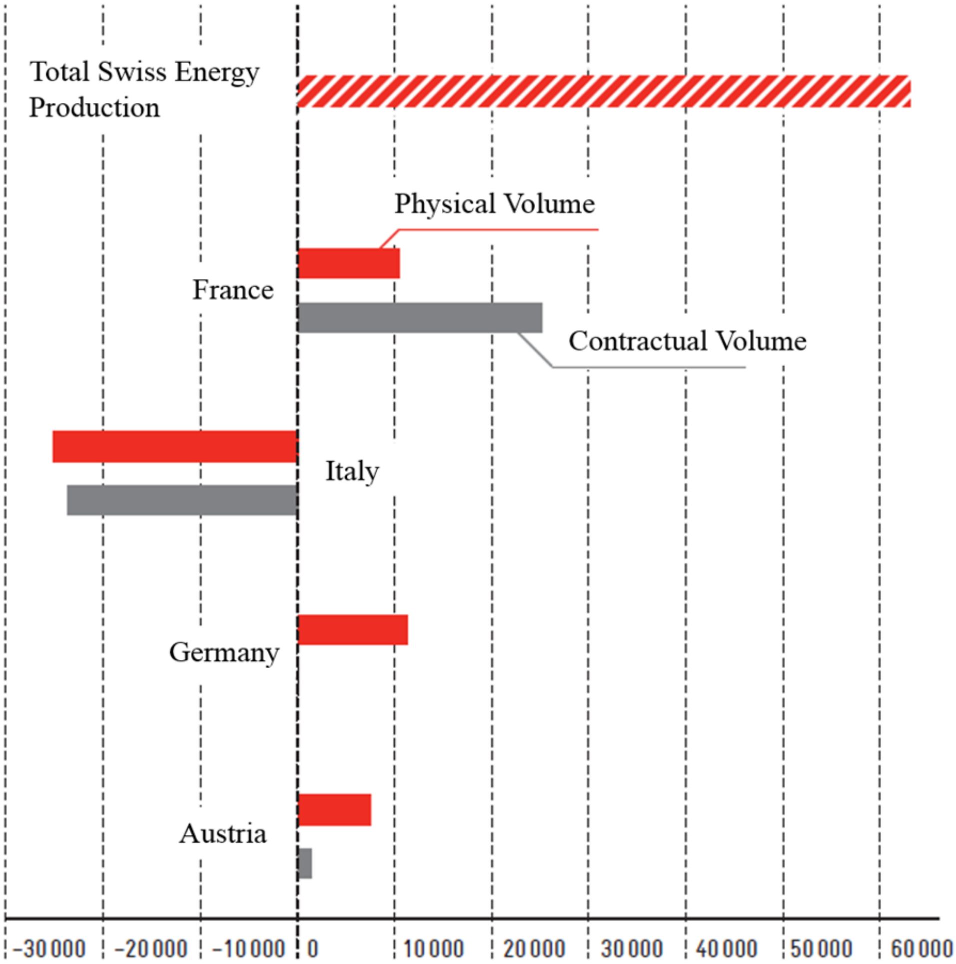

Figure 8: Daily average volume of energy exports and imports in 2011. Contractual Volume is the net position of sold cross-border obligations. Volume in GWh, negative figures represent exports (Avenir Suisse, 2013, p. 15)

2.5. Integrated Energy Market

Another key element to reach Europe's energy policy objectives is to closer interconnect national electricity markets. This one market approach is known as Internal Electricity Market (IEM). Europe's IEM composes of two mechanisms. The first is closer TSO cooperation (e.g. in stress events). The second mechanism is called market coupling. The aim of market coupling is to increase interconnectivity of European national markets, optimise cross-border transportation capacity usage (ENTSO-E, 2015, p. 2). This is achieved by the allocation of cross-border capacities in implicit auctions. Network constraints and conditions in foreign markets will therefore, at least partially, be included in spot prices. This alteration allows for a better informed pricing and more economical distribution of electricity. A large group, consisting of TSOs, collective service providers for capacity calculation, spot energy exchanges and others, will have to closely interact to achieve appropriate spot prices. A convergence of European price levels is expected as a result of these closer interlinked markets. The contrary method, explicit auctions, splits this one action into two separate steps. Generators would have to trade energy with a foreign party and simultaneously secure cross-border capacity with interconnectors to ensure delivery (swissgrid, n.d.). The process will lead to more market liquidity, increase competitiveness of price levels and enhance SoS. The process towards a fully-fledged IEM can be divided into three phases. A first phase, from 1990 until 2004, included market liberalisation, as discussed above. Liberalisation was mainly implemented at national levels. Focus of the second phase lies on increased cross-border trading through market coupling. The third period, planned to start as of 2014 includes further measures to increase market integration (booz&co, 2013, p. 64). The start of this last phase is pushed into the future due to delays in completing market coupling. Initially the deadline for IEM completion was set for 2014 and full integration of all EU Member States by 2015. This timeline however cannot be realised and completion is postponed (EC, 2014a, p. 2). Despite delays, the process has already delivered some favourable results. Prices for wholesale electricity declined by one-third between 2008 and 2012, consumers are able to choose from more energy suppliers, infrastructural links between countries have been built and cross-border trade has increased (EC, n.d.).

First market coupling took place in 2006, when France, Belgium and the Netherlands combined their markets. This trilateral agreement was extended with 15 further countries from North Western Europe in February 2014. Spain and Portugal joined the agreement in May of the same year. Market coupling is currently only implemented for day-ahead markets. Market coupling for intraday markets is not yet realised but in preparation (swissgrid, 2015b, p. 1). Discussions about participation in market coupling for the Swiss market were in advanced stages. Swiss network operator swissgrid ensured technical feasibility as of 2014. However, they were discontinued in April 2015, three months prior to becoming effective. Conflicts between the EU and Switzerland in other regulatory questions are assumed to be the reason for this unexpected shift in positions (Alder, Bühler & Fellmann, 2015).

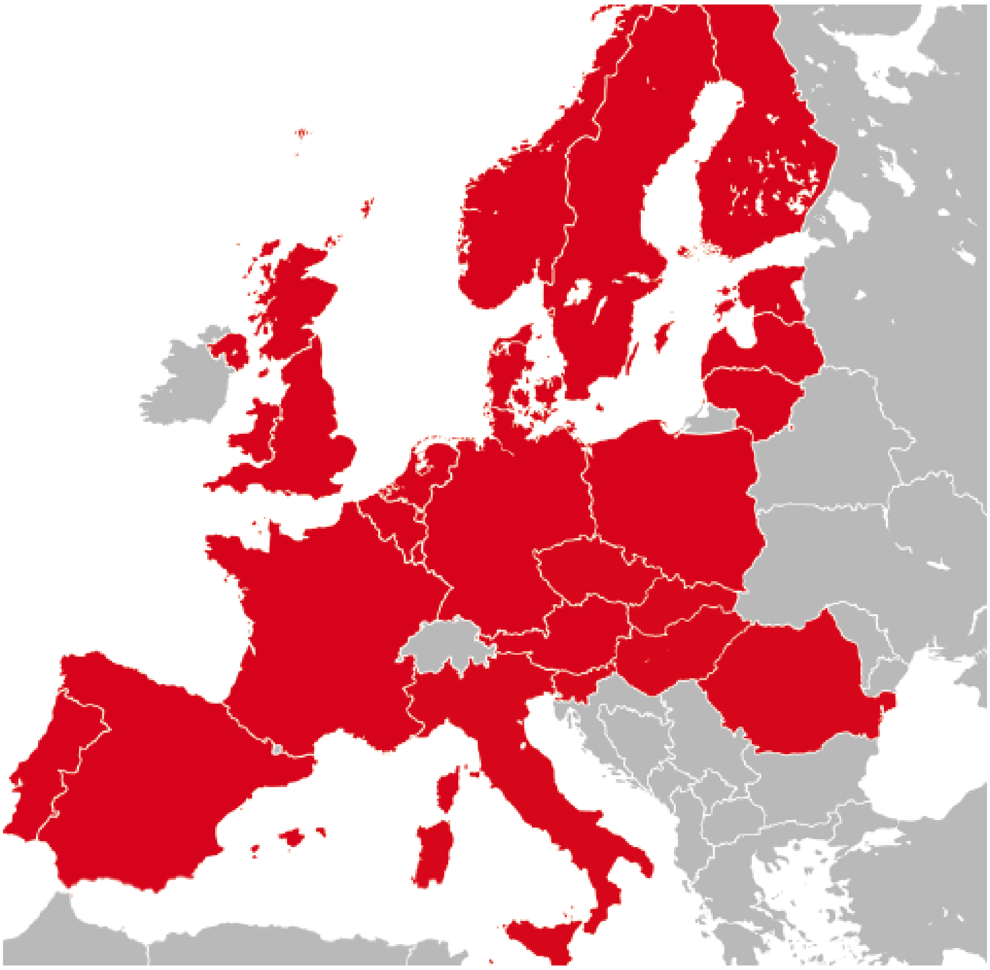

Figure 9: Current participating countries in European market coupling (swissgrid, 2015b, p. 1)

2.6. Capacity Mechanism Designs

This chapter analyses capacity mechanisms applied in some countries around the world. Prior to implementing capacity mechanisms three basic factors have to be assessed. First, necessity should be proven by a thorough analysis of the gap in capacity adequacy. This analysis ought to include cross-border capacity. Secondly, assessment of alternatives should identify the desired capacity mechanisms as most appropriate. This point is especially important since every region has its own needs and capacity mechanisms lead to different outcomes, depending on their design. Lastly, introduced actions have to be proportional to the prevalent system. Capacity mechanisms should not unduly increase system costs upon adjacent markets (DG ENER, 2013, p. 112). In general, capacity mechanisms can be grouped in three types based on their properties (e.g. focus, degree of centralisation and base for capacity determination). Different types will be discussed into more detail. Groups include:

- Capacity payments; generators receive fixed payments for being available on the market.

- Strategic reserves; authorities bind capacity to remain as a reserve to the system and not bid in the market.
- Capacity markets; capacity requirements are defined by the market and compensation by supply and demand of capacity. This group contains of three sub-types:
    - Capacity auction; the required volume of capacity is auctioned centrally several years before it is required.
    - Capacity obligation; suppliers are required to meet expected load of their customer portfolio and a predefined security margin.
    - Reliability options; owners of options receive the right to receive the difference between strike and spot price. (Linklaters, 2014, p. 9)

	Strategic Reserve	Capacity Payments	Capacity Markets		
			Capacity Auction	Capacity Obligation	Reliability Options
Price vs Volume based	Volume	Price	Volume	Volume	Volume
Centralised vs Decentralised	Centralised	Centralised	Centralised	Decentralised	Centralised
Targeted vs Market-wide	Targeted	Targeted or Market-wide	Market-wide	Market-wide	Market-wide

Table 2: Categorisation of capacity mechanisms (Linklaters, 2014, p. 9)

2.6.1. Strategic Reserve

Strategic Reserves ensure SoS by binding generation capacity to not participate in the market but to stand by and produce during stress events. Definition of stress events varies amongst countries. In general, these resources are only deployed when day ahead markets are not able to meet demand. The required capacity is set by predefinition of a certain volume by central parties (e.g. TSO). Both generation and demand response capacity can participate. Capacity has however to be firm since no additional security can be achieved (DG ENER, 2013, p. 31).

Payments are specified by individual tendering documents and vary from case to case. Costs for this form of SoS insurance are usually carried by end users. Overall impact on electricity markets depend on the rules for activation. Typically engagement is triggered by a predefined market price level. This represents a form of price cap. Other trigger events can be set with regard to physical balance in the market (DG ENER, 2013, pp. 31-32).

"Strategic reserves may incentivise early retirement of capacity (into the strategic reserve). Although strategic reserves may be very accurately targeted (type, location, duration, etc.), there is a risk that one pays for capacity and interruptible load that would even be available without the mechanisms.” (DG ENER, 2013, p. 32)

2.6.2. Capacity Payments

With this form generators receive a payment for their capacity. Payment flows can be greatly steered by the regulatory body. In general, it has to be decided whether to follow a market-wide approach or to target a certain type of generators. Targeting can refer to age of plants, type of plant (e.g. base load or peak capacity) and other characteristics. Demand side resources are typically not included (DG ENER, 2013, p. 31).

Generators receiving payments remain in the market. Price caps are frequently applied in order to avoid extreme price spikes. Drawbacks for this method include difficulty of determining effects resulting from payments, voluntary blackouts can still occur due to price spikes, and it is not clear what consumers pay for and what they get in return (DG ENER, 2013, p. 31).

2.6.3. Capacity Markets

The last group, Capacity Markets, is made of three sub-types of capacity mechanisms. These mechanisms rely on market based mechanisms to ensure an efficient outcome, mainly determined by supply and demand (DG ENER, 2013, p. 32).

2.6.3.1. Capacity Obligation

This method obliges Load Serving Entities (LSE) to ensure sufficient generation capacity for the expected volume demanded by their customer portfolio and a certain margin. Generation can be ensured by full or partial ownership of power plants or by holding capacity certificates. Requirements can be designed upon current or future load volumes. Estimation of future load volumes might pose a challenge for LSE due to more liberalised markets which allow consumers to move more freely between suppliers. This decentralised method of demand estimation can be supported from authorities by providing estimation tools and publication of common norms and rules (DG ENER, 2013, pp. 33).

Documentation of fulfilment can be standardised (e.g. with the use of capacity certificates) and assessed on a periodical basis by authorities. Markets with forward obligations can be more challenging for LSE since volumes have to be assessed several years in advance. A solution to this problem could be the tradability of standardised certificates. This enables LSE to continuously adjust their position. Generators that committed their capacity to LSE are still required to offer produced energy on the market. Negative effects resulting from Capacity Option include high volatility of capacity prices, sensitive to gamin, no locational signals (e.g.

network constrains) are included and potential complexity of the method (DG ENER, 2013, pp. 33-34).

2.6.3.2. Capacity Auctions

This form also relies on capacity certificates but is centrally organised through auctions. Main difference to Capacity Options is the degree of standardisation. The centralisation through auctions allows LSE to pass estimation of future total load to regulatory entities. Also, it enables the introduction of more standardised products and is more likely to generate additional information for market participants (e.g. clearing price, volume etc.). Auctions are organised usually at different points in time for a given starting date of capacity availability. This allows new entrants to bid and construct plants during the given lead time. The auction also enables authorities to steer the capacity able of bidding to a certain degree. Allocation of capacity however is defined by the supply structure and outcome of the auction, what ensures market efficiency (DG ENER, 2013, p. 34). Pre-requisites for the auction are of high importance since they could theoretically exclude certain generation sources. Hydroelectric plants for example could be excluded by a high requirement of delivery duration.

2.6.3.3. Reliability Option

Reliability Options are composed of a variety of centralised capacity auctions. The traded contracts differ to other forms since they are designed as one-way call options. Providers forgo price spikes by committing to a strike price and in return receive certain compensation. This process causes the implementation of a price cap (e.g. strike price plus option premium) but enhances planning quality for generators. The only penalty generator have to face is the forgoing of price spikes (DG ENER, 2013, p. 34).

Well-functioning wholesale markets as well as a market-wide system price are required for Reliability Options to function. Strike prices are set with respect to wholesale prices which therefore need to be reliant. This method contains several difficulties. Including eligibility requirements, duration of the scheme, estimation of capacity markets and others (DG ENER, 2013, pp. 34-35). Decentralised variations might contribute towards a better market outcome. This due to efficiency gains compared to centralised approaches (Pöyry, 2015, p. 7). However, the method is expected to result in optimal long term capacity mix, even if margins are set too high (DG ENER, 2013, p. 35). Also, its hybrid characteristics between physical commitment and commercial option provide SoS and adds to the solution of the Missing Money problem (Pöyry, 2015, pp. 6).

2.7. Cross-Border Participation Models

"Mechanisms to ensure generation adequacy should be open to all capacity that can effectively contribute to meeting the required generation adequacy standard, including from other Member states." (Linklaters, 2014, p. 20) This Guideline stated by the EC gives a clear direction to include cross-border participation in capacity mechanisms. A better outcome is expected in line with European IEM. Also, interconnector flows between countries without cross-border inclusion are expected to be disturbed and hinder other energy markets to reach optimal results as an effect of this. The market design imbalance could also lead to reduced investments in the market without capacity mechanisms and therefore create risks to SoS. Other limitations to fully integrated cross-border participation are posed by network congestions. Congestions prevent to reallocate unlimited capacities from one region to another. Incentives would however be generated to enable cross-border participation upon introduction of capacity mechanisms (Linklaters, 2014, pp. 20-21). Current EU legislation provides guidelines with regard to cross-border obligations. The legislation states that, even in national stress events, market operators must not discriminate between national and cross-border contracts (EC, 2006, p. 4).

The following subchapters will each analyse a distinct design aspect and discuss potential variations. Variations will be discussed in a later chapter upon their effectiveness and ability to enable cross-border participation.

2.7.1. Participants

Eurelectric (2015) identifies two potential participants who could partake in foreign markets. The two options are interconnectors, facilitating cross-border capacity, or capacity providers (pp. 15-16). A third participation model which combines interconnectors and generators emerges from a report by Elforsk (2014, p. 19).

2.7.1.1. Interconnector Participation Model

Interconnector models imply the participation of interconnector operators in capacity mechanisms. This would result in no direct participation of capacity generating parties. Drawbacks from interconnectors as market participants would be the double role for TSO owning interconnector capacities. In most cases TSOs hold the role of market facilitator and should therefore not participate in market activities. This new commercial role could result in conflicts of interest since previous activities might influence this addition and benefits from bidding behaviour and adjustments of capacity requirements could emerge (Elforsk, 2014, p. 26). Frontier Economics (2014a) defined two general types of interconnector participation (p. 38). The two types are classified by risk allocation upon non-delivery.

In a first model the interconnector is eligible to receive all rights resulting from trade in markets with capacity mechanisms but would also bear all obligations (e.g. penalty payments in case of non-delivery).

A second model advocates for risk sharing in which the interconnector remains the biding party, main risk on the other hand is shared with the market's generators. Interconnectors therefore cannot be penalised in case of non-delivery. However, they need to make their cross-border capacities available to the market. Penalties might apply if interconnectors fail to do so (Frontier Economics, 2014a, p. 46).

2.7.1.2. Generator Participation Model

Market participant in this subset are generators and load assets directly. All rights and obligations remain with the generator. This supports a more decentralised approach. Aim of this model should be that all generation capacity can participate and none is left out due to the system's complexity. Further difficulties for this model could pose the application of controls. It has to be defined how foreign authorities can control for contractual fulfilment (Elforsk, 2014, pp. 16-19).

Two approaches exits when cross-border capacity is allocated, analogous to trading in energy-only markets. The first is allocation through explicit auctions. This complicates the procedure for generators since they have to secure either capacity payments or cross-border capacity first. This risk can however be mitigated by implicit auctions. An adoption of implicit auctions would in addition also be in line with IEM objectives. However, studies suggest that this aspect is not relevant for cross-border flows since the direction will always be defined by physical short-run markets (e.g. day-ahead and intraday trading).

2.7.1.3. Combined Generator and Interconnector Participation Model

This third model is based upon two simultaneous auctions. An auction for foreign capacity mechanisms and a second for interconnector capacity. Distortions resulting from individual capacity mechanisms should reduce by separating these auctions. Capacity limit should be defined upon the interconnector's limits. Interconnectors receive payments as long as prices for capacity mechanisms exceed the price paid for interconnector capacity. This facilitates a splitting of the capacity payment between capacity generators and interconnectors (Elforsk, 2014, pp. 19-20).

2.7.2. Product

Another important decision to facilitate cross-border trading has to be made with respect of the traded product. The product traded cross-border can be designed as physical delivery or availability (Eurelectric, 2015, pp. 16-17).

Capacity providers are reliable to ensure delivery of energy to the foreign market when physical delivery is traded. What means that, in order to fulfil the contractual duties, the seller has to direct interconnector flows towards the foreign country, regardless of movements in other electricity markets. This action is likely to distort energy markets by forcing delivery of energy that could otherwise be out of the merit order. Cross-border flows should always be defined by movements on markets other than capacity mechanisms. This is more likely to result in an economic market outcome since flows are driven by market prices (Eurelectricity, 2015, p. 17). ENTSO-E (2015) supports this position by stating that market coupling will ensure most efficient flow of electricity. Markets outcomes will direct energy flows to market zones with scarcities due to this mechanism. Furthermore, reservation of interconnector capacity, what would be required with physical delivery, will not result in additional guarantees on the firmness of cross-border contribution to SoS. On the contrary, reserving capacity would force interconnectors to hold certain volume of capacity at hand. This reduces the maximum potential of energy transmitted cross-border through market coupling effects. ENTSO-E does therefore not recommend implementing products which require capacity reservations (p. 9).

The sold good can also be designed as availability. Here, capacity providers are only obliged to hold their generation capacities available in stress events. They are, in contrast to the first option, not reliable for the direction of cross-border flows. No reservation of interconnector capacity is therefore required. A challenge for this design is the implementation of sufficient control mechanisms to verify effective availability of capacity providers. Benefits resulting from this design overweigh and would make the question of cross-border capacity allocation redundant, as previously mentioned (Eurelectricity, 2015, pp. 17)

2.7.3. Double Counting

Double counting stands for the ability of an individual capacity provider to participate in more than one capacity mechanism. ENTSO-E (2015) suggests that double biding raises efficiency and fairness issues and recommends assessing consequences into more detail (p. 9). Positive results can be expected from double counting under certain conditions. These include no or negative correlation of seasonal peak loads and others which avoid commitments to overlap. This might however be challenging to implement and control (ENTSO-E, 2015, p. 9).

2.7.4. Conclusion

Four possible cross-border participation models can be identified when looking at participant and product characteristics (see figure 10). The assessment from previous chapters indicates more favourable outcomes from designs in which availability is sold. Its main advantage over physical delivery is the absence of reservation needs of interconnector capacities. On the axis of participants multiple solutions could create a viable result. However, Eurelectric expects inefficiencies resulting from a participation of interconnectors. Eurelectric (2015) therefore prefer the design with capacity providers as participant and capacity availability as traded product (p. 9).

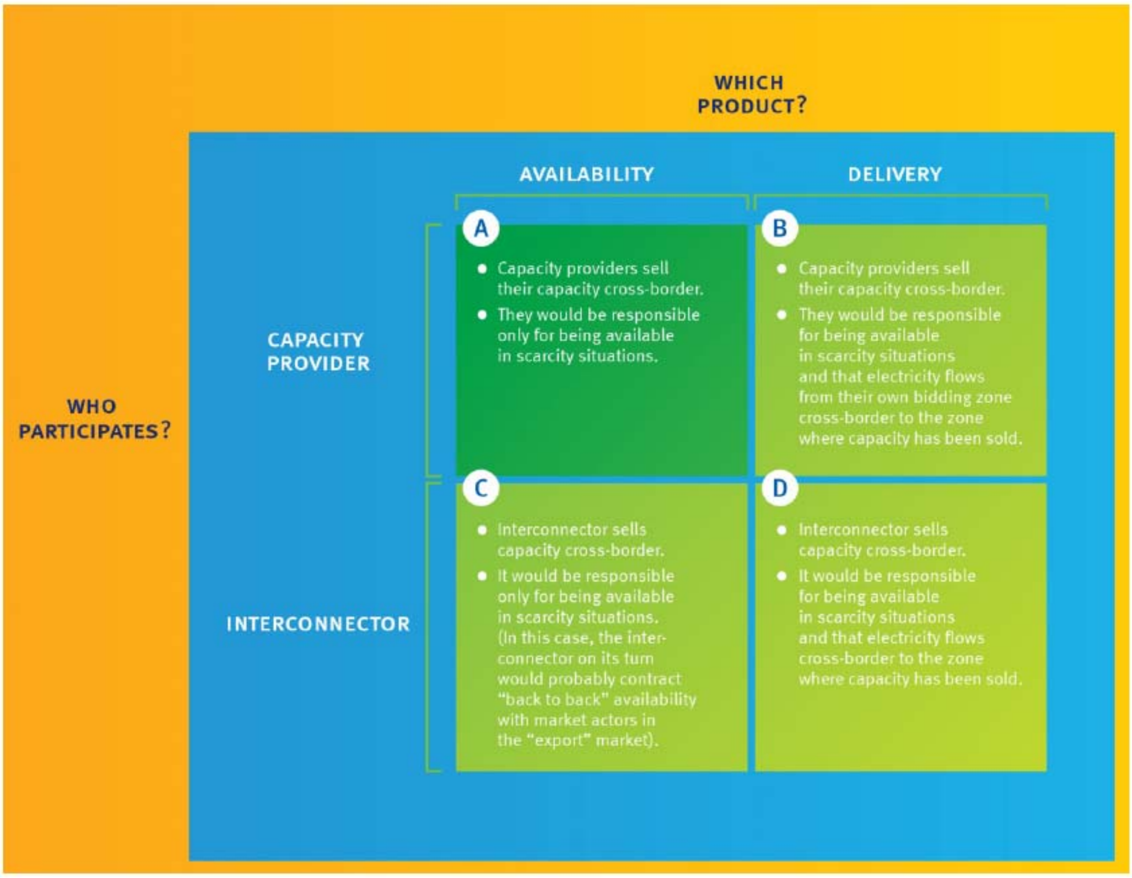

Figure 10: Combinations of possible cross-border participation designs (Eurelectric, 2015, p. 17)

2.8. Existing mechanisms per region

Although capacity mechanisms are relatively new to today's European electricity markets other regions made use of these mechanisms since already some years. Operation of these mechanisms is not in every case successful and some markets frequently changed their model in order to find an optimal solution to their situation. Western Australia, being isolated from the other national markets, introduced capacity mechanisms almost a decade ago. But future power needs were assessed too high, due to miscalculation or too cautious assessments, and end users had to pay for the additional costs. Current discussions might even lead back to energy-only market approaches (Schlandt, 2014). Status quo for markets in other regions reach across all phases (e.g. from "no-discussions" over "in-operation" to "exit"). It can be stated that stand alone markets (e.g. Western Australia) are able to assess impacts of capacity mechanisms more exact and are able to implement mechanisms with more easily than countries in highly interconnected regions with multiple neighbouring countries and supranational policies to comply to (e.g. Germany, France or other European Member states).

Another difference amongst regions is the choice of capacity mechanisms as well as design of cross-border participation. The design choice can be explained with the varying needs from country to country. Most countries are in unique situations due to network constraints and historical investment activities. Optimal solutions for these countries require, as previously described, individual solutions. Also, degree and design of cross-border participation varies across countries and regions due to the markets' characteristic. Reasons include the geographical absence of other markets (e.g. Western Australia), insufficient experience to facilitate participation (e.g. first capacity auction in the UK) and others.

The aim of this chapter is to assess status quo of individual markets. Focus of the assessment lies on cross-border participation design as well as a geographical focus on European markets.

2.8.1. North America

Most prominent market which implemented capacity mechanisms in the United States is the Regional Transmission Organisation PJM Interconnection LLC (PJM). PJM operates the electricity wholesale market across 13 states in the North Eastern part of the United States. 61 million people are connected to PJM's grid (PJM, 2015). This chapter focuses also on the Texan Electric Reliability Council of Texas (ERCOT) since that market makes use of another form, namely reliability options.

First capacity mechanisms were introduced to PJM in 1999, at the same time when authorities opened the market for competition. Transactions were made on a bilateral basis and traded capacity in the form of capacity obligations (Bowring, 2013, p. 47). The market design did not however address revenue sources to cover investment cost and thus did not address endogenous sustainability of the market design. Overcapacities which resulted from new investments were reduced by load growth and retirement of existing capacity, due to a correction of expectation towards more pessimism. This situation lead to a new market design replacing the previous Capacity Credits Model, the Reliability Pricing Model (RPM), which was implemented in 2007 (Bowring, 2013, p. 50).

RPM is designed as capacity options, an improved version of the earlier approach. The lead time to settlement date amounts to three years. The market is divided into 23 Locational Deliverability Areas (LDA) which each holds an own auction (Süssenbacher, Schwaiger & Stigler, 2010, pp. 1-5). This zonal organisation enables the application of nodal prices. Benefits from nodal pricing are an efficiency gain since prices can be set upon regional situation. Therefore prices also account for network congestions and transmission losses (booz&co, 2013, p. 12). The organisation through LDA allows prices to account for transmission congestions and directs investments in new capacity to the respective location with capacity needs. Eligible for participation are four types of capacity, I) generation capacity, II) demand response, III) efficiency enhancements, and IV) network constructions improving network congestions (Süssenbacher, Schwaiger & Stigler, 2010, pp. 1-5). Breaches of contractual obligations are penalised by fines and are triggered in several pre-defined situations (Süssenbacher, Schwaiger & Stigler, 2010, p. 11).

Based upon the market's geographical location no cross-border participation can take place. However, capacities from neighbouring markets are able to participate in the capacity mechanism. Physical transmission rights, used by interconnectors, enable generators to proof delivery when dispatched. Effective interconnector flow remains a result of total bids and no actual delivery can be guaranteed. Participating generators are required to bid into energy market every hour to proof their availability. Volume of total cross-market participation is limited by the derated capacity of the respective interconnector (Frontier Economics, 2014a, pp.15-16).

2.8.2. Europe

Energy markets in Europe assess the need for capacity mechanisms differently from county to county, despite approaches to integration and harmonisation of markets. Differences mainly occur due to the country's individual needs resulting from their current situation. Table 3 provides an overview of market features, main issues and objectives for the big five countries in Europe. Varying previous market designs, differences in network infrastructure and other market properties have led to this environment. Progress in market integration, in the context of IEM, resulted in more efficient operations of short-term markets (e.g. day-ahead and intraday). However, market coupling is not directed towards increased cross-border participation in capacity mechanisms. This and a lack of clear set of regulations and policies have enabled countries to adopt mechanisms which focus on their needs and mainly ignored cross-border participation (Linklaters, 2014, p.8).

	France	Germany	UK	Spain	Italy
Local market features	Electrical heating Highly temperature-dependant consumption	Nuclear phase-out High renewable energy sources (RES) development Grid constraints	Ageing coal and nuclear power plants Limited interconnection High RES growth	Demand decrease High RES development Limited interconnection Quasi-obligatory pool	Internal zones and grid constraints Historically, capacity deficit High RES growth Central despatch
Key issues	Very high peak demand (+25% in 10 years) 'Missing money' for peak plants Low profitability for new CCGT	Nuclear replacement Need for flexibility Low profitability for thermal plants Capacity needs in the south	Strong impact of Large Combustion Plant Directive (LCPD) and Industrial Emissions Directive (IED) Major investments needed in the coming years	Overcapacity and low profitability for CCGT Need generation back-up due to RES penetration	Limited coordination of generation and network investment Need for flexibility
Main objectives	Adequacy Not strengthening market power Development of DSR	Keep capacity and deliver investment in the south Ensure availability of back-up generation	Adequacy New investment and avoiding shut-downs Development of DSR	Limit price spikes/price volatility Incentivise availability and flexibility Avoid massive shutdowns	Adequacy Competition

Table 3: Market assessment for the big five European countries (Linklaters, 2014, p. 8)

EC has published guidelines on public interventions in energy markets in 2013. The guidance states that public interventions have to comply with requirements set in the European Electricity Directive. These require such obligations to be clearly defined, transparent, non-discriminatory (e.g. non-discrimination of generation technology and location), verifiable and guarantee equality of access (EC, 2014c, p. 3). Furthermore, capacity mechanisms must not distort trade and facilitate cross border participation (cf. inclusion of interconnectors in UK's 2015 capacity auction and plans to allow for cross-border participation in French capacity market). Certain designs of capacity mechanisms might represent barriers of trade and reduce the efficiency of IEM. Trigger events should, for efficiency reasons, be defined by market price. The European Council therefore recommends considering the following points first:

I) Analysis of the cause for inadequate national generation

II) Actions to remove such obstructions should be assessed and implemented

III) The market design should ensure that renewable electricity producers react to market signals and market operators should promote flexibility on the demand side (e.g. by adjustment of tariffs) what would reduce adequacy problems

IV) Capacity mechanism solutions should consider a regional, European view, instead of an only national approach (EC, 2013a)

2.8.2.1. United Kingdom

The UK, with the exception of Northern Ireland, was the first European country to lately adopt capacity mechanisms. Capacity mechanisms are designed as capacity auctions. Design proposals by the DECC (2013) to UK Parliament outlined possible configuration of design details. It states that two auctions for the same period should be held with lead times of 4 years, and 1 year respectively. Eligible for participation are all existing and new technologies (e.g. application of technologic neutrality) as well as demand side response. Assessment of prequalification will be carried out by the UK system operator. Other roles which are assigned to the system operator include administering of auctions and issuing capacity agreements. He also receive the capability to introduce zonal actions to account for network constraints, this decision has to be approved by UK's Office of Gas and Electricity Markets. Furthermore, participants will be able to adjust their position through secondary market (DECC, 2013, pp. 7-8). Providers with capacity obligations will be able to sell it to non-obliged providers. Trading will commence one year prior to delivery (DECC, 2013, p. 29). The design proposal also outlines that capacity mechanisms have been designed to enable exit from the mechanism when necessary. An exit may be considered when energy-only markets are able to ensure SoS by itself. Regular reviews of market need for capacity mechanisms will be conducted every five years (DECC, 2013, pp. 7-9).

The first auction traded generation capacity during winter 2018/19. Accordingly, a second supplementary auction for this time period will be held one year prior to delivery. The first four-year-ahead auction was held in December 2014 resulted in an auctioning of 49.3 GW at a price of GBP 19.40/kW, which is one third lower than market expectation. Contract duration for existing capacity varied between one to three years, duration for new entrants are limited at up to 15 years. 2.8 GW were allocated towards new capacity to be build. Interconnectors, on the other hand, were not allowed to participate (DECC, 2015). However, the UK has committed to accepted interconnector bids for the second four-year-ahead auction, which will be held this year (EC, 2014).

> DECC (2013) base this decision on the expectation that "interconnected capacity would increase efficiency by increasing competition in the auction, and provide appropriate incentives for additional investments in interconnection. Any solution must […] be compatible with European IEM rules since completion of the single market in energy is an important Government priority." (p. 23)

Frontier Economics (2014b) assessed possible scenarios for cross-border participation. The report concludes that interconnector capacity should be derated to reflect expected physical availability as well as likelihood of coincident stress (e.g. higher correlation of stress events lead to higher derating). Availability is recommended as traded product in order to reduce risks for foreign market participants. Responsibility for correct cross-border flows (e.g. imports) during stress events therefore remains with UK short-term electricity market. The report however does not favour a certain participant since slight changes in criteria will deliver different results. Nevertheless, the interconnector option is simpler to implement since it results in fewer bidding participants and eliminates the need for control mechanisms over foreign power plants compared to generator models. Frontier Economics (2014b) state the European trend towards generator models and its switching costs at a later state as a negative factor. Furthermore, implicit auctions are regarded as more efficient and equitable. This recommendation is in line with IEM principles (Frontier Economics, 2014b, pp. 7-10).

In its report DECC (2013) considers interconnected capacity to participate when two conditions apply. First, penalties for non-delivery during stress events must be consistent with penalties on UK capacity. Secondly, interconnectors have to provide a certain level of security that physical flows will be directed towards UK markets. (p. 23). This would imply physical delivery as traded product and raises questions on how to assure these flows across border. The proposal accounts for this and states that negotiations will only be held with interconnectors which are prepared to face exposure to capacity market penalties. However, further assessment of this aspect is already carried out or is planned (DECC, 2013, p. 23). This problematic will be discussed later in this paper into more detail.

Capacity market participants will be notified by the system operator at least 4 hours before an anticipated stress event. A lack of this warning will result in non-punishment of contract breaches. Otherwise penalty payments are set at respective VOLL with a cap at a multiple of costs for new entry per energy unit. Providers' obligation follows the load (i.e. occurrence of a stress event when demand is at 70% obliges participants to deliver 70% of committed capacity). Generators that produce more than the agreed volume will be compensated by the inverse of applicable penalty payment.

2.8.2.2. France

Main challenge in French energy markets is highly temperature sensitive electricity consumption. Demand varies strongly during the year due to high demand in winter caused by electrical heating. This and the rarity of cold days lead to an insufficient utilisation of peak plants. Also, peak demand is expected to grow by 25% by 2024 what challenges capacity adequacy. Adequacy for French markets is given if LOLE does not exceed 3 hours. Additional challenges to the market will arise from increasing volumes of fed-in energy produced by RES. France addresses these upcoming challenges with the introduction of capacity certificate scheme, based on capacity obligation designs (Réseau de Transport d'Électricité [RTE], 2014, pp. 25-26). Capacity certificates are designed with four years of lead time and duration of one year (e.g. capacity requirement equals yearly consumption). The design will result in zero or very low costs for certificates in periods of over overcapacity. Hence, a reduction of available capacity on the market will result in increasing prices. Planning risks for LSE can be reduced by enabling rebalancing through bilateral or organised trading. Figure 11 displays a potential timeline for certificate trading. This option allows LSE to adjust their position until a given transfer deadline. No fees are charged for position rebalancing prior to delivery period. Rebalancing during the period will be charged with a, over the time, increasing fee. Prices are expected to increase closer to the deadline. This however does not always have to be true since an adjustment due to lower than expected levels would free certificates. Decreasing prices would imply an overall reduction of demand which is not expected in France's case (RTE, 2014, pp. 144-145). These circumstances decrease the probability for LSE to generate additional revenues through price changes. LSE underestimating their capacity needs would profit from lower prices since capacity can be bought at lower prices. However, lower prices are not expected when capacity needs are underestimated. Higher prices could benefit LSE which overestimated their needs. Triggers for overestimating needs is lower than planned demand by customers what implies lower revenues and reduction of overall return. The inability to generate additional returns from simple trading of certificates would be desired circumstances for such schemes since their aim is to promote investments in capacity. It is however open if this reciprocation will ensue in real market environments.

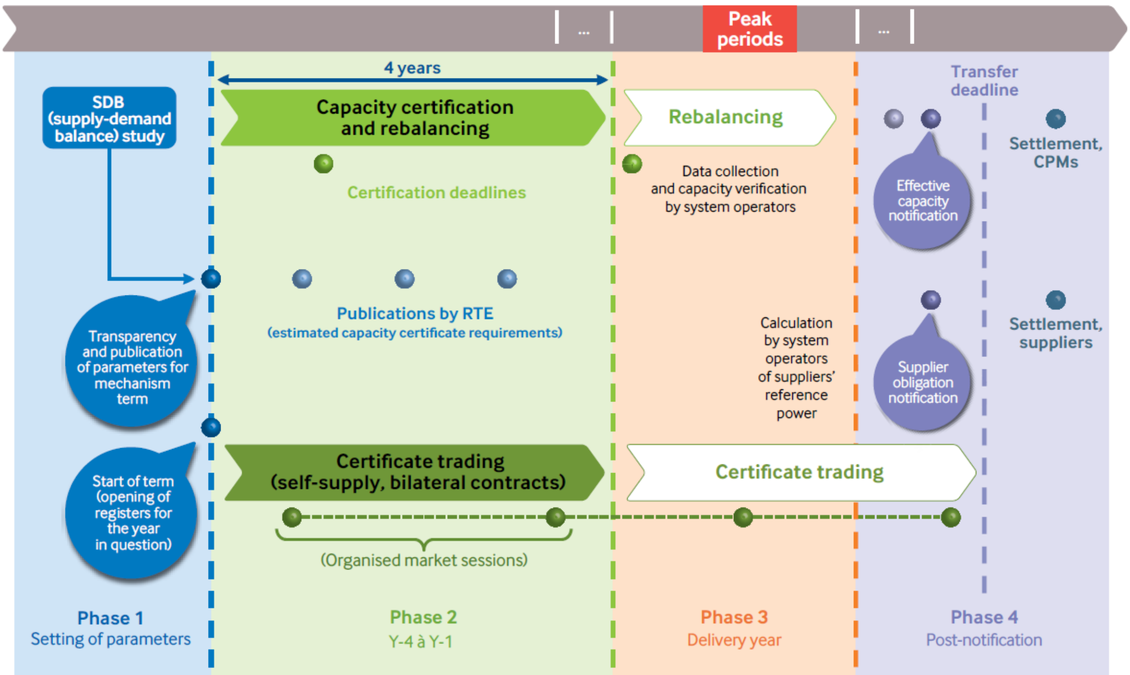

Figure 11: Timeline for French capacity certificate scheme (RTE, 2014, p. 68)

The decentralised approach enables authorities to hold market participants (i.e. consumers and suppliers) directly reliable for a beneficial market outcome. Consumers will face the decision to acquire sufficient certificates or reduce demand within their portfolios during peak periods. LSE are liable for any negative or positive imbalances between the level of coverage and actual needs (RTE, 2014, pp. 56). Penalties for these differences are calculated and charged ex post, what corresponds to phase 4 of figure 11.

France also recognises the need for cross-border integration. Firstly, it would result in a more competitive market. This is especially true for France due to the dominant power structure of Electricite de France (EDF) which holds 79.4% of total French electricity generation capacity

(RTE, 2014, pp. 169). Secondly, cross-border trading is essential to France's SoS. And lastly, market operators want to support further integration of European markets. Current cross-border participation takes place on an implicit basis. Capacities from interconnectors are taken into account when calculating capacity requirements. Capacities are derated based on their reliance, analogous to the applied method in the UK. A change towards explicit participation is planned in the long-run. Several obstacles prevented implementation of an explicit participation model. RTE (2014) list following obstacles and uncertainties for explicit participation:

- Certification and control of foreign capacities;
- Participation of demand-side capacities from countries where their integration in the market is not as developed as in France;
- Equivalence of the commitments of foreign and French capacities;
- Settlement of imbalances for foreign capacities;
- Selection of foreign capacities participating in the French capacity market;
- Guarantees on the individual contribution of cross border capacities participating in the French capacity market to SoS in France;
- Limited interconnection capacities require dedicated cross border capacity calculation and allocation processes;
- Scope of cross border participation, from selected countries to any interconnected country;
- Involvement of relevant foreign TSOs;
- Involvement of relevant foreign public authorities in charge of SoS;
- Consistency in capacity mechanisms participations and avoidance of double counting.

2.8.2.3. Italy

Italy introduced strategic reserves in 2004. This action was taken as a result of a blackout in September 2003. Interruption of a Swiss/Italian interconnector caused a domino effect and ever more cross-border electricity lines to be disconnected. Lack of imports caused Italy a deficit of nearly 6,650 MW and a frequency drop throughout the network. The consequent blackout cost an estimated USD 139 million (IEA, 2013b, p. 87).

Currently Italy is facing adequacy issues despite high volumes of generation capacity from gas fired power plants and a significant growth in renewable energy plans. Low price levels do not allow for economic operation and therefore result in retirements of these gas fired plants. This process would undermine Italy's long-term SoS (Linklaters, 2014, pp. 2-5). Italian regulators approved a proposal for capacity mechanisms in 2013. The proposed products are reliability options. The options would be set up with a lead time of four years and contract duration of three years. Implementation of these mechanisms would allow gas fired plants to bridge the period with oversupplies and be at hand when the situation inverts. Division of the market into three zones allow for inclusion of network constraints into local auctions (Terna, 2015). Cross-border participation is not yet explicitly defined. Italian TSO, Terna, has however the possibility to negotiate participation on a bilateral basis (Italian Regulatory Authority for Electricity Gas and Water, 2013, p. 10).

2.8.2.4. Germany

Germany already makes use of capacity mechanisms to certain extend with its Winterhilfe scheme. Capacity requirements are assessed by the Federal Network Agency on an annual basis and required additional capacity needs are communicated to plant operators. Details of participation are agreed upon in bilateral negotiations between plant operators and respective TSO. German generators which participate in the market are excluded from other market activities in return they receive a payment for holding the capacity at hand. Participation is also open to generators from other markets (i.e. Switzerland). Differences in contract design exist depending on the provider's location. Little information and data is available on contractual details since they are closed on a private basis (Linklaters, 2014, p. 29).

Discussions on complementary capacity mechanisms are currently held. A Weissbuch outlining views of the Federal Ministry for Economic Affairs and Energy (BMWi) and a possible timeline is expected to be published at the end of May 2015. Two movements, which belong to the triggers of these discussions, can be observed in the German market which are also present in other European Markets. First, nuclear power plants which amount to a total generation of approximately 12 GW will have to exit the market by 2022 as a consequence of the Fukushima accident. And secondly, an inflow of new capacity from RES, mainly wind and solar production. The replacement of flexible capacity with less flexible could cause scarcity events. These events are likely to be more extreme during winter when production from RES is lower (Avenir Suisse, 2013, p. 30). Also, Germany's electricity network contains several bottlenecks what is critical due to a deficit of production in the south of the country (Linklaters, 2014, p. 8).

BMWi (2014) states that flexibility is a possible method to address the prevailing issues. Forms of flexibility include supply- and demand-side, storage as well as efficient networks. Also, it is expected that competition amongst different forms of flexibility will increase welfare. This since clear and informed (i.e. reflect volume and volatility at other markets amongst other factors) price signals reduce costs (p. 18).

> Several studies have projected adequacy problems in the mid-term in Germany and have proposed various capacity mechanisms as a remedy. Other more recent studies have suggested on the contrary that an energy-only market design could overcome potential threats to SoS in the power market.
> (DNV GL, 2014, p. 11)

Key question for German market authorities and other stakeholders is whether to rely on an improved energy-only market or introduce additional capacity mechanisms. Choosing to improve existing energy-only market design would imply that decision takers rely on the market to deliver sufficient investment incentives to ensure SoS. This option would require the market to provide for all requirements necessary to achieve an optimal outcome for energy-only markets, what includes allowing for high price spikes. For the other option, capacity mechanisms, three market designs are more likely to be adopted. The design options are targeted as well as market-wide capacity auctions and capacity options (BMWi, 2014, pp. 39-43). Cross-border participation is likely to be allowed for regardless of which option is being adapted. This since cross-border trade, and therefore increased competition, is recognised as beneficial and desired by German. The country already collaborates closely with its neighbouring in several aspects, including a project to realise a common concept to ensure SoS across regions (BMWi, 2014, p. 50).

A joint statement on the German Grünbuch was published in February 2015 by Swiss market authority, swissgrid, swisselectric and other market participants drafted. This statement is the first in its kind and shows the importance of a future design of German markets for Switzerland. In brief, the authors state that adaption of national market design will have regional effects and therefore should aim to include EU member states as well as non-member states. Furthermore, improvement of energy-only markets and allowing prices to adjust to regional specification should be the preferred solution in their view (SFOE, 2015, pp. 1-5).

A conclusion of the public consultation following the Grünbuch is expected to be published ate the end of Mai. This Weissbuch will give further guidance on how challenges of Germany's electricity markets will be addressed and what further timeline is to be expected.

2.8.2.5. Switzerland

The Swiss electricity market is also undergoing changes, as described earlier. However, the country's needs differ greatly from most other markets. Capacity adequacy is given for near future and would be able to meet current demand, even without nuclear plants (see figure 12). Not fully covered is the estimated demand for 2030 by today's generation capacities (excl. nuclear plants). This gap shows the need for replacement of discontinued nuclear generation capacities. Investment incentives should however be given, based on a historic perspective. Also, replacing capacity should receive similar compensation to the one for replaced capacity since market structures does not change.

However, the country faces other problems. Operation of hydroelectric storage plants is no longer economically viable due smoothening of price spikes and other factors, as discussed earlier. Also these plants cannot provide continuous energy production since reservoirs have to be refilled after dispatch. This makes the market more dependent on cross-border trading.

Absence of this ancillary source of energy could pose a threat to Swiss SoS. However, current and near term market conditions do not imply endangering effects for the Swiss market. Therefore no need for capacity mechanisms is given which is triggered by the market itself. A need for such a design could nevertheless be triggered when foreign market situations change and cause adverse effects for Switzerland (Avenir Suisse, 2013, p. 47-48).

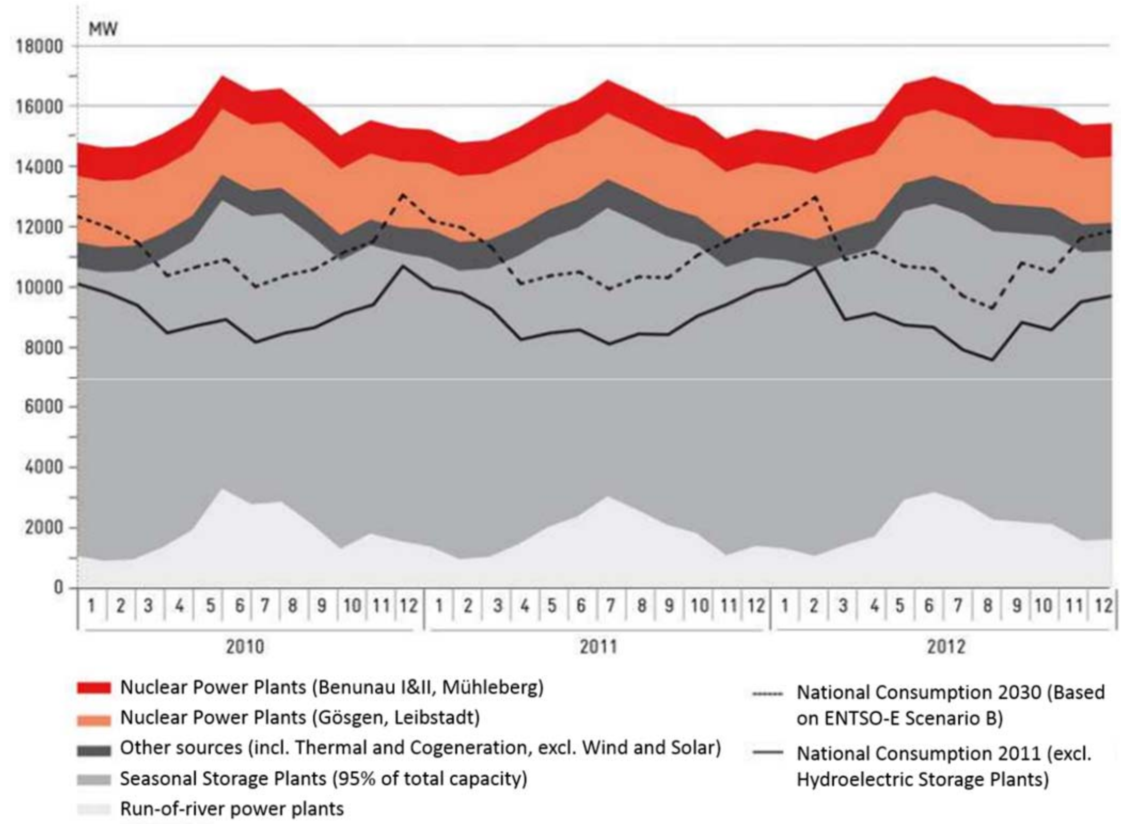

Figure 12: Swiss installed electricity generation capacity, by source, in comparison to national consumption (Avenir Suisse, 2013, p. 48)

2.8.2.6. Others

Aside from the mentioned markets, other countries also adopted capacity mechanisms (see figure 13). Applied designs are strategic reserves (in Finland and Sweden) as well as capacity payments (Portugal, Spain, Ireland and Greece).

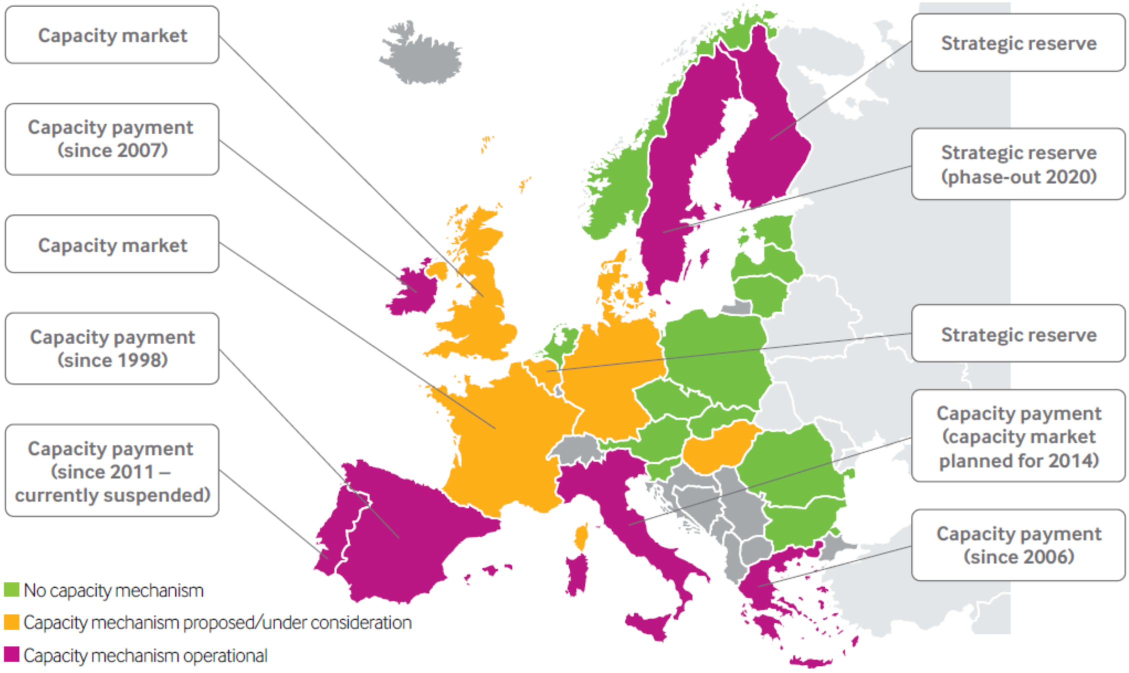

Figure 13 Status quo of capacity markets in Europe (Agency for the Cooperation of Energy Regulators [ACER], 2013, p. 8)

Nordic countries rely heavily on hydroelectricity and need to ensure sufficient available capacity during dry years. Sweden's strategic reserve plan is operated by the Swedish TSO and is aimed at providing sufficient capacity for winter peak demand. Capacities are tendered annually and binds capacity for one year (Linklaters, 2014, p. 30). Plants which committed their capacities to reserve mechanisms are allowed to sell energy on the market during normal market situations (DG ENER, 2013, p. 40). The market currently has to reassess its needs and corresponding alternative approaches since the existing plan is due to be phased out in 2020 (Linklaters, 2014, p. 30).

The energy market in Spain introduced capacity payments in 1996 during market liberalisation. Trigger for the introduction was mainly due to existence of a price cap. Spain experienced a significant growth of renewable energy plants over the last years, as most of Europe. Existing capacity payment scheme was altered in 2007 towards an availability approach as a result thereof (DG ENER, 2013, p. 39). Opposing to other markets Spain expects decreasing demand levels and, due to its geographical situation, is connected to only few interconnections. The market is in need for additional reliable capacity to secure generation in situation of low renewable electricity production. Existing plants which could fulfil this function are, however, are non-economic due to low price levels and high price volatility (Linklaters, 2014, p. 8). Linklaters (2014) states that in Spain, "no proper capacity mechanisms are in place, but there are incentive mechanisms" (p. 29). These incentives result from government payments towards investors in new capacity as well as remunerations to existing plants, based on the level of availability and installed capacity. Recipients are determined by the respective ministry.

Value of payments is determined by Spanish TSO, REE (Linklaters, 2014, p. 29). Portugal adopted an identical capacity system in 2010 (DG ENER, 2013, p. 39).

2.9. Methodology

The research question of this paper will be explored by assessing and interpreting the information of this chapter. Due to the practical focus of this paper a critical, practically relevant but still scientific evaluation is undertaken. Various concerns and questions will be discussed and partially tested against industry feedback. The evaluation combines theoretical concepts, industry views and actual actions taken in order to assess these aspects in a holistic manner. Practical limitations to theoretical concepts will be described and theoretical optimisation potential for industry practised will be pointed out.

Theoretical concepts which are referred to originate from the general study fields of economy as well as finance and have no particular time limitation. Detailed information is drawn from reports of energy economists and date approximately between 1990 and 2010. This timeframe represents the beginning of market liberalisation and ends at the origins of today’s challenges.

Industry feedback was gathered in interviews and conversations with experts. This constitutes a critical source for assessing practical feasibility. However, the feedback does not reflect overall industry thinking since only certain market participants are respected. Nevertheless, input from these conversations is of highly valuable to this report. Information was whenever possible confirmed by other sources.

Information on actual actions was gathered from various sources. Prominent groups of publishers are government agencies, TSO and international associations. These sources provided information on current developments and are mainly issued between 2008 and 2015. Inclusion of these sources allows the paper to draw from industry expertise and integrate latest market developments.

The following chapter attempts to answer most prominent questions with the theoretical framework established in this chapter. A first part addresses questions and potential conflicts of capacity mechanisms with regard to cross-border aspects. Findings will be discussed and recommendations are formulated for Swiss market participants in a second part. This paper will be concluded by a fourth chapter which gives an overview of conducted research and summarises findings of the Bachelor’s Thesis.

3. Results

As established, most countries recognise the need for increased cross-border integration in national capacity mechanisms. This is mainly due to expected improvement of market outcome due to higher competition. Integration is desired by the EU in particular since realisation of fully integrated markets are expected to mitigate existing as well as upcoming challenges. Other parties, such as Switzerland as a non-member country, also assume being able to benefit from participation in foreign capacity mechanisms. Nevertheless, a number of questions have to be clarified and solutions are required for problems hindering full integration of cross-border capacities is. This chapter addresses key challenges and questions. The second part discusses situation for Swiss market participants as well as potential future developments.

3.1. Findings

The conducted research in this paper has proven that cross-border participation depends on numerous aspects. A result of this complexity are numerous open issues which have to be addressed based on theoretical knowledge as well as practical experience. Issues which are discussed in this subchapter result from the conducted research and are divided into challenges and questions. The division is made based on expected amount of effort which has to be undertaken to solve the respective issue.

ENTS-E (2015) suggests that complexities of cross-border integration in capacity mechanisms and allowance for functioning IEM require coordination of solutions for regions as a whole. In Europe various policy makers and other stakeholders have relevant competence, legitimate interests or experience varying effects on their functioning. A consistent approach is needed to facilitate and coordinate a consistent approach to cross-border interactions in capacity mechanisms. More clarity could for example be achieved by more consistency in the governance framework for SoS. This would also address defining parameters for several questions (i.e. steering of interconnector’s energy flows). A lack of coordination will most likely result in suboptimal market outcome (pp. 5-6).

3.1.1. Challenges

This group contains issues which are critical to successful extension of market interconnection. Some of the described issues outline limitations of theoretical approaches and possible corrections.

3.1.1.1. Traded Product

Two options exist when the traded product has to be defined. One is availability of capacities and physical delivery on the other hand. Literature describes physical delivery as a viable product practise, however, indicate likely distortion of other markets such as IEM. This is mainly because this method requires the participating party to deliver the committed capacity. Regardless of other circumstances such as spot market prices (ENTSO-E, 2015, p. 8).

Feedback from industry experts confirms possibility of this negative effect. Their opinion is that energy flows across borders should always be determined by current market prices. Determination of electricity flow direction through prices is not incompatible with physical delivery of capacity obligations. However, interconnector capacities, of the same volume as capacity obligations, would have to be set aside for eventual delivery in scarcity situations. Market coupling, which bases its price calculations on available interconnector capacities, would receive information of reduced capacities at a border and therefore reduce traded volume. This is, in this situation, wrong since interconnector capacities taken out of the market due to capacity mechanism duties might not even be used. Another effect resulting from reduced cross-border trading is the likelihood that energy plants are activated which would, under full utilisation of cross-border capacities, be situated out of the market. This reduces overall market outcome.

Designs of cross-border participation should therefore thoroughly assess effects of physical delivery before implementation. It is likely that the assessment will determine capacity availability as preferred product due to the above reasoning. A market which prefers and provides necessary structure for physical delivery is US PJM market. Generators located outside of the market have the possibility to acquire physical transmission rights with the respective interconnector. This enables them to proof PJM's market operator that they possess a commercial path do deliver electricity. However, this does not guarantee flows into PJM market since overall flow is determined by the net position of cross-border flows. European's high level of interconnectivity and market coupling in particular, does not allow for this option since generators are not able to document effective delivery (Frontier Economics, 2014b, pp. 15-16).

3.1.1.2. Harmonisation

The Lisbon Treaty provides EU Member States with the right to determine general structures of its energy markets. It therefore left final responsibility for national markets (e.g. ensuring SoS) with the countries itself. Market design choices therefore allow accounting for the country's unique situation. On this basis multiple countries developed individual capacity mechanisms which are not fully compatible with each other. This in its turn is again an opposed direction as to the European IEM where integration is key and should be promoted (RTE, 2014, p. 207). ENTSO-E (2014) would favour an approach to align capacity mechanisms and allow for a certain set of basic guidelines to allow for higher integration and to limit potential market distortions (p. 4).

Further harmonisation is also recommended in the context of adequacy assessments. "ENTSO-E and its member TSOs are actively developing the tools and techniques to address and add more transparency to concerns […].” (ENTSO-E, 2014, p. 4) This enables European-wide long-term network development plans, including a European generation adequacy outlook. A pre-stage of this target are adequacy studies conducted by PLEF for its five member states. Neighbouring countries are also included and assessed with a less detailed method since the PLEF region depends on cross-border trading. Not accounting for these capacities would falsify estimates. European-wide coordination and common guidelines of assessment would therefore allow accounting more reliably on cross-border flows. Further improvements can be realised from elimination of estimation differences which emerge from differences in designs of assessment models.

3.1.1.3. Simultaneous Stress Events and Double Biding

Increasing harmonisation and coordination will lead to a convergence of market characteristics. These might also include alignment of stress events. Simultaneous stress events would involve that cross-border capacities can be used towards only one market. However, individual market characteristics can also lead independent or negatively correlated stress events. Non-correlated conditions might emerge between markets which implemented capacity mechanisms for different purposes (i.e. Italy for flexibility and France for capacity reasons) or where seasonal peaks differ between the markets. These conditions are beneficial since capacities can be used to serve more markets (double bidding). Effects of enabling double biding have to be assessed for each case individually (ENTSO-E, 2015, p. 9).

ENTSO-E (2015) also states that during simultaneous stress events market signals might be insufficient to provide a clear guidance for electricity flows. Clear guidelines and policies on defining factors were established or are drafted to avoid conflicts in these scenarios (p. 6). One key aspect is that markets may not reduce or even fully close cross-border flows to avoid outflows from exports to markets with higher prices. In practise, these flows are defined by individual price levels.

As an example; an ecosystem of two countries, A and B, have similar markets and stress events tend to occur simultaneously. Market prices are determined by VOLL, penalty payments in capacity mechanisms do not depend on respective national VOLL, no network constraints exist and interconnector capacity is unlimited. National generation capacities in both countries exceed regular demand but amount to below respective peak demand. Effects on respective national electricity price from stress events are not assessed.

Situation I (non-simultaneous stress events): Non-simultaneous occurrence of stress events would cause the country to import the deficit of peak load and national generation. This is possible since the other market experiences regular demand and has therefor available generation capacities. Also, double biding in capacity mechanisms of both countries is possible since it is expected that stress events do not occur at the same point in time.

Situation II (simultaneous stress events, availability): In this case total capacity is below total demand. Simultaneous stress events therefore cause some demand not to be served, usually the portion with lowest VOLL. The flow between the countries is therefore defined by respective market price levels. The country with higher price levels will consequently import from the lower-price country. This causes the demand with lowest VOLL to forgo electricity consumption. Double bidding is in this case not beneficial since generator's obligations to deliver energy are triggered for both markets. The plant is however only able to generate sufficient to serve only one obligation to the full extend and therefore faces penalty payments for the non-served contract. Economic theory suggests that the generator will opt to fulfil commitments in the market with higher penalties and accept the penalty payment in the not-served market. There is however no change in energy forgoing party since the generator's obligation is availability and will bid its generated energy in the market. Cross-border flows remain based on price levels.

A third scenario is added to illustrate effects of product decision (see 2.7.2. for more information on traded products).

Situation III (simultaneous stress events, physical delivery): This last scenario conditions are similar to Situation II, with the exception that the traded product in capacity mechanisms is physical delivery. This change in product could lead to a distortion of overall market outcome. Physical delivery forces the committed generator to effectively deliver electricity to the respective market. Penalty payments therefore determine to which country the electricity is delivered. The energy forgoing party, in this situation, is defined by the new determinant of cross-border flows which are penalty levels. Because penalty payments are independent of VOLL it is possible that not the party with lowest VOLL have to forgo energy delivery.

Energy flows will be directed towards Country B, under assumption of higher penalty payments compared to A. The forgoing party is therefore consumers with lowest VOLL in country A. This direction flow will remain even if country A's lowest VOLL exceeds lowest VOLL in B. This exhibits the situation in which not the party with lowest VOLL in the ecosystem, consisting of countries A and B, will be forgone but the party with lowest VOLL in the market with lower penalty payments. The welfare loss amounts to the volume of energy which is directed to the country with lower VOLL multiplied by the difference of VOLL.

3.1.2.Questions

The second subgroup contains open questions which seem to be less complex to address or are not crucial to implementation of cross-border participation. Only a selection of questions on cross-border participation for Swiss market participants will be discussed.

3.1.2.1. Information Adequacy

The complexity of cross-border participation in capacity mechanisms can be observed by looking at historical approaches as well as theoretical and practical research findings. Varying needs from country to country hinder the implementation of a one-market design for all countries. This requires customised solutions to facilitate for cross-border participation. ENTSO-E (2015) states that despite this need for individual solutions a coordinated approach should be aspired. Capacity mechanisms should therefore promote clear and transparent market operation in order to allow for regional coordination. Also, market participants should make sufficient information available to identify opportunities and threads as well as assess consequences. This paper uses the term information adequacy to describe this level of required information. Information adequacy will be assessed for control of contract fulfilment and other aspects.

France controls actual availability of committed capacity in three ways. Data from generators which are regularly dispatched is compared to actual market data. Generators which do not regularly partake in the market are obliged to place multiple bids during the delivery period at prices outside the merit order. Availability which cannot be verified by these methods is evaluated through individual audits. “RTE is focused on proposing control procedures that allow for an efficient verification of the effective availability of capacities and their contributions to reducing the shortfall risk, are extensions of existing systems, as this minimises costs.” (RTE, 2014, pp. 149-150) This standardised approach allows French market operators to efficiently and effectively assess availability of generating capacity. Questions arise when foreign generators have to be assessed. Other methods or assessment through other entities would have to be introduced. Direct controls of physical delivery is possible in PJM market not however in the European environment where this approach would distort optimal market outcome. Therefore a method to assess foreign participants is likely to result in cooperation with foreign market authorities or respective TSO (ENTSO-E, 2015, p. 5). Implementation of such control mechanisms could benefit from general standards in the market. Guidelines for a regional approach would facilitate negotiations and provide certain minimum standards for contractual fulfilment control mechanisms.

A second area where information adequacy is of importance is the assessment of overall market situation. Market operators and TSO should always be aware of present and future obligations of market participants. An up to date market regulator will also be able to detect participant which do not act in accordance with policies and guidelines. Possible transgressions to be detected also include undue double biding. Effective access to information would also lead to a better informed market. This in its turn would address doubts that during simultaneous stress events market signals could be insufficient to provide a clear guidance for electricity flows. Another opportunity, arising from information adequacy, is the ability to closely monitor participant's market behaviour what could be used for an internationally accessible database. Combined with ancillary information such a database could foster confidence in foreign parties and increase overall market transparency.

A further theoretical possibility to introduce appropriate information adequacy is by establishing a Regional Transmission Operator (RTO). This entity would possess similar duties and rights to TSO is however responsible for Europe as a region and therefore superior to TSO. Processes, policy developments and market control could be carried out by such an entity. This would also be similar to PJM where one market is created for 13 states and its 61 million consumers (PJM, n.d.). A European RTO is however theoretical and is not likely to be realised in the near future as industry experts indicate. EU member states as well as non-member states would have to find common grounds on which such cooperation can be build. Clear delimitations for national law have to be defined and decision making has to stand isolated from other interests (e.g. Swiss migration laws in the context of Europe). Views change depending on the relative position of the person whereas the regulatory side is more in favour of such an approach than producers.

3.1.2.2. Definition of Maximum Participation

Regional standards across Europe to define maximum volume of possible cross-border participation should be developed in order to allow for efficient auctions. Common measures will also ensure non-discrimination of generator upon their geographic location. UK applies derating to adjust interconnector capacities to their reliability to deliver energy into UK markets during stress events. Amount of derating is based upon expected physical availability and correlation of stress events. The later results in higher derating when markets' stress events tend to occur under same conditions or during same points in time (Frontier Economics, 2014b, p. 6).

Another possible delimitation would be national overcapacity deducted by a given generation reserve. This is basically the sum of installed generation capacity deducted by national consumption, transfer losses as well as a given capacity margin to ensure SoS.

Inputs from market participants have pointed out that the limiting factor should determine overall volume eligible to receive capacity mechanism contract. This approach would mean that participation is limited to the lower of the two values from interconnector capacity and national overcapacity.

The more economic option would be to limit participation to maximum, derated interconnector capacity. The other option of limiting participation to national overcapacity would represent an administrative intervention. It also implies that capacity adequacy might be realised by reducing exports which is the contrary of progressive market designs. These state that cross-border trading should be allowed for and steered by market price signals. Therefore it can be concluded that limitation of participation is preferably based on derated interconnector capacity.

3.1.2.3. Other challenges

Common ground for discussions on key aspects of a potential target capacity mechanism has to be found. Alignment in basic design characteristic will allow countries to prepare for future developments which might tend to a one-market approach, analogous to IEM. The questions concerning cross-border participation are amongst the most crucial. Market views vary concerning traded product as well as participant. Product design is most likely to cause no or limited market distortion is the trading of availability as outlined in chapter 2.7.2. and situation III of chapter 3.1.1.3. An ideal participant can however not be identified unequivocally. Research suggests that Generator models are likely to result in lowest distortions due to direct participation power producers. A drawback of this model could be increased bureaucracy and amount of market participants. Participants will be reduced when interconnector models are applied and thereby facilitate operations. No study was heretofore able to prove a clear preference in participant. Lack of clarity in this aspect prevent from defining a holistic target model for capacity mechanisms. Also, national mind sets have to be put aside and allow the market to determine optimal outcome. Regional coordination would suffer when governments would be able to overrule market results and define energy flows themselves.

Lacking experiences with capacity mechanisms in today’s European energy markets pose a challenge on responsible parties which work on capacity market integration. Europe’s unique characteristics do not allow for comparison with existing markets such as PJM and require a try and error approach to work towards an optimal design. The process of realising high levels of interconnection in capacity mechanisms will therefore not be concluded in the short-run. Effects on the exporting market due to cross-border participation in capacity mechanisms should be monitored closely. The industry however does not expect participation to result in decreasing SoS. It might even result in increasing national capacities since functioning capacity markets will incentivise investments in new capacities where it is most lucrative.

3.2. Discussion

As discussed, the introduction of individual capacity mechanisms combined with the absence of a one-fits-all solution make it difficult to find common grounds on which international participation can be agreed upon (Frontier Economics, 2014, pp.150-151). These circumstances require market participants to engage in bilateral discussions to find interim solutions which bridge the time until a coordinated approach is implemented. Switzerland has vast experience with negotiating bilateral contracts with the EU and individual Member states.

This should be an opportunity to promote cross-border trading. Latest developments have however shown that the EU can influence such bilateral contracts and make negotiation closures dependent on non-related topics. Such action was taken in April 2015 when the EU stopped negotiations on integration of Switzerland in Europe's IEM because of a lack of convergence in institutional agreements (Alder, Bühler & Fellmann, 2015). The decision to reject the negotiated integration was taken against industry expectations.

3.2.1. Influence on Swiss market players

Potential benefits from allowing Swiss generators to participate in foreign capacity mechanism are ample. The additional revenue stream could also contribute towards national adequacy since investment signals will direct new capacity to the location where it generates the most additional wealth. This location will not always be in the geographic reach of the country with capacity mechanisms in place. However, Swiss market participants have to be prepared in order to seize this opportunity. It is therefore recommended that clear roles are allocated and occupied.

3.2.1.1. Energy producers

It might seem as if generators do not have significant influence within international negotiations on market design. However cross-company organisations such as Swisselectric contribute towards decision making by actively following market developments and conducting research. The acquisition of such knowledge enables them to influence discussions and suggest structures which fit best for Swiss producers. Generators should also be closely integrated in defining prequalification for participation eligibility since they are the party with most information on power generating assets. Allowing generators to partake directly or indirectly (through the Association of Swiss electricity companies [VSE], TSO or other parties) in the configuration of participation eligibility is likely to create additional economic efficiency. Another possible benefit could be directed towards profitability and sustainability of their generation portfolios. Swisselectric will most likely to remain their prominent role since they proactively contribute towards optimisation of market outcome and represent the majority of Switzerland's electricity generation (swisselectric, n.d.).

3.2.1.2. TSO/swissgrid

TSOs probably hold the most prominent role in present energy markets. Their position between the government and generators allow for a certain degree of freedom. They are considered in most discussions and solution findings. This not only result from their independent situation but also from the fact that they provide access to other markets and are in charge of overall network design. Swissgrid is here for an ideal example. Partaking in international cooperation and organisations (i.e. ENTSO-E) will provide the TSO with additional credibility and acceptance.

Swissgrid will however also have to do its homework in order to remain an informed position. One upcoming challenge is the definition of roles and obligations within the Swiss market. Swissgrid should already assess designs for a market in which cross-border participation is allowed for. Being prepared for this event will contribute towards Switzerland's credibility and enable participation through a well-defined framework. Of especial interest will be the calculation of limits to cross-border participation and the management of simultaneous scarcity situations (ENTSO-E, 2015, pp. 5-6). Further questions which have to be clarified include the determination how foreign market can receive sufficient information on actual availability of Swiss plants which partake in foreign capacity mechanisms.

3.2.1.3. Government Agencies

Government agencies are required to prepare and eventually implement the regulatory environment to allow for cross-border participation in capacity mechanisms. The research in this paper suggests following a more market opening approach (i.e. allowing for more integration towards IEM). Positive effects from participation in neighbouring capacity markets can be expected for national markets. Also frameworks should be designed to allow for determination of outcome by market signals. Limitations of these signals will most likely result in distortions of market outcome.

3.2.2. Conclusion

It can be determined that electricity market will always tend towards further integration since only holistic solutions and approaches will lead to beneficial outcomes, due to the commodities special characteristics. This implies that Switzerland and Europe will follow common paths and try to realise further market integration. Both markets will profit not only financially but also structurally from cooperation. However, complex regulations do not allow for straight forward integration. Swiss market participant have therefore take on clearly defined roles and prepare their respective area of activity for potential integration.

4. Conclusion

This last chapter concludes the thesis with a brief summary of the established findings. The paper has investigated both theoretical approaches and effective designs. Information from experts enabled these findings to be critically reviewed and to draw relevant conclusions thereof. However, the high pace of change and prevailing uncertainties do not allow for long-term predictions and recommendations.

4.1. Summary

It has been established that Europe faces unique upcoming challenges which will test the policies of the European Union on resilience and sustainability. Main challenges include continuous liberalisation of energy markets, less flexible generation capacity and capacity adequacy concerns. Insufficient functioning of energy-only markets creates the need for ancillary market designs. Capacity mechanisms are therefore increasingly introduced in European markets. However, different needs which vary from country to country require other market designs and make it challenging to coordinate integration on a pan-European level. Additionally, Europe’s case cannot be compared to other markets which made use of these mechanisms. This is mainly due to the regions interconnectivity as well as efforts to avoid distortions in other markets (i.e. day-ahead and intraday).

Research on Switzerland confirmed that the country is not in a need for capacity mechanisms and have valuable generating sources, such as hydroelectricity, which provide for certain flexibility. Furthermore, existing interconnector capacities and the country’s central positioning in Europe would allow benefiting from increased cross-country trading. Lastly, Switzerland’s installed generation capacity exceeds annual demand and therefore makes a certain volume available for export.

Analysis of the design has shown that the implementation with physical delivery as product creates challenges and might, in some cases, not be feasible. Availability of capacity is therefore the preferred option and would mitigate needs for complex policy designs. Another benefit arising from this option is no distortion of other markets and their cross-border flows. Price would hence remain the determining factor. This is assumed to result in optimum market outcome. However, not such a distinct conclusion can be drawn when assessing participating entity. In general generators are likely to improve market outcome compared to interconnectors. The application would yet result in higher administrative expenses. Industry views also vary for this question. Where experts who are closer to the generating side would prefer being able to bid directly and not having to go through a third party, such as interconnectors or even TSOs, which are expected to remain a facilitator and not commence to take part in the market.

It will be interesting to see what results from Germany’s Weissbuch which is due at the end of May 2015 and will elaborate on the feedback submitted by other market participants and the view of German regulators.

4.2. Recommendation

The market’s situation, uncertainties and differences do not allow for a clear recommendation for Swiss market participants. It can however be concluded that the Swiss market does not face endangering scenarios and can therefore adopt an observing position. It is however important to take some proactive measures which include definition of clear roles and duties in case cross-border integration of capacity mechanisms materialise. Also, certain standards and tools have to be developed to allow for participation in foreign markets. These standards most importantly include assessment of contract fulfilment and regional risk assessments (i.e. regional capacity adequacy assessment which account for cross-border trade). Switzerland will find itself in a comfortable position upon realisation of integration when such proactive measures are taken.

This bachelor’s thesis therefore concludes that the Swiss market does not face endangering effects from the introduction of European capacity mechanisms. In contrast, this development provides Switzerland most likely with opportunities which have to be realised by Swiss market participant through adaption to the relative situation and preparation of the market to allow for cross-border participation.

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