Chapter 2

The Integrated NORDIC Power Market and the Deployment of Renewable Energy Technologies: Key Lessons and Potential Implications for the Future ASEAN Integrated Power Market

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Chapter 2

The Integrated Nordic Power Market and the Deployment of Renewable Energy Technologies: Key Lessons and Potential Implications for the Future ASEAN Integrated Power Market

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The report examines the integrated Nordic power market and its linkages to renewable energy technology (RET) deployment for power production. It has two purposes. First, it aims to improve the understanding of the expansion of the Nordic power market and integration and deployment of RET. Secondly, it takes lessons from the Nordic experience that could inform the development, deployment and integration of RET in the future ASEAN integrated power market. Whenever possible, historical or co-evolution aspects are addressed.

The study analysed three central building blocks underpinning the development of the Nordic market: i) the Nordic power system and its links to the European (EU) power markets ii) significant policy and regulatory characteristics that have driven both market power integration and RET deployment and iii) the complexities and technicalities of the Nordic power market exchange (the Nord Pool Spot). Different evaluation criteria are used to assess RET deployment in the integrated Nordic power market. These criteria include information asymmetry/transparency, market concentration, barriers to entry, transmission bottlenecks, balancing resource and price volatility/uncertainty. Information was collected from a critical literature review, expert interviews and a key stakeholder survey. Links with European policies and power markets are covered wherever existing knowledge allows. To formulate suitable recommendations, different studies addressing energy market integration in the ASEAN region were reviewed. Recommendations have emerged by contrasting lessons from the Nordic/European region with the situation in the ASEAN region.

Our findings strongly suggest that a decisive mix of RET policy support mechanisms and ambitious RE targets are essential to developing RET power in the ASEAN region. The gradual integration and transformation of electricity markets can further strengthen RET incorporation into the ASEAN market. One key recommendation is to develop international structure(s) or organization(s) to design, support and enforce relevant policies and regulations. Since RET markets need time to develop and mature, aggressive RE policies in the ASEAN region should be introduced as soon as possible. This will ensure that RET is in a very good (national/local) position to be integrated into the future ASEAN power system. For the deployment of RETs, power systems cannot be left to energy integration policy efforts alone. RET support policy mechanisms are indispensable.

[1] The views expressed in the article are purely those of the authors and may not in any circumstance represent those of IRENA. The authors will be solely responsible for the content of this chapter. Corresponding author email address: mundacatoro@gmail.com.

1. Introduction

Electricity markets in the Nordic region have changed significantly since the early 1990s. Nordic countries have opened up power trading and electricity production to market competition. All Nordic countries have liberalized their electricity markets. The region now has the world's most harmonized cross-border power market.

The objective of market liberalization in the region was to improve and encourage efficient utilization of production resources and transmission network operation. Renewable energy (RE) sources have played a critical role, and climate and energy policies encouraging the transition to a low-carbon Nordic society have grown in importance.

Since the liberalization and integration of the Nordic electricity markets, the region has received substantial attention from other regions with similar policy and market objectives. Renewable energy sources and corresponding technologies have always played a critical role in the Nordic power system. This means increasing attention has in recent years been given to climate and energy policy instruments encouraging the transition to a low-carbon Nordic society. This study analyses the liberalization/integration of power markets and its relation with the deployment of renewable energy technologies (RETs).

The International Renewable Energy Agency (IRENA)[2] has commissioned this study to extract key lessons from the Nordic region, which have the potential to support energy market integration within the Association of Southeast Asian Nations (ASEAN)[3]. Given its particular focus on RET, the Nordic region is expected to provide valuable lessons to ASEAN countries aiming to integrate their power markets and ensure regional energy security.

1.1. Objectives and Research Questions

This study has two main objectives: 1) to improve the understanding of the relationship between the expansion of the Nordic power market and grid network and the integration and deployment of RET; 2) to analyse and generate lessons from the

[2] For further information visit www.irena.org

[3] For further information visit http://www.asean.org

development of the Nordic power market and deployment of RET that can support energy market integration in the ASEAN region. It covers two specific issues. Firstly, it includes an assessment of the Nordic power market and market exchange (i.e. the Nord Pool Spot) and its links with the European power markets. This is considered in relation to the integrated market for the utilization of renewable energy resources (particularly small-scale hydro power plants). Key factors and critical elements that may facilitate or restrict the integration of unconventional RET (i.e. excluding large hydro) are identified. Secondly, we draw key lessons from the Nordic region. These in turn yield suitable recommendations for ASEAN Power Grid (APG) expansion. To guide the study, we sought to answer the following research questions:

- What are the characteristics of the Nordic power system and the role of renewable energy?
- What market reforms have been used to deregulate and integrate it? How has RET deployment been encouraged?
- How does the Nord Pool Spot market exchange work? How does price formation take place? What is the level of power trading within and outside the Nordic region?
- How has the Nordic power market performed after integrating and deploying RET?
- What critical lessons from the Nordic region can be extracted from the analysis?
- To what extent can the Nordic experience assist ASEAN countries integrate the energy market integration and increase RET deployment?

1.2. Methodology

To achieve the objectives and answer the research questions, different research methods (i.e. triangulation) were used to approximate objectivity and reduce uncertainty.

Interviews played an important role during the research since there is little or no literature on, for example, the effects of the Nord Pool Spot on renewable energy development. In particular, no empirical information about the co-evolution of the Nordic integrated power market and the development of RET is available. However, experts provided some anecdotal information. Semi-structured interviews were based on interview protocols. In addition, an inspection of peer-reviewed material, statistical databases, books and grey literature (i.e. project reports, workshop/seminar presentations, institutional publications, policy statements, etc.) was conducted. Official information from the Nordic energy authorities was used extensively throughout the research. To support the data, a key stakeholder survey was launched. It focused on critical issues relating to the Nordic power market and RET deployment.

We analysed public policy development associated with RET that could be related to the liberalization and integration of the Nordic power market. In particular, we used different evaluation criteria to guide the analysis. The multi-criteria approach includes:

- **Information asymmetry/transparency**: this refers to the level, quality, degree of uncertainty and timeliness of information market participants get to support decisions associated with transactions (e.g. selling or buying power).
- **Market power/concentration and market liquidity**: market power refers to the amount of influence a firm has on the industry in which it operates. In the neoclassical economic model, companies are assumed to have zero market power (part of the conditions for "perfect competition"). Firms with market power are said to be "price makers" as they can set the price for an item while maintaining market share. Market liquidity is often characterised by a high level of trading activity whereby agents can quickly convert commodities into cash.
- **Barriers to entry**: this relates to the efficiency of the administrative process for concessions, procedures for new generation, and to what extent restricted site availability and environmental regulations prevent market entry or not.
- **Transmission bottlenecks and balance resources**: this relates to the option and related impacts of accessing the transmission grid, management tools to handle bottlenecks, trans-border power trading and capacities, and grid connectivity. It also relates to the Nordic power system's ability to deal with variable and discontinuous production from wind power.
- **Price volatility/uncertainty**: this focuses on the impacts (if any) of price volatility or uncertainty on RE power producers. An understanding of price dynamics is critical for RET investment risk management.

1.3. Scope and limitations

Our study dealt with a broad set of issues relating to the Nordic power market, power system and RET deployment. In addition, the total costs of the project, the time period for its development (35 days approx.) and the defined length of the report created practical limits to its scope. It is important to note that there is no empirical information available on the co-evolution of the Nordic integrated power market and the development of RET. The experts and survey yielded only anecdotal evidence on these issues. Our findings reveal that it is sometimes difficult to distinguish clearly between the impacts of the liberalization/integration of the Nordic power markets and the renewable energy policy instruments. To the best of our knowledge, there is no study in this field.

From a geographical point of view, our focused on Denmark, Finland, Norway and Sweden (i.e. Nordic countries). Wherever feasible (e.g. due to data availability), linkages with European power markets (e.g. Germany) were also addressed.

The Nordic power system is dominated by renewable energy sources, especially large hydro. This study aims to focus mostly on unconventional RET, that is wind energy, bioenergy, solar and small-scale hydro. However, the reader has to note that the bulk of existing knowledge relates to large hydro and to some extent wind energy. This is relatively consistent with the share of these technologies in the Nordic fuel mix. Much less is known about solar photovoltaic (PV), for instance.

RET deployment in the Nordic regions is strongly associated with specific policy instruments, such as feed-in tariffs (FITs) or tradable green certificates. EU climate and energy-related targets and instruments such as the European Emission Trading Scheme (EU ETS) also play a major role. We do pay close attention to specific supportive instruments, but an evaluation of their effectiveness is outside the scope of this study.

2. The Nordic Power System – An Overview

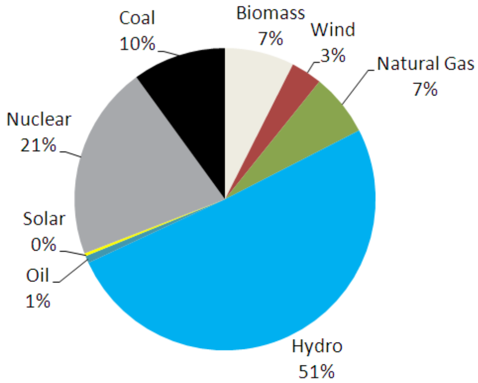
2.1. Supply side

The Nordic region is powered by fossil fuels, hydropower, wind and biomass. Installed generation capacity reached more than 98 000 MW in 2011 and is very diverse (NordREG, 2012a). Hydropower has over half of generation capacity (most Norwegian and nearly half the Swedish capacity). Combined Heat and Power (CHP) is the second largest generation source (31%), mainly using biomass. Thermal power generation, especially in Finland and Denmark, uses swing production. This means it acts as backup production capacity when hydropower generation in Sweden and Norway decreases (NordREG, 2012a). Nuclear power is the third largest source

(Sweden and Finland). It has 12% of total Nordic generation capacity, while wind energy has nearly 7 %.

By 2010, power production reached 389 TWh, and renewables represented 62% (see Figure 1). Hydropower was responsible for more than 50% (197 TWh). Biomass represented 7% (29 TWh) and wind 3% (13 TWh). Nuclear power represented 21% (81 TWh). Solar PV was responsible for nearly 1TWh (Denmark and Sweden). In 2011, total power generation in the region reached 370 TWh. A weaker economy and warm weather, which reduced heating needs, explain the reduction from 2010. Thermal power (Finland and Denmark) accounted for most power production decrease (NordREG, 2012a).

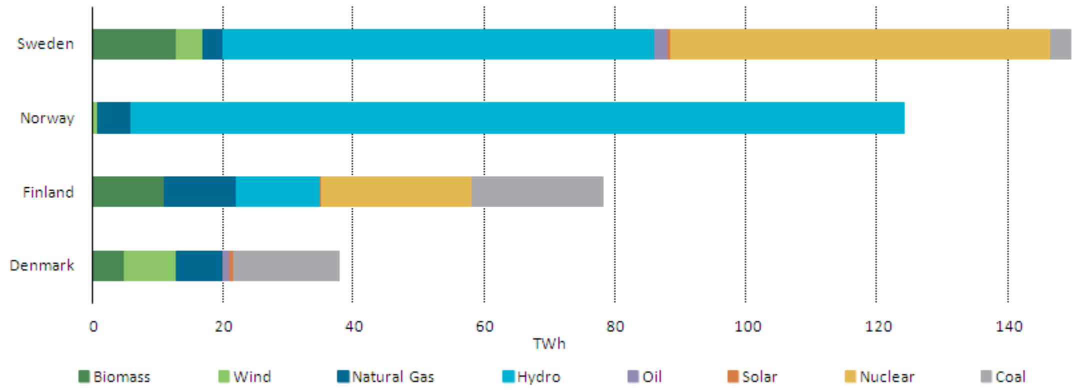
Figure 1: Fuel mix for electricity generation (389TWh) in the Nordic region (2010)



Data Source: NER & IEA (2013)

We observe sharp differences across Nordic countries when it comes to power production (see Figure 2). First, Sweden has the greatest electricity generation (149 TWh in 2010), with hydropower, nuclear and biomass-fired production representing the major share (NER & IEA, 2013). In addition, wind power has become increasingly relevant in Sweden, with power generation reaching 4 TWh. Secondly, hydropower dominates Norway‘s fuel mix (95%), with only minor production from wind (1 TWh) and natural gas (5 TWh). Thirdly, Finland has the most diverse fuel mix (NER & IEA, 2013). Biomass and hydro are 31%, while fossil fuels represent 40% and nuclear 29%. Domestic wind energy has an impressive share of the Danish market. This increased from 12% in 2000 to 21.9% in 2010 bringing total net wind power to nearly 9 TWh (NER & IEA, 2013). Wind power development differences within the Nordic countries can be attributed to particular factors: policy instrument choice, electricity price, domestic fuel availability and energy sources etc. (Pettersson, Ek, Söderholm, & Söderholm, 2010).

Figure 2: Electricity Generation in Nordic Countries (2010)



Data Source: NER & IEA (2013)

Power generation capacity in Sweden grew by 1072 MW, while 329 MW was decommissioned. Wind made the largest contribution to net capacity increase (734 MW). Nearly 736 MW was added to installed capacity, 34 % more than in 2010 (NordREG, 2012a).

2.2. Demand side

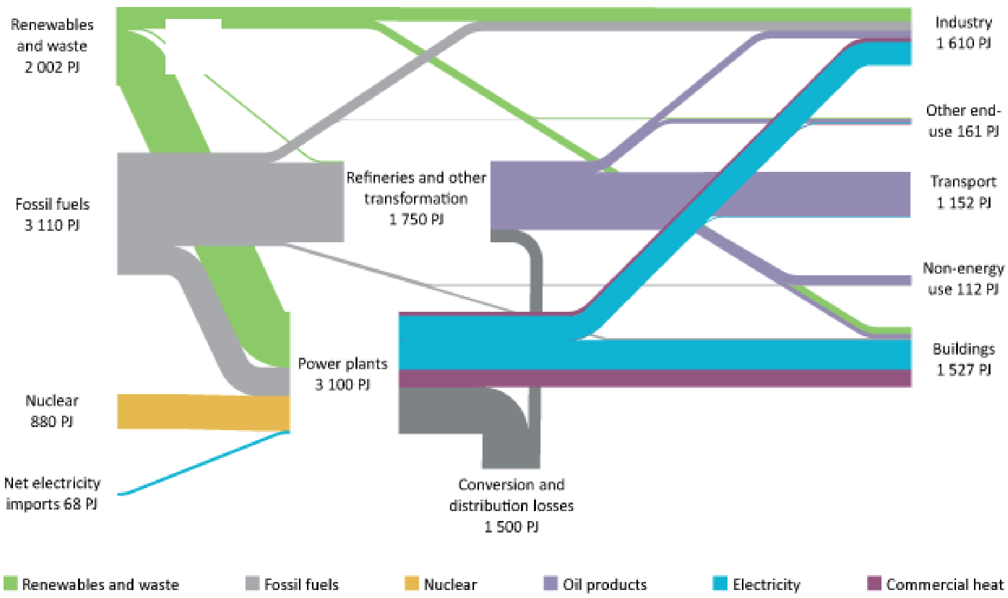
Electricity generation and relatively low electricity prices (see section 4.3) are a critical component of the Nordic energy-economy system and have thus framed the region's economy by creating an electricity-intensive industry centre.

Electricity consumption in Scandinavia is higher than in other European countries due to cold winters, relatively low prices, electrically heated houses and relatively high industrial demand. Demand in Finland, Sweden and Norway is significantly affected by energy-intensive industries, and is also significant in the household sector. Electricity demand fluctuates more in these three nations than in Denmark. Per capita power consumption in Norway is one of the highest in the world at around 25.000 kWh/per year (2010).

The building and industrial sectors dominate renewable energy demand (including conversion losses – see FFigure 3). Sweden has the largest share of total power consumption followed by Norway, Finland and Denmark. Electricity consumption in the Nordic region varies widely due to specific conditions in each country as well as population and economic structure; however, it is generally affected by temperature variation and economic growth.

Peak loads (mornings and afternoons) often take place during cold spells. In 2011, maximum capacity generation was put into operation by the end of February. Nevertheless, power consumption exceeded aggregate production, necessitating net imports of 3278 MW from Germany and Russia. Finland often requires imports from neighbouring countries (especially Russia). However, this should change when a new nuclear reactor (Olkiluoto 3), with an installed capacity of 1600 MW is ready to run. For details of exports and imports see section 4.4.

Figure 3: Energy Flows in the Nordic Region in 2010

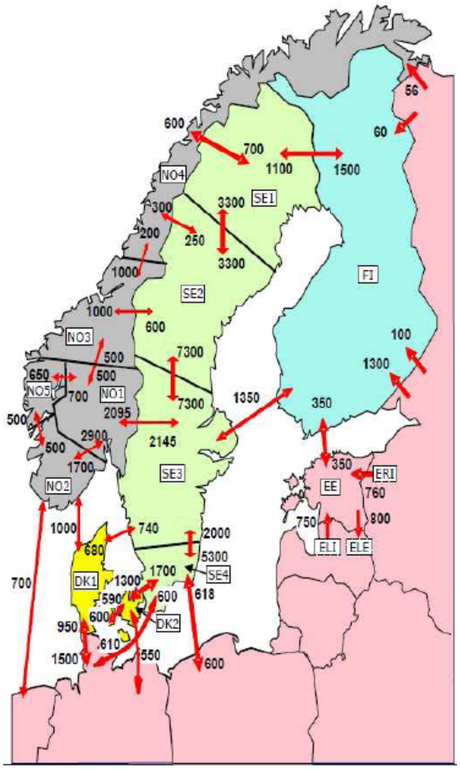


Data source: NER & IEA (2013)

2.3. Transmission Grid

The transmission grid covers all the Nordic countries and combines all the national grids (excluding western Denmark) into one common power system (see Figure 4). The Nordic grid (6 GW in 2010) is decentralized: national transmission companies are responsible for operating and investing in the national network (NordREG, 2007, 2011a). Voluntary cooperation between transmission companies takes place through NORDEL (now replaced by ENTSO-E, see section 3). This body was founded in 1963 for cooperation between transmission system operators in Denmark, Finland, Iceland, Norway and Sweden. The grid is part of the transmission network of North West Europe. Eastern Denmark is synchronous with the Nordic grid while western Denmark is synchronous with the area of continental Europe. A DC transmission cable linking eastern and western Denmark has been running since 2010 (NordREG, 2012a). Transmission interconnectors also link the Nordic market to Estonia, Germany, the Netherlands, Poland and Russia.

Figure 4: Transmission Capacities between Different Nordic Pricing Areas (2011)



Source: NordREG (2012a)

The Nordic power system uses two models to handle transmission grid congestion. These are the area price model (also called market splitting), leading to different area prices calculated by the Nord Pool Spot, and the countertrade model (Flatabo, Farahmand, Grande, Randen, & Wangensteen, 2003; NordREG, 2007). In the former, the Nordic area is divided into different price bidding regions (see section 3). This means congestion in the Nordic spot market results in market splitting. At present, there are 12 price bidding areas: five in Norway, four in Sweden, one in Finland and two in Denmark (see Figure 4). Sweden was split into four bidding areas in November 2011. It is argued that this change took place to improve market efficiency and lay the groundwork for financing future network improvements (NordREG, 2012a).

Once divided, internal congestion - transmission bottlenecks within the Transmission System Operator (TSO) control area - is handled via countertrade or by reducing interconnector transmission capacity at bidding area borders (NordREG, 2007). Countertrade here means the TSOs correct the electricity flow using market-based redispatch to assure that it does not exceed grid security limits (i.e. down or upregulation. See details in section 4.2). TSOs have to pay for this service, and this is covered by the grid tariff (NordREG, 2007). Countertrade is often used after gate closure in the ELSPOT or day-ahead market (see section 4).

In 2011, market splitting in the Nordic electricity market was forced 74 % of the time. This means all Nordic countries shared a common system price 26% of the time (NordREG, 2012a). These figures were nearly the same in 2010.

According to NER & IEA (2013), Nordic transmission capacity needs to increase to around 15 GW by 2050 (from around 6 GW at present). This is obviously required to facilitate the effective use of the entire power system in relation to growing demand, increase security of supply and support trading among Nordic countries and with the rest of Europe. Substantial reinforcements have been made and/or are planned in the transmission system, most notably (NordREG, 2012a):

- Finland: the Fenno-Skan 2, a submarine 500kV DC-link with 800 MW transmission capacity started up in November 2011. This link between Finland and the SE3 Swedish price areas was built by the Finnish and Swedish TSOs

(Fingrid and Svenska Kraftnät). Since then, these two have shared the same price 92% of the time. A new transmission link, the EstLink 2- a submarine HVDC cable of 650 MW between Finland and Estonia, is due to start up in early 2014.[4]

- Denmark: a transmission link to improve connectivity between eastern and western parts of the country was commissioned in 2010. Since then, prices in both areas have been much more uniform. This link is critical to channelling wind generation, which dominates the western region, to other parts of the Nordic market. Grid companies are also reinforcing transmission and distribution according to the national 2008 Danish Cable Action Plan. This includes improvements between central and southern Sweden and Norway and Denmark.[5]
- Norway: several projects in the country will improve and strengthen transmission capacity. For instance, a 92 km link (420 kV OH) between Sima and Samnanger is due to be commissioned in 2014. The line will also integrate new hydropower in the region. The Skagerrak IV is a new 140 km DC cable between Norway and Denmark with a 700 MW capacity. It is expected to start up in 2014. A 285 km (420 kV) OH line from Sogndal to Ørskog also aims to improve security of supply in Mid-Norway. This link, due in 2015, is intended to improve RES integration and net transfer capacity. Likewise, a 360 km (420 OH) line from Balsfjord to Hammerfest will improve security of supply in North Norway. This link, due in 2018, will benefit RES integration and growth load. Finally, the Norwegian TSO (Statnett) and UK National Grid signed a cooperation agreement to commission a new DC cable between Norway and UK with a capacity of 1400 MW by 2020.[6]
- Sweden: various projects will increase the capacity and operational reliability of the Nordic power system. For instance, the South West Link will reduce existing transmission restrictions in southern Sweden and between southern Norway and Sweden. This will be ready by 2016. The Swedish TSO (Svenska Kraftnät) is also planning the NordBalt, a link between Sweden and Klaipeda in Lithuania. More projects are under way to strengthen the grid in major urban regions.[7]

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[4] For further information visit www.fingrid.fi/
[5] For further information visit www.energinet.dk/
[6] For further information visit www.statnett.no
[7] For further information visit http://www.svk.se/

3. Policy and Regulatory Framework

3.1. Electricity Market Liberalization in the European Union

Liberalization in the EU has followed a top-down process driven by legislation. It came in force in 1996 through Directive 96/92/EC on common internal electricity market rules. However, it faced fierce opposition and took over a decade to get approval in the European Council (Fouquet and Johansson, 2008a). It was replaced by Directive 2003/54/EC, elaborating rules on new capacity authorization procedures, third party access and the tasks of TSOs. Unbundling was required of TSOs and Distribution System Operators (DSO). This Directive was in turn replaced by the present Directive 2009/72/EC. This states that national regulatory authorities are to cooperate within the Agency for the Cooperation of Energy Regulators to guarantee compatible interregional regulatory frameworks. Member states must designate a national independent regulatory authority and exercise its powers impartially. It is mainly responsible for setting transmission or distribution tariffs; cooperating on cross-border issues; monitoring transmission system operator investment plans and ensuring access to customer consumption data. Directive 2009/72/EC is also part of the Third Energy Package, containing the most critical rules for electricity markets. The most important rules in the context of this report are:

- Regulation (EC) No 714/2009 on conditions for access to the network for cross-border electricity exchanges, which establishes the European Network of Transmission System Operators for Electricity (ENTSO-E) and its main tasks.[8] It also sets rules on developing network codes, how TSOs are compensated when hosting cross-border flows of electricity, regional TSO cooperation etc. In addition, it lays out principles for information sharing and congestion management.
- Regulation (EU) No 1227/2011 on wholesale energy market integrity and transparency (REMIT), which aims to prevent abuse in the wholesale energy

[8] For further information see The European Network of Transmission System Operators for Electricity (2013).

markets, including rules on market surveillance and penalties and disclosure of information

Functioning markets require other types of institutional cooperation. These include forums for legal harmonization, development of network codes and standards and technical assessment and well-functioning forums for exchange of best practice. Besides treaties and directives, the following are key to the liberalization process:

- The Directorate-Generals (DGs) of the European Commission[9] are responsible for developing and implementing European policies in their overlapping fields: DG Energy and Transport (DG TREN), DG Competition and DG Environment;
- The ENTSO-E represents all electric TSOs in the EU and others connected to their networks. Important assignments include the development of network codes and secure power system operations.
- The Agency for the Cooperation of Energy Regulators (ACER)[10] ensures market integration and harmonization of regulatory frameworks respects EU energy policy objectives.
- The Council of European Energy Regulators (CEER)[11] is the voice of Europe's national regulators of electricity and gas at EU and international level.
- The Electricity Regulatory Forum (Florence Forum)[12] and the electricity cross-border committee[13] was set up to discuss the creation of the internal electricity market, including cross-border electricity trade, cross-border electricity exchange tariffs and the management of scarce interconnection capacity.

The internal market rules for electricity require regulated third party access for all transmission and distribution infrastructures. Directive 2009/72/EC states: “Member states shall ensure the implementation of a system of third party access to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users.” Infrastructure operators must grant third parties non-discriminatory access and earn a regulated return on their investment for such assets. From March

[9] For further information see European Commission (2013a).
[10] For further information see The Agency for the Cooperation of Energy Regulators (2013).
[11] For further information see The Council of European Energy Regulators (2013).
[12] For further information see European Commission (2013b).
[13] For further information see European Commission (2013b).

2012, member states must unbundle transmission systems and TSOs. An undertaking must be certified before being officially designated as TSO.

The Directive also lists TSO and DSO tasks. It requires the accounts of electricity undertakings to be available to member states and competent authorities, providing confidentiality of certain information is preserved. Electricity undertakings must keep separate accounts for transmission and distribution; member states must arrange third party access to transmission and distribution systems. A regulatory authority must approve and publish tariffs. Member states must also lay down criteria for granting authorization to construct direct lines in their territory. The Directive also requires owners of natural monopoly infrastructure facilities to grant access to parties other than their own customers, usually competitors, on commercial terms.

Member states may choose between three types of unbundling: ownership unbundling, independent system operator (ISO) and independent transmission operators (ITO). Ownership unbundling splits generation (electricity production) from transmission (electricity from electrical generating station to a distribution system operator or to the consumer). The ISO option also gives member states the opportunity to let transmission networks remain under the ownership of energy groups, but transfers operation and control of their day-to-day business to an independent system operator. Under the ITO model energy companies retain ownership of their transmission networks. However, transmission subsidiaries are legally independent joint stock companies operating under their own brand under a strictly autonomous management and stringent regulatory control. However, investment decisions are made jointly by the parent company and regulatory authority.

3.2. Electricity Market Liberalization in Nordic Countries

Norway was the first country to liberalize its electricity market, starting with a new Energy Act in 1990. The reform was driven by poor resource utilization in the system, which led to major overcapacity.[14]Hydro was the main Norwegian power source. Its dependence on the climate was causing frequent supply and demand

[14] For a full historical account on deregulation in Norway see Bye and Hope (2005).

shocks that needed to be prevented using other power sources (Amundsen, *et al.*, 1999). In 1972, the Norwegian power market was officially organized as a spot market in a power exchange, known as Samkjøringen. Norwegian electricity market reform in the 1990s established a spot market for power trade. This was a separate legal entity within the TSO, Statnett. There were also rules on access to the network system on a transparent and non-discriminatory basis.

The dominant, state-owned and vertically integrated company Statkraft was split into two legal entities: the generating company, Statkraft, and the transmission company, Statnett. The other vertically integrated power companies were separated into generating or trading divisions and network divisions for accounting purposes. The network companies were subject to natural monopoly regulations. The regulatory regime was administered and enforced by the Norwegian Water Resources and Energy Directorate (NVE), on the basis of rate-of-return regulation. Market liberalization took place without ownership changes, as power sector privatization was politically unacceptable. The creation of a financial forward market and introduction of standardized financial futures contracts followed. New rules aimed to stimulate the consumer's active retailer choice.

In 1992, the Swedish State Power Board was split into two separate entities, a grid operator and a power producer. The 1996 Electricity Act introduced market deregulation. Swedish investment laws are more open to foreign and private investors than Norwegian laws. Sweden and Norway established the Nord Pool Spot in 1996. Like Sweden, Finland liberalized its market in 1996. Integrating Finnish power with the Nordic market has been complicated, as Finland has a large share of industrially produced thermal power. Finland had its own power exchange before joining the Nord Pool Spot. Denmark also faced integration problems, and did not introduce third party access to the grid until 1998. While early reforms aimed to develop national and Nordic markets, national rules in the 2000s were often introduced to comply with the EU Electricity Directives of 2003 and 2009 (replacing the EU Directive (96/92/EC)). Nordic countries had already established NORDEL in 1963. This was formed by TSOs from Denmark, Finland, Norway, Sweden and Iceland, who aimed to create the foundations for developing an effective and harmonized Nordic electricity market. NORDEL provided advice and recommendations, taking into account conditions in each Nordic country. It was abolished by Nordic TSOs in 2009 and replaced by the European Network of Transmission System Operators (ENTSO-E). Regional cooperation within ENTSO-E is now the official platform for developing transmission grids and an integrated electricity market.

Energy regulators from Denmark, Finland, Norway and Sweden cooperate through NordREG.[15] The cooperation was formalized in a Memorandum of Understanding in 2002. NordREG has a rotating presidency lasting one year. Its main task is to "actively promote the legal and institutional framework and conditions necessary for developing the Nordic and European electricity markets".[16] The cooperation means exchanging views and experiences, mapping and analysing electricity markets and preparing common reports and position papers. NordREG cooperation is based on 1) initiatives from the Nordic Council of Ministers, and 2) initiatives from Nordic regulators. Work is organized through working groups addressing electricity wholesale and end-user markets. NordREG regularly produces work programmes, roadmaps and updates on harmonizing Nordic markets and coordinating grid expansion.

Different Nordic TSOs vary somewhat in terms of tasks and regulatory frameworks (see Table). When national TSOs decide independently on grid investments, their priorities affect the Nordic electricity market (e.g. national investments remediating grid bottlenecks have a positive effect on the whole Nordic market). National parliaments and governments should therefore actively engage with grid development and not leave all decisions to the national TSO (Swedish National Audit Office, 2013).

Nordic countries are all subject to EU rules on supply competition, unbundling and net access and related market surveillance and reporting to the European Commission. They have all chosen the ownership unbundling model. The 2009 EU Electricity Directive sets different deadlines for when all unbundling rules must be in place. A recent report evaluated EU countries excluding Norway, which is not an member (CEER, 2012). It stated that Denmark and Sweden were complying with EU

[15] For further information see Nordic Energy Regulators (2013a).
[16] For further information see Nordic Energy Regulators (2013b).

unbundling rules. Finland gets a good grade though some EU rules still have to be transposed into Finnish law. All countries have opted for the regulated TPA (rTPA) for accessing the transmission and distribution network. This means access prices are published and not subject to negotiation. However, the rules differ somewhat in terms of obligations to connect and costs.

The existence of national rules for costs does not necessarily lead to equal or objective cost allocations. Guidelines are in place but different calculation methods mean grid operators charge different fees for connection and use. Sometimes this leads to lengthy legal disputes. According to some interviewees, some grid operators charge more because their owners demand higher profit margins rather than for any objective reason. There are indications that private and state-owned companies charge higher fees than companies owned by municipalities. These are usually viewed as service providers for local citizens and therefore have less strict profit requirements. Companies whose owners demand high profits may underinvest in grid capacity to meet short--term goals; too much profit is distributed to shareholders and too little put aside for grid investment.[17] If a grid owner is a large player, it is in a better position to handle lengthy legal disputes than small players, and small electricity plants may therefore have difficulties upholding their legal rights on fees.

Table1: Key Regulatory Framework for TSOs in Nordic Countries

Element	Denmark	Finland	Norway	Sweden
The legal basis	EU level and Energy Act and law on Energinet	EU level and Electricity Market Act	EU level and Energy Act	EU level and Energy Act, Governmental decree
Who appoints the TSO?	Government – the Act	EMV (Energy Market Authority)	NVE (NO Water Resources and Energy Directorate)	Government – regulation 1994: 1806
Who gives licences to build network components?	Government	EMV	NVE	Government
Where is the system operation	Energy Act and law	In the Licence given by the EMV. Details	Regulation decided by NVE- Reg. no.	Energy Act, Governmental decree on the

[17] There is currently a media debate in Sweden about the incentives of various market players and the need for more control over grid operator fees.

responsibility specified?		(SO) in the Licence are unchanged since 1998	448 of 7 May 2002	system operator for electricity
Where is the method of economic regulation specified?	Executive order nr. 965 of 2006 on economic regulation of Energinet	EMV methodology decision. Dnro 831/430/2011, 23.11.2011	Regulation decided by NVE – Reg. No. 959 of 7 December 1990	Governmental decree (2010:304) establishing the revenue cap under the Electricity Act
Main objectives of the regulation	Promote and ensure security of supply, efficiency, consumer protection and reasonable consumer prices.	Ensure preconditions for an efficiently functioning electricity market; secure the sufficient supply of high standard electricity at reasonable prices.	Ensure that generation, conversion, transmission, trading, distribution and use of energy are conducted in a way that efficiently promotes the interests of society.	Ensure preconditions for an efficiently functioning electricity market so as to secure the sufficient supply of high-standard electricity at reasonable prices.
Main system operation tasks	Upholding security of supply; extending infrastructure in electricity area; creating objective and transparent conditions for competition in energy markets; implementing cohesive planning including further needs for transmission capacity and the long term security of supply.	Technical functioning and system security; maintain frequency using production reserves needed by virtue of an agreement between the Nordic TSOs; take care of duties pertaining to system responsibility in an equal and neutral manner.	Operate the transmission grid; national power system planning of the grid; manage congestion and establish bidding zones; set transmission capacity limits between and within bidding zones; ensure sufficient frequency reserves at all times.	Overall responsibility for power installations; establish objective and non-discriminatory targets for operational security in the national grid and in interconnections to other countries; ensure grid is being expanded to increase its reliability and availability.
Economic regulation of network model	Cost-plus regulation	Ex-ante revenue cap model	Ex-ante revenue cap model	Ex-ante revenue cap model

Sources: NordREG (2011a, 2012b)

Table 2: Legal and Financial Aspects of Transmission Grid Access

	Denmark	Finland	Norway	Sweden
Obligations of grid operator	Plant operators are entitled against the grid operator to the connection of their plants to the grid. No deadlines are specified for the connection procedure.	Plant operators are entitled to connect. The grid operator must enter into an agreement if the plant in question meets the grid operator's criteria. Detailed provisions are specified in a connection agreement.	Obliged to connect new plant, but exemptions may be granted. Obliged to provide schedule for grid connection.	Obliged to connect unless special reasons (e.g. insufficient grid capacity). Obliged to deal with application within reasonable period and provide a roadmap.
Legislation	Act on Electricity Supply Order 1063/2010	Electricity Market Act	Energy Act and Energy Regulation	Electricity Act
Cost allocation	The plant operator bears the cost of connecting a plant to the grid. The plant owner and TSO bear the cost of connecting a wind energy plant.	The plant operator pays the grid operator a reasonable cost for connecting its plant to the grid. It may request a detailed list of costs from the grid operator.	Plant operator.	Plant operator through network tariff.

3.3. Direct RET Policies

Some key EU legislation has acted as umbrella policy for all EU countries. The Directive 2001/77/EC aimed to support the promotion of electricity from RE sources. It covered all RE sources and sets specific indicative targets for each member state. However, this was revoked (from January 2012) by the EU Renewables Directive 2009/28/EC. This requires EU member states to ensure an agreed proportion of energy consumption derives from renewable sources, setting national RET targets.[18] These are in line with the EU 20-20-20 targets by 2020.[19] This Directive is in a portfolio of EU energy and climate change legislation that includes energy efficiency and greenhouse gas (GHG) emissions. EU member states must produce action plans

[18] For further information see RES Legal Europe (2013).
[19] A 20 % share of renewables in EU energy consumption, a 20% of energy efficiency improvements and a 20 % reduction of GHG emissions compared to 1990.

to meet their targets.[20] The Directive also establishes a common framework for the production and promotion of energy from renewable sources. Each member state must be able to guarantee the origin of electricity, heating and cooling produced from renewable energy sources. The information contained in the guarantees of origin is standardized and may be used to inform consumers on the composition of different electricity sources. EU member states must comply with the Directive through appropriate changes in national law and provide progress reports.[21]

Member states, including Nordic countries, have used a number of direct RET policy instruments, including regulatory approaches, informative schemes and market-based instruments. The most common of these are as follows, according to the European Renewable Energy Council, 2013:

- **Tradable Green Certificate (TGC) schemes**: the RE target under the TGC scheme is determined by the authorities and the certificate price by the market. A given electricity supply chain agent (e.g. generator, supplier or consumer) must meet an individual quota and show a fixed minimum quantity of green certificates, often on an annual basis. Green certificates are originated per MWh of RE electricity (RES-E) generated. Obligated parties can thus generate or buy certificates on the market; the certificate price represents the premium for the renewable energy production. Section 6.2 includes some lessons from the TGC schemes in Norway and Sweden.
- **Feed-in-tariffs (FITs)**: This is a specific guaranteed price, often set for a period of years. It must be paid by electricity companies (often retailers), to domestic producers of green electricity. Section 6.2 includes some lessons from the FIT scheme in Denmark
- **Tendering systems**: member states issue a series of invitations to tender for the supply of RES-E, which will be sold at market price. The additional cost is passed on to the final consumer in the form of a special tax.

The EU Renewable Directive targets are binding, but Nordic countries also have individual political targets.[22] For instance, Norway's target is to be carbon neutral in 2030 if emissions cuts are made by other countries or by 2050 regardless of international emission cuts. Denmark has also adopted a 100% RE supply target by

[20] The EU has a number of additional legal acts related to various aspects of RET, including rules on fuel trade and classification, cogeneration of heat and electricity, and rules on state support and competition.
[21] For more information about this process see European Renewable Energy Council (2013).
[22] These targets can be found in the Nordic Council of Ministers (2013).

2050. These national targets stress the role of RET in Nordic countries. From 2012 there is a common Swedish-Norwegian market for electricity certificates. This means certificates issued in Norway can be used to fulfil the Swedish quota obligation and vice versa. The common market target is to increase electricity production from renewable energy sources in Sweden and Norway by 26.4 TWh in 2012-2020. This means new renewable electricity production is split evenly between the two countries regardless of where production is located.

3.4. Indirect RET Policies in EU and Nordic Countries

Many EU policies provide indirect RET incentives. The EU ETS Cap-and-Trade scheme for CO_2 is the most well-known.[23] The EU also sets minimum energy taxation rules.[24] In addition, EU legislation affects grid investments and lead times for new energy production and new grid infrastructure projects. Environmental impact assessment and public participation rules for new infrastructure projects are the most fundamental examples. Denmark, Finland, Norway and Sweden all use carbon and energy taxes, though with different rates and different exemptions. National rules on environmental impact assessments and public participation vary. This affects the time it takes to undertake new projects to strengthen grid capacity and build new power plants.

Table 3: Direct RET Support Policy Instruments and Related Institutional Aspects

	Denmark	Finland	Norway[25]	Sweden
EU Renewable Directive target 2020 (% gross final energy consumption)[26]	30 % (35% national decision)	38 % (20% renewables in road transport)	67.5%	49 % (50% national decision)
Main RET policies	1) Feed-in and premium tariffs for electricity	1) FIT for electricity from RET 2) A heat	1) TGC scheme (joint system with Sweden) 2)	1) TGC scheme (joint system with Norway) 2) Real

[23] For further information see European Commission (2013c).
[24] For further information see European Commission (2013d).
[25] Norway is not a member of the EU. It is however a member of the European Free Trade Area (EFTA). The EFTA and EU together constitute the European Economic Area (EEA). EFTA countries have agreed to implement a number of EU directives.
[26] Set in Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

	from RET 2) Loan guarantees for wind planning 3) Subsidies for small-scale RET	bonus allocated to CHP plants using biogas and wood as fuels	funding scheme for renewable heat and electricity	estate tax reductions for wind 3) PV subsidies
RET & grid access	Non-discrimination[27]	Non-discrimination	Non-discrimination	Non-discrimination
RET & grid use	RET has priority	Non-discrimination	Non-discrimination	Non-discrimination
Key actors	1) Danish Energy Agency 2) Danish Ministry of taxation 3) Danish Ministry for Climate and Energy 4) Energinet (TSO) 5) Danish Energy Regulatory Authority	1) Fingrid (TSO), 2) Energy Market Authority 3) Ministry of Employment and the Economy 4) Ministry of Agriculture and Forestry 5) Ministry of Finance	1) Stanett (TSO) 2) Norwegian Water Resource and Energy Directorate 3) Ministry of Petroleum and Energy	1) Swedish Energy Agency 2) Energy Markets Inspectorate 3) Svenska Kraftnät (TSO) 4) Ministry of Enterprise, Energy and Communications, 5) Ministry of the Environment 6) Swedish Tax Authority
Main legal acts	1) Act on Electricity Supply, 2) Law on the Promotion of Renewable Energy	1) Electricity Market Act, 2) Act on Production Subsidy for Electricity Produced from Renewable Energy Sources	1) Energy Act, 2) Electricity Certificates Act	1) Electricity Act 2) Electricity Certificates Act 3) Energy Tax Act

4. Nordic Power Market Exchange

Taking into account the objective of our study, this section briefly unravels the technicalities of Nordic power market trading.[28]

4.1. Nord Pool Spot Market

The common Nordic power market started with the deregulation of the Norwegian power system in 1991 (see section 3.2). Within this policy-driven liberalization market process, the Norwegian TSO established a power market exchange (originally known as Statnett Marked). This was named the Nord Pool Spot when the Swedish power market was also liberalized and joined its Norwegian

[27] Non-discrimination means that all types of energy sources have equal access.
[28] This section relies extensively on information provided by the Nord Pool Spot. For further information visit http://www.nordpoolspot.com/

counterpart in 1996. The Nord Pool Spot is the world's first and largest international power trading market. It acts as the financial focal point in the Nordic power market and is the largest in Europe. It is dedicated to the wholesale electricity market. Electricity producers and buyers, intermediaries and traders participate in the market as do major end-users.

The Nord Pool Spot supplies accurate and transparent information to market agents; provides liquidity and security; offers equal access and guarantees contract settlement and power delivery. It is 100% owned by the Nordic and Baltic TSOs - the organizations responsible for keeping their respective geographical areas electrically stable (e.g. Statnett in Norway, Svenska Kraftnät in Sweden, Fingrid in Finland, and Energinet in Denmark). A TSO regulates and controls the electricity systems in its own country.

The Nord Pool Spot organizes and operates a power marketplace which has to contribute to effective price formation and an adequate flow of power. It is obliged (through the ELSPOT market, see below) to ensure the exchange of power with neighbouring countries is as effective as possible. Power exchange must be based on relevant area prices. The concessions oblige the Nord Pool Spot to undertake certain tasks, such as market supervision, to identify price manipulation. Trading on the Nord Pool Spot is governed and regulated through a detailed rulebook. This is a set of private legal agreements applying to all parties involved in trading and related activities.[29] Rule updates and clarifications are provided regularly, [30]often to comply with EU Directives.

4.2. Markets in the Nordic Power Market Exchange

The Nord Pool Spot covers four wholesale markets that work together. These are essential for the power market exchange to function. The wholesale power market is a common integrated Nordic market, in which electricity is traded on the Nordic power market exchange, i.e. the Nord Pool Spot. Trading on the Nord Pool Spot is voluntary; however, all day-ahead cross-border trading must be done on the Nord Pool Spot, which consists of two sub-markets, the ELSPOT market (day-ahead)

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[29] For further information visit http://www.nordpoolspot.com/TAS/Rulebook-for-the-Physical-Markets/

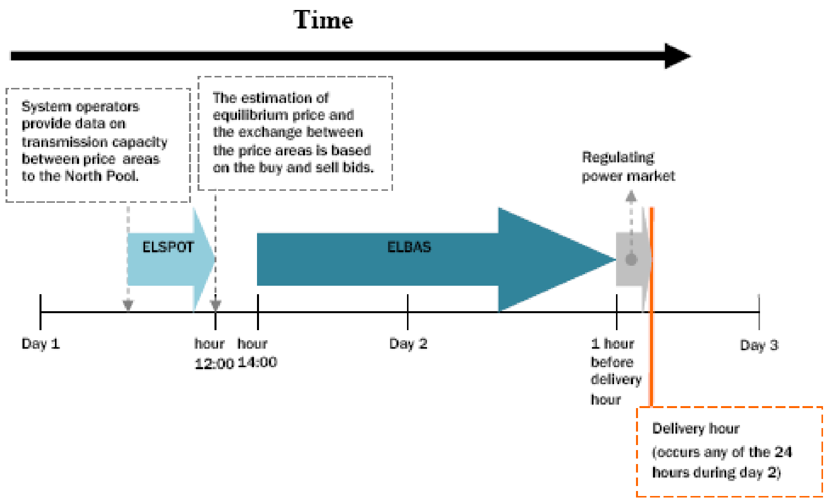
[30] For further information visit http://www.nordpoolspot.com/Download-Centre/

and the ELBAS markets (intra-day). These markets are described below (Nord Pool Spot, 2013):

- **ELSPOT market**: in this day-ahead market, electricity is auctioned for delivery in the next 24 hours. TSOs report transmission capacities before 10.00 a.m for each Nordic bidding area. All market players must send in supply and demand bids (via the internet) by noon every day at the latest for each hour in the day before power is delivered. Prices are based on the intersection of supply and demand. Prices are calculated for each hour of the day based on orders and transmission capacities. This is the system price, i.e. the price that would be realized if there were no congestion between bidding areas (see next section). Prices for each hour of the day are announced and trade is invoiced between sellers and buyers. Approximately 75% of Nordic power consumption is bought on the ELSPOT market. Transmission congestion occurs when large volumes are needed to meet demand. Different area prices avoid bottlenecks. When transmission capacity is constrained, the price rises to reduce demand.
- **ELBAS market**: this is a continuous market in which trading for a specific hour takes place until 30 minutes before electricity is actually delivered. It is critical to adjust power supply or demand plans. Trading is on a first-come first-served basis. If transmission capacity in the Nordic power system remains, neighbouring countries can also trade on the ELBAS market. In the intra-day market, participants in Norway, Finland, Sweden, Denmark, Germany and Estonia can trade for the next day once the day-ahead spot market has closed.
- **Financial market**: this is a future or forward-contract market in which legally binding trading agreements are arranged for up to six years. The financial market is often used for managing risks. Market agents secure prices for future purchases or sales of electricity, with contracts made for up to six years. The ELSPOT System Price is used as a reference price. Given the critical role of hydro in the Nordic system, forward prices or futures represent the value of hydro resources and are needed for optimal use of hydropower during different time periods.
- **Regulating power market**: this market has its own specific regulation and is run by the TSOs aiming to provide a stable transmission grid frequency. If a supply/demand imbalance arises within the operational hour, the TSO uses bids to balance the power system. On the one hand, if consumption exceeds power generation (i.e. frequency of alternating current falls below 50Hz), the TSO buys more electrical power from suppliers that claim to have excess generation capacity. This is known as up-regulation. If power generation on the other hand exceeds consumption, the TSO sells electrical power back to suppliers, encouraging them to reduce power generation. This is known as down-regulation. The balancing power market is also used for congestion management. Settlement

works as follows (Nord Pool Spot, 2013): when the TSO buys regulating power, the price is set the same way as when the TSO sells regulating power. If there is down-regulation, the TSO invoices the down-regulating price (normally lower than the market price). Conversely, if there is up-regulation during a given hour, the TSO invoices the up-regulating price (normally higher than the market price). In 2011, the Nordic balancing power market represented 4.3 TWh; nearly 1% of total electricity production. The balancing market set-up differs slightly between European countries; an overview is provided by Heden and Doorman (2009).[31] In Sweden, the Electricity Act outlines the main balancing rules, with some rules in other ordinances. This states that an electricity producer can only supply the grid if a market player is responsible for balancing at the feed-in point. The producer can enter into an agreement with a balancing player, who must in turn have a contract with the Swedish TSO Svenska Kraftnät.[32] In Norway and Denmark, Balancing Power Option Markets allow buyers and sellers to bid available capacity for balancing power on a weekly or seasonal basis.

Figure 5: Graphic Representation of the Different Markets in the Nord Pool Spot



Source: Nord Pool Spot (2013b)

The Balancing Power Market (BPM) settlement plays a critical role in settling imbalances as a result of power delivery the Nordic power market. TSOs arrange two types of settlements (NordREG, 2012):

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[31] At the EU level, Directive 2009/72/EC (see section 3.1) states that national balancing rules must be objective, transparent and non-discriminatory. It sets some general principles for balancing services, but does not provide detailed regulations. Nordic countries in 2008 agreed some common balancing principles. There are, however, still national differences in rules.

[32] Svenska Kraftnät regularly publishes on its website information and standard contracts (and other relevant material) related to the Balancing Power Market.

- A settlement *between* countries: balancing power between two countries is priced and settled in the BPM. This is known as a TSO-TSO market.
- Balancing settlement *within* a particular country: this is a settlement between the respective TSO and the parties responsible for balancing. It is governed by national balance agreements. TSOs are trying to find common procedures for balance settlements between the TSO and the parties responsible for balancing (i.e. a Nordic Balance Settlement). Nordic countries have become more harmonized due to the 2008 NORDEL agreement. Nevertheless, the regulatory frameworks are quite complex. For an examination of the systems of different countries see Heden and Doorman (2009). In Sweden, for example, specific regulation addresses the BPM, where the TSO makes the sales/purchases required to maintain the balance. The TSO requests bids from balancing partners ranked every hour. They are accepted in ranked order until there is no more grid capacity. The balancing partners are paid either by the most expensive up-regulation bid accepted or the least expensive down-regulation bid accepted. There are some deviations to this rule. The economic responsibility for imbalance among balancing partners is calculated with a user balance (applicable to all partners) and a production balance (applicable for partners with responsibility for production balancing). The pricing of imbalance is rather complicated and depends on the spot price and the price area (see Heden & Doorman, 2009) Balance power is calculated per hour. Balance calculations consist of several steps, the most important ones being *a*) balancing partners report production plans and trade a day in advance *b*) the grid operators report electricity use (based on metering) the morning after *c*) the TSO makes the first balance estimate at 12:15 the day after the relevant hour *d*) the TSO reports calculations to the balancing partners *e*) balancing is updated once grid operators have provided the latest electricity use data *f*) billing is calculated twice a month and corrections provided through recalculations within a 45-day period.

4.3. Price Formation in the Wholesale Market

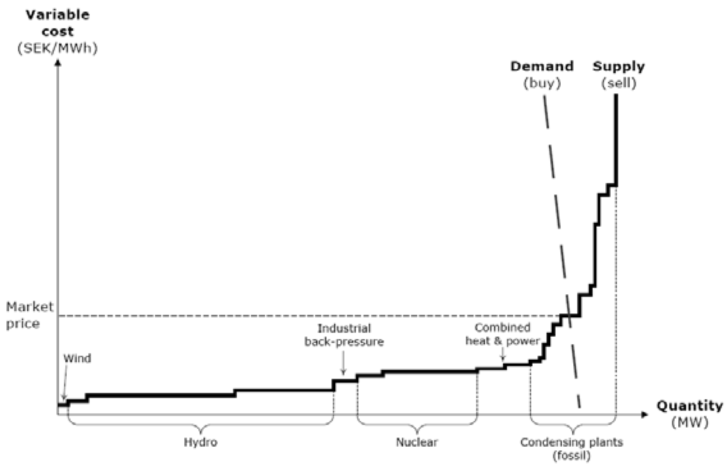
Prices in the Nord Pool Spot are based on supply, demand and transmission capacity. Once the noon deadline for market agents to submit bids is passed, all buying and sales orders are aggregated into two curves for each delivery hour: an aggregate demand curve and an aggregate supply curve. There are three different types of prices (Nord Pool Spot, 2013a; NordREG, 2007):

System price. The system price for each hour of the day is estimated by intersecting the aggregate supply and demand curves that represent all bids and offers for the entire Nordic region. It is a clearing price in which transmission bottlenecks between bidding areas are eliminated. Most standard financial contracts in the Nordic region use the system price as reference price. Some standard financial contracts refer to specific area prices.

Area price. Available transmission capacity is set by the TSOs on an area-by-area basis and thus fluctuates from the available grid transmission capacity. When electricity flows between bidding areas exceed the maximum amount of electrical power (trading capacity) that can flow from one bidding area to another, area prices are calculated and price differences across different areas emerge. The purpose of the area price calculation is to reduce transmission congestion. The area price exercise is repeated so that capacity between the high and low price area is maximized. A price area refers to a section of the ELSPOT market using a similar price. This may encompass a single bid area or two or more bid areas. At times of grid congestion, the Nordic area is divided into 12 different price areas. Bids in the bidding areas on each side of the congestion are aggregated into supply and demand curves in the same fashion as in the system price calculation. Transmission congestion within a price zone can either be handled via capacity setting in the ELSPOT Market and/or through the BPM.

Equilibrium price. All generators that produce and all consumers that consume power in a specific hour use the equilibrium price. This defines the market price in the wholesale market. Depending on the conditions outlined above, especially transmission congestion, the system price or area price represents the equilibrium price. It corresponds to the variable (marginal) production cost for the most expensive production plant needed to meet demand. The equilibrium in the market reflects the costs of producing the last needed unit of electricity to meet demand. This means the price of electricity is defined at the margin (i.e. the cost of increasing total production by one additional unit). This is defined by the marginal production costs of the most expensive technologies, e.g. combined heat and power plants or condensing coal plants in the Nordic region (see Figure6). This means producers with the lowest marginal cost (e.g. wind and hydro) often earn a margin equal to the market price minus the marginal production costs.

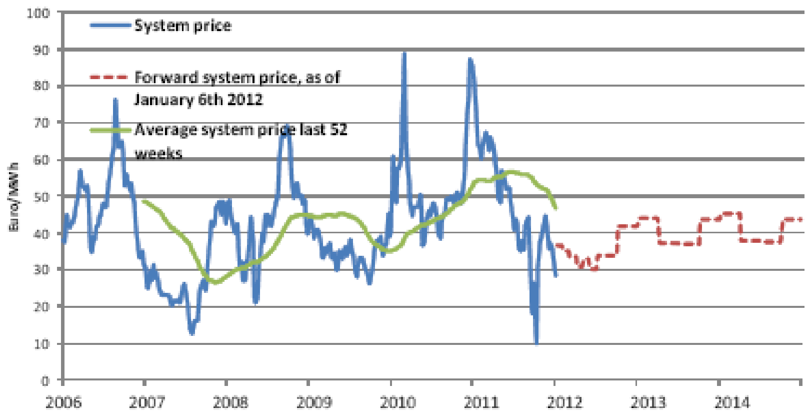
Figure 6: Graphic Representation of Price Formation in the Nord Pool Spot Market



On the Nord Pool Spot, all agents who submit purchase bids at prices equal to or exceeding the equilibrium price may buy that quantity of electricity at the equilibrium price. Players who submit purchase bids below the equilibrium price may not buy any electricity (EMIR, 2006). Likewise, all market agents who submit sales bids at a price equal to or lower than the equilibrium price may then sell the offered quantity at the market clearing price. Thus market agents who submit sales bids above the market clearing price may not succeed. Hence all available electricity production competes at the same level.

Price formation in the Nord Pool Spot is complex due to a variety of other factors. Historical prices can be explained by fundamental factors, such as weather patterns, capacity developments, the EU ETS, economic activity and fuel prices. For instance, there is a strong correlation between annual rainfall levels and electricity prices. Sharp price increases correlate well with dry seasons and thus lower hydropower production in Norway and/or Sweden. Likewise, very cold winters can also raise demand and thus prices. Technical problems (e.g. in nuclear reactors) can take place in cold or dry seasons and also trigger high prices. Conversely, low electricity prices correlate well with high rainfall levels and also lower economic activity during the global financial crisis and the Euro crisis. Figure 7 shows the development and fluctuations of the Nordic wholesale electricity system price in recent years.

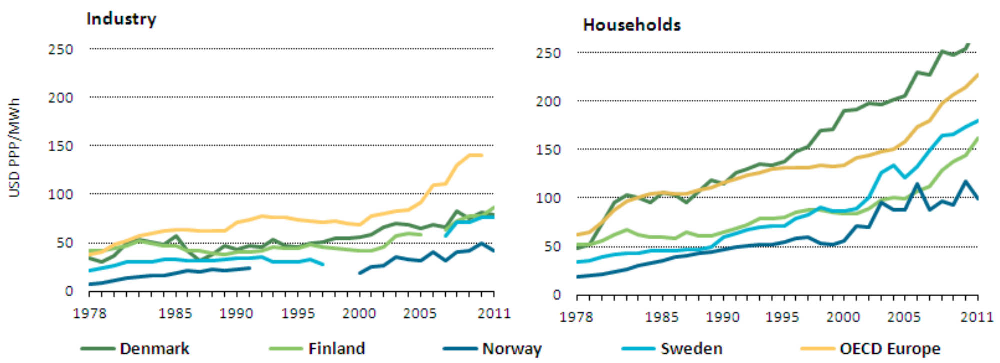
Figure 7: Development of the Weekly System Price and Forward Price at Nord Pool Spot (2006-2014)



Source: NordREG (2012a).

There was a common Nordic price (i.e. system price) for 26.2 % of hours in 2011 (i.e. a situation with no transmission congestion) and 18.6 % of the time in 2010. Sweden and Finland faced a common system price for 74% of the hours in 2011. Although retail electricity prices vary among Nordic countries (e.g. due to energy taxes or VAT), prices in the Nordic region (with the exception of Denmark) have been historically below OECD averages for both residential and industrial consumers.

Figure 8: Electricity Prices in the Nordic Region (1978 - 2011)



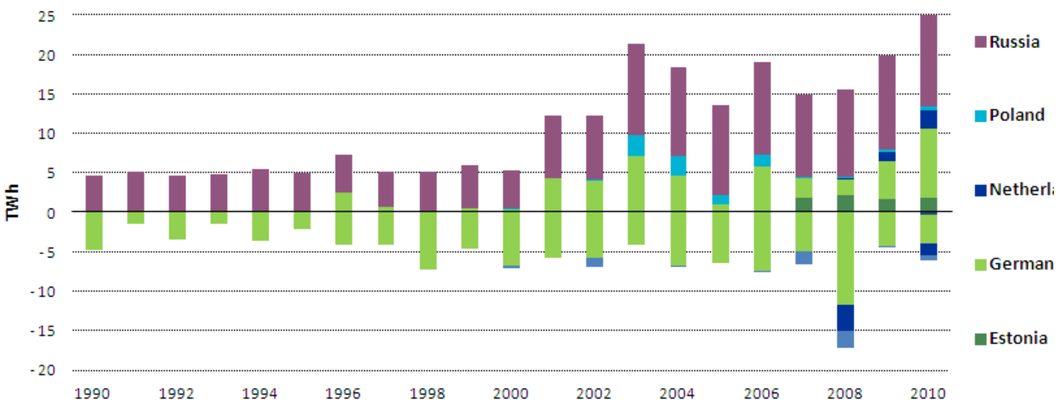
Data source: NER & IEA (2013).

4.4. Electricity Trading among Nordic Countries and European Power Markets

The liberalization and integration of national Nordic power markets, including the abolition of border tariffs, has increased cross-border trading since 1990. Whether the country is a net exporter or importer of power depends heavily on hydro inflows in Norway and Sweden and also on other climate conditions, especially temperatures (NER & IEA, 2013). Whereas Norway, Sweden and Denmark are sometimes net importers in a given year, they can also be net exporters in the next (Nord Pool Spot, 2013a). Conversely, Finland has been a net importer most years, buying electrical power mainly from Russia.

Average export from Denmark has been 1.75 TWh and from Norway 3.85 TWh (NER & IEA, 2013; Nord Pool Spot, 2013a) since 2000. Over the same period, Finland imported 10.89 TWh and Sweden 1.66 TWh. Russia and Germany are now much more integrated with Nordic countries (see Figure 9). The Nord Pool Spot trades with Central and Eastern Europe, including Germany, Russia and the Netherlands (NER & IEA, 2013; Nord Pool Spot, 2013a). Figure 9 shows the volume of trade has grown gradually since 2000. 2010 was a particularly dry for hydropower in Norway and Sweden, and three Nordic countries were net electricity importers: Denmark from Germany; Finland from Estonia and Russia and finally Norway from Russia (Nord Pool Spot, 2013a). Sweden was a net exporter to Poland but it also required power from Germany (Nord Pool Spot, 2013a).

Figure 39: Power Trading Outside the Nordic Region 1990 – 2010 (in TWh)



Data source: NER & IEA (2013) and Nord Pool Spot (2013a). Note that positive numbers depict imports and negative numbers exports.

The expansion of transmission capacity between the Nordic region and Central Europe will play a crucial role (see section 2.2.). Nordic energy organizations in the region agree that several European countries are using flexible generation from the Nordic region to complement variable renewable electricity capacity deployment (see e.g. NER & IEA, 2013; NordREG, 2012a). See section 6.

5. Nordic Power Market and Renewable Energy Development

This section provides a brief analysis of the deployment of RET in relation to the integrated Nordic power market. We had a lack of empirical evidence and could only collect anecdotal information on this issue.

5.1. Information Asymmetries, Transparency

The Nord Pool Spot power exchange plays a dual role as trading platform and information database for market agents. Nordic market agents and renewable energy producers have a good opinion of the role of the Nord Pool Spot in this respect. Interviewees agree that the Nord Pool Spot serves a very important function by providing price information. In addition, rules and procedures in the integrated power system ensure that both expected and unexpected situations affecting the market are properly and immediately reported online by the Nord Pool Spot (Bye, 2007). Quality information flows have been critical to assuring a well-functioning power exchange market (Srivastava, Kamalasadan, Patel, Sankar, & Al-Olimat, 2011). Renewable and non-renewable producers, sellers, traders and brokers are evenly informed of market developments to ensure fair access to information. This also includes transmission capacity considerations such as availability and constraints (Svenska Kraftnät, 2012).

There is strong consensus that high quality information and market data resolution influences the integration of RET. This is supported by Amundsen and Bergman (2006), who found that the Nord Pool Spot market rules maximise transparency because they are rigorous on the provision of information to all market agents. Thus data on the operation of nuclear power plants or levels of hydro stocks must not be withheld (Amundsen and Bergman, 2006). This is consistent with Srivastava, *et al.* (2011). Transparency applies to everyone regardless of their size or generation capacity, and this is critical for unconventional RET players to avoid bad contracts due to limited price information.

In the last couple of years, RET owners have become better informed, not least because of green certificates, but also the low costs of electricity. In the integrated power market, RET producers do not need a customer base since they can sell electricity directly on the Nord Pool Spot. Its data are mostly used by electricity traders on behalf of small-scale RET owners, as they cannot act alone in the market for different reasons (see next section). Information on bilateral contracts (common among unconventional RET producers and power buyers) is not publicly available. However, ELSPOT (the system price) is commonly used as a benchmark for such contracts.

We found that RET investors are more interested in getting a very clear understanding of the rules and regulatory framework associated with RET policies than with power trading. They want a simple, clear operational and regulatory RET policy framework. They find the level of information on how transmission grids are economically regulated at the macro level easy to follow. For instance, Nordic countries regulate network companies by setting revenue caps. In addition, the goals of the regulatory framework are very similar (see section 3.2). However, RE producers have difficulties understanding Nordic economic regulations for transmission grids e.g. decisions and assessments about rate-of-return when setting revenue caps (cf. NordREG, 2011a).

Nordic authorities with links to the power market (e.g. regulators, TSO, competition bodies, financial inspectorates) have agreements to share confidential information and best practice about their respective energy markets. This information exchange also increases transparency and competition on the market (Flatabo *et al*, 2003; Nordic Competition Authorities, 2007). For instance, NordREG includes all Nordic energy regulators. Its mission is to promote legal and institutional conditions needed for the Nordic electricity market development and integration with the rest of Europe. NordREG works and cooperates in four areas: dialogue on competition regulation, analysis of energy markets, development of technical information, and decisions on common action and policy measures. Public consultations are also carried out by NordREG.[33]

The level of high quality information and related exchange in the Nordic region aims to overcome one of the key challenges of economic regulation: that the regulator does not know in advance the true level of (efficient) production, costs and price formation on the market (NordREG, 2011a).

5.2. Market Power/Concentration and Liquidity

There is consensus that the Nordic power market has promoted a competitive market structure (Srivastava *et al.*, 2011). Despite medium-to-high market concentration (Bye, 2007; EMIR, 2006; Flatabo *et al.*, 2003), levels shown by the Nordic power market have not been distressing (Bye, 2007; Hjalmarsson, 2000). We found that the degree of market concentration/power depends on the level of integration of the four national power markets. This heavily depends on transmission capacities and institutional barriers to trade (cf. Amundsen and Bergman, 2006; Tennbakk, 2000). The potential for exercising market power therefore increases due to transmission bottlenecks in the Nordic region (Bye, 2007; Purjasoki, 2006; Srivastava *et al*, 2011).

Before market liberalization, one could easily identify a dominant agent with a market share of 50% or more, such as Vattenfall in Sweden. Market liberalization and integration was therefore one key strategy to overcome this market concentration (Skytte, 1999). For instance, the abolition of border tariffs and adoption of a transmission pricing system independent of distance considerably expanded the overall market. Market power exercised by national champions (one per Nordic country) was reduced automatically (Amundsen & Bergman, 2006). In addition to this, market liberalization also helped unbundle the production and transmission of vertically integrated companies. This in turn reduced their potential for exercising market power. Interviews with officers from the Norwegian and Swedish competition authorities (Konkurransetilsynet and Konkurrensverket respectively) reveal that when the Nordic electricity market is actually integrated by minimising or abolishing transmission constraints, market concentration is low.

[33] For further information visit https://www.nordicenergyregulators.org/

Now liberalization and integration are in place, several indicators can be used to resolve the level of market power. First, price equalization (i.e. system price) is used as a proxy for the existence of any company exercising market power. The higher the market integration, the less companies can influence the wholesale price. In 2001, the Nordic market was fully integrated 52% of the time (Bye & Hope, 2005). Statistics from 2011 show there has been complete price equalization 25-74% of the time (on an annual basis), and only marginal price differences appear the rest of the time (NordREG, 2012a). These figures can be compared to 2005, in which price equalization occurred 30-60% of the time and minor price differences the rest of the time (Amundsen & Bergman, 2006). The Swedish and Finnish markets have been completely integrated most of the time since 2003. When looking at the interaction with EU power markets, prices have been gradually brought in line since 2000, especially between Germany and the Nord Pool Spot area (NER & IEA, 2013).

Secondly, market share in terms of generation capacity can be used to approximate levels of market concentration. In 2003, the four main Nordic power producers had high market shares nationally - 19-47% (see

Table 44). However, from an integrated market perspective, their market shares were lower: 8-17%. The combined Nordic market share of these companies was below 50% in 2003. The figures reveal that when the Nordic power market is taken as a single market, the combined market share of the main power producers decreases - from 48% in 2003 to nearly 40% in 2011. Analysts conclude that neither Vattenfall nor other major power companies together dominate the Nordic market (Bye, 2007; NordREG, 2012a).

Table 4: Market Shares of Nordic Power Producers

Power producer (country)	**National market share (2003)[2]**	**Nordic market share (2003)[2]**	**Nordic market share (2011)[3]**
Fortum (Finland)	29%	14%	5.2%
Statkraft (Norway)	27%	9%	11.3%
Vattenfall (Sweden)	47%	17%	16.9%
E.On Sweden[1] (Sweden)	19%	8%	6.7%
	TOTAL	48%	40.1%

Note: [1] former Sydkraft
[2] Data source: Swedish Energy Agency
[3] Data source: NordREG (2012a)

The Herfindahl–Hirschman Index (HHI), indicates market concentration and is often used in economic regulation assessments (Rhoades, 1993). Figures for the Nordic market for 2012 reveal high-to-medium concentrated wholesale markets. Only Norway shows low market concentration (HHI index < 1000) but Denmark, Finland and Sweden show relatively high market concentration (HHI index = 2000 approx - NordREG, 2012a). However, these figures take into account transmission bottlenecks, which mean the time the Nordic power market has to be split in different bidding areas. Nordic energy regulators stress that high market concentration can damage market competition, but power generation is a very capital-intensive business which naturally leads to concentrated markets (NordREG, 2012a). Again, Nordic authorities stress that transmission constraints are critical to a fully integrated Nordic market and reduce market concentration (Purjasoki, 2006). For instance, before a transmission link started up between western and eastern Denmark, market concentration in western Denmark was considered a problem (Bye, 2007). This is no longer the case (see also section 2.2.)

Further unbundling of production and transmission can also reduce existing levels of market power (Bye, 2007). The risks of market concentration should never be overlooked (cf. EMIR, 2006). In addition, more transmission capacity reduces the risk of market power from transmission congestion (Srivastava *et al.*, 2011). Finally, it is argued that authorities should reject mergers and/or acquisitions that increase corporate market share (e.g. Bye, 2007).

There is agreement that the market has performed well in terms of liquidity, notwithstanding market concentration considerations (cf. Bye & Hope, 2005). The Nord Pool Spot has played a large part in this.

To increase liquidity, we found that small-scale RES-E producers tend to use traders (e.g. ENEAS, BIXIA) to sell their electricity (including green certificates and to some extent certificates of origin). Interviewees agree that minor players often cannot act on their own in the market and tend to operate through larger organizations. This is explained by their relatively insufficient market knowledge (compared to large producers), high balancing responsibility costs and insufficient volumes for portfolio management. Indeed increasing power production volumes and achieving economies of scale when selling (by reducing transaction costs) was a common trading strategy for unconventional RE producers. This was also stressed by the RET organizations (SREA, SWPA) and traders interviewed. It was further confirmed when interviewing a small-scale hydro investor. To that end, small-scale Swedish RET organizations have negotiated a general agreement on price-setting clarity for their members. Members greatly appreciate this, according to the SREA. Swedish interviewees note that similar contracts are common in other Nordic countries.

5.3. Barriers to Entry

Regardless of generation technology, concerns have been expressed about complexity and fairness in transmission capacity management and down-regulation by TSOs (see section 4.2). This relates to trans-border transmission capacities used to solve domestic capacity constraints (Bye, 2007). Some producers feel limiting trans-border trading because of domestic capacity constraints and different price areas is unfair (see details in next section).

Nordic countries have all opted for the rTPA to access the transmission and distribution network. This is acknowledged as a better option to encourage a competitive power market than a regulatory approach in which third-party access is negotiated (Amundsen and Bergman, 2006; NordREG, 2011a). Since border tariffs were abolished to encourage market integration, experts agree that the only barrier in this respect is the actual transmission capacity of the interconnected grid for trading among Nordic countries (Amundsen and Bergman, 2006; NordREG, 2012a; Srivastava *et al*, 2011). Transmission tariffs all are all similar across the Nordic area and independent of geographical distances between trading partners (Amundsen and Bergman, 2006). However, different tariff values can emerge depending on specific calculations used at the national level. The threshold effect is often a major problem for small-scale RET plants. This means any power plant requiring access to a grid with no capacity has to pay the whole cost of capacity investment (to strengthen grid capacity) as well as extra capacity not used by the plant. The Swedish TSO has proposed solutions for this, including cost calculation changes and TSO risk acceptance (Svenska Kraftnät, 2009). The Swedish wind energy associations have lobbied to change the rules. The Swedish National Audit Office recently found that different lead times and practices in Swedish regions create major differences in the time it takes to undertake grid investments (Swedish National Audit Office, 2013).

Our sources strongly indicated that FITs are the most effective policy instruments for overcoming financial barriers and uncertainties. They agree that RET is capital-intensive and requires support mechanisms and long-term policy goals. Our interviewees credit the role of FITs (as opposed to green certificates) in providing greater financial certainty over time. Cost barrier reduction and guaranteed grid access are key benefits recognized in the Nordic region and Germany for making RET financially viable.

The literature often cites restricted site availability and environmental regulations (e.g. environmental impact assessments) as local barriers, especially for unconventional RE producers (Söderholm, *et al.*, 2007). Our survey found that restricted site availability and environmental regulations can prevent small-scale RET investments, especially in wind and hydro. Interviewees and survey results reveal that small-scale hydro is more difficult than wind energy because it is subject to the same kinds of demands as large-scale hydro. This came through in our interview with the small-scale hydro investor, especially in terms of inefficient administrative processes for environmental permits, but much less for the concession process. Planning and permitting are also considered potential barriers to entry in Sweden, where municipalities must agree to the configuration of wind farms at a certain location in order to give the go-ahead (Pettersson *et al.*, 2010). Small-scale wind energy producers have complained that local planning processes often give high priority to local impacts (e.g. visual interference) and much less to wind conditions and low grid connection costs (Pettersson *et al.*, 2010; Söderholm *et al.*, 2007). While they have local planning power in the area, they should recognize that some places have been identified by the Energy Agency as areas of national interest for wind power production. Swedish municipalities have a high level of independence and this sometimes creates conflicts with national land planning guidelines. A recent Swedish evaluation revealed significant variations in planning permission lead times in different Swedish regions (Swedish National Audit Office, 2013).

Sweden is not like Denmark or Norway, where the planning system is much more vertically integrated and gives greater scope for the local adoption of national wind power policy (Pettersson *et al.*, 2010). However, social acceptability is sometimes also mentioned as a barrier to entry. Local acceptance is critical to both offshore and onshore wind energy (NER & IEA, 2013). We found that getting social acceptance can be difficult and that municipalities have the right to veto installations (EMIR, 2006). However local government and energy companies can provide information and consult regularly with communities on potential environmental impacts reducing the risk of community rejection (McCormick and Kåberger, 2005).

5.4. Transmission Bottlenecks and Balance Resources

RE power producers, especially small-scale and also independent power producers, do not welcome transmission bottlenecks. Interviewees remarked that the market concentration rises when transmission capacity constraints prevent integration. If transmission capacity is adequate, the system price prevails in all Nordic countries and full market integration is met. When there is lack of transmission capacity, cross-border trade is blocked and area prices arise (the system price disappears). Countertrade then emerges and costs are covered by a grid tariff increase.

When transmission constraints split the market, price areas are viewed as an efficient means for regulating it (NordREG, 2011a). In our case, RE power producers can confront two situations depending on their geographical location or spatial markets. On the one hand, RE power producers benefit financially by raising the sales price in the deficit area. On the other, RE power producers in the surplus area sell at a lower price. Each country has different views of transmission access. For instance the Swedish and Norwegian electricity systems have been evolving more hierarchically, especially in relation to wind power. It is claimed that national power boards (Vattenfall and Statkraft) have exercised important control over the transmission grid. These are lesser concerns in Norway because hydropower dams are more widely distributed (Pettersson, *et al.*, 2010). Conversely, Danish electricity has been organized bottom-up with cooperative organizations (wind farm owners) and municipalities owning distribution utilities and power stations (Pettersson, *et al*, 2010). Simplified grid connection administrative measures have played a very positive role (NER and IEA, 2013).

Connection to the main grid from the point of source seems much more important to RE producers than the expansion of the transmission network in itself. For instance, the distinctive grid connection of Nordic offshore wind farms (where technical potential is very large) at present consists of turbines connected along radial feeders brought together at an offshore substation. This is followed by offshore and onshore voltage transformation. However, it is argued that this solution is no longer suitable for large and distant offshore wind farms due to excessive power loss and need for expensive reactive power-compensating equipment (NER & IEA, 2013). Beyond a certain power and distance, it is agreed that high-voltage direct current technology is the most suitable option (NER & IEA, 2013). Certainly, there is always a need for onshore transmission capacity to convey power to demand hubs let alone transmission capacity from offshore wind farm to land.

EU countries diverge significantly when it comes to strengthening grid infrastructure or building and connecting RET plants, especially in relation to national RET policies, grid features and national environmental protection and biodiversity rules. Practices for conducting stakeholder dialogue and environmental impact assessments and lead times for obtaining permits also differ. There may also be national and regional differences (e.g. on grid fees). Often, grid owners and power producers have legal disputes over appropriate and fair fees for a) connecting new power plants to the grid and b) regular fees paid to the grid owner.

The high concentration of wind energy and small-scale CHP plants in western Denmark has created problems in the grid. For instance, surplus power production combined with transmission bottlenecks in neighbouring countries have often distorted market prices (Lund and Münster, 2006; NEPP, 2011a). Since 2010, however, variable wind energy production has been better balanced with hydropower mostly from Norway. A new transmission link between eastern and western Denmark has improved the situation. This has added a technical facility for also balancing wind with Swedish hydropower (see below). In addition, there are ongoing efforts to find more reliable and cost-effective flexible regulation (e.g. including CHP units in balance regulation, investment in heat pumps and heat storage capacity) in order to avoid production surplus losses and to better exploit international power trade (Lund and Münster, 2006; NEPP, 2011a).

Our research reveals that the availability of balancing power from hydro within the energy system is very important for integrating RET into the power market. The literature also stresses that the Nordic power system does not lack balancing resources (NEPP, 2011a). Nonetheless, there are certain limitations to using hydropower as a balancing resource. These include court decisions setting limits for lower and upper reservoir levels, and unpredictable conditions like hydro inflow and wind (NEPP, 2011a). Intermittent power source development and the potential phase-out of some nuclear capacity mean the integrated market can also serve important functions for regulating net flows in the future.

Interviewees indicated that an efficient and flexible transmission grid is of prime importance for hydropower to facilitate the effective decarbonisation of the European power system (cf. NER and IEA, 2013). Nordic hydropower is likely to be progressively more valuable for regulating the North European power system. Another 11 transmission projects (double the number of transmission lines available at present) are required to enable grid interconnections with central Europe and Russia and among Nordic countries (NER and IEA, 2013; NordREG, 2012a).

One of the interviewees argued that mainland Europe is more affected by increased wind power on the grid than Scandinavia (e.g. Germany with its large production fluctuations is much more vulnerable than Sweden and Norway who have limited wind and solar and major hydro capacity). This means more backup power than usual is required when more wind power is installed but the wind is not blowing. With present low electricity prices, there is a clear risk that producers will scrap balancing power capacity or not invest in new backup power. In order to avoid this, preliminary discussions are under way within the Nord Pool Spot and among other market players to set up a new, complementary market for balancing power. This would also create incentives for investing in backup power.

5.5. Price Volatility/Uncertainty

Deregulation opens up a more competitive market, which can benefit end-users with lower prices. Price risks and uncertainty in the wholesale market may slow

RET investment. High returns are often needed to make RET investments profitable, but higher profits may be heavily associated with higher risks. When price fluctuations became large and unexpected (e.g. with seasonal variations, as observed in the Nordic region), they can create uncertain or negative long-term financial conditions for RET (e.g. affecting balance of payments).

Our interviews and survey reveal that price volatility is sometimes considered a problem for RE power producers, especially in Sweden and Norway. They rely on TGC schemes to support RET, with certificates also subject to market fluctuations. However, interviewees also stressed that increased electricity prices after market integration positively affected RET deployment. Interviewees agree that RET deployment has much more to do with: *i*) supportive policy instruments *ii*) RET price development and *iii*) capital costs affecting investments than with the integrated power market.

According to market regulators and energy authorities, price creation in the Nord Pool Spot is efficient (EMIR, 2006). Even when the power system is exposed to dry/cold seasons, the power market exchange works well in terms of economic efficiency and market functionality (cf. Bye and Hope, 2005; Proietti, 2012). However, this does not mean that price volatility is not a challenge for RE power producers. The literature presents different views on this problem:

- Bask and Widerberg (2009) found that electricity prices became less volatile over time. This was the case when the Nordic power market was enlarged (due to further integration) and thus the level of competition improved. This suggests that the gradual integration of the Nordic power market is less sensitive to price shocks than before. Further Nordic power market integration has been beneficial to reduce price volatility and provide more confidence to RE power producers.

- The relationship between spot and future prices has also been analysed. Even with price volatility, Botterud, *et al.* (2010) found future prices tend to be higher than spot prices. This is important for two reasons. Firstly, some small-scale RE power producers do also trade in futures (e.g. via bilateral contracts). Secondly, the relationship between spot and future prices is partially explained by the hydro inflow. Thirdly, balancing capacity from hydro is critical for market performance and system operation. Bach (2009) also found weak correlations between wind power and (volatile) spot prices. It is thought that variable production from wind power (negatively) influences spot prices, which in turn deters wind power integration. The author finds this not to be the case for Denmark and Germany. One of our interviewees agreed, saying: "The more wind we have on the trading market, the less volatility". However due consideration must be given to transmission capacity and balancing power. Whereas price volatility is not a problem, it can hinder confidence among wind energy market players (Bach, 2009).

- Price peaks in the Nordic wholesale power market did take place during the winter of 2009-2010 (see fFigure 7). According to Nordic Energy Regulators (2011b) various drivers behind price peaks were identified. Firstly, it was a very cold winter. Secondly, the availability of Swedish nuclear power was low. Third, the methodology for allocating transmission capacity lacked flexibility. The resulting low transmission capacity availability towards areas with scarce production resources also contributed to the price peaks. The authorities concluded that the tools, conditions and network utilization needed improvement (NordREG, 2011b).

- Hellström *et al.* (2012) also analyse possible electricity price peak drivers. The authors found that market structure plays a significant role in whether price shocks in demand and supply translate into price peaks. The market structure in terms of capacity constraints is fundamental. For instance, after Finland joined the Nord Pool Spot, the intersection of supply and demand was closer to the capacity constraint in the market. Price jumps were more likely to take place. The situation changed when Denmark joined the Nord Pool Spot, as the intersection between demand and supply moved away from the aggregated capacity constraints (Hellström *et al.*, 2012).

Our survey and interviews strongly suggest that FITs are powerful financial mechanisms to counteract price volatility. They provide the financial certainty that spot markets cannot always provide (Fouquet and Johansson, 2008b; Lipp, 2007). Interviewees also agreed that long term contracts (with futures) are greatly preferable for small scale RET. Futures are less volatile and, according to Botterud *et al* (2010), tend to be higher than spot prices. Stakeholders also perceive that climate policies have had a positive effect on RET investments, rather the Nord Pool Spot or green certificate market. Fluctuation in certificate prices is problematic (Oikonomou and Mundaca, 2008). The Swedish-Norwegian TGC market works largely towards 31st March, the annual clearing date. Assigning a value for green certificates is very complex when there is no continuous market during the year. Permanent price signals are lacking (see section 6).

The literature, interviews and survey strongly suggest that RE policy instruments have had a much stronger influence over RET development than the Nord Pool Spot and especially as far as price volatility is concerned.

6. Key Lessons from the Integrated Nordic Power Market and RET Development

This section briefly elaborates some key lessons from the Nordic experience that may inform the ASEAN region in its first steps towards market integration. It uses new material and builds on findings from the previous section. Lessons are drawn from institutions, regulatory and policy schemes, the power market exchange and infrastructure.

6.1. Political and Institutional Considerations

Strong political support was critical in kick starting electricity market liberalization and integration (Amundsen & Bergman, 2006). Norway took the lead and others followed. Commitment towards market transformation has been very relevant. In addition, energy market integration and the deployment of RET in Nordic countries has been seen as a long-term political commitment and objective (NCM, 2009; NER & IEA, 2013). The Nordic Council of Minister has the vision of "a free and open market with efficient trade with neighbouring markets".

Nordic power market integration closely replicated or assembled steps set out in EU directives (especially in 1996 and 2003). It contained four building blocks for electricity reform: restructuring (e.g. vertical unbundling), competition and markets (e.g. wholesale market and retail competition), regulation (e.g. establishing an independent regulatory body) and ownership (e.g. allowing new/private investors). These building blocks initially aimed for better market competition and efficient production resource utilization and transmission network operation. Integrating power markets and reducing supply and demand shocks arguably showed that energy security was also a major implicit policy objective.

The Nordic experience strongly suggests that building international partnerships and organizations was crucial. For instance, the establishment of NORDEL in the early 1960s created significant conditions for the further development of an effective and harmonized Nordic power market. NORDEL was the foundation for international cooperation and information exchange in the power system and renewable electricity market. It was a significant supranational platform for advice and recommendations promoting an efficient power system in the region, taking into account the conditions in each country. The development of NordREG (Nordic Energy Regulators) has been another milestone for the region. NordREG promotes legal and institutional frameworks and conditions necessary for developing the Nordic and European electricity markets. Another example is the Nordic Working Group on Renewables within the Nordic Council of Ministers and ongoing efforts to establish a Nordic TSO. Collaboration and common purpose in engineering an integrated power market is also evident in the region (e.g. abolition of cross-border tariffs). The common TGC scheme between Norway and Sweden is another example.

Cooperation among countries is another lesson of interest for the ASEAN region. The creation and further development of the Nord Pool Spot market is a remarkable example. Dialogue in the Nordic region takes place through different channels e.g. the Policy of Regional Cooperation on Energy R&D (since 1985), or through Nordic Energy Ministers and the Action Plan for Nordic Energy Cooperation. The latter is considered to be the cornerstone of the vision for Nordic energy cooperation as adopted by Nordic energy ministers in 2004 (NER, 2005). This Action Plan was created to solve the most important and politically most relevant energy policy challenges faced by the Nordic region. The latest efforts within the Action Plan emphasise five critical issues related to the particular case of the Nordic integrated power market: *i*) support national grid investment processes *ii*) strengthen national TSOs for better grid planning *iii*) start dividing the market into additional bidding and/or price areas *iv*) harmonize balancing power rules and *v*) improve congestion and balance management practices.

Policy and research dialogue among Nordic countries on a carbon neutral energy future is increasingly channelled via NORDEN.[34] A high-level group of Nordic ministers (e.g. employment, energy, enterprise) forms the Electricity Market Group

[34] For further information see the Nordic Energy research http://www.nordicenergy.org/

(EMG), which is responsible for following up and implementing the resolutions of the Nordic Council of Ministers in this area. It is argued that each Nordic country has its own specific approach towards energy policy and related issues, but that there are various common elements of close cooperation. These include a strong focus on research and development (R&D) and carbon/energy taxation (NER & IEA, 2013).

6.2. Policy and Regulatory Issues

Early liberalization efforts in the Nordic countries were driven by domestic agendas and efforts to develop a Nordic electricity market, but later developments have been driven to a larger extent by EU policies and regulations. These aim to create an integrated EU electricity market. Despite the complexities involved, it has been possible to simultaneously develop national, regional and supraregional electricity markets once (EU and/or national) regulations and institutional cooperation (e.g. at the international level) are in place.

National electricity market reforms are often introduced to obtain a better balance between power generation capacity and demand, increase efficiency within the power industry and reduce regional differences in electricity prices. EU efforts to create an integrated electricity market have greatly stimulated competition and cut prices, and contribute to energy security. Experience from the Nordic region suggests the deregulation of the power market works well if *i*) no price regulation and constraints are imposed on financial market development and *ii*) there is continuous political support for market-based power even if electricity is in short supply and prices are high (Amundsen and Bergman, 2006). EU member states must report market surveillance practices and prices regularly to the European Commission, and this is also a strength of the EU system.

However, European electricity markets are becoming increasingly complex, as are policies affecting RET development. Not only are the rules complex, but policy-making takes place on five levels. The EU level is fundamental, as the EU has comprehensive legislation that regulates the electricity market set-up. EU rules on fair competition as well as on electricity are both relevant here.[35] At the Nordic

[35] Sweden added a fourth price area because the previous system was considered to breach EU fair competition rules. Danish players claimed the previous system breached EU treaties, as the TSO Svenska Kraftnät used its dominant position in a way that affected Danish electricity

level, individual countries have taken significant steps to harmonize electricity market developments. Plans to move towards a customer-oriented Nordic power market will require further regulatory framework harmonization. There are also ongoing efforts to harmonize Nordic RET markets and increase the cost-effectiveness of policies. One example is the joint Sweden-Norway market for green certificates. At the national level, differences in national rules may exist as long as they do not breach EU rules or cause problems in the joint electricity markets. The regional level is important too as many grid infrastructure projects require permits from regional authorities. Finally, the municipal level is important because municipalities are often local grid operators and energy company owners. In some countries municipalities can veto wind power projects.[36]

Findings and developments in the Nordic region strongly suggest that policy support mechanisms have been essential for RET deployment (NER & IEA, 2013). Power integration has further supported RET integration. The literature shows that the performance of supportive policy instruments for RET is rather case-and context-specific (EC, 2013) — see below for national experiences.

Mandatory renewable energy targets, sometimes aiming higher than EU targets, are an essential precondition for RET deployment. Nordic/European countries have used a variety of support mechanisms to deploy RET and mobilize needed finance (Fouquet and Johansson, 2008a). The internalization of negative social and environmental externalities from fossil fuels has been high on the policy agenda in recent decades (NER and IEA, 2013). In addition, strong political commitment has been necessary to minimize regulatory risk so that stakeholders can effectively plan, develop and/or adjust their investment and compliance strategies.

The experience in Denmark and Germany shows policy makers must give special attention to six key elements in the FIT regime. First, impose a priority purchase obligation. This means grid operators must be obliged to connect RE producers to the grid and transmit the power. Secondly, determine which technologies will be covered by the law. Obviously, a FIT has to be crystal clear

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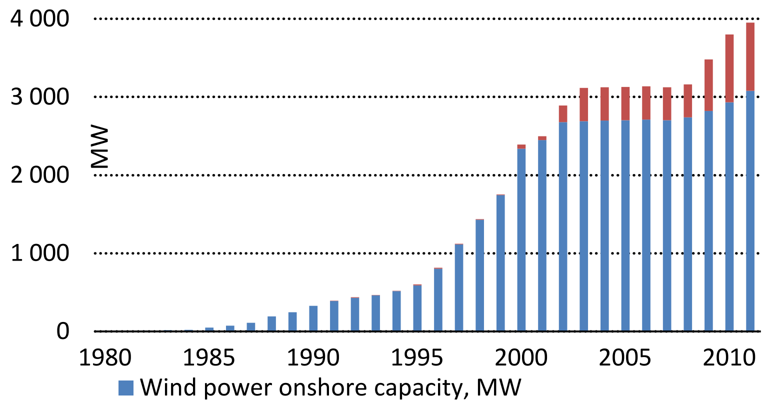
consumers unfairly. Svenska Kraftnät then proposed to introduce a new price area approved by the European Commission. The rule is current and found in Article 102 in the Treaty of the Functioning of the European Union.

[36] This is the case in Sweden; the municipal veto is stated in chapter 16 of the Environmental Code.

about this. Thirdly, set an attractive tariff rate that guarantees financial feasibility/profitability for RE generation. It must reflect the costs related to electricity production from the specific RET source/plant. Fourthly, guarantee the tariff over a specific period of time once qualified RE power producers are connected to the transmission grid. Policy makers must also establish an effective way to finance the FIT scheme[37]and also reduce the tariff rate over time. This is critical to encouraging innovation and cost reduction among RE participants.

The Danish experience of wind power generation is successful but also complex. Wind power has grown rapidly since the 1990s (see Figure). However, the FIT programme contained two distinct stages of decreased deployment rates in wind capacity. This was when the feed-in law came into force in 1992 and after the 2002 reform.

Figure 10: Installed Wind Power Capacity in Denmark (1980 – 2011)



Source: Danish Energy Agency (2012a).

The 1992 FIT law for wind power had a fixed (although not constant) price premium averaging 0.0336 – 0.0524 EUR/kWh. It was accompanied by a subsidy programme where wind power would receive a carbon tax refund of 0.013 EUR/kWh and a production incentive 0.023 EUR/kWh (Agnolucci, 2007). However, in 1991 - 1994, wind power technology deployment decreased (Danish Energy Agency, 2012a). It is argued that this investment delay was rooted in regulatory risk rather

[37] Experience shows that two options are used at present. Firstly, costs are covered by a sharing mechanism covering all electricity end-users. In Germany this option roughly equates to €1.5 per month per household. A second option is via a dedicated fund which receives financial flows, for instance, from carbon or fossil fuel taxes or a reallocation of fossil fuel subsidies

than planning constraints and tariffs (Agnolucci, 2007). It has also been attributed to increased public opposition to wind power (Danielsen, 1995) and low oil and coal prices (Valentine, 2013). But the pace of technology deployment recovered, backed up by government funded R&D and a new investment subsidy in 1994 (Valentine, 2013). This resulted in a 2086 MW rise in wind power capacity in 1995 – 2002 (Danish Energy Agency, 2012a). Critics of the FIT scheme were arguing the feed-in law was over-subsidizing and that there were problems of substandard grid interconnectivity (Valentine, 2013). The government decided to reform the FIT scheme in 2002. Instead of the previous fixed price FIT, wind generators were paid the market price (set at the Nord Pool Spot) and an environmental premium price of around 0.013 EUR/kWh. In subsequent years (2002 – 2008) the deployment of wind turbines stagnated at 271 MW of installed wind capacity (Danish Energy Agency, 2012b). In 2008 the Danish government revamped the FIT scheme yet again, introducing a balancing cost subsidy of 0.03 EUR/kWh on top of the 2002 premium price FIT of 0.013 EUR/kWh and the Nord Pool Spot price. The statistics indicate the change reinvigorated wind power investment. Another 789 MW of wind capacity was added, roughly tripling capacity increases of 2002 – 2008 in just three years (Danish Energy Agency, 2012b).

Wind power in Denmark is often associated only with the FIT scheme, but it is actually the result of a portfolio of policies. These include simplified grid connection procedures, interconnection with hydro-dominated power systems and government supported R&D connected to a strong local industry (NER & IEA, 2013).

The main expectations when the TGC scheme was introduced in Sweden were as follows: *i*) it would substantially increase the share of renewable electricity[38] *ii*) it would increase the renewables share in a cost efficient manner with low social and consumer costs, and generate an equitable distribution of costs and benefits and *iii*) it would increase the competitiveness of renewable electricity through technical change.

We found that the TGC scheme underwent significant changes in 2007. These included an increased target and time frame: to 17 TWh by 2016 (later amended to

[38] . The initial goal was to add 10 TWh of green power to the power balance by 2010. The goal was amended in two later stages, and the current objective is to add 25 TWh from 2002 to 2020. An additional objective of 26 TWh is set in relation to the joint Swedish-Norwegian scheme.

25 TWh to 2020); a shift in parties subject to quota obligation (from end-users to suppliers); new allocation periods for certificates (a maximum period of 15 years and cut-off dates were introduced for plants commissioned at the start of the scheme). The fact that the scheme was given a longer time horizon and received political backing as the main RET policy instrument had a substantial effect on market confidence. It led to an increased willingness to invest in new RET capacity (Bergek and Jacobsson, 2010; Oikonomou and Mundaca, 2008). Before the scheme was extended, some utilities postponed investments due to uncertainty. The Swedish scheme has been cost-effective (Bergek and Jacobsson, 2010; Oikonomou and Mundaca, 2008). It has successfully contributed to new wind and bioenergy installed capacity in particular, with developers given very high importance in the TGC scheme when investing in increased electricity production capacity (see Svebio, 2011).[39] Evaluations of cost-effectiveness are positive (with due consideration to transaction costs —see below), but consumer costs are higher than expected. Large rents are generated by both existing and new RET facilities i.e. windfall profits as a result of free-riding (Bergek and Jacobsson, 2010; Kåberger, *et al.*, 2004; Nilsson and Sundqvist, 2007). Transaction costs are the administrative costs electricity producers and retailers bear in handling the renewable energy quota obligation on behalf of end-users (Bergek and Jacobsson, 2010; Kåberger, *et al.*, 2004). The initial design of the Swedish TGC scheme, however, allowed electricity retailers to charge customers for the certificate-handling service they provided. A significant amount of money paid by end-users to retailers did not in fact reach RE electricity producers (Kåberger *et al.* 2004; Nilsson & Sundqvist 2007). Transaction costs associated with bilateral contracts outside the Nord Pool Spot are unknown (cf. Srivastava *et al*, 2011). It is argued that the scheme's contribution to technological innovation is poor, as it only promotes mature cost-effective RET (Bergek and Jacobsson, 2010; Kåberger *et al.*, 2004; Oikonomou and Mundaca, 2008). From 2007, investment has been directed at bioenergy and wind. The effect on solar is marginal at best. It is commonly accepted that the TGC scheme will not be a driver for new radical technologies, which require other policies.

[39] For statistics and up-to-date figures visit
http://www.ekonomifakta.se/sv/Fakta/Energi/Styrmedel/Elcertifikat/

A draft law for introducing certificates was presented in Norway in 2004, but it was heavily debated and shelved (Tudor, 2011). Norway and Sweden entered into an understanding of the development of a joint market for certificates in 2008. This was later updated and formalized through several rounds of negotiations until a common scheme was created in 2012.[40-41] Tudor (2012) argues that a joint TGC market can provide better stability through the diversified energy mix. The author also claims the system requires limited state involvement as corporations provide many of the tasks imposed by the regulatory framework. According to our interviews, the fact that clearing only takes place once a year means there is no continuous market. In addition, interviewees stressed that different circumstances may lead to suboptimal outcomes (e.g. best wind conditions are found in Norway but wind investment may still take place in Sweden because of better conditions for obtaining permits and grid access). These kinds of trade-offs (cost-effectiveness versus national policy interests) could challenge the joint scheme.

The literature suggests that national FIT schemes are preferable to TGC schemes as far as policy objectives are concerned (i.e. a stable RET investment climate, more RET deployment, better energy security, GHG emission reductions, etc.) (Fouquet and Johansson, 2008a; Kåberger *et al.*, 2004; Lipp, 2007). The fact that countries such Denmark and Germany have FIT schemes and are world leaders in RET deployment (including related job creation and industrial development) is no coincidence (Lipp, 2007).

Finally, even if Nordic countries have made progress in integrating the power market and deploying RET for power production, energy efficiency has been a key priority to transform the energy system (NER and IEA, 2013). It complements the policy efforts devoted to energy market integration and RET development.

6.3. Power Market Exchange

The Nordic experience shows that the process of market integration (or market coupling) and the development of the Nord Pool Spot have been gradual and smooth.

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[40] The target for the joint scheme between Norway and Sweden is to increase RET with 26.4 TWh between 2012 and 2020 (13.2 TWh of quota obligations in Sweden and Norway respectively), representing approximately 10 % of electricity production in the two countries.

[41] For more information about the joint scheme in English visit http://www.nve.no/en/Electricity-market/Electricity-certificates/

Norway started restructuring its power market and developed the original power market exchange platform in 1993. Sweden joined in 1996, followed by Finland in 1998 and Denmark in 2000. Power trading growth has been incremental. Market surveillance is a critical component and was established as an independent function nearly ten years after its creation. Also following an incremental EU path in power market integration, the Nord Pool Spot engaged very recently in the North West European Price Coupling (NWE) project, alongside 13 TSOs and four power market exchanges. This EU initiative will provide a new price coupling system for day-ahead power markets. It has been labelled a cornerstone for the pan-European power market, covering 75% of the EU power market.[42]

It is agreed that the Nord Pool Spot has provided a well-functioning power exchange (Amundsen and Bergman, 2006; NER and IEA, 2013; Srivastava *et al.*, 2011). As indicated in section 5, findings and interviewees revealed important and positive features, such as clear trading rules, an adequate level of transparency and efficient market-based mechanisms for handling transmission congestion. Eliminating border tariffs and putting in place a system with transmission prices independent of distance has significantly enlarged the Nordic power market. The market power of dominant generators has in turn been diluted (Amundsen and Bergman, 2006). However, market power emerging from transmission congestion, high transaction costs (in particular for small-scale RES-E producers) and tough market entry needs further improvements. The unbundling of dominant (publicly-owned) firms (Srivastava *et al*, 2011) is one contentious political area (Bye, 2007).

Nordic countries have learnt that correct price signals must be visible to market agents (Bye, 2007). Despite high wholesale prices due to, for instance, dry or very cold seasons, Bask and Widerberg (2009) show that prices have increased in stability over time. This process correlates well with the expansion of and more intense competition in the Nordic power market. Price stability and a very efficient power market are primarily dependent on hydro reservoirs (also used to balance capacity resources) across Norway and Sweden (Botterud *et al*, 2010; Proietti, 2012).

[42] For further information visit http://www.elia.be/en/projects/market-integration/nw-eur-day-ahead-marktkoppeling

It is agreed that the Nordic region has good potential to provide flexible and low-carbon power as the rest of Europe seeks to further decarbonise its electricity fuel mix (cf. Lund, 2005; Pettersson *et al.*, 2010; Srivastava *et al.*, 2011).

The Nordic experience also reveals that the wholesale market has low demand-side flexibility (NordREG, 2011b). This can in turn intensify problems due high market concentration. Arguably, real-time pricing (combined with emissions allowances) can positively promote RET market access (Kopsakangas and Svento, 2012) to correct this problem. This is consistent with claims that market efficiency improves when end-users respond to hourly price variations in markets with a great deal of wind power (Grohnheit, *et al.*, 2011). Energy regulators have also suggested that publishing area bidding curves to all market agents can promote demand flexibility (NordREG, 2011b).

There is some agreement on the importance of transmission tariff transparency, which has an impact on power trading (NordREG, 2007, 2011a; Srivastava, *et al*, 2011). Tariffs are independent of the geographical distance between trading parties. This approach adds transparency and fairness to the system. This is appreciated by unconventional RE producers according to our interviews and survey. However, different tariff values can emerge, depending on specific calculations used at the national level. The Swedish Energy Markets Inspectorate has recently proposed rules to remedy some problems associated with high tariffs. These include stricter guidelines for fee calculations, changing accounting practices and allowing national agencies to intervene more often on unfair fees and contracts (Energimarknadsinspektionen, 2013).

Another lesson from the power market exchange is the increasing cooperation and coordination across energy and competition authorities. For instance, the Nord Pool Spot established the Cross-border Regulatory Council Dialogue in 2011 to improve regulatory aspects concerning the power market exchange. This involves all the Nordic energy regulators and market surveillance authorities including Estonia. The Council was greatly needed to facilitate dialogue and information exchange on market surveillance among national regulators. In addition, there was also a need to establish this cooperation platform to support EU electricity market regulation (e.g. monitoring, transparency).

6.4. Infrastructure and Transmission

The Nordic experience suggests that legal reforms in electricity infrastructure were critical to improving transmission infrastructure and thus raising RET involvement. A high share of variable electricity generation from wind and solar has required extensive system integration in the Nordic/EU region. Nordic hydropower has become the centrepiece of the balancing resource to all nations with renewable electricity production. However, interviews revealed that grid expansion brings a number of technical, financial and social acceptance challenges. On the one hand, falling low-carbon electricity generation costs, coupled with transmission grid reinforcements, can make the Nordic countries major net exporters of electricity and increase economic efficiency (cf. Bye and Hope, 2005). This may lead to positive reactions among renewable producers as electricity prices increase. On the other hand, increased Nordic export will raise electricity prices in a region with traditionally low prices. This may trigger negative reactions among Nordic power consumers (NER and IEA, 2013).

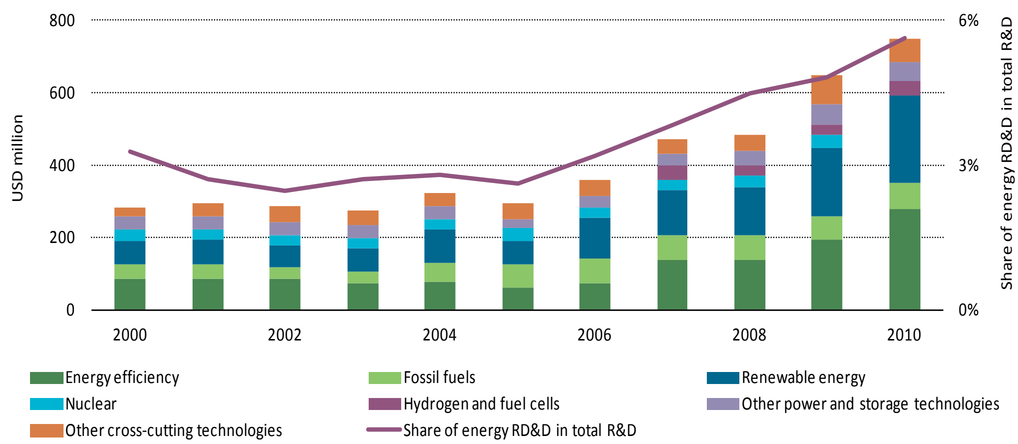
Price differences between zones incentivize the construction of new transmission capacity and avoid transmission congestion. By raising the price in the deficit area, market agents will sell more and purchase less, while in the surplus area a lower price will lead to more purchase and fewer sales (Flatabo, *et al.*, 2003; NordREG, 2007). Nevertheless, it is argued that short periods with limited capacity and very high electricity prices (e.g. caused by an unexpected nuclear reactor shutdown in winter) do not provide enough incentives to expand transmission capacity in the Nordic region (Norden and IEA, 2013). When a market is split due to transmission constraints, it is claimed price areas are an efficient means to regulate it (NordREG, 2011a). At the same time, free trade is a priority. Nonetheless, capacities are sometimes limited in the international transmission grid to secure domestic balances with equal prices between regions. This is not consistent with free trade (Bye, 2007). We found some TSOs have sometimes limited cross-border transmission capacities to secure domestic reserves. This means that a given country moves some of the costs of domestic capacity constraints to other countries by restricting international connection capacities (Bye, 2007).

Assuming that Nordic power generation is carbon neutral by 2050, wind energy generation will increase substantially from 3% in 2010 to 25% in 2050 (NER and IEA, 2013). Once again, this will increase the need for flexible generation capacity and grid interconnections, in particular to accommodate variable and discontinuous wind power production (NEPP, 2011b). Raising and strengthening transmission capacity will be critical to improve the security of RE supply.

Experience shows that a lack of balancing resources has never been a problem due to major hydro resources. However, there are increasing efforts to analyse more cost-effective and flexible regulation systems. These include CHP units in balancing wind powerfluctuations, heat pump investments and more heat storage capacity. These options could allow wind power to double its installed capacity in Denmark (Lund and Münster, 2006).

Capacity building and R&D in the Nordic/European region have been essential for new technologies. To support RET development and its integration into the power market, Nordic countries have had a policy of regional cooperation in energy R&D since 1985. National funding agencies contribute to a common fund administered by Nordic Energy Research. This supports projects involving research partners from three or more Nordic countries. Public R&D spending for RET and energy efficiency has increased substantially in the past decade (see Figure1).

Figure 11: Nordic Public R&D Spending per Energy Source (2000-2010)



Source: NER and IEA (2013)

Given the high share of renewable energy, Nordic countries are in a very good position to make the transition from fossil fuels to low carbon and support the rest of the Europe in doing so (NER and IEA, 2013). As an exporter of low-carbon power supply, transmission capacity needs to be strengthened to facilitate this role. One wind power representative stressed that this is critical for Norway, where transmission capacity is relatively poor compared to other Nordic countries but wind conditions much better. Respondents consider it very important to raise cross-border capacity investments. These alleviate bottlenecks between the physical market areas and help incorporate renewable energy sources in an integrated power market.

Nordic hydropower has become vital as a balance resource to accommodate variable and discontinuous wind power. As shown in section 2.1, the Nordic power system deals with large amounts of wind power (especially from western Denmark). This means it is often necessary to change production to maintain the second-to-second balance between production and consumption (Lund and Münster, 2006). The capacity of hydropower to go from maximum production to zero (or vice versa) quickly and predictably makes it suitable for reducing variation and maintaining electricity supply and demand balance. Hydropower can easily be controlled with a high ramp rate. North European Power Perspectives states the Nordic experience is positive: during normal conditions, hydrological constraints and court decisions allow hydropower to be used for balancing hourly variations even for large amounts of wind power.

The Nordic experience suggests there has been progress in harmonizing transmission regulation. This includes system planning and investment, congestion management and transparency. Nevertheless, there are growing calls for a common Nordic TSO (or a jointly owned and operated TSO) that will benefit and solve many harmonization challenges. Optimal grid investment is a key task for a Nordic TSO (Bye, 2007; NordREG, 2011a, 2012b).

7. Recommendations to the ASEAN Region

This section aims to provide plausible recommendations for the ASEAN initiative. Recommendations have emerged by contrasting findings and lessons from the Nordic region with the situation in the ASEAN region. Recommendations focus on market integration, policy and regulatory issues. The Economic Research Institute for ASEAN (ERIA) and experts from the region have provided critical information about energy market integration in ASEAN.

7.1. Power Market Integration

Support and develop international structures/organizations

ASEAN should consider developing an international body to design, support, implement and enforce policies and regulations to develop an integrated power market and deploy RET. It should assess whether the ASEAN Power Grid (APG) initiative, backed by ASEAN heads of state/governments, could play the role of NORDEL or NordREG, for instance. Continuous and effective political decisions are crucial for further development at this early stage of energy market integration. The need and opportunity for a regional solution should persuade ASEAN countries to find a common political agenda. A number of ASEAN initiatives could sustain long-term political dialogue. For instance (descending in order of importance): ASEAN summit meetings, ASEAN Ministers of Energy Meeting (AMEM), ASEAN Energy Regulatory Network (AERN), ASEAN Power Utilities and Authority Meetings (HAPUA), and the ASEAN Centre for Energy Initiative (ACE).

Coordinate national, regional and supraregional institutional developments

It should be possible for ASEAN countries to develop at different but gradual rates, forming submarkets (e.g. country-to-country market coupling), leading to eventual integration. This may not be the preferred path, but the Nordic/European experience shows it is possible. Coordination is essential. EU legal developments have provided a guiding regulatory framework that has harmonized the practices in various electricity markets. Attempts to create an international electricity market exchange should therefore pay considerable attention to overarching institutional frameworks.

ASEAN countries could develop an Action Plan on Energy Cooperation to encourage collaboration (see section 6.1 and NCM 2005), as in the Nordic region. The 6th ASEAN Energy Ministerial Meeting has laid foundations in this area. The plan could initially target the electricity and renewable energy market. The Economic Research Institute for ASEAN (ERIA) is in an excellent position to further support ASEAN collaboration.

Facilitate cross-border and free movement of green electricity

The Nordic experience suggests ASEAN countries may benefit from improving electricity market competition so the right incentives for renewable investments are set up. A legal framework must be developed and enforced to provide investors the assurance to invest in new renewable energy production and storage. Since the renewables market has developed from local to cross-border supply in the EU, requirements for a pan-Nordic/European trade in renewable energy is being defined on the basis of best practice. Grid infrastructure is critical to developing renewable energy technology and competitiveness with conventional technologies. Transparency, fair terms and reciprocal conditions (e.g. price mechanisms) are important to establish cross-border trade.

Ensure long-term harmonized investment plans for energy market integration

Energy security in the grid is an important building block for a combined energy market. With an increasing RET balancing resource, power availability is of major importance. As a combined energy market develops, it should be accompanied by strategic transnational investments in transmission capacity from key regulating production units to key consumption areas based on location. Authorities should ensure investment decisions allow for a time lag for construction permits. Investment costs should be shared between TSOs according to the benefit to market player.

Build strong international partnerships with neighbouring countries

Since the ASEAN region is much more diverse than the Nordic area, finding neighbouring partners will be easier during the early stage of market integration.

Existing cross-border interconnection projects between Thailand-Malaysia (Sadao-Bukit Keteri) and Thailand-Lao PDR (Roi Et2-Nam Theun 2) support this hypothesis. Common goals on poverty alleviation, energy security, energy access, investment, trade (substantially covered in bilateral/multilateral ASEAN agreements) and economic growth will significantly help ASEAN energy market integration.

Stay the course politically, provide safeguards

In 2002-2003 – when prices were very high due to lack of hydro - the political support for the market was severely tested. While the public demanded price intervention, no action was taken, especially in Norway. In some countries it may be difficult to maintain the system in the face of strong public pressure. It is probably unwise to regulate market prices in such a situation, so other safeguards can be put in place. A fund of electricity subsidies using designated revenue streams for vulnerable consumer groups is a possible solution. The mixed character of the ASEAN market means it is worth planning for such eventualities using instruments like this fund.

Gradually develop and test a trading platform

Power market integration in the ASEAN region will depend on a core power exchange market. This is a critical component in Nordic power market integration. The growing number of neighbouring ASEAN interconnection projects (more than 15 as at January 2013) provides the potential to develop and test small-scale trading platform(s) as a building block (e.g. for power market coupling). In the long run, interconnection projects across Thailand, Vietnam, Lao PDR and Cambodia (some of them to be completed in 2025) represent a great opportunity to further develop and assess an ASEAN power market exchange.

Guarantee and monitor a well functioning power market exchange

For ASEAN countries, key functions of a power market exchange should include: providing liquidity and security, accurate and high-quality information, equal access to market participants and guaranteeing all trade and delivery. A distinction also needs to be made between the physical trade in electricity and the green value of the electricity. Electricity from RET is subject to the same restrictions as conventional electricity in the Nordic/EU region; including mandatory disclosure. ASEAN regulators need the power to collect and exchange relevant information to enforce the law and enhance market performance. Market surveillance plays a critical role in giving confidence in and integrity to the market, especially to small-scale RE producers.

Harmonization across transmission power markets takes time

Transmission networks are natural monopolies, and regulation is often used to control existing market power. The regulation and management of network companies and network constraints differs, so harmonization is critical. Likewise, a clear mandate and understanding of responsibilities becomes essential. Congestion constraint management demands good coordination between system operators using common rules. Well-defined and transparent investment decision criteria need to be established that take the impact on transmission pricing and charges into account. For a supranational TSO, political agreement and ownership issues are major challenges.

Improve and adapt transmission infrastructure

RET cannot simply slot into existing market structures. Wind and solar, for instance, are fundamentally different from conventional technology sources in terms of cost structure, dispatchability and size. The ASEAN region should expect to improve electricity grid operation transmission and distribution to cope with RET integration. Adapting the electricity grid and system operation with storage capacity improvements, better system controls and forecasting techniques greatly improves the efficiency of the power infrastructure. In operation and grid development, rules for grid access, congestion management tools and cost-sharing approaches should be considered. In some European countries, renewable energy enjoys certain support in terms of grid access and use (e.g. the national TSO may pay part of the costs of grid connection or renewable energy may have primary access). In other countries, renewable energy is treated like other types of energy production in all matters relating to the grid. Each country should evaluate the pros and cons of these options.

They should consider creating a long-term ASEAN multilateral finance model/fund that aligns private and public sector investment (including regional development banks) with low-carbon infrastructure investment.

Pay attention to all relevant policy areas in order to support grid development and investment in RET

A number of policies affect the investment climate for renewable electricity production. While RET support policies are crucial, other developments, less often discussed, can be very important. There are major differences between countries and regions in the time it takes to obtain concessions and relevant permits for grid investment. This strongly influences the time it takes to resolve bottlenecks and can also influence the willingness to invest in RET in certain regions. In some countries, the threshold effect is a major barrier to RET investment. This is when a power plant that wants access to a grid with no capacity has to pay the whole cost of capacity investment (to strengthen grid capacity) and also the extra grid capacity not used by the plant. We recommend that these issues are dealt with as early as possible.

Give extensive consideration and analysis of balancing resource mechanisms

This is important already in the short-term harmonization of the integrated power markets and increased deployment of RET. More RET with intermittent energy production will affect the primary electricity system needs to regulate power on the market. This results from the complex interactions of several parameters, including the rate of RET deployment, fuel prices, transmission capacity investments, new technologies and the success of smart grid solutions. With increasing intermittency, incentives engaging market players in balance power capacity exchange are required. If market regulation does not promote energy balance, there is a risk of repeatedly underestimating production forecasts. This endangers grid security, adversely affects the hydro reservoir needed for energy-intensive seasons and affects trust between market players. In the Nordic region, limiting factors affect the balancing capacity of hydropower, such as hydrological coupling, court decisions, transmission constraints and weather uncertainty. Hydropower producers want to maximize profits rather than balance capacity, which they will only do if it is profitable.

7.2. Policy and RET Aspects

Design and implement a mix of policy mechanisms to support RET financing and deployment

Our findings strongly suggest that the development of internal electricity cannot be separated from the policy instruments supporting RET (and vice versa). ASEAN countries need to implement a mix of policy instruments to foster RET. Power market integration is not sufficient for that purpose. Options include FITs combined with a renewable portfolio standard (RPS) and complemented with GHG pricing, R&D and per-kWh tax credits, R&D and demonstration programmes, green electricity labelling and soft loans. There should be thorough evaluations. ERIA is in an excellent position to support ASEAN in this area. A multi-criteria evaluation (e.g. cost-effectiveness, economic efficiency, environmental effectiveness, distributional equity) should be applied accordingly. RE policy instruments should eliminate or correct market failures and not create or maintain market distortions. ASEAN countries should also ensure consumers are informed about the way RE policy instruments affect them. Continuous assessments are recommended once instruments are in place in order to improve their performance.

Set ambitious renewable energy targets

Mandatory RE targets are an essential precondition for RET deployment. RE targets automatically become the benchmark for evaluating the effectiveness of policy instruments. As RE electricity is a moving target addressed by multiple policy instruments, the reference scenario(s) must be periodically updated. If targets are ambitious, support policy mechanisms, non-compliance rules and effective enforcement become increasingly important. Events in the ASEAN countries suggest the region is on the right track: in 2004-2009, ASEAN met its 10% target to increase renewable electricity installed capacity. Following this policy path, the ASEAN Plan of Action for Energy Cooperation 2010-2015 - Programme Area N^{o}5 on Renewable Energy - includes a collective 15% target for renewable energy in installed power capacity by 2015. It is worth raising the bar even further. Continuous evaluation is a must.

Ensure long-term policy objectives to provide confidence in emerging RET markets

RE policy scheme design and implementation must be a long-term policy objective rather than a single dash. A secure long-term policy horizon will help market players factor the costs and benefits of RE policy instruments into their investment and commercial plans. It will also help them develop adequate marketing strategies compatible with other policy instruments and encourage technological change capable of meeting higher RE target levels. The Nordic experience shows that in the long term, the high added value of RET (including its public good) will positively affect growth and employment in ASEAN.

Develop clear but simple RE institutional frameworks

The development of the institutional framework for RE policy instruments has a direct impact on red tape. Simple but clearly defined operational and regulatory frameworks are necessary to ensure effective implementation and learning among stakeholders. A simplified, robust enforcement system can ease the burden for the authorities without compromising the integrity of any given support scheme. Additionality must prevent eligible parties from free-riding, thus only encouraging RET that would not have developed in a business-as-usual scenario. Authorities should design streamlined procedures that can counteract approval delays and help eligible parties reduce related transaction costs (e.g. fast-track or simplified modalities for small-scale RET). Standardized contracts (or at least key contractual provisions) can reduce transaction costs for legal services and perceived liability. Developing and enforcing fair and transparent investment cost-recovery mechanisms is critical.

Market surveillance, smooth legal processes and transparency are crucial

The regulators' role as market watchdog is increasingly important. Their supervision of grid operator tariffs and grid investment practices is paramount; tariffs vary greatly not just within countries but also smaller regions. Great efforts are needed to find good mechanisms for solving legal disputes over grid costs. Major players can often afford lengthy legal processes, unlike their smaller counterparts. These are at a disadvantage. Mechanisms that provide transparency will help create a fair market. Grid operators must be forced to publish tariffs and other types of information to increase transparency. The institutionalized cooperation between EU national energy regulators could also be relevant to ASEAN nations. Activism, staffing, funding and rights to intervene may differ greatly between energy regulators in different countries. This can lead to an uneven playing field, even in situations where the rules *per se* are harmonized.

Provide legal and policy flexibility

While harmonizing certain practices, the legal framework can also allow for flexibility when appropriate. The EU often allows member states to choose the means for reaching targets. Flexibility means member states can make options that suit their existing regulatory and organizational structures. Furthermore, exemptions should be possible. EU rules on unbundling through DSOs, for instance, allow the exemption of integrated electricity undertakings serving less than 100 000 connected customers or serving small isolated systems. Exemptions make sense when comparing costs and benefits. For ASEAN countries, this means a proper balance between harmonization and flexibility. Too much flexibility and too many exceptions can be a problem, but we should also avoid too much harmonization, leading to higher costs etc. A clearing house can keep market players updated on the dynamics of policy instruments and regulatory frameworks.

Develop clear and enforceable non-compliance regulatory frameworks

The Nordic/EU experience strongly suggests that RE policy instruments rely on non-compliance rules and effective enforcement. For instance, penalties for non-compliance in the form of ceiling prices act as penalties for non-compliance in tradable green certificates. The logic is that they must be high enough to act as a deterrent to non-compliance with individual RE quotas. RE target-hitting relies on enforcement mechanisms alongside specific penalties for non-compliance, legal regulations and effective M&V approaches. Non-compliance must not pay.

Price mechanisms must send correct signals to market actors

Electricity prices in Nordic countries fully reflect the true social and private costs of power production and consumption. Without efficient price signals, policy objectives and targets will be more costly to meet. In a well-functioning competitive power market, the price must give efficient signals to any market player for generation, investment and consumption decisions. This guarantees competitive prices for the benefit of the end-user. With due consideration for energy poverty, ASEAN countries should consider eliminating fossil fuel subsidies or grant justified equivalent subsidies to renewable energy. Price signals caused by transmission system bottlenecks should contribute to incentives for efficient investment both in the production and transmission grid.

Develop local/national capacity for RET transitions

Any policy and political effort will depend on local human knowledge and expertise. ASEAN development of local/national capacity will require feedback, flexibility and the support of RE strategies and policy instruments. At micro level, capacity development should be an integrated process of change in knowledge, practices, norms and skills across institutions. It is necessary to create and/or strengthen local capacities for the design, manufacture, distribution, maintenance and repair of RET. RE resource assessments should be the starting point for countries that have not evaluated their potential. National or regional RE data collection programmes should be put in place, identifying appropriate sites for private investment (e.g. wind, small-scale hydro). Demonstration projects indicate the feasibility of renewable electricity projects, especially in areas where they have not been implemented. They could be directly linked to a concrete RE financing project, allowing developers and local host entities to learn directly from them. Careful technical planning, baseline and monitoring methodologies are essential. Nordic cooperation and technology transfer could play an important role in supporting local/national capacity development in ASEAN countries.

8. Conclusions

The Nordic/Europe experience demonstrates that decisive policy support mechanisms, especially to overcome cost barriers, have been an essential platform for renewable energy development. The gradual integration and transformation of electricity markets has further strengthened RET incorporation into the Nordic power market.

The objective of Nordic market liberalization was to lay better foundations for competition and encourage the most efficient use of production resources and operation of transmission networks. It was quickly followed by Nordic power market integration. The establishment of the Nord Pool Spot, the Nordic electricity exchange, was a significant milestone in market integration. The liberalization and integration of the Nordic power market was in many ways ahead of Europe.

National electricity market reforms have aimed to obtain a better balance between power generation capacity and power demand, increase efficiency within the power industry and reduce regional differences in electricity prices. Early liberalization efforts in Nordic countries were driven by domestic agendas and the efforts to develop a Nordic electricity market. Later, EU policies and regulations to integrate the electricity market predominated. The system is complex. However, European countries have been able to develop at a different pace. This was possible due to a regulatory framework that lays foundations for integrated markets yet allows some flexibility for national regulators and the emergence of regional markets. This is exemplified by the Nord Pool Spot.

The Nord Pool Spot shows it is also possible to set up a functioning electricity market when participating countries have a good energy mix, diverse RET policies and different kinds of ownership of production. It has laid the foundations for a well-functioning power exchange, smooth interaction with other European power markets and an adequate level of information and transparency.

There have been robust efforts to create an integrated, interconnected and competitive Nordic power market, the heart of which is RET and green electricity. Nordic countries have put in place aggressive renewable energy policies as well as transposing EU power market integration legislation to support RET for power and heat production. Ambitious targets, long-term policy objectives and strong political commitment have also played a significant role. There is limited knowledge of the historical interplay between power market integration and Nordic RET deployment. However, findings suggest FITs combined with a quota system (RPS) are the most effective support mechanisms for RET deployment. They have to be supported by R&D, simplified grid connection and major hydro balance resources. This has greatly helped overcome cost barriers, reduce power system disturbance and increase the economic and technical feasibility of deploying RET. Carbon pricing (as an indirect policy mechanism) and GHG emissions reduction targets also improve the RET policy framework and investment climate.

We have identified many lessons from the Nordic/European experience that can further help integrate RET into the power market in the ASEAN region. The Nordic experience suggests ASEAN countries need strong political commitment, policy cooperation, international partnerships and a supranational or interregional organization. To develop a fully integrated, effective cross-border power market with a large share of renewable electricity production, policy making must be directed at five distinct levels: supranational, regional, national, provincial and local. Regulatory frameworks and institutions for cross-national cooperation are only one part of the story. Quite often, long lead times, red tape and unfair tariffs at the provincial and local level raise major barriers to investment and grid strengthening. Market surveillance and transparency rules are therefore key elements of a successful regulated energy market.

The Nordic experience strongly suggests the design, evaluation and implementation of aggressive renewable energy policies is very significant for deploying and integrating RET. Long-term policy objectives and targets have provided confidence and certainty in (emerging) RET markets. Ex-ante and ex-post policy evaluations have also supported the process and informed policy. ASEAN countries should also note the importance of market surveillance, smooth legal processes and transparency. Eliminating border tariffs and introducing transmission prices independent of distance significantly helped enlarge the Nordic power market. Policy makers should also prioritize energy efficiency.

Integrating and coupling different national power markets was a gradual and incremental process. There is good cause to believe that ASEAN energy market integration will follow a similar path. Power market integration and the ensuing market exchange have promoted competitive market structures and market-based management tools for handling transmission congestion. Market surveillance is a critical component and functions independently. It is possible to simultaneously develop national, regional and supraregional electricity markets despite the complexities involved if the regulations are well thought through and institutional cooperation in place. The price must give efficient signals to any market player for generation, investment and consumption decisions if the market is to function successfully. These guarantee competitive prices for the end-user.

The Nordic experience suggests legal electricity infrastructure reforms are needed to improve transmission infrastructure for RET involvement. Wind and solar, for instance, have intrinsically different characteristics from conventional technology in terms of cost structure, dispatchability and size. RET cannot merely slot into existing unadjusted market structures. RET grid access is fundamental. A priority purchase obligation via FIT schemes can greatly ensure this process. Adapting the electricity grid and system operation, including storage capacity improvements, better system controls and forecasting techniques (e.g. wind, hydro) greatly improve the efficiency of the present power infrastructure. While Nordic hydropower has become a core balancing resource to any countries deploying RE electricity production, different options in the ASEAN region should be continuously analysed. The development of local/national capacity to support RET market transformation is essential.

Finally, the process of power market integration in the Nordic/European region has been gradual. However, that is no reason to delay the design, evaluation and implementation of aggressive policy instruments to promote RETs in the ASEAN region. RET markets need time to develop and mature and the sooner the process starts, the better. Energy integration policy efforts in themselves are not enough to drive and effectively support the deployment of RETs.

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