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The role of electricity price in competitiveness of the manufacturing industry in liberalised electricity markets: the case of NordPool

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Supervisors: Prof. Urmas Varblane (PhD), University of Tartu, Estonia

Prof. Torstein Arne Bye (PhD), Norwegian University of Life Sciences, Norway & Director of Statistical Bureau of Norway

Opponents: Prof. Einar Hope (PhD), Norwegian Business School, Norway

Märt Ots (PhD), Head of Estonian Competition Authority

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LIST OF ABBREVIATIONS

CHP	Combined heat and power plant
CO_2	Carbon dioxide
Comtrade	Trade statistics database of the United Nations
DK	Denmark
DSO	Distribution system operator
EC	European Commission
EE	Estonia
EEA	European Economic Area
Electricity cost	The cost of using electricity as production input
Electricity expenditure	Total payments for electricity use by a consumer
Electricity price	The price which consumers pay for electricity[1]
EU	European Union
EU-ETS	European Union's emissions trading scheme
EUR / €	European euro
Eurostat	Statistical Bureau of the European Union
FI	Finland
GDP	Gross domestic product
GW	Gigawatt
GWh	Gigawatt-hour
HS	Harmonized Commodity Description and Coding System
IPP	Independent power producer
kVA	Kilo-volt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelised cost of electricity
LPG	Liquefied petroleum gas
LRMC	Long run marginal costs
LV	Latvia
LT	Lithuania
MVA	Mega-volt-ampere
MW	Megawatt
MWh	Megawatt-hour
NACE	General industrial classification of economic activities used within the European Union (this dissertation uses NACE rev.2 classification[2])

[1] Total price of electricity = price of supplied electricity + grid fees + taxes, ref. section 1.1.2.
[2] NACE rev.2 is a revision of NACE rev.1 in 2007, considering technological updates and structural changes in the economies. For more information, see http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC

NACE #16[3]	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
NACE #17	Manufacture of paper and paper products
NACE #20	Manufacture of chemicals and chemical products
NACE #23	Manufacture of other non-metallic mineral products other than rubber and plastics
NACE #24	Manufacture of basic metals
NO	Norway
O&M	Operation and maintenance
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares regression
PSO	Public service obligation
PV	Photovoltaic
RES	Renewable energy sources
SE	Sweden
SITC	Standard International Trade Classification
SRMC	Short run marginal costs
SSB	Statistical Bureau of Norway
TSO	Transmission system operator
UN	United Nations
USD	United States dollar
VAT	Value added tax
WTO	World Trade Organisation

[3] For a full list of NACE rev.2 categories for the manufacturing industry, see Appendix 1

LIST OF AUTHOR'S PUBLICATIONS

Articles in international journals

1. **Pikk, P., Viiding, M.** (2013) «Dangers of Marginal Cost Based Electricity Pricing», *Baltic Journal of Economics*, Volume 13, Issue 1, pp 49–62.

2. **Viiding, M., Kallemets, K., Pikk, P.** (2013) «Electricity Cost as a Driver of Competitiveness in Northern Europe: the Case of Estonia», *Transition Studies Review*, Volume 19, Issue 3, pp 367–381.

3. **Viiding, M., Joller, L.** (2012) «Energy Intensity in Northern Europe's Economic Development: Curse or Bless?» *Discussions on Estonian Economic Policy*, Volume 20, Issue 2, pp 306–318.

4. **Kleesmaa, J., Viiding, M., Latõsov, E.** (2011) «Implications for Competitiveness of Estonian Carbon-Intensive Industry Post-2013», *Baltic Journal of Economics*, Volume 11, Issue 2, pp 41–58.

Presentations in conferences

1. **Viiding, M.** «Turbinprising sett i lys av sertifikatmarked og globale trender». *Presentation at Norwea's annual meeting*, Gamle Logen, Oslo, Norway, 30 March 2011.

2. **Viiding, M.** «Dangers of Marginal Cost Based Electricity Pricing», *Presentation at 4th International Conference «Economic challenges in enlarged Europe»*, Tallinn, Estonia, 17 – 19 June 2012

3. **Viiding, M.** «Energy Intensity in Northern Europe's Economic Development: Curse or Bless?» *Presentation at conference «Economic policy in the EU member countries – year 2012»*, Värska, Estonia, 28–30 June 2012.

4. **Viiding, M.** «Har vindkraft fremtiden i Norge?» *Presentation at Norsk Hydro*, Lysaker, Norway, 3 December 2015

INTRODUCTION

Motivation for the research

Recent decades have witnessed large-scale deregulation, leading to breakdown of trade barriers and competition at global level. Freedom of movement of goods, people and capital have become the pillars of the European Union (EU), thus converging much of the costs across EU member countries. For several goods and commodities, prices are set globally, thus any firm from any country can compete at global market terms.

Market liberalisation and exponentially increased trade levels have led to increased focus on drivers of competitiveness – on firm, industry and country level. Particularly from the point-of-view of countries, it has become more important to consider the underlying drivers of what makes a given country an attractive location for firms to set up business and produce innovative goods and services that can be exported abroad, and accordingly growth of industries.

Liberalisation has also reached the electricity sector: whereas electricity is a unique commodity with no direct substitutes (except for lighting and heating)[4], electricity markets have moved from being closed and regulated to liberalised and open to competition. Motivated by the aim to lower socio-economic costs and offer customers choice, many countries have disintegrated vertically connected state-owned utilities; an increasing number of power plants are privately owned; rapid technological changes in generation have redefined principles for installation of new electricity supply; and investments in new transmission lines and regional interconnectors mean that electricity can flow to longer distances. Consequently, electricity has become an international commodity that can be traded across borders; and this has affected its price. Therefore, electricity pricing has become one of the instruments for shaping firms', industries' and countries' competitiveness.

In economies where the cost of electricity generation is low, electricity-intensive manufacturing industries have developed. In line with factor abundance theory, such industries might be significant exporters since access to low-cost electricity would be a source of relative competitive advantage.

In regulated electricity markets, governments usually directly control how much consumers pay for electricity through state-owned vertically integrated utilities that often have monopoly. In liberalised electricity markets governments no longer control the entire electricity supply chain, which leads to changing

[4] On some occasions, electricity can be replaced by liquid fuels as a source of lighting. Use of electricity for heating is generally not considered to be optimal and in several countries it is more common to use other sources such as burning of waste, coal, gas etc. Increasingly, electricity and heat are generated at the same time in co-generation plants.

priorities in energy policy-making as an instrument of competitiveness. Electricity demand and supply (and consequently price of supply) are formulated in free markets. The price of electricity transport (i.e. payments to grid operators) is still regulated, but often so that it is more transparent. Thus, fostering a thriving business environment through market organisation and regulation takes centre stage in government activities. Given electricity's uniqueness, electricity markets exhibit several market imperfections. Setting up large-scale electricity generation is capital-intensive, which sets barriers to entry. Coming from government-controlled status quo, most liberalised electricity markets also have incumbent generators with a large market share, i.e. significant market concentration. Infrastructure has been historically developed to connect large-scale producers with consumption centres and capital intensity of new infrastructure development stipulates that extending the network to new producers takes time, leading to capacity constraints. Not least, electricity markets also have positive and negative externalities: recent trends in subsidised renewable electricity generation have increased generation capacity, thus lowering prices; whereas expansion of power production capacity over the last decades has been subject to increasing environmental costs. Hence, the ultimate means of regulation for governments in liberalised electricity markets is taxation[5], which impacts the total price paid for electricity. Accordingly, the total price paid for electricity remains different across countries despite market liberalisation[6].

Although companies' payments for electricity often make up around 2–3% of total costs[7], a number of industries exist where electricity costs[8] have a considerably higher share: in metal processing, pulp & paper manufacturing and several chemical manufacturing industries electricity costs can reach up to 10–20% of total costs; in aluminium smelting the cost share can be higher still[9]. Thus price paid for electricity as a production input factor may have a noteworthy influence on the competitiveness of several firms and industries, and thereby affect competitiveness of countries if these industries play an important role in a country's economy (cf. factor abundance theory).

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[5] In some countries, both electricity generators and electricity end-users are taxed. Taxation of generators is ignored in this dissertation, given the focus on competitiveness of the manufacturing industry as electricity end-users.

[6] See sections 1.1.2 and 1.1.3 for a more detailed discussion on changes from liberalisation of electricity markets.

[7] It should be reminded that a profit-maximising agent will strive to minimise all cost components in order to compete effectively, including cost components that make up only 2–3% of total.

[8] See List of Abbreviations for definitions of electricity cost, electricity price and electricity expenditure.

[9] See section 2.3.2 for a comparative overview.

Academic research into competitiveness of firms and countries dates back several decades, with Porter (1985) as one of the earlier attempts to establish a framework on what drives competitiveness. Numerous literature on various aspects of competitiveness has followed on firm, industry and country level, see e.g. Barney (1991), Waheeduzzaman & Ryans (1996), Ambastha & Momaya (2004), Rugman et al (2012). Abundant academic literature also exists on the importance of electricity costs and electricity pricing – both in theoretical and empirical studies. See e.g. Green & Newberry (1992), Hattori & Tsutsui (2004), Bye & Holmøy (2010), Friedman (2011), Roozbehani et al (2010) – to name a few. Several authors have particularly researched implications from electricity market liberalisation: see e.g. Steiner (2001), Nagayama (2007, 2009), Erdogdu (2011, 2014) etc. There are much fewer studies examining changes in firm, industry or country competitiveness from changes in energy policy (or aspects of it) although e.g. Barker & Johnstone (1998), Graichen et al (2008), Burinskiene & Rudzkis (2010) and Daugbjerg & Svendsen (2011) have explored a number of aspects within this topic. To the author's knowledge no studies directly link aspects of electricity pricing to firm and industry-level competitiveness and examine this relationship – constituting a research gap.

In an effort to help close the research gap, this dissertation analyses how electricity prices affect the competitiveness of the manufacturing industries in the NordPool member countries (Denmark, Finland, Norway, Sweden, Estonia, Latvia and Lithuania)[10]. Five reasons justify this choice: (1) the total price of electricity in the region is below European average – potentially a source for relative competitive advantage; (2) the manufacturing sector has an important role in the economies of all seven countries; (3) NordPool consists of a heterogeneous group of seven member countries, with members that liberalised their electricity markets 10–20 years ago, and also members that have only recently liberalised their electricity markets; (4) NordPool is one of the World's first regional power exchanges: it has been operational for more than 20 years and all its members use it for daily electricity trading; and (5) all 7 countries in the region have relatively small domestic markets (Estonia being the smallest with a population of 1.3 million and Sweden being the largest with a population of 9.6 million[11]) so international trade and competitiveness of firms/industries is important.

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[10] Denmark, Finland, Norway and Sweden are commonly referred to as Nordic countries. Estonia, Latvia and Lithuania are usually referred to as the Baltic countries. Throughout this dissertation these seven Nordic and Baltic countries are together referred to as Northern and Northeastern Europe. Iceland is also called a Nordic country, but is not a member of NordPool due to its geographical remoteness – and is hence excluded from further analysis in this dissertation.

[11] For proof, see datatable «demo_gind» in Eurostat.

(1) Compared to their counterparts elsewhere in Europe the Nordic and Baltic industrial users pay a lower price per kWh electricity consumed[12]; several electricity-intensive industries have developed in these countries[13].

(2) Choice of the manufacturing sector as the focus of research and empirical studies is reasoned by the fact that in 6 of the 7 countries manufacturing accounts for around 25% of total value added in the national economies[14].

(3) Norway deregulated its electricity market already in 1991 and is widely regarded as one of the pioneering countries in electricity market liberalisation, together with England and Wales (see e.g. Erdogou, 2011). Sweden followed suit a few years later, with Finland and Denmark also having fully liberalised electricity markets for more than 15 years. The three Baltic countries liberalised their electricity markets only a few years ago, with Estonia first (in 2010), Lithuania following and Latvia last to liberalise. As such, the region comprises of countries that have a long history of operating with a liberalised electricity market and countries that are rather new to it.

(4) The regional power exchange NordPool has its roots in launching of a Norwegian intra-day and inter-day electricity exchange «Statnett Marked» in 1993. The exchange was renamed «NordPool» when Sweden joined in 1996. Over time other neighbouring countries joined; today NordPool hosts most trading of electricity in and between Norway, Denmark, Sweden, Finland, Estonia, Latvia and Lithuania[15].

(5) Denmark, Finland, Norway and Sweden are often highlighted as a very well integrated Nordic community with closely shared norms and values besides virtually non-existent cross-border business barriers. This has resulted in significant cross-border trade, although in several industries the countries are also competing with each other at global markets. The Baltic countries (Estonia, Latvia and Lithuania) are likewise similar to each other as they are small in size, have similar GDP levels and similar economic structure; economies of all three also used to be part of a much larger value chain in the Soviet Union with their industries and electricity sectors tuned accordingly. The Baltic countries also cross-trade actively with each other; in addition the Nordic countries are the Baltics' significant trade partners[16]. Yet there is also significant rivalry among the Baltic countries that have similar industry sturcture.

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[12] For proof, see datatable «nrg_pc_205» in Eurostat.

[13] This is further shown in section 3.1.1 and 3.1.2

[14] For an elaboration on this, see section 2.3.1

[15] For more information on history and present-day status quo of NordPool and its member countries, see http://www.nordpoolspot.com

[16] For proof, see datatable «DS-016890» in Eurostat

Aim and research tasks

The aim of this dissertation is to **assess the role of electricity price as a driver of competitiveness of the manufacturing industry in liberalised electricity markets**, using the case of 7 NordPool member countries in Northern and Northeastern Europe (i.e. Denmark, Finland, Norway, Sweden, Estonia, Latvia and Lithuania).

In order to reach the aim the following research tasks have been set up:

1. Highlight differences for electricity price setting in regulated markets and liberalised electricity markets.
2. Discuss how firms, industries and countries achieve and maintain competitiveness, and how to measure it.
3. Synthesise a framework on how electricity pricing affects competitiveness of industries in countries with liberalised electricity markets and develop a set of research propositions for empirical testing.
4. Classify and identify electricity-intensive industries in the 7 NordPool member countries.
5. Provide an overview of electricity pricing and historical price developments in the 7 NordPool member countries.
6. Test the research propositions and if necessary update the framework using empirical data from 7 NordPool member countries.
7. Synthesise general recommendations for economic policy-making towards electricity-intensive industries through theoretical argumentation and empirical analysis.

Intended contribution of this dissertation

The dissertation contributes to the academic literature in at least three ways:

1. First and foremost, the dissertation presents a framework on how price of electricity influences firms' and industries' competitiveness in liberalised electricity markets. Using electricity as one of firm's many input factors, it is shown how the firm's production function depends on the price paid for electricity and how this ultimately affects firm and industry-level performance – and competitiveness.
2. This dissertation shows that price paid for electricity – as seen from the perspective of the industrial end-user – comprises of three different components: the price paid for electricity supply; the price paid for electricity transport (i.e. grid fees); and a product of payable taxes and receivable subsidies. The dissertation offers a detailed analysis of these components and shows how they influence firm and industry-level

competitiveness differently in regulated vs liberalised markets. Specifically, it is shown how the taxation component becomes an important energy policy tool for the governments in liberalised electricity markets.

3. The dissertation identifies suitable means of measuring changes in competitiveness of electricity-intensive industries by reviewing various competitiveness measures in general and in the context of electricity use in particular.

Additionally, the dissertation provides novelty through empirical analysis in at least four different ways:

1. Currently no comparative overview exists on the prices paid for electricity by different manufacturing industries in the 7 NordPool countries, as data is reported on consolidated levels (at best, industry-level data across countries is publicly available for all energy payments, of which electricity is only a part; or industry-level electricity payments are available for selected countries only). By combining different data sources, this dissertation provides a more detailed comparison of total prices of electricity in each industry in the seven countries.
2. There is no commonly agreed list for electricity-intensive industries in the European Union nor across the Nordic and Baltic countries. This dissertation discusses various means to measure electricity-intensity and identifies the electricity-intensive industries for the 7 NordPool countries.
3. Data on price paid for electricity is incomplete in publicly available sources due to differing views on whether certain taxes (e.g. renewable energy support fees) should be seen as taxes for electricity consumption. A fully comparable overview of all electricity price components along with the total price of electricity for different industrial consumers across the 7 Nordic and Baltic countries is developed in this dissertation.
4. No comprehensive ex-post study exists on the impact of electricity market liberalisation on firm performance across different industries in different countries with different backgrounds. The dissertation observes changes in price of electricity and analyses changes in output from the electricity-intensive industries, discussing to what extent changes in the former have impacted changes in the latter in the liberalised electricity markets of the 7 NordPool countries.

In several countries, there is ongoing discussion about the appropriate means of taxing and/or subsidising use of electricity as a production input factor. Such discussions are persistent also within NordPool countries: cf. the debate in Norway and Sweden whether installation of solar panels should entitle manufacturers for tax exemption[17], the debate in Estonia about whether electricity taxation should be linked to investments[18], the debate about whether decreasing the very high electricity taxes in Denmark could boost the country's development[19] etc. These discussions underline the actuality of one of the key topics in this dissertation: the role of electricity taxes in liberalised electricity markets. Therefore, findings in this dissertation have a high applied value for energy policy-making.

In discussing the links between electricity pricing and competitiveness, one can delve into a variety of theories and considerations. It therefore also needs to be emphasised that this dissertation is deliberately not addressing the following:

- This dissertation is not discussing individual firm strategies within the same industry within the same country. It is acknowledged that firms compete with each other at all levels, including intra-industry. In this dissertation, firm-level competitiveness drivers are generalised to industry level. This is because of lack of firm-level data for empirical studies – and thus intra-industry developments are unknown.
- This dissertation is not addressing competition of different manufacturing industries within the same country, nor assessing structural changes within the countries. Indeed, all manufacturing industries within a country can be to a certain degree seen as competing with each other – for access to capital, labour, materials, energy etc. Whereas it is shown in this dissertation that in some countries the more electricity-intensive industries benefit from more favourable electricity prices than other manufacturing industries within these countries, the impact of such benefits is in this dissertation compared for the same industries across the seven countries. This is because of limited time-series of data: only 6 years of consecutive information is available, covering the period 2008–2013[20]. Hence, rather than analysing long-term structural changes within the economies, this dissertation examines changes in inter-country competition and inter-country competitiveness of industries, assuming path dependency of development of the various industries in the countries.

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[17] See e.g. http://www.europower.com/no/article272564.ece

[18] See e.g. http://www.wec-estonia.ee/documents/89/Kisel_Riigikogus_04_05_2016.pdf

[19] See e.g. http://www.google.ee/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0ahUKEwiYmfiQkb3QAhUDiywKHXqmAu0QFggrMAI&url=http%3A%2F%2Fwww.ecocouncil.dk%2Fdocuments%2Ftemasider%2F1599-140829taxes-and-competitiveness-december-2013&usg=AFQjCNGaHzm3-Qv3OLER2_fMVojnVfrF_Q

[20] Industry-level payments for energy across the seven countries are only to be found in structural business statistics collected and reported by Eurostat. Earliest available data is from 2008; and new data is published with close to a three-year delay.

- This dissertation is not discussing appropriate legal solutions for governments to assist firms and/or industries in becoming and staying competitive – e.g. principles of state aid, compliance with EU directives, WTO rules, etc. Discussing this is in fact a separate topic of research. The dissertation points out what steps different countries have taken for their different industries and compares results.
- This dissertation does not aim to define suitable levels of taxation of electricity use. This is due to both limited time-series of data, as well as the fact that NordPool comprises of very different countries with different backgrounds (industry profiles, consumption patterns etc). Ultimately, each country is to set their own taxes; this dissertation examines what different governments have done.
- This dissertation is not aiming to establish a one and only framework on how electricity pricing impacts firm and industry competitiveness – not least because of the undefined and complex scope of what competitiveness stands for, as further shown in section 1.2.1. It is acknowledged that several frameworks may exist in parallel, i.e. there may be and likely is more than one way of interpreting the interlinkages. In this dissertation, it is shown how electricity has been priced for different industries in different countries and how this has affected a set of indicators which represent changes in industry level performance.

Structure of the dissertation

The starting point of this dissertation is explanation of specificity of electricity as a good/commodity. Participants in the electricity supply chain are introduced: different types of electricity generators, the electricity transmission and distribution networks, and end-users. Given the research question and aim, only industrial end-users are further examined in this dissertation (i.e. residential and public sector electricity users are ignored). Next, formulation of electricity price is discussed, at first in regulated markets and thereafter differences in liberalised electricity markets are highlighted. Three different components of the electricity price – i.e. price of supply, price of transport, and taxes – are discussed separately to better highlight differences between regulated and liberalised electricity markets. A literature review of various empirical studies on different outcomes from electricity market liberalisation concludes chapter 1.1.

On a parallel track, the concept of competitiveness is discussed in chapter 1.2, showing how it has evolved from earliest trade theories into a separate field of research. It is shown that no universally agreed definition exists for competitiveness; the author defines competitiveness in the context of this dissertation as a means of fostering development of firms and industries that can sustainably compete internationally and thereby create welfare to the society over long-term. Next, means for becoming and staying competitive are reviewed, along with a conclusion for the role of governments and role of firms in the pursuit for competitiveness. Finally, chapter 1.2 ends with a section that discusses how competitiveness should be measured. Both quantitative and qualitative means of measurement are reviewed, concluding that in the context of this dissertation quantitative measures are best. Specifically, most appropriate methods to measure changes in competitiveness in the context of electricity pricing are reviewed, and suitable measures for reaching this dissertation's aim are pinpointed.

The importance of electricity pricing in the pursuit for competitiveness is synthesised in chapter 1.3. The role of governments in electricity price setting as a means of creating and sustaining competitiveness is discussed, along with necessary steps in addressing possible market failures and firms' response to government activities. A set of research propositions are set up for empirical testing in the process of developing a holistic framework.

Chapter 2.1 elaborates on appropriate means of analysis and data sources. Both preliminary descriptive analysis through plotting of data and econometric analysis are discussed, with presentation of the methodology for data analysis. Different types of data sources and variables are discussed and reasoning is provided for relying mostly on just one source – Eurostat. Finally, in chapter 2.2 this dissertation's focus on the manufacturing sector is justified and electricity-intensive industries in the 7 NordPool countries are identified.

In chapter 3.1, introduction is given to the country profiles of the 7 NordPool members, including electricity supply and demand levels, primary sources of supply, interconnectivity to neighbouring countries, and general energy intensity levels. Next, importance of electricity in different industries is shown, and most electricity-intensive industries in the 7 NordPool members are compared to each other. Afterwards, an overview of historical electricity price levels in the 7 NordPool countries is provided. It is discussed how these have been impacted by country governments with focus on electricity taxation levels, and tax exemptions to selected industries (as governments' most important levers for shaping competitiveness in liberalised electricity markets).

In chapter 3.2 preliminary descriptive analysis as well as econometric analysis is conducted to analyse correlation between electricity prices and chosen competitiveness indicators of the electricity-intensive industries in the 7 NordPool member countries. The tests aim to verify research propositions and validate the constructed framework on importance of electricity pricing in the pursuit for competitiveness of firms and industries.

Finally, a discussion of results concludes the dissertation. The research aim and research tasks are revisited to conclude on results. Limitations are pointed out, and areas of future research are suggested. The below figure provides a visual summary of this dissertation.

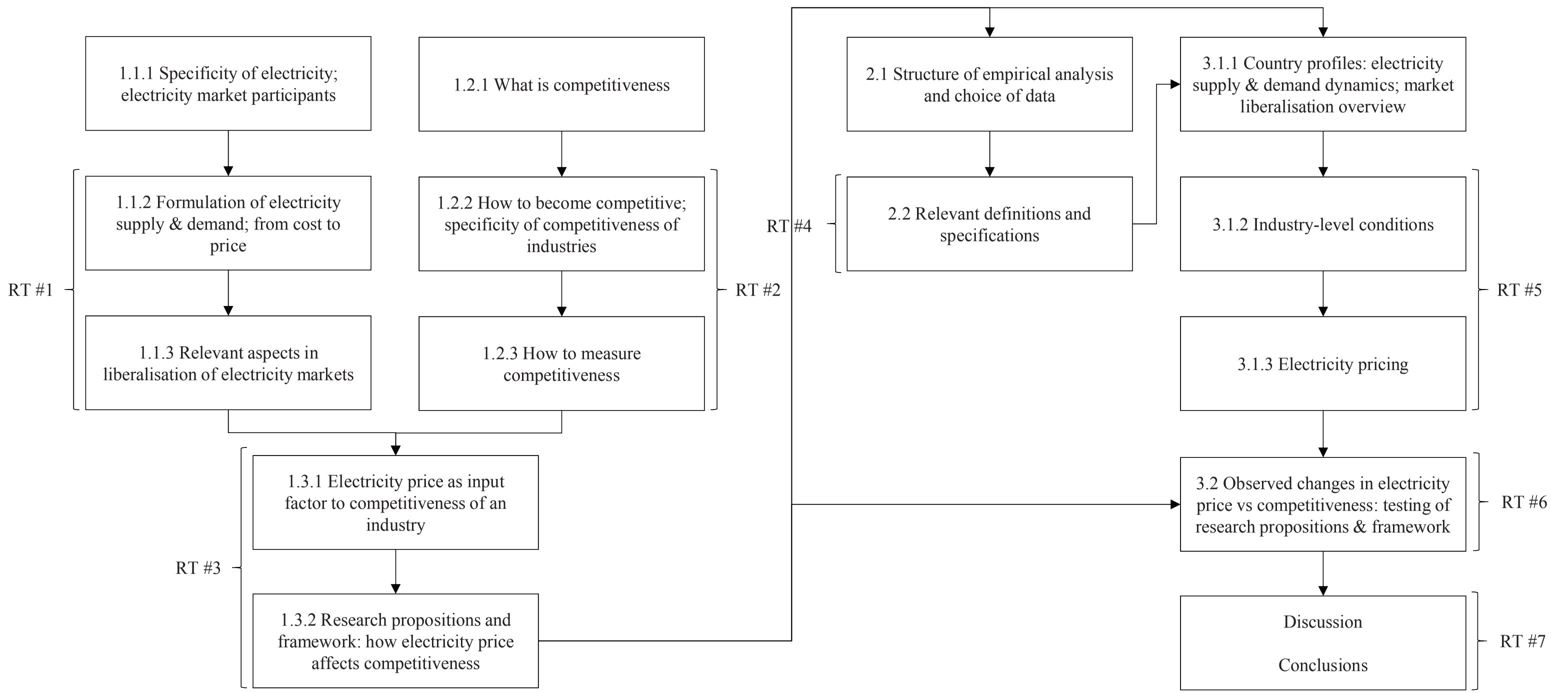

Figure 1. Structure of this dissertation, showing where each of the 7 research tasks («RT») is addressed.

Acknowledgement

First and foremost, I wish to thank Prof Maaja Vadi for encouraging me to take up PhD studies. The PhD programme has been very rewarding in terms of both academic as well as social aspects, and it has enriched my life significantly.

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In parallel to PhD studies, I have worked full-time at Multiconsult, a Norwegian energy engineering consultancy. I particularly wish to thank Mr Jan Olav Øderud for having invited me to Multiconsult and for having found a scheme where I can both work and study at the same time; and Mr Tom Edin Ødegaard for approving and supporting this. I also owe my gratitude to Mr Ryan Glenn Anderson, Mrs Julia Viola Obrovac and Mr Tore Eliassen for having continued this scheme after Mr Øderud's departure from Multiconsult. Special thanks goes to my colleague Dr Andrew Yager for his review of this dissertation and comments both with regards to the topic as well as English grammar.

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1. THEORETICAL VIEWS ON THE ROLE OF ELECTRICITY PRICE IN COMPETITIVENESS

1.1. Electricity pricing in liberalised electricity markets

Starting point of this dissertation is description of electricity as a unique commodity and introduction of electricity market participants. Section 1.1.2 discusses electricity supply and demand; and consequently components and formation of electricity price. Finally, section 1.1.3 discusses previous research on the impact of market liberalisation to electricity prices.

1.1.1. Specificity of electricity and the electricity market

Scientists first started studying electric charge in the 17th century, but it was not until early 20th century that first electric devices appeared (Encyclopædia Britannica 2016). Ever since, rapid developments in research and development have led to a present-day situation in which almost everything depends on electricity. In fact it has become such a normal part of everyday life and self-evident that it is only noticed when missing (Timpe et al 2002 through Ringel 2003). Electricity occupies a unique place in contemporary economy: most modern domestic appliances and several industrial technologies run only on electricity; electricity is also the primary source for lighting. Except for heating, substitution with oil, gas and liquefied petroleum gas (LPG) is limited and even if such substitution is possible, it comes with opportunity costs[21] as oil, gas and LPG can be used for several other purposes, such as transport, chemical manufacturing etc. In modern homes, few activities are possible without electricity; most services and manufacturing industries cannot function without it. Thus the specialty of electricity does not lie so much in electricity as a commodity itself rather than the fact that it can be used to produce millions of goods and services. Haas et al (2008) go as far as to view a country's GDP as a sum of direct and indirect energy services, arguing that virtually all activities comprise of some form of embedded energy. Hence, economic welfare depends directly on the availability of (affordable) access to energy services (Haas et al 2008: 4012), including electricity.

OECD statistics show that whereas primary energy supply grew at an average annual rate of 2.2% from 1971 to 2010, electricity generation grew 60% faster (at a rate of 3.7%) over the same period (OECD 2013). This means that electricity is used as primary source of energy for more activities than ever before.

[21] Such opportunity costs are also included in the commodity's price: e.g. use of oil to generate electricity has become a costly alternative.

The specificity of electricity stipulates that after generation, it needs to be transformed, transported and distributed before it can be consumed. Figure 2 visualises physical electricity flow[22] from generation to consumption; the following paragraphs discuss the individual components.

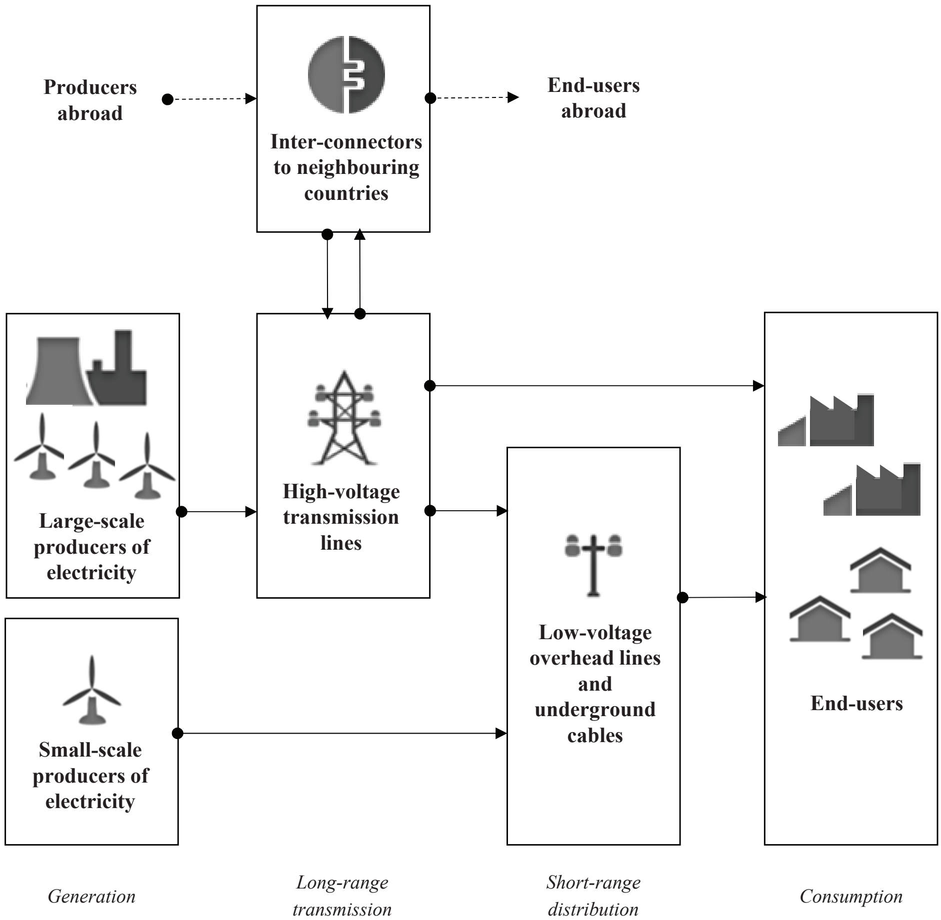

Figure 2. Simplified overview of physical electricity flow. Source: Elektrilevi (2014), further modified by the author.

[22] The (physical) supply chain of electricity is somewhat different from the (monetary) value chain of electricity: end-users buy their electricity from retailers, who buy from generators in a wholesale market such as the NordPool exchange. A few large-scale end-users also buy directly from the wholesale market or directly from generators. Electricity retailing is a commercial activity that is similar to most other forms of retailing and hence not the focus of this dissertation. Accordingly, this chapter only discusses market participants from the point of view of physical electricity flow.

Electricity generation

Electricity needs to be generated from primary sources of energy. These are various sources of crude energy that have not been converted or transformed (United Nations 1997). Historically, electricity has been primarily generated from coal and/or lignite; but also from oil and natural gas. From mid 20th-century nuclear power has additionally been used for large-scale electricity generation. All of the above mentioned generation technologies use non-renewable fuel which usually needs to be mined on a continuous basis (although nuclear fuel rods have a long lifetime and thus nuclear power plants do not require a constant intake of fuel). In addition, multiple renewable electricity generation technologies exist, with electricity generation from hydropower as more than a century-old technology. Since late 20th-century also wind, solar power and burning of biomass have increasingly gained ground as renewable sources of electricity generation.

Historically and in several countries also at present day (especially in countries with regulated electricity systems[23]), electricity generation was/is a government-owned (or heavily government-regulated[24]) activity. In several countries governments have taken steps to liberalise electricity markets, with the first step usually being opening of electricity generation for competition to private investors. Consequently, it is increasingly common to see both private and public, domestic and foreign-owned companies setting up new generation capacity or acquiring existing generation capacity[25]. Introduction of new renewable technologies – that are relatively less complex to install and operate than conventional technologies (e.g. wind or solar plants as opposed to a nuclear plant) – has further contributed to increased competition from the private sector[26]. The basics of electricity generation – as discussed below – are the same regardless of whether it

[23] In this dissertation, regulated electricity systems are defined as nation-wide systems where government-appointed regulator sets prices and the country's electricity system has no interconnectors to neighbouring countries.

[24] Throughout this dissertation, various public institutions – including but not limited to government ministries, various public departments and the market regulator – are commonly referred to as «the government», even though strictly speaking, the government usually denotes a cabinet of ministers.

[25] Acquiring established companies is generally more attractive, as they have strategically important supply points and sufficient grid capacity (Stankova et al 2010) so especially new renewable technologies often face a high entry barrier due to distant grid connection and/or need for grid strengthening. In fact market shares of the largest generators in the electricity market have not significantly decreased for majority of the EU countries from 1999 to 2009 (Moreno et al 2012) and in some countries smaller producers have exited as only larger market actors can remain profitable (Burinskiene & Rudzkis 2010).

[26] An increasing share of owners of such new-technology power plants is made up by institutional investors that are motivated by a relatively straight-forward business model and predictable cash flows; and rely on professional management to run the plant.

is publicly owned or privately owned; the rationale for and implications of market liberalisation are further explained in section 1.1.3.

Unlike most other goods, electricity cannot be produced beforehand and stored for later sale and/or use, i.e. its generation and consumption have to be simultaneous and its supply and demand have to be constantly balanced[27]. Electricity supply is usually made up of less flexible base load plants (including most renewable technologies) that have relatively low short-run marginal costs (SRMC) once they are running, but cannot economically be switched on and off as needed; and peak load plants that have higher SRMC but more flexibility in terms of adjusting generation capacity to meet changes in demand. This means that electricity supply curve is steeply rising (ref. Figure 3), and fluctuating demand ($D_1 \rightarrow D_2$) leads to a different market equilibrium every time.

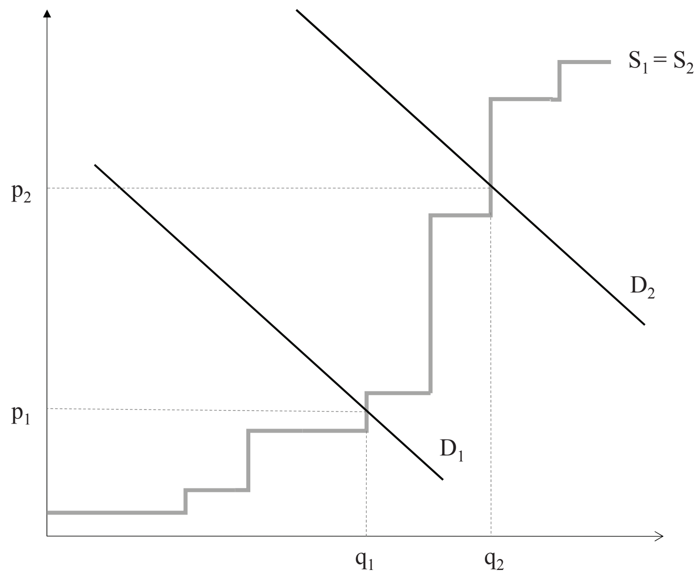

Figure 3. Formation of supply and demand in the electricity market. X-axis represents quantity whereas Y-axis represents price. Consequently D_1 and D_2 indicate various aggregated demand levels, p_1 and p_2 indicate market price and q_1 and q_2 quantity supplied to the market accordingly. Source: Pikk & Viiding (2013)

In regulated electricity markets governments control the entire electricity supply chain and hence maintain a tighter grip on the total price charged from electricity consumers. Depending on the regulator, (usually government-owned) producers might have to absorb the short-term price risk – or there might be some flexibility

[27] Whereas development of electricity storage technology has made some progress, large-scale storage of produced electricity is still unavailable or economically unfeasible.

to adjust for generation fuel costs, changes in cost of capital etc. In liberalised markets changing demand leads to a much higher volatility of market price ($p_1 \rightarrow p_2$) up and down the supply curve ($S_1 = S_2$, $q_1 \rightarrow q_2$). Hence, as different generators have different electricity production costs, how much electricity will be produced (and from which sources) will eventually be determined by end-users' willingness to pay (owing to the need to constantly balance supply and demand, all short-term adjustments are on the supply side) and capacity in the grid. In fact demand response to increasing or decreasing price is asymmetric, i.e. different every time (Fezzi & Bunn 2010).

Producers with lowest SRMC are generally owners of hydropower plants, solar PV panels, onshore wind turbines and nuclear plants. For hydropower plants the direct hydropower operation costs are in a range of 2–5 €/MWh. Indirect costs are the opportunity costs of releasing water as the water could be stored and used for future generation – opportunity costs are therefore equal to the expected future value of produced electricity (Faria & Fleten 2011)[28]. The short-run marginal costs for power production in onshore wind parks consist primarily of operation and maintenance (O&M) costs, approximately at 5 €/MWh (Reuters 2012). Therefore, hydropowered and windpowered plants (onshore) often make up the beginning of the supply curve on Figure 3. An increasing share of electricity is also generated from solar power, yet it is ignored in this dissertation as solar-generated electricity volume is yet to become noteworthy in electricity grids, especially in Northern and Northeastern Europe[29]. Next technology with lowest SRMC is nuclear power, where short run marginal cost includes fuel and O&M costs, approximately at 10 €/MWh (Roques et al 2006). These sources are followed by combined heat and power (CHP) units, condensing power plants, coal, biomass, gas and oil fired generators. Actual costs vary depending on exact location, country regulations (especially regarding CO_2 quotas, imposed taxes and subsidies – as further shown in section 1.1.2) but the short run marginal costs for a conventional coal fired power plant equal approximately 40 €/MWh with efficiency rate of 40% (Reuters 2012). This covers fuel cost, emission costs and O&M costs.

Technological development has also allowed for some alienation from central grid-based electricity supply: recent years have seen advancement in self-generation technologies, which effectively stands for simultaneous production and consumption of electricity at the same location with limited externalities[30].

[28] For more on this topic, see e.g. Philpott et al (2010), who investigated electricity supply systems where production from hydropower plays a dominant role.

[29] In any case, the SRMC of solar power is also very low: recent news from Dubai state an SRMC of only 0.03 USD/kWh. See for example
http://www.thenational.ae/business/energy/costs-tumble-as-dubais-mohammed-bin-rashid-al-maktoum-solar-park-sets-the-mark

[30] Strictly speaking, in case of grid-connected generators usually all self-generated power needs to be reported as sold and then re-purchased even if the generator consumes all the power itself.

Technological solutions that are common both among industrial users as well as residential consumers range from transportable fossil-fuelled generators to mini-hydro, solar PV panels and small-scale onshore wind turbines. Whereas residential users might choose self-generation because of lack of access to grid in remote areas (e.g. at summer cottages) or set up renewable self-generation due to environmental concerns, for electricity-intensive companies self-generation could be a viable alternative to mitigate rising electricity costs. In Finland 44% of the company that operates the Olkiluoto nuclear power plant is owned by members of the Finnish industry. As highlighted in the nuclear power plant's annual report, the aim of the owners is to receive electricity at (predictable) cost price, which can be consumed by themselves or re-sold to third parties (Teollisuuden Voima Oyj 2012). While energy-intensive companies can also choose to invest in less capital intensive power plants (such as mini-hydropower), smaller scope power plants might not be sufficient to convert electricity cost into an endogenous variable as is expected to be the case in Olkiluoto.

Excess electricity produced for self-generation purposes can be sold to other households or businesses nearby. Main challenge with such small-scale producers is greater deviation of generated power and the fact that they are usually connected to the distribution grid (ref. Figure 2), so they are not part of the electricity market and depend on load of the local users (Tammoja 2007)[31]. In some instances such producers can also feed their electricity to the transmission grid via the distribution grid. Thus electricity systems have become more complex, as one needs to consider two-way power flows for consumers that are also small-scale producers. The increasing number of such small-scale producers in the future necessitates setup of virtual power plants or intelligent distributed generation integration systems that bundle all small-scale producers and manage their production as a single power plant (Vare 2015). Hence in this dissertation it is assumed that in the electricity market small-scale producers act on the same principles as large-scale ones.

However, in general electricity generation is a capital-intensive activity, primarily owing to large start-up costs and in case of non-renewable generation also fuel use and disposal/waste costs. Accordingly, for most firms in most industries grid-based electricity supply will remain the norm, given high costs of investing in self-generation equipment and questionable returns if electricity production is not a core business. This means that today's electricity market's producers and consumers are likely to remain in two distinctly separate groups in the short to medium term.

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[31] This is more relevant in remote areas, where mini-grids have developed. In the future, such users might not need any grid-related services.

Transmission and distribution grids

The transmission grid is the backbone of the entire electricity system as it enables power delivery from generators to consumers. Transmission grid delivers power in bulk from one hub (substation) to another as its main aim is to bring electricity generated further away closer to the end-user and contribute to its quality: reliability, voltage and frequency (Wei & Yves 1999). Hence power is delivered at much higher voltages (typically 110–420 kV, sometimes as low as 66 kV or as high as 600 kV[32]) that has lower losses. However higher voltage equipment also costs more, as power needs to be rated up and down at the substations. For that purpose, only large-scale electricity generators and large-scale consumers are directly connected to the transmission grid (ref. Figure 2).

As electricity transmission is a natural monopoly (it is economically implausible and also impractical to build parallel power lines), the transmission system operator (TSO) has in most countries remained a state-owned business – including those with fully liberalised electricity markets.

In addition to physically enabling the system's operation, an important part of the transmission system operator's job is to provide market balancing services, i.e. to ensure that generation exactly meets the needs of the consumers and settle surplus or deficit electricity exports and imports with neighbouring countries (provided that there are interconnectors to other countries). This is usually regulated with nodal pricing, i.e. by asking generators to place a bid at each node of a supply curve, usually on an hourly basis. With addition of capacity from new renewable technologies – where electricity supply cannot be easily predicted due to changing weather conditions (e.g. wind power) – the task of balancing the electricity system has become more challenging.

Having an important role as enabler of power delivery, expansion of the transmission grid (including construction and operation of inter-connectors to neighbouring countries) is also a vehicle for carrying out the government's energy-, environment-, regional geopolitics- and other policies.

Transmission grid terminates at substations and continues as distribution grid: overhead lines and underground cables that lead directly to end-users, generally rated at 0.4–66 kV. Similarly to transmission grids, also distribution grids are local natural monopolies. However, (regulated) competition has been introduced to distribution networks in several countries – motivated by the aim to improve efficiency through private ownership while allowing for yardstick benchmarking as distribution operations are generally alike in similar geographical areas[33].

[32] Voltage levels may differ across countries.

[33] Regulators' imposed requirements to commitment to operation and fixed profit margins have lately encouraged institutional investors to take buy ownership of several distribution networks, as they constitute predictable cash flows when run with professional management teams.

Operation, maintenance and expansion of both transmission and distribution grids is financed by network tariffs paid by end-users (and in some countries also generators) of electricity. Given the fact that the networks are monopolies, one would expect money charged for network tariffs to be in line with necessary investments and maintenance, validated by market regulators (cf. section 1.1.2).

End-users

Aggregated electricity demand is primarily dependent on temperature, length of the day from sunrise to sunset, and the level of industrial production (Hjalmarsson 2000). Most studies (see e.g. Davis et al 2007, Psiloglou et al 2009, Jamil & Ahmad 2011, Blázquez et al 2013) also add disposable income and price of electricity as demand factors, applying this to both residential users (for short and long term demand) and industrial users (for long term demand levels).

Considering this dissertation's topic, it is only relevant to focus on the industrial users since they use electricity as production input and create value-added to the national economy. A firm's production function is a product of all input factors, energy being one of them (cf. e.g. Haas et al 2008). Equation (1) below visualises this with a typical Cobb-Douglas production function (Varian 1992):

$$X = A \times K^{\alpha} \times L^{\beta} \times M^{\gamma} \times E^{\zeta} \times e^{\tau} \qquad (1)$$

…where X represents output, A is a constant, K denotes cost of capital, L is for labour, M is for materials (and other resources), E is for energy used and e^{τ} is a residual for productivity; and $\alpha + \beta + \gamma + \zeta = 1$.

Therefore, cost of energy is a determinant for cost of doing business similarly to capital, labour, materials and other resources. The share of the cost of energy will vary depending on the activities to be conducted – whether they are energy-intensive or not – and can range from very low (e.g. printing of newspapers) to very high (e.g. manufacturing of aluminium). Similarly, different activities will require different forms of energy as input (e.g. electricity for lighting and powering the machinery, gas for heating, petroleum for transportation etc) so that total cost of energy to a firm can be shown as a function of several forms of energy purchased:

$$C_E = f(p_{electricity}, p_{oil}, p_{natural\ gas}, p_{coal}, p_{other\ energy}, S, T, e) \qquad (2)$$

…where C_E represents the cost of using energy to conduct business activities, p indicates prices paid for various types of energy sources, S stands for subsidies received from the government, T for taxes paid to the government, and e is for technical efficiency of the different technologies used.

Accordingly, how much electricity will need to be supplied to the market for industrial use at a given point of time will depend on aggregated individual needs of the businesses that use electricity to conduct business activities. These in turn depend on electricity-intensity of the firms in a country, i.e. the country's industry structure. This in turn is shaped (in the long run) by the price paid for electricity, as further discussed below.

1.1.2. Formation of electricity price

The electricity price, as seen from end-users' perspective, typically consists of three separate components: the price paid to the electricity generators (i.e. price of electricity supply); the price paid to the grid companies (i.e. price of electricity transport); and taxes and fees to the government:

$$p_{electricity} = p_{el.supply} + p_{el.transport} + T_{el.use} \tag{3}$$

The shares of these three components vary by country and by different consumer groups within a country; all are equally important. The following paragraphs discuss the individual price components.

Price of electricity supply

In regulated electricity markets electricity generators (that are typically government-owned vertically integrated utilities) calculate the aggregated average cost of supply and negotiate end-user sales prices with the (government-appointed) regulator. The regulator's task is to control the electricity supplier's profit margins and ensure an acceptable end-user price, with reward (i.e. greater profit potential) for more efficient performance.

Historically and in areas with limited electricity transmission/distribution capacity, many generators opted to sell their power via direct power purchase agreements to (larger) end-users. Bye and Holmøy (2010) refer to several large-scale Norwegian electricity consumers that built their production facilities close to electricity generation sites to minimise transmission losses and thereby also better position themselves as «key account» buyers subject to more preferential rates. In the mid-20th century the Norwegian state-owned power producers used to sign 50–60 year electricity price and volume contracts with such manufacturers. However due to the «locked prices», by year 2000 these users were enjoying 25–40% lower prices than what was available on the open market (Bye & Holmøy 2010) – constituting a significant opportunity cost to electricity suppliers.

In liberalised electricity markets, both producers and consumers always make an optimal choice, which leaves no room for errors: as consumers seek greater satisfaction they always choose the best alternative; and as producers strive to maximise profits they always strive to use resources as efficiently as possible. As per neoclassical theory only quantities that minimize average costs of production are supplied to the market, which endorses least-cost technology (Pikk & Viiding 2013). The same applies for electricity market, hence – as was visualised on Figure 3 – the electricity supply curve is made up by aggregated electricity offering from various generation technologies with supply from the least costly technology offered to the market first and supply from most expensive generation units entering the market last (Pikk & Viiding 2013). This will allow the market to achieve production efficiency and match it with exchange efficiency and optimal product mix efficiency from consumer side (Boettke 2010), so in a competitive electricity market power producers will always bid at their short-run marginal production cost level.

Friedman (2011) argues that real-life electricity prices are almost never equal to the (short-run) marginal costs of providing it. Referring to United States' electricity markets he maintains that electricity sales rates are usually set at average cost of production: several high marginal cost power plants have been built with the aim to operate only during peak periods, with substantial unused capacity during the off-peak. The idea that market pricing cannot be based on marginal costs is also found in Jakubiak (2004), as he contends that market entry is well above zero and hard to calculate into marginal costs (especially since it isn't instantaneous).

The electricity sales market consists of several bidders, each with a different cost base. As market price is set by the most costly auction winning unit[34], all of the producers get the same price even though they offer to sell at different prices. In case a producer bids higher than its short-run marginal costs (ref. $BP_1 > SRMC$ on Figure 4) and the market clearing price will be between these two values ($BP_1 > MCP_1 > SRMC$), the bid will not be accepted and the producer will lose right to sell electricity to the market. The producer would otherwise have earned the difference between market price and its short-run marginal costs as shown in equation (4) below (Pikk & Viiding 2013):

$$\pi_1 = q^* \times (MCP_1 - SRMC) \tag{4}$$

…where q^* is amount of electricity that could have been produced and π represents a one-time profit from sale.

In case the producer makes a bid which is lower than short-run marginal costs ($BP_2 < SRMC$) and the market clearing price will also be lower ($BP_2 = MCP_2$), the producer will be forced to sell below its marginal costs and make a loss as

[34] In this context, auction refers to handling of supply bids submitted to the power exchange, e.g. NordPool.

shown in equation (5) below (Pikk & Viiding 2013), so in a competitive market this will never happen.

$$-\pi_2 = q^* \times (SRMC - MCP_2) \tag{5}$$

The above is also visualised on Figure 4 below:

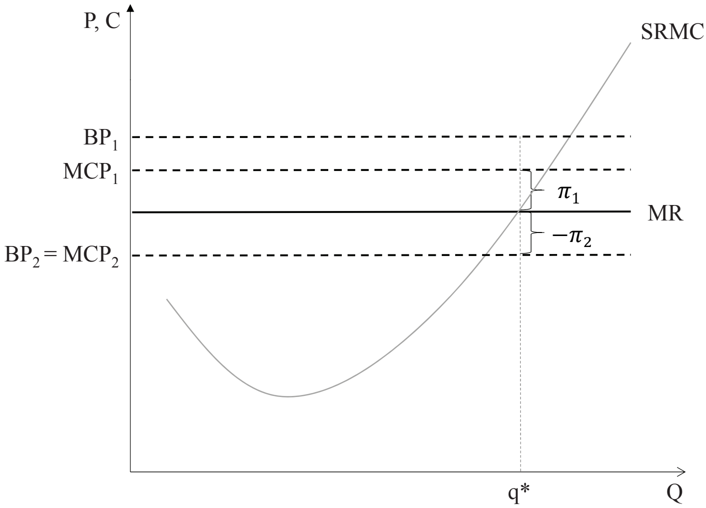

Figure 4. Bid placement alternatives for power producers. Source: Pikk & Viiding (2013)

In the long run the relationship between prices and production costs will depend on the level of demand and the way costs vary with output. If a producer exhibits increasing returns to expanding output, average costs will fall as output expands and marginal costs will be smaller than average costs. If there are decreasing returns to scale, average costs will rise as output expands and marginal costs will exceed average costs (Hartley & Moran 2000).

However as producers invest based on long-run-marginal costs (p=LRMC) but bid based on short-run marginal costs (p=SRMC), the shadow price of capacity will dictate the actual market price – see e.g. Green & Newberry (1992). Accordingly, the market price (shown as P on Figure 5) can be higher than the short-run marginal cost of the last qualifying bidder if the market demands more capacity than all qualifying bidders cumulatively offer (q_1+q_2+q_3 on Figure 5) – but needed capacity is not enough for an additional producer's (q_4) bid to be accepted. The shadow price of capacity is marked with γ on Figure 5.

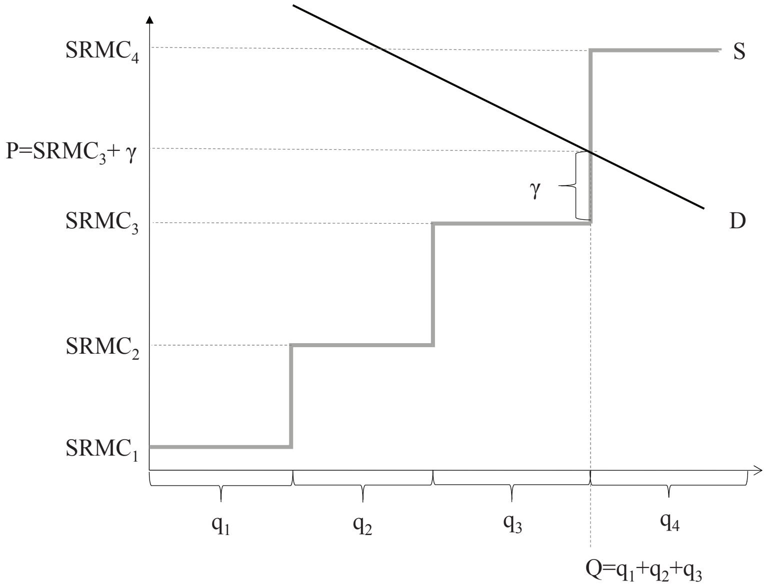

Figure 5. Visualisation of shadow price of capacity (shown as γ). The supply curve (S) is made up of quantities offered to the market by various producers (shown as q_j, where j marks qualifying producers 1–3), and their asking price (bids based on their short run marginal costs, shown as $SRMC_j$). Shadow price is formed by the difference in consumers' requested capacity and willingness to pay vs producers' available capacity and asking price. Thus the market clearing price equals short-run marginal cost of the last qualifying bidder plus the shadow price. Author's drawing converted from Green & Newberry (1992).

Consequently it can be concluded that in liberalised electricity markets it is optimal for producers to always bid at a price that is equal to short-run marginal costs; as the eventual selling price is the same for all bidders, producers will prefer to bid close to their own short term marginal costs and have the highest possible chance of winning the auction (Nielsen et al 2011). Indeed, electricity trading in open markets is a rather short-run process: auction markets set prices on an almost continuous basis to balance supply and demand. In the short run all capital equipment is fixed so marginal costs include the cost of producing an additional unit of electricity with existing capacity (Malik & Al-Zubeidi 2006). As the sales price for a given amount of power at a given amount of time will be the same for all producers, economically most efficient production units will earn the most, and units with the highest bidding price (if their sales bid is below the market price) will earn just enough to cover their SRMC (Pikk & Viiding 2013).

Price of electricity transport

Historically, delivery of electricity (to end-users) was considered a public service, where remuneration was based on cost of service (Román et al 1999). For electricity tariff-setting, regulators used several non-electric indicators, such as purpose of consumption (e.g. agriculture, manufacturing etc) and commercial codes in addition to electric indicators (e.g. contracted power or supply voltage level). Customers with different indices would have different tariffs. Usually, these types of indices were unrelated to the actual load diagram, which led to inconsistencies in customer classification (Chicco et al 2003).

In liberalised electricity markets, TSOs and DSOs are incentivised to develop their offering so that it allows for dynamic retail pricing based on demand response (Roozbehani et al 2010). The natural monopolistic nature of transmission and distribution networks posits that regulators must set use-of-system charges and power quality control mechanisms. In liberalised electricity markets, remuneration of grid operators (both TSOs and DSOs) is determined by the services provided, not the cost of operations. Regulators have to ensure that use-of-system charges allows for investments, promotes efficiency, reduces losses and achieves a prescribed level of quality of service (Román et al 1999). Accordingly, both the TSO and the DSOs are interested in developing profit-maximising strategies for tariff collection. They are free to formulate their own classification of customers based on their electrical behaviour, so that tariff offer can be based on impact of different customer classes on the total aggregated load in the grid (Chicco et al 2003).

Consequently, grid fees remain regulated also after electricity market liberalisation. Given that in regulated markets electricity generation and transmission/distribution are often bundled into a vertically integrated utility, and that market liberalisation stipulates vertical dis-integration, then the most significant change is increased transparency of the grid operator's business, as potential cross-subsidisation is eliminated. It is thus assumed in this dissertation that grid fees for a given consumer group in a given country reflect the operating costs and investment needs of the local grid operator, but also incentivise the operator to develop efficient operations (especially so in liberalised electricity markets).

Electricity taxes and fees

According to Jamil & Ahmad (2011) several studies show that electricity demand is income elastic and price inelastic, meaning that consumers consider electricity a normal good and a necessity. Also Wang & Wu (2012) conclude from their research that markets have almost no memory when it comes to pricing. This suggests that taxation of electricity will not significantly influence electricity consumption in the short and medium run. Consequently, most countries apply taxes on electricity consumption as a means of additional revenue to state budgets or re-distribution of funds from one market participant to another.

Earlier (ref. Figure 3 in section 1.1.1) it was shown that renewable electricity generation has lowest short run marginal costs, and therefore renewable electricity is always supplied to electricity markets ahead of conventionally generated electricity (e.g. from coal). Yet nearly all renewable generation – with the exception of large-scale hydropower – is still a maturing technology with lower capacity factor and relatively higher capital investment needs upfront. Several countries have introduced renewable electricity price premiums, usually as «feed-in tariff» support schemes that constitute either fixed payments to generators or price premiums to market price. In several countries a «green certificate» market exists, where producers of renewable energy are awarded certificates which can later be sold to electricity distribution companies that are required to purchase them (and forward the cost to end-users). Whatever the solution to support increased supply from renewable sources, most such support mechanisms effectively work as negative Pigouvian taxes, where governments provide a premium payment to renewable energy investors to offset positive social externalities (see right on Figure 6).

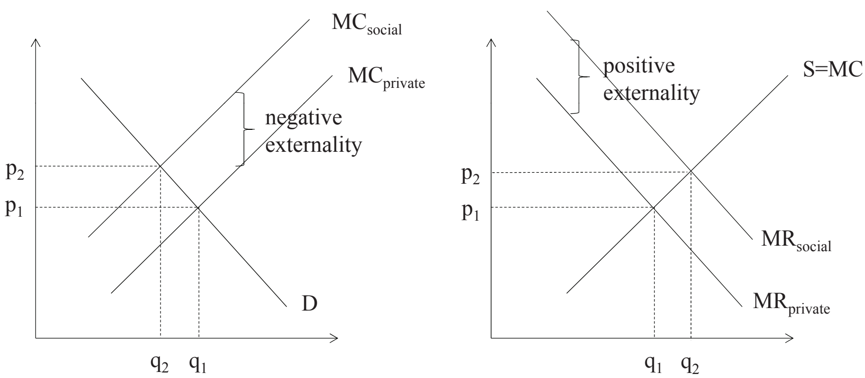

Figure 6. Pigouvian taxes for negative and positive externalities. Source: Raudsepp (2014)

As the argument goes, renewable technologies create a public good in the form of clean air and limited environmental deterioration. Investors are hesitant to invest in creation of public goods unless incentivised or unless it is more profitable to do so vis-à-vis the alternative (i.e. invest in conventional energy generation facilities). The challenge with incentivised payments for renewable energy generation is the fact that political goal-setting might prefer certain technologies and thereby hinder natural development of other technologies which could prove to be more beneficial in the end. However in some countries, electricity generated from such newer renewable technologies is already able to effectively compete with conventional power sources at market terms: in some countries this has been reported for onshore wind power and in some countries the same is reported for solar PV installations (see e.g. Narasimhan 2012, Cardwell 2014, Engerati 2014). Therefore in these markets investors are incentivised to invest in such technologies even without subsidies.

By encouraging and compensating new renewable energy generation governments principally encourage increased supply: as such renewable technologies have lower marginal costs (ref. section 1.1.1), the supply curve is shifted to the right, leading to a drop in market price (ref. Figure 7). Thus, encouraging renewable electricity generation does not only create a public good but also favours consumers through lower prices.

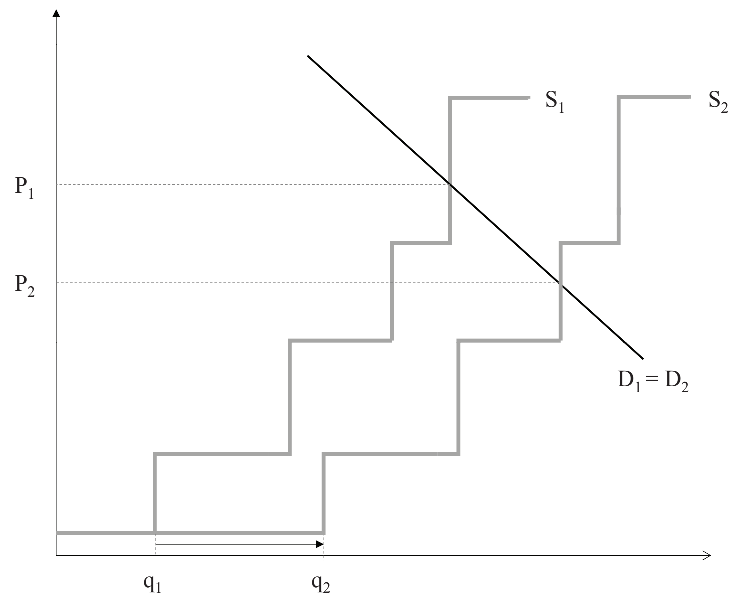

Figure 7. Impact of increased renewable electricity supply on the market price. As governments subsidise installation of new renewable electricity generation capacity (which has high capital costs but low marginal costs), there is increased supply with low marginal costs ($q_1 \rightarrow q_2$); the supply curve shifts to the right ($S_1 \rightarrow S_2$), lowering the electricity market price ($P_1 \rightarrow P_2$). Author's drawing.

In most countries the compensation paid to renewable energy generators is effectively charged from end-users per every kWh consumed. Hyland (2016) notes that in several cases installation of new renewable generation capacity necessitates construction of new power lines (e.g. if the former is in a more remote area). As elaborated earlier in this section, the cost of grid investments and operation is usually charged to the customers. Thus both the RES fee and increased grid fees somewhat offset the lower total electricity price for end-users.

Given that many conventional electricity generation technologies are still in use today – and that these emit pollution – many countries also apply (positive) Pigouvian taxes to such electricity producers. Concerns of global warming and EU's commitment to reduce CO_2 emissions have led to establishment of a pan-EU emissions trading scheme (the EU ETS), which assigns each country a quota to emit a certain amount of CO_2 gases and buy the right for additional emissions from another country that has emitted less than its quota allows. This way, the right to emit a tonne of CO_2 (Pigou's negative externality on Figure 6, left) has a market-driven price that applies to all companies that generate electricity from fossil fuels[35]. As the CO_2 emissions are specific to technology and vary by companies, they cannot be forwarded to end-users and have to be absorbed by the generating companies as part of their short-run marginal costs (see Figure 8).

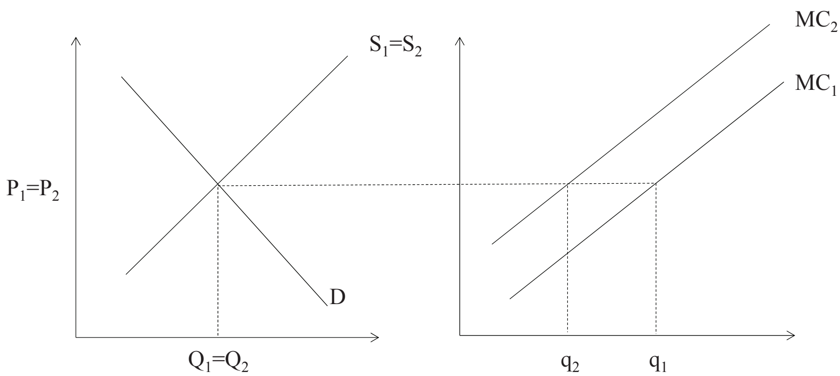

Figure 8. Visualisation of how pollution tax applicable to only one company (such as with CO_2 emission quotas) will lower their supply to market (shown on right) as the costs cannot be forwarded to end-users (shown on left). Author's drawing adapted from Kleesmaa et al (2011).

Bye & Bruvoll (2008) note that almost all electricity generation technologies have some negative externalities: use of fossil and bio fuels can result in emissions of sulphur and particulate matter, wind turbines generate noise and negatively affect the aesthetic value of landscape, hydropower involves physical intervention in pristine areas and threatens wildlife (especially plants with large dams and reservoirs), and nuclear power plants can increase exposure to radiation. So any discrimination of a specific technology (e.g. CO_2 emitting production) implies indirect subsidies to other less polluting technologies, and thus does not fully eliminate all negative externalities.

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[35] The EU ETS scheme regulates CO_2 emissions from production activities in many industries, not just electricity generation. However, only electricity generation is relevant in the context of this dissertation.

In addition to support for renewable energy generation as outlined above, governments may also impose taxes on electricity consumption to finance other strategically important energy projects, such as construction of inter-connectors to neighbouring countries (see e.g. BaltPool 2015) or developing renewable energy technology (see e.g. Daugbjerg & Svendsen 2011). Private consumers usually also pay a value added tax on their electricity bills, but this is ignored in this dissertation, given the focus on industrial consumers as further explained in section 1.1.1 above.

Governments may also impose negative taxes (i.e. subsidies) to certain consumers. It is common for pressure groups to affect politicians in designing instruments that overrule free market mechanisms in determining a price of electricity for a given level of consumption. Boettke (2010) criticises price controls for blocking the market's ability to adjust to changing conditions of supply and demand. Free market proponents claim that price capping may lead to postponed investments, harming system reliability and causing shortages, imposing large outage costs on the economy and thereby further harming consumers (Tishler et al 2008). Waheeduzzaman & Ryans (1996) add that the aim of governments must be to force companies to innovate, while not creating disadvantages to competing nations. Porter (1990) specifically dismisses governments' attempts to devalue currency or offer subsidies rather than review economic policies and tackle weaknesses in business environment to ensure that a country keeps on the path of sustainably improving its nation's standard of living. Hence, e.g. suppressed wages or currency are short-sighted measures as they do not support an attractive standard of living (Porter et al 2007).

Yet several countries have exempted selected energy-intensive industries from energy taxation or otherwise supported their operations. Negotiated prices (including price caps) or discounted taxation could be motivated e.g. by the will to maintain historical industries in the country on two grounds: (1) if too high electricity costs forced energy-intensive companies to move their production abroad, it would result in higher unemployment and lost taxes for the country; (2) if electricity to the energy-intensive company is sourced from renewable generation, one could further argue that setting up production in another country with lower electricity taxes – and hence lower overall cost of electricity – might contribute to increased CO_2 if such country's generation would not be renewable, i.e. countries try to avoid establishment of pollution havens (OECD 2011), (Commins et al 2011).

Indeed, despite the European Union's willingness to achieve a 20% reduction in energy intensity by 2020 it has also been acknowledged by the EU's leaders that converting the EU's economy from manufacturing to low-carbon-based research activities and service-based industries is unrealistic, i.e. transfer of all heavy duty production facilities outside EU will not be a viable solution (European Commission 2011). Divestments due to too high electricity costs would decrease supply of electricity-intensive goods to the market, which could negatively impact export performance of a country. Furthermore such a move would have high impact on the employment of population currently engaged in such industries; as well as the future technical development ability of the EU. It is therefore to be expected that energy and electricity intensive industries have a place in the European Union and price controls are still found amongst energy- and electricity-intensive users in Europe.

1.1.3. Takeaways from electricity market reforms

Historically, the entire supply chain of electricity was viewed as a natural monopoly because transport of electricity (from where it is generated to where it is consumed) is a natural monopoly (cf. transmission and distribution networks in section 1.1.1). As per Steiner (2001) it was therefore perceived that the electricity industry functions best as a regulated monopoly, with the regulator forcing the monopolist to charge prices that are below marginal revenue and closer to marginal costs. Most countries chose to consolidate the electricity industry into state-owned, vertically integrated monopolists – under the assumption that public ownership leads to greater welfare. Some countries opted for regulated private firms, assuming that private firms are more efficient yet strict regulation assures that the firms would not abuse their market power and pricing focuses on reasonable rates of return.

As transmission grids expanded country-wide and ultimately inter-connected to neighbouring countries, eventually many countries around the World liberalised their electricity industries by redefining electricity markets: what used to be a fully regulated and primarily government-owned system has evolved into an interconnected regional market with competition from privately owned generators, improved efficiency and optimised capacities. As with almost any-thing, there are also opponents and advocates of electricity market reforms: Erdogdu (2011) notes that market liberalisation opponents often point to the 2001 California crisis[36] as an important example of reform failure; whereas advocates tend to generalise conclusions based on the reforming countries in Northern Europe and the success story of NordPool.

[36] During 2000–2001 in California, low hydroelectric production and high combustible fuel prices combined with abuse of market power triggered previously unseen high levels of electricity wholesale prices. This allowed suppliers to make super-profits, whereas regulated utilities (that had to buy power at market prices and sell to end-users at much lower regulated prices) suffered huge losses on the demand side, with the state's largest utility declaring bankruptcy. Eventually the entire market collapsed. For more information, see e.g. Borenstein (2002).

Erdogdu (2014) notes that most academic research within electricity market reforms focuses on Europe. He lists at least 11 academic papers that have provided case studies in Europe, and at least 16 more studies that have contributed to the same literature by presenting regional case studies, starting with year 1995. Accordingly, two primary objectives seem to have driven electricity market reforms: to reduce the cost-price margins (cf. discussion about electricity supply pricing in section 1.1.2) and improve the quality of electricity delivery (cf. discussion about electricity transport pricing in section 1.1.2). Ugur (2009) refers to Napolitano (2005), stating that despite some variations across countries, typical sector liberalisation in Europe has addressed three components: (i) progressive market opening that allows for free entry of suppliers and consumer switching between suppliers; (ii) unbundling of production, transmission and retailing of electricity; and (iii) establishment of an independent market regulator.

Most researchers refer to Steiner (2001) as one of the first to have not only discussed electricity market reforms but also carried out an empirical analysis. Steiner (2001) focused on the effect of market liberalisation on end-user electricity prices and efficiency of operations – both of which are expected to result from electricity market reforms – using data from 19 OECD countries in the years 1986–1996. One of her most important findings was the fact that electricity market reforms led to a greater reduction of electricity prices for industrial users than prices for residential users, i.e. that industrial users benefit more from electricity market liberalisation. In parallel, the study identified that unbundling of utilities did not automatically lead to lower electricity prices, but higher efficiency through capacity utilisation and lower reserve margins.

The study of Steiner (2001) was repeated by Hattori & Tsutsui (2004), who used the same dataset of 19 OECD member countries, but with a 2 year longer period (1987–1999). In their research, Hattori & Tsutsui (2004) found that industrial electricity prices are also lowered by greater retailing of electricity; but in line with Steiner (2001) they found that this comes with greater spread between industrial and residential electricity prices. Furthermore, they found that unbundling of utilities does not automatically lead to lower electricity prices but may in fact have resulted in higher retail prices.

Other authors have come to similar conclusions. Stevens-Huffmann (2011) noted that retail choice of electricity has significantly benefitted Pennsylvanian industrial users. Zarnikau & Whitworth (2006) surveyed effect on electricity prices from liberalisation of power market in Texas and found that residential electricity costs for consumers of 1 MWh monthly increased at a greater rate in areas of Texas where customers had retail choice than in areas where they did not. Also Treibing (2001) found that residential energy consumers – who have very little bargaining power in the marketplace – often can suffer most visibly.

Tishler et al (2008) found that electricity price spikes are not dependent on the number of producers, implying that a policy of competition to promote market entry to mitigate price volatility is unlikely to alter the probability of spikes.

Zhang et al (2008) did not analyse market liberalisation effects per se, but analysed how components of it – existence of an independent regulator, a wholesale market, and independent power producers (IPPs) correlate with electricity generation volumes and electricity prices for both industrial and residential users. The dataset comprised of 51 developing countries, with data from the period 1986–2000. The study found that establishment of a regulator on its own or privatisation on its own do not automatically lead to better performance, although it correlates with greater electricity capacity and availability. However, it was argued that performance improves by introduction of competition.

Nagayama reviewed electricity prices for countries in the developed World, Latin America, Asia, the former Soviet Union and Eastern Europe over the period 1985–2003 in two studies: one published in 2007 (with 83 countries) and another in 2009 (with 78 countries). In Nagayama (2007) it was concluded that introduction of foreign IPPs contributes to lower industrial electricity prices in the developed countries as well as Eastern Europe and the former Soviet Union, but not elsewhere in the sample. Privatisation was reported as having a statistically significant effect on lowering industrial electricity prices in the developed countries, whereas no conclusions could be drawn for the rest of the sample. Unbundling of generation from transmission led to higher electricity prices (both for industrial and residential users) both in developed countries as well as in Eastern Europe and the former Soviet Union, whereas results were statistically insignificant for Latin America and Asia. Introduction of retail competition led to lower electricity prices in the former Soviet Union and Eastern Europe, whereas it raised prices in Latin America. The same trend was observed with introduction of an electricity wholesale spot market.

In Nagayama (2009), differences across regions and between developing and developed countries were studied further. An attempt was made to observe the impact of electricity prices on choice of a market liberalisation model, concluding that high electricity prices encourage governments to liberalise electricity markets. However, market liberalisation per se did not lead to lower electricity prices – in fact prices had the tendency to rise in all observed regions.

Erdogdu (2011) concluded that any study on impact of electricity market reform on electricity prices must consider variations in fuel costs and country-specific factors. For that purpose, Erdogdu (2011) calculated price-cost margins based on use of coal and natural gas imports for electricity generation in each country. The study could not detect a uniform pattern for the impact of market reforms on either price-cost margins nor cross-subsidy levels across consumer groups – suggesting that each activity in reform has a different impact for each consumer and country group. This means that success stories from one region or country cannot be applied without alternation in another region or country, as each country has specific circumstances.

Hyland (2016) aimed to summarise electricity market reforms across EU, concluding that whereas the aim of reforms was always to improve efficiencies and thereby lower prices, the prices did not fall in all EU countries. One of the reasons may have been the fact that unbundling of national utilities led in some cases to loss of economies of scale and increased operational costs (instead of the expected opposite). Another reason is the unclear effect on prices from sector privatisation: whereas private ownership usually leads to higher efficiency and cost savings, these savings may not be reflected in lower prices in the absence of effective regulation. The additional need for better regulatory oversight may itself lead to higher costs. Hyland (2016) also mentioned the unclear total effect of subsidisation of renewable energy sources: whereas the latter come with lower supply costs, embedded subsidies, additional infrastructure costs (e.g. to build new power lines to connect these new power plants) and the occasional need for backup generation sources might in fact increase total prices. She thus concluded that «different reform steps may have opposing effects on prices» and that «more empirical studies are needed» (Hyland 2016: 34).

Chapter summary

The main difference between electricity pricing in liberalised electricity markets vis-a-vis regulated markets is shifting of focus on what governments can do to influence total electricity prices. Unlike in regulated markets, in liberalised markets the formulation of electricity supply price (cf. $p_{el.supply}$ in equation (3)) is determined in the market, and hence should be considered as optimal given supply and demand. There are few changes to grid fees (cf. $p_{el.transport}$ in equation (3)) in regulated vs liberalised electricity markets: they are regulated so that they allow for investments yet encourage efficiency improvements and loss reduction. Consequently, the tax component (including exception rules to certain consumers) becomes the largest differentiator for governments to influence electricity prices (cf. $T_{el.use}$ in equation (3)) in liberalised electricity markets. Background to why countries need to consider this is further explained in the following chapter (chapter 1.2), whereas how this is done and with what impact is discussed in chapter 1.3.

1.2. The pursuit of competitiveness

Despite frequent use of the word «competitiveness» in both academic literature as well as amongst policymakers, what is meant by competitiveness remains open for interpretation. Section 1.2.1 elaborates how the idea behind competitiveness has evolved and what it largely stands for today. Next, section 1.2.2 discusses how competitiveness could be achieved and its implications on an industry level. Finally, section 1.2.3 discusses how competitiveness is measured and its relevance in the context of this dissertation.

1.2.1. Evolution of the concept of competitiveness

Competitiveness as a term is rather new in economic thought: no literature exists on competitiveness until the last quarter of the 20th century. The origins of pursuit for competitiveness are however rooted already in earliest trade theories and can be seen throughout development of international trade theories. In the classical approach to international trade a country had to develop several location-specific advantages which a number of firms could successfully internalise. International trade could then act as a catalyst for development; and the more trade occurred, the more everybody benefitted: customers had more choice, import/export activity created more employment opportunities and the state collected more taxes. Ezeala-Harrison (1999) has even concluded that exploding international trade was one of the most important phenomena that shaped the development achievements of countries during the 20th century.

Although according to some sources competitiveness-related issues have been addressed in public policies as much as 500 years ago, the starting-point is usually set with the Mercantilists in the 17th century (Reinert 1995). According to the Mercantilists a country becomes more rich and powerful through exporting more than importing. Hence Mercantilists advocated a zero-sum-game: a nation could only gain at the expense of another, since it is impossible for all countries to have a positive trade balance at the same time.

As volumes of trade increased, a newer theory was offered in the 18th century by Adam Smith, who introduced the concept of absolute advantage. Smith was the first to point out that unrestricted trade and free international competition benefit a nation more than the Mercantilist thinking (Schumacher 2012). According to Smith (1991), specialisation and concentration of workers on a single task in a factory would lead to greater skill and overall higher productivity than what would be achieved if these workers attempted to carry out many different activities. Hence, workers that specialise have an absolute advantage over others (Yu 2011). Similarly, if other workers abroad focused on another activity, nations could trade their commodities with each other. Society as a whole would gain as resources would be used more efficiently and total production of both commodities from the same resources would be higher.

Theory of absolute advantage was developed into theory of comparative advantage in the 19th century by David Ricardo who proved that a nation could engage in trade even if it was less efficient than another nation in production of both commodities (Frederking 2009). The worse-off nation would specialise in production of a commodity where its absolute disadvantage is smaller, as it would likely have a comparative advantage over the other nation owing to differences in labour and commodity costs so that it would be more profitable for the other nation to only produce goods with absolute advantage (Ricardo 1971).

Whereas Ricardo took international productivity differences as given, presentation of the Heckscher-Ohlin model in 1933 highlighted differences in international factor endowments (Neary 2009), which made it a pillar for modern international trade theory (Caliendo 2010) – and competitiveness. Assuming that production is a function of two factors (labour and capital), different products have different factor intensity (i.e. amount of labour and capital needed) and different nations have different levels of factor abundance (i.e. amount of labour and capital available) (Ohlin 1979). A country will produce and export the good which uses its abundant factor most intensively – under the assumptions there is no-impediments to international trade (Nyahoho 2010).

In 1953 Wassily Leontief showed how input-output tables of the American economy can be used to calculate capital and labour intensity of various American industries, arriving at a conclusion that contrary to common belief, the United States' economy is characterised by a relative surplus of labour rather than capital. Thus, in order to economise its labour the country needs to engage in exports as such labour would otherwise be (less effectively) used in import-competing industries at home – a finding that later became known as the Leontief paradox. Although Leontief (1953) explained that the United States possesses more productive capital per worker than any other country (which would emphasise the need to focus on capital-intensive rather than labour-intensive industries as per the Hechscher-Ohlin theory), he argued that the relatively better production potential for American labour is in fact explained by higher productivity of that labour. Not least, Leontief (1953) also highlighted the importance of natural resources, showing how the United States has a comparative advantage in (and exports more) products that use the country's abundant natural resources, and vice versa for imports.

Specialising in what one can do best and allowing for free exchange means that any deviation from Pareto optimum will temporarily benefit one party, but is collectively counter-productive (Begg 1999). Hence production specialisation leads to economies of scale. Staffan Linder argued in 1961 that a nation would focus on producing products for which a large domestic market exists (Vaghefi et al 1991), i.e. economies of scale would be achieved from domestic sales, with firms gradually expanding to other nations with similar tastes and income levels after acquiring expertise at home. Such an argumentation ultimately led to formulation of the Uppsala internationalisation model in 1977 by Johanson and Vahlne and similar conclusions by Luostarinen in the Helsinki internationalisation model in 1979.

It has long been recognised that economies of scale and market structure have significant impact on a country's comparative advantage and pattern of trade (Das 1982). On a parallel track back in 1966 Bela Balassa argued that countries would boost their welfare by reducing customs tariffs and allowing for more imports. This would lead to reallocation of resources from import-competing industries to export industries and increase a country's welfare as factors used more intensively in production of importable goods would experience a decline in their real income. Hence tariff reductions would stimulate inter-industry specialisation. Furthermore most of the goods traded internationally are differentiated products not standardised products, which favours specialisation in narrower ranges of products, i.e. intra-industry rather than inter-industry specialisation. Balassa (1966) backed up his arguments with proof that establishment of the Common Market in Europe (which later evolved into the European Union) did not result in a wave of bankruptcies.

Balassa's arguments were further developed in the «new trade» theory by Paul Krugman (1980) and later by Marc Melitz (2003). According to Krugman, contemporary international trade rests increasingly on economies of scale, product differentiation, imperfect competition and transportation costs. Hence from the point of view of total welfare it is not important who produces what within a group of differentiated products as all parties benefit from increased product diversity (Krugman 1980). Melitz showed how exposure to trade ensures that only most productive firms enter the export market, while less productive firms gradually close down. Consequently as industries' exposure to trade further increases, inter-firm allocations enable aggregate industry productivity growth and overall gain in welfare (Melitz 2003).

More recently, the «born global» phenomenon was introduced, showing that a company in a given country could serve foreign markets from start, and in some cases have no domestic market at all. The born global concept relies on the assumption that such companies possess a unique set of competences that could be used to serve a special niche market and in that case the company could become competitive even if the market to be served would be geographically spread out. Hence, born global firms exploit firm-specific knowledge to offer their services across countries and are less dependent on country-specific locational advantages than traditional international companies. Country-specific advantages can however dictate whether a born global firm has activities in a given country or not. The born global phenomenon has been facilitated by vast advancements in information and communication technology as well as global logistics supply chains, so such companies cannot be found in every industry.

Whereas research on international trade is ongoing, discussion on how to increase prosperity encompasses more than just trade and is today discussed separately by referring to the term «competitiveness». According to Ajitabh & Momaya (2004) the term originates from the Latin word *competer*, which stands for rivalry of businesses in markets. One of the earliest publications to specifically use the term «competitiveness» was written by Fenyves et al in 1977, examining «new ways for improving the competitiveness of lignite fired power stations».

However, despite the fact that «competitiveness» has been used in academic literature for several decades now, there is a lack of clear and generally accepted formulation of what it stands for (Zadoroznaja 2010). In fact every author seems to define and use competitiveness as it best matches their discipline and the large number of different measures that are in common use today often diverge appreciably (Turner & Dack 1993). Toming (2011) refers to White (1994: 310), who states that «whatever level of aggregation competitiveness is defined, its determinants are nearly infinite». For example the World Economic Forum states that competitiveness is «the ability of a national economy to achieve sustained high rates of economic growth, as measured by the annual change in gross domestic product per person» (Cho & Moon 2005: 2). According to World Competitive Yearbook competitiveness involves «a combination of assets and processes, where assets are inherited or created and processes transform assets to achieve economic gains from sales to customers» (Ambastha & Momaya 2004: 50). In macroeconomic terms competitiveness could be seen as addressing real exchange problem by observing the price/cost index in a common currency (Lall 2001); whereas in international trade competitiveness could be a measure of an organisation's advantage in marketing its products and/or services in global markets (Hult 2012). One can distinguish between one-dimensional and multi-dimensional, unilateral, bilateral and multilateral, static and dynamic, positive and normative, ex-ante and ex-post, deterministic and stochastic, actual and potential competitiveness that can be treated both as dependent or independent variable (cf. Ajitabh & Momaya 2004, Siggel 2006, Toming 2011).

Given this variety, there appears to be a broad consensus in literature that competitiveness is more of a concept than a specific term and appropriateness of one definition over another should be judged for a specific research or policy in question (Ketels 2006), i.e. competitiveness is context-dependant (Siggel 2006). In fact many studies only discuss strategies that contribute to increased competitiveness without actually defining it (Aiginger 2006). Durand & Giorno (2013) explain that even within a well-defined conceptual framework defining and measuring competitiveness is a result of compromises with available data as trade-offs need to be made among different criteria and objectives. This is somewhat natural given that competitiveness seems to be applied to different levels of assessment and analysis – as is also the case in this dissertation.

It is important to understand the difference between competitive advantage, comparative advantage and competitiveness. The former relates back to Ricardo's theory, but assumes that costs are based on equilibrium markets. If that would not be true, wage hikes or currency appreciation could impact the ability to export goods, i.e. competitive advantage reflects market prices (Siggel 2006). Competitiveness relates to the ongoing management of competitive advantage, i.e. economic growth from growing and/or maintaining relative advantage that a country's industries have in terms of their ability to operate profitably within a competitive environment (Ezeala-Harrison 1999). Hence competitiveness shows the relative position of an economic subject vis-à-vis its competitors (Önsel et al 2008).

In economic modelling, maximisation of income is often the overriding economic principle, depending on attached constraints (amount of labour, hours reserved for leisure, capital, natural resources, state of technology etc.). As investments target profitable sectors of the economy, high profitability should be the ultimate aim as it implies high competitive potential (Tharakan et al 1989 and Viaene & Gellynck 1998 through Toming 2011). Most economic goals are typically united in welfare function but given the fact that welfare as a term is more static it makes sense to define competitiveness as the ability to create welfare (Aiginger 2006).

It is therefore acknowledged in this dissertation that competitiveness is not an end-goal, but a suitable subject of examination as means to welfare creation, i.e. competitiveness is the «fundamental underpinning of prosperity» (Porter et al 2007: 52), (Mercan 2014). But Porter (1990) and Rugman et al (2012) also stress that becoming and staying competitive must be a nation's long-term dedicated choice that must be continuously pursued through a combination of strategic (long-term) activities: competitiveness develops consistently, emerging and disappearing if appropriate measures are not skilfully retained (Lombana 2011), (Ezeala-Harrison 1999). Accordingly, in this dissertation competitiveness is defined and used as a means of fostering development of firms and industries that can sustainably compete internationally and thereby create welfare to the society over long-term.

In recent years discussions on competitiveness have spread from academia to practitioners, with increasing amount of non-academic literature and reports providing comprehensive frameworks and data for competitiveness-related decision-making (Ambastha & Momaya 2004). Of these, the most popular are the Global Competitiveness Report published by WEF[37] (the World Economic

[37] See e.g. http://reports.weforum.org/global-competitiveness-report-2015-2016/

Forum) and the World Competitiveness Yearbook published by IMD[38] (the Institute for Management Development), although numerous other national and regional competitiveness reports published by various countries and organisations also witness increasing subscriptions. Also a number of institutions have been set up. One of the first to be created in early 1990s was the National Competitiveness Policy Council in the USA; followed by European Council of Competitiveness set up for the European Union. Several private consultancies have followed suit, with most renowned ones being the World Economic Forum based in Switzerland, the Competitiveness Institute based in Spain and the Council on Competitiveness in Washington D.C., USA. Even Harvard Business School has set up the Institute for Strategy and Competitiveness (Kitson et al 2004).

1.2.2. Becoming and staying competitive

Of the six enablers of competitiveness that Porter et al (2007) have proposed (domestic investments, exports, imports, inbound foreign direct investment, outbound foreign direct investment, domestic innovation) none could be assigned to be a responsibility of governments or firms alone. It is common to talk about competitiveness both on country and firm level (Waheeduzzaman & Ryans 1996) whereas it has also been argued that competitiveness could be discussed on any level from product, firm and industry to nation, bloc and globe (Cho 1998). Although Krugman (1994: 28) has warned that measuring country-level competitiveness is «a dangerous obsession» as competition of countries is not similar to that of firms where one can win at the expense of another (although this would be possible in the short term if one followed Mercantilist thinking), increase in competitiveness of one country does not come at the expense of another – improved productivity and thereby improved competitiveness raises the value of goods produced and improves local incomes, thereby expanding global demand to be met (Porter et al 2007).

Yet Krugman (1994) is right to draw attention to the fact that governments or other societal institutions cannot create actual wealth in an economy – wealth is created by the ability of (both domestic or subsidiaries of foreign) firms to create valuable goods and services using efficient methods (Porter et al 2007). Firms play an important role in shaping the business environment and thereby influence development of industries and total economic balances, meaning that how competitive a country ends up being is a reflection of the success of its companies (Dunning 2001), as «firms are deeply ingrained in and shape up countries» (Cho 1998: 13). In order to develop competitive advantages, firms must be able to foresee the changes in external environment and respond to them fast. There are

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[38] See e.g. http://www.imd.org/wcc/wcy-world-competitiveness-yearbook/

numerous schools of thought on firm behaviour and firm level strategies; discussing these would exceed the scope of this dissertation. However it is relevant to state that any choice of firm strategy stems from industry structure, as not all options are equally viable for a given firm (Porter 1985), (Murray 1988). Recent international trade trends highlight two opposing views: from one direction increasing globalisation and flow of price information brings about increasing competition and significance of costs as element of competitiveness; from another side increasing sophistication of products and quality-based competitiveness decreases significance of cost as the primary purchase decision criteria (Carlin et al 2001). Porter (2004) considers both as equally important: from the point of view of welfare maximisation the aim of all firms should be to produce at highest reasonable quality with lowest reasonable (direct and indirect) costs.

Raymond Vernon is attributed to be one of the first to have pointed out that economies grow fastest (i.e. welfare is created) if countries can establish a supporting environment for their firms so that the latter can become and stay competitive both at home and abroad. Vernon focused on overseas activities of US firms in the 1950s and 1960s and identified that the success of such firms is built on country-specific factors, which influence the competitive advantages of firms. Vernon's line of argument suggested that as long as firms exploit these location-specific advantages in their country of origin they gain strength to compete overseas by leveraging on these advantages (Dunning 2001). Such firms would have to match and exceed activities of rival firms in other nations by creating attractive goods and services (Waheeduzzaman & Ryans 1996) hence competitive success would be reflected in strong export performance (Siggel 2006). But such firms would also have to be successful in their home market as becoming less competitive would mean that producers of traded goods in that country would see an erosion of market shares in both domestic and foreign markets since imports would increase (Lipschitz & McDonald 1991).

Porter (1990) developed Vernon's argument further, stating that aim of a country should be to become home base for successful internationally active companies by searching for resources that create competitive advantages and then developing processes that sustain them (Aiginger 2006). Indeed it should be remembered that a country's business environment will host both local as well as international firms – since both are competing for local customers' attention (and sales) along with access to local (production) resources. If firms earn profits and can sustainably grow their business then this increases the country's reputation and lures more firms to set up their business there – accordingly, industries develop. As per Porter (1980), all firms could become successful by minimising costs (the so-called cost-leadership strategy), or by developing a unique business offering (the so-called differentiation strategy) or by applying a mixture of both, with focus on special market niches (the so-called focus strategy).

Fagerberg et al (2007) list four types of generic competitiveness strategies. Technology-based competitiveness is linked directly to innovativeness, including technological know-how. In the context of this dissertation, technology-based competitiveness would be reflected in e.g. different types of electricity generation technologies. Capacity-based competitiveness indicates potential to absorb and exploit technological innovation. This would be reflected in e.g. openness of the local electricity market and consequent opportunities it creates for both generators and consumers. Price-based competitiveness emphasizes potentially damaging effects of excessive factor input growth – such as price of electricity – on the economy. Electricity can also impact demand-based competitiveness. Transmission grids carry power from major production sites to major consumption hubs; power is further sent to smaller locations through distribution networks. This means that businesses located closer to power lines with higher voltage level usually have better access to large volumes of electricity and can therefore engage in electricity-intensive production.

According to Trabold (1995), governments need to work towards four long-term abilities of firms (and ultimately, industries): «ability to sell», «ability to attract», «ability to adjust» and «ability to earn». Government activities aimed at increasing «ability to sell» need to ensure that there are no barriers to business growth – such as by establishing free markets (in the context of this dissertation: including liberalisation of the electricity market) and facilitating transparency. This will benefit the nation through increased current account surplus as successful companies target export markets to increase sales, increased worldwide market shares and better knowledge of the country as well as it will also impact the real exchange rates. Activities aimed at increasing «ability to attract» target availability of production resources, most importantly capital but also labour and materials. This means that governments must work on taxation policies (including taxation of electricity) and address the unemployment rate and minimum wage requirements. Guaranteed easy access to electricity (and consequently enabling energy-intensive production) is another relevant and more specific example in the context of this dissertation. Third, for increasing «ability to adjust» governments need to ensure that the business environment supports fast adaptation of the market players, most notably through efficient public services and infrastructure (including reliable electricity grids). Although innovation is primarily associated with product and process development in the private sector, it is equally important to strive for more effective and efficient public services. This can be seen in eco-efficiency initiatives that support demand for those technologies to set incentives for and create new markets (Edler 2009). Some authors even claim that countries become successful if they have the ability to absorb and make use of new technologies – developed at home or abroad – rather than striving to become an attraction centre for regional R&D (e.g. Bihde 2006 through Edler 2009; and Porter et al 2007)). Hence, adjustment also refers to the ability to cope with changing market conditions, which affect electricity supply and pricing. Combining the three abilities with knowledge (in the form of human capital and technology) will help shape the «ability to earn». Earning is a product of sales less by costs, which again points to electricity price as a relevant factor (Trabold 1995).

Begg (1999) highlights that governments' main attention should focus on capacity-building and capacity-utilisation: although the most apparent preoccupation is to raise productivity so as to create more output from a given supply of inputs, it is also relevant to have a broader overview of how resources are distributed. Competitiveness depends on the entire structure of the economy and sectoral specialisation, as well as the character and effectiveness of institutions, quality and spread of infrastructure and other factors which increase the efficiency of the system as a whole. For example, despite many countries' efforts to reform their electricity markets the market shares of the largest generators in the electricity market have not significantly decreased from 1999 to 2009 in majority of the EU countries (Moreno et al 2012) and in some countries smaller producers have exited as only larger market actors can remain profitable (Burinskiene & Rudzkis 2010). This is partly explained by the fact that established companies in the electricity industry have strategically important supply points and sufficient grid capacity (Stankova et al 2010) so especially new renewable technologies often face a high entry barrier due to distant grid connection and/or need for grid strengthening. This can lead to consumer-harming price manipulation if cross-border trading options are insufficient[39].

Narula (1996) highlights the changing role of governments as countries pass through different stages of development. The same idea is highlighted by Porter (1990), as he discusses three stages of competitive development: from factor-driven economy to investment-driven economy to innovation-driven economy. In a factor-driven economy, competitive advantage is based on low-cost labour and unprocessed natural resources; and companies mostly compete on price, usually without direct access to foreign consumers. In an investment-driven economy, companies strive to produce goods and services more efficiently than competitors abroad; however the goods and production technology are not globally differentiated. Therefore, such economies usually concentrate on manufacturing and outsourced service exports. In an innovation-driven economy, competitiveness is rooted in use of globally leading-edge technology to create innovative products and services that are supported by well-integrated links with industries. Hence, companies must shift from competing on inputs and inherited endowments to created advantages from efficient and distinctive products and services (Porter et al 2007), as long-term competitiveness depends on the ability to sustain change in the factors that give rise to productivity growth (Begg 1999). In the context of

[39] This also explains why governments prefer to retain control of national transmission lines and regional interconnectors via ownership of transmission system operators.

this dissertation, Porter' logic means that electricity should rather be used as input factor for production of high-value-added goods, rather than exported as a commodity.

Thus the aim of countries should be to encourage development of firms (and industries) that can produce goods that can be sold to international markets under free and fair market conditions, while simultaneously maintaining and expanding the real incomes of the people (Begg 1999). Becoming and staying internationally competitive contributes to higher incomes of companies; and high-earning companies are expected to also share their wealth with the community (Trabold 1995).

1.2.3. Measurement of competitiveness

There is an ever-present need to compare a number of relevant economic features across countries (Durand & Giorno 2013) in order to make investment decisions, analyse trade flows and track development. Similarly, there is a need to measure competitiveness if one is to analyse performance and compare a country vis-à-vis others: by measuring competitiveness, one can track improvement in competitiveness (Bruneckiene & Paltanaviciene 2012). Measurement of competitiveness has to meet requirements of complexity, reliability, comparability and simplicity (Snieška & Bruneckiene 2009): this means that competitiveness has to be measured in a number of different aspects; the method for measurement needs to be methodologically and statistically founded; results must be comparable across regions; and results need to be clear and easily interpretable. Furthermore, as competitiveness has not been universally defined, its measurement needs to be relative to a yardstick or criterion, such as another industry in the same country, the same industry in another country, another point in time or similar (Traill & Gomes da Silva 1996). Most authors seem to agree on the importance to measure development over time (i.e. dynamic rather than static competitiveness) when comparing firms, industries and/or countries. Changes over time allow for analysing trends so that competitiveness indicators can become a yardstick of sustainable competition between firms or industries in different countries, showing how they enhance or retain their position (see e.g. Porter 1990, Siggel 2006, Toming 2011, Durand & Giorno 2013 and Viilmann 2013).

One of the most popular ways to measure competitiveness remains Michael Porter's 1990 model for «Competitive Advantage of Nations». In line with previously introduced theory where countries create a favourable business environment for firms to develop an internationally competitive offering (see section 1.2.2), Porter's model helps to illustrate how locational advantages offered by countries act as basis for firm productivity and thereby help generate national wealth by applying a multi-analysis methodology. Porter (1990) argued that each industry has several market forces affecting the firms active in it and depending on the balance between these forces as well as how well the firms themselves manage to exploit the situation to their advantage, national wealth is created through development and growth of the respective industries. The above was summarised into what became known as «Porter's Diamond» and later developed into «Porter's 5 Forces». The forces are defined as factor conditions (i.e. influence from suppliers), demand conditions (i.e. influence from buyers), related industries (i.e. threat of substitution), firm strategy and rivalry (i.e. competition among existing firms) and threat of new entrants and all of them have equal weight when assessing how they influence a firm's competitiveness (Porter 2008). As with most popular models, Porter's 5 forces model has also received criticism, primarily owing to the fact that it is easier to be applied in bigger and richer countries: the domestic variables of smaller economies are very limited (Waheeduzzaman & Ryans 1996), (Rugman et al 2012). Consequently, several modified versions of Porter's model have been proposed. One of the two common modifications is the «Generalized Double Diamond model» which pairs countries (Rugman et al 2012) to broaden Porter's focus into international context: the model observes «diamonds» of two countries in relation to each other. Another common modification is an «Extended Diamond model» or «nine-factor model» which incorporates the role of several human factors (politicians, entrepreneurs, workers) and chance events (Cho & Moon 2005), so that human variables are observed separately from the physical variables; and that the government variable is incorporated as endogenous.

Porter's 5 forces model exemplifies that competitiveness has several dimensions so it cannot be analysed with one measure alone: for example, focusing only on international trade could make countries with lower level of development and abundant natural resources (e.g. oil and gas) appear as very competitive despite low productivity of their economies (Waheeduzzaman & Ryans 1996). Similarly, analysing real effective exchange rates might give an understanding of relative prices of goods manufactured in countries, yet they fail to clarify reliability or technical novelty of the same goods. Use of unit labour costs can show labour use per nominal value added, but dismisses companies' differentiated access to technology, resources, financing etc.

It also needs to be kept in mind that countries need to be compared based on their similarities on selected criteria so that important factors underlying the competitiveness position of each stage for a particular country could be identified. This would allow for better understanding of the internal dynamics of country development as a country tries to «catch up» with other countries located at higher competitiveness stages (Önsel et al 2008)[40].

[40] Consequently, in this dissertation seven Northern and Northeastern European countries are in several occasions broken into two sub-groups – the Baltic and the Nordic countries.

Combination of several macro-economic and/or industry-specific indicators is the methodology behind composite indexes. As composite indices have several sub-indicators, the objects under examination can be ranked on the ground of it. Hence the main issue to be resolved with composite indices is assignment of appropriate weights for each sub-indicator (Snieška & Bruneckiene 2009). Use of sub-indicators is also the underlying logic among the World's most popular competitiveness indices, such as the Global Competitiveness Index published by World Economic Forum (WEF) and World Competitiveness Yearbook published by Institute for Management Development (IMD). Siggel (2006) praises the WEF and IMD indicators as serving a useful purpose for foreign investors, but argues that their theoretical base and aggregation methods are problematic, as they rather measure a country's «business climate», which is more subjective and harder to quantify. Also Bruneckiene & Paltanaviciene (2012) conclude that such indexes contain an element of subjectivity, as results are based on interpretation of facts not the facts as such[41].

The most robust means of measuring competitiveness use only comparative quantitative analysis. Many authors suggest measurement of economic performance in terms of GDP per capita as main means of understanding how well a country or nation is doing (in fact Porter et al (2007: 60) state GDP per capita to be the «best single measure of competitiveness performance»); but there are also suggestions to compare countries' export market share, trade balances, and price ratios (see e.g. Siggel 2006, Lee 2010, Matysek-Jedrych 2012, Bruneckiene & Paltanaviciene 2012).

Similarly to aforementioned indexes, it is also possible to combine quantitative measures to calculate indexes. One of most popular such indexes remains Balassa's Revealed Competitive Advantage index from 1965, as shown in equation (6) below:

$$RCA_{ij} = \left(\frac{x_{ij}}{X_j}\right) \Big/ \left(\frac{x_{iw}}{X_w}\right) \tag{6}$$

…where RCA_{ij} is the revealed comparative advantage index for industry i of country j, x_{ij} represents exports of industry i of country j, X_j is total export of country j, x_{iw} is the world export of industry i and X_w is total world exports.

Although originally developed as a generic means of measuring competitiveness, Balassa's RCA index could also be used to analyse how an electricity-intensive industry in one country performs in comparison to another. The index would foremost provide useful guidance for countries with relatively

[41] In several cases, country rankings are determined through interviews with people doing business in a given country, thus his or her (subjective) perception.

small domestic markets (as is e.g. the case in Northern/Northeastern Europe, where exports are important for GDP growth) – and assuming that growing export volumes are also a sign of growing productivity or profitability (which might not always be the case). A country has revealed comparative advantage if the value of the index is greater than one; there seems to be lack of consensus as to how to understand the degree of competitiveness above index values of one (Havrila & Gunawardana 2003). Balassa's RCA index is in line with argumentation that countries need to host internationally successful companies, i.e. strong export performance is a sign of competitiveness; however the RCA index does not capture industry productivity/efficiency or changes therein.

The open interpretation of competitiveness posits that one is not limited to using one index over another, as several indicators could be combined to best serve the purpose. For a more comprehensive list of possible competitiveness measurement indexes, see e.g. Toming (2011).

Several authors have developed methods that specifically measure electricity use in the context of firm, industry or country competitiveness. Steiner (2001) measured utilisation rate of installed electrical capacity as means of determining greater efficiency in use of electricity in connection with electricity price changes. The rate is calculated by dividing a country's net electricity production (e.g. in GWh) by the installed capacity (e.g. in GW). The capacity utilisation rate is directly related to openness of the electricity market: in regulated systems power producers have to maintain excess generation capacity to meet the occasional peak demand, whereas in liberalised electricity markets deficit electricity can be imported to meet peak demand. On the other hand, the capacity factor of several new renewable energy sources – e.g. wind and solar – is below 40%, which reduces the capacity utilisation rate of the country as more RES capacity is added. The capacity utilisation rate is therefore not likely to provide a definite overview of efficiency, and cannot be used on firm or industry level.

The European Commission (2014a) suggests to measure energy cost levels over time and/or between countries as inputs and choose e.g. gross production, value added or other indicators as outputs. More specifically, Davis et al (2007, 2008) conducted a series of econometric analyses based on firm-specific measurement data for manufacturing companies in the US in 1963–2000. Of these most relevant for this dissertation is the Davis et al (2008) analysis that measured electricity productivity (φ) as shown in equation (7), that is further split into physical efficiency in use of electricity (γ) and electricity price efficiency (p) – see equation (8).

$$\varphi_{et} = \frac{VA_{et}}{EE_{et}} = \frac{VA_{et}}{PE_{et} \times QE_{et}} \tag{7}$$

$$\log(\varphi_{et}) = \log\left(\frac{VA_{et}}{QE_{et}}\right) - \log(P_{et}) \equiv \gamma_{et} - p_{et} \qquad (8)$$

…where subscripts e and t refer to firm and year; VA stands for value added, EE is total electricity expenditure, PE is unit cost of each kWh of electricity, and QE stands for number of kWh purchased. Even if Davis et al (2008) applied their measures for firm-level analysis, they are equally applicable on consolidated industry-level to compare performance of the same industries across different countries.

The European Commission (2014a) operates with a relatively similar measure, which is referred to as «real unit energy cost» ($RUEC$) – shown in equation (9) below. Similarly to Davis et al (2008), the European Commission (2014a) observes the ratio of energy costs to value added (both in current prices), further split into two sub-indicators – energy intensity (labelled ϑ) and average real energy price (labelled $p_{e\,(real)}$).

$$RUEC = \frac{EC}{VA_{current}} = \frac{EC}{VA_{constant} \times P_{VA}} = \frac{EC}{Q_E \times P_{VA}} \times \frac{Q_E}{VA_{constant}} \qquad (9)$$

so that

$$\frac{EC}{Q_E \times P_{VA}} = p_{e\,(real)} \qquad (10)$$

and

$$\frac{Q_E}{VA_{constant}} = \vartheta \qquad (11)$$

… where EC represents energy costs in current prices, Q_E is the calorific value of energy input, $VA_{current}$ and $VA_{constant}$ stand for value added in current and constant prices respectively, and P_{VA} is the deflator for value added.

When comparing time series, the Statistical Bureau of Norway (SSB 2010) suggests to replace value added (VA) with production value (PV) since value added on firm level includes labour remuneration, depreciation costs, as well as return – all of which are expected to be different in every firm, every industry, every country, every year:

$$VA = \omega L + \delta K + \rho K \qquad (12)$$

…where ωL is the total labour expense, δK is depreciation and ρK is the profit (K represents capital), so that:

$$PX = \sum_{i=1}^{n} c_i x_i + VA \qquad (13)$$

…where PX denotes turnover from sales and the sum of $c_i x_i$ indicates costs of all inputs. As the price index needs to be adjusted for every year, the connection between value added (VA) and produced volume (X) is less obvious. SSB (2010) argues that in production value (PV), income is directly connected to the produced volume (X) so if one uses fixed prices (P_{fixed}), the change in fixed price volume is the same as change in total volume:

$$PV = P_{fixed}X \tag{14}$$

Also relevant are the analyses by Hourcade et al (2007) and Graichen et al (2008), both of which analyse impact of additional CO_2 emission costs from the EU ETS scheme on competitiveness of UK and German industries respectively. Industries are categorised according to two measures: by «value (added) at stake» as shown in equation (15) and «intensity of trade», as shown in equation (16).

$$VAS_i = \frac{DC_i + IC_i}{GVA_i} \tag{15}$$

…where VAS_i is value (added) at stake in industry i. DC_i is direct cost to industry i from emitting CO_2 in the production process, whereas IC_i is indirect cost to industry i from intermediate inputs to production that may become more costly due to them being subject to CO_2 emission costs e.g. higher electricity costs if such electricity is CO_2 intensive. GVA_i is gross value added from industry i at market prices.

Although both Hourcade et al (2007) and Graichen et al (2008) calculate additional cost burden to each industry from introduction of a new fee (the CO_2 emission cost from EU ETS), their suggested calculation formula can also be interpreted as that for $RUEC$ from the European Commission (2014) (cf. equation (9)) and a reciprocal of physical efficiency of electricity use (γ) in Davis et al (2008) (cf. equation (7)), if direct and indirect costs from a tax are to represent total cost of electricity. Similarly to «value at stake» measured by Hourcade et al (2007) and Graichen et al (2008), the physical efficiency of Davis et al (2008) and «real unit energy costs» of the European Commission (2014a) measure the relationship between value added and a specific cost. Thus, such ratio seems to be a common means of analysis.

For «intensity of trade», both Hourcade et al (2007) and Graichen et al (2008) use the following formula:

$$TI_i = \frac{EV_{im} + IV_{im}}{T_i + IV_{in} + IV_{im}} \tag{16}$$

…where TI_i represents intensity of trade in industry i; EV_{im} represents value of exports from industry i to outside EU (i.e. the common market that is in a customs union, with common taxation rules); IV_{im} represents value of imports to industry i from outside EU, T_i represents total turnover in industry i; and IV_{in} represents value of imports to industry i from other EU countries (i.e. from within the common market).

Thus the «intensity of trade» measures openness to foreign competition, which varies greatly across industries: e.g. bread or newspapers are predominantly produced for and consumed within the national market, thus increase in production costs in these sectors is unlikely to impact the country's overall trade (Graichen et al 2008). On the other hand, in sectors with high trade intensity changes in government policies (which affect taxation of these industries) must avoid distorting international competition, as it could undermine the country's own firms' international competitiveness in the long term.

If one does not differentiate between different export and import markets with different regulatory backgrounds, a simpler formula could be used. The author of this dissertation suggests dividing total export value from industry i (EV_i) by sum of total production value in industry i (PV_i) and total import value to industry i (IV_i) in order to measure trade intensity of industry i (TI_i), as shown below:

$$TI_i = \frac{EV_i}{PV_i + IV_i} \tag{17}$$

It has been shown in this section that four different publications – Hourcade et al (2007), Graichen et al (2008), Davis et al (2008) and European Commission (2014a) – measure the relationship between value added and a specific cost to determine changes in firm/industry level productivity or impact on firm/industry level performance. As shown in equation (12), value added consists of labour remuneration, depreciation, as well as profits. This makes it a suitable indicator for charting the journey towards greater welfare as the ultimate aim of competitiveness. It therefore makes sense to use value added per electricity expenditure as primary means of measuring changes in competitiveness in the electricity intensive industries.

It should be noted that in both Davis et al (2008) and European Commission (2014a), the main indicator of value added per electricity expenditure is further broken down into two cub-components – value added per energy consumed and average price of electricity. Thus, whereas value added per electricity expenditure measures productivity of electricity use, value added per kWh measures efficiency (or energy intensity) to emphasise changes in power requirements as one determinant of productivity, and different prices paid for each kWh of electricity act as the other determinant.

Chapter summary

The pursuit of competitiveness is rooted in earliest trade theories and thus a centuries-long discussion among economists. Whereas specific literature on competitiveness has emerged in the past few decades, there is no common definition of what competitiveness is and how it should be measured – it is context-dependent. By building on the thoughts presented by different researchers above, in this dissertation competitiveness is defined as a means of fostering development of firms and industries that can sustainably compete internationally and thereby create welfare to the society over long-term. In this dissertation, it is assumed that firms and governments influence each other; and no distinctions are made between firm and industry level competitiveness, i.e. it is assumed that the latter is generally representative of the former.

By building on suggestions from several different authors, changes to competitiveness of electricity-intensive industries are in this dissertation measured by foremost by changes to value added, although it has been shown that production value and exports are also suitable means of measurement.

1.3. Electricity price as a factor of competitiveness in liberalised electricity markets

Section 1.3.1 discusses the role of countries in regulating electricity markets as a means of shaping firm and industry-level competitiveness and addressing market failures. Since firms constantly adapt to government activities, patterns for firms' response are also discussed. In section 1.3.2 a synthesis of how electricity pricing affects competitiveness is proposed, and a number of research propositions are formulated to be empirically tested in the second half of this dissertation.

1.3.1. Basis for electricity-policy-making

A country's business environment significantly affects firm behaviour and success: for companies to be productive and successful, they need to be able to choose their labour from a pool of highly skilled people, have access to more advanced research institutions, be able to rely on excellent infrastructure, be able to choose from a wide array of suppliers, be able to efficiently communicate with the government (e.g. in taxation), have access to capital, incentives for investment and production etc. This is shaped by both market forces and government activities – and both are equally important. Competitive pressure enforces efficiency in firm rivalry and encourages firms to develop new capabilities, whereas predictable government activities provide security for long-term business planning and development (Lall 1992), (Boettke 2010).

Bad economic ideas result in bad public policies, which in turn produce bad economic outcomes. But figuring out best economic solutions and keeping aside the bad ideas is not an easy task given the counterintuitive nature of economic reasoning as well as vested interests in the development of public policy (Boettke 2010). Furthermore, information asymmetries, transaction costs and agency problems may lead to incomplete contracts between consumers, suppliers, regulators and governments. These in turn may lead to sub-optimal regulatory foundation (Ugur 2009).

In order for electricity markets to deliver electricity flawlessly to end-users, regulators have set up several requirement criteria for producers, such as operating reserves, frequency control, voltage support and reactive power and black-start capability (Bhattacharya et al 2001 through Wang et al 2011). Joskow & Tirole (2007) suggest that most retail customers are unable to react to real time prices because of legacy meters, non-price rationing of demand, wholesale power market problems and imperfections in mechanisms adopted to mitigate these problems – in other words, because retail electricity markets are not truly competitive. Electricity and electric power networks have special physical characteristics, which in turn leads to market failures that are unique to electricity. Failing to understand such market imperfections can be one of the principal causes of market actors' inability to adapt (Badcock & Lenzen 2010) so the governments need to step in.

It is too simplistic to assume that all firms have access to the same knowledge, produce goods of identical quality, and sell these in same markets: in fact different actors have different market knowledge even at the same time in the same location (Fagerberg et al 2007). Society as a whole is richer when resources go to their highest-value uses, but market imperfections can cause resources to be directed to places other than those most highly valued e.g. in case of externalities from consumption or production (Haltom 2011). Already in 1937 Ronald Coase concluded that different knowledge by different economic subjects at the time of carrying out market exchanges leads to different transaction costs for each firm. This different knowledge is reflected in discovery of relevant prices of factors of production and negotiating contracts for each sale-purchase transaction (Pitelis & Pseiridis 1999). Moreover, human needs do not automatically translate into clear market demands (Mowery & Rosenberg 1979 through Edler 2009).

Fagerberg et al (2007) point out that market imperfections have a two-way effect – some companies can win at the expense of others. Thus, companies' success is dependent on their ability to use market failures to their own advantage (rather than become a victim to another company that abuses market failures). Trebing (2001) surveyed US electricity and gas markets and highlighted three trends: (1) increasing economic concentration, which means both vertical and horizontal mergers and acquisitions and/or joint ventures both domestically and internationally; (2) emergence of constrained supply as demand increases and investments to production and transmission cannot keep up; and (3) low attention and protection of small business and residential customers, owing to the fact that independent suppliers with smaller supply volumes try to optimise their serving costs by targeting larger customers, leaving this consumer group with major suppliers that have market power. For similar reasons, Porter et al (2007) conclude that governments – or more broadly, public institutions – have pivotal role in setting the right rules and incentives and in overseeing public investments needed to develop a productive economy.

Accordingly, it is inevitable that companies' transaction costs are to a degree influenced by the presence and activities of various public institutions (Toumanoff 1984) who occasionally need to intervene to firms' activities in order to ensure better use of the nation's resources (Waheeduzzaman & Ryans 1996), (Ringel 2003). Kydland and Prescott (1977) point out that there are limits to it, as politicians' attempts to regulate activities of rational economic agents never maximise social gains. The rational agents will always adjust their behaviour based on their expectations of future policy actions (Kydland & Prescott 1977) and despite idiosyncrasies there is a common element of response of firms to policy, market and institutional framework (Lall 1992: 169). Indeed, regulators have never full information as the regulated firms are unlikely to disclose all relevant information to them – firms hope that regulators would then set fewer limitations, which allows firms to make higher rents (Kopsakangas-Savolainen & Svento 2010).

Paraphrasing Adam Smith's «invisible hand» of the market, Waheeduzzaman & Ryans (1996) refer to the government's implementation of a series of policy measures as the «visible hand». Daugbjerg & Svendsen (2011) add that policy measures usually comprise a mix of different instruments, as it is rare for policies to rely on a single instrument in order to keep the status quo or encourage changes. Governments set the scene for firms through a number of policies, from fiscal and monetary policies to regional geopolitics. As such, policy-making generally addresses the broader business environment, but might also be targeting specific sectors. For example, a country's energy policy might among other things govern electricity generation, regulate transmission/distribution and thus have a bigger importance for more energy-consuming companies, e.g. by addressing increased energy efficiency and increased use of non-polluting technologies (Vehmas et al 1999), although it to a degree affects all electricity consumers.

Yet several factors are not set or directly controlled by governments (Barney 1991): these include interest rates, relative cost levels, geographical location and availability of natural resources. Porter et al (2007) argue that governments can however shape such factors indirectly. A country with sea-border can turn it to its advantage if governments develop policies that allow investments in port infrastructure and thereby grant access to international waterways. Governments also control how a country makes use of its location by channelling investments to infrastructure (e.g. how many grid inter-connectors are built between the two countries) or establishing regulations for international trade (including trade of electricity). Proximity to countries with a large population is useful if governments establish rules of open and free trade, so that firms can engage in cross-border business. Similarly, impact of natural resources on prosperity of a nation is dependent on how well countries pursue policies that set the stage for development of supportive industries and distribute wealth from extraction, processing and exports more evenly across the society (Porter et al 2007) – a task that several countries have struggled to perform well.

The extent and success of government interference is linked to the openness of the economy. For an open economy, international competitiveness is affected by terms of trade (Lee 2010) and the need for as well as actual influence of government intervention is lower since the country's firms are exposed to world market prices and conditions (Bjertnæs & Fæhn 2008), which in itself dictates the level of competition. This also holds for electricity markets: markets where generation costs depend on global fossil fuel prices are by nature more deregulated, as they are less reliant on monopoly pricing (Simpson & Abraham 2012).

Having observed the link between a country's natural assets (natural resources, skilled labour, domestic market potential etc) and a country's internationalisation, Narula (1996) noted that absence of one or more of aforementioned country-specific characteristics lead domestic firms to undertake FDI in overseas markets to acquire or address these assets, and inward investment to their home country was lower. Consequently net outward investment position of such a country was likely to be more positive at all points of investment development path relative to «average». Exactly the opposite was the case for countries with absolute advantage in some country-specific natural assets e.g. large domestic market in the USA or natural resources in Australia. Narula (1996) argued that depending on economic orientation pursued by a country, economic development and scope of competitiveness would be substantially affected. Logically, more outward-looking countries would experience a faster learning curve as well as faster growth and structural upgrading. Edler (2009) discusses this as demand-driven innovation, stating that the government can significantly influence firm development through selective public procurement that favours innovative products or processes. Empirical studies showed that over longer time periods, public procurement triggered greater innovation impulses in more areas than direct R&D subsidies (Rothwell & Zegveld 1981 through Edler 2009). More generally, this means that traditional factor endowments and market size are decreasingly important as economies evolve, and the importance of created assets (quality and extent of technology, trade and education factors) increases (Narula 1996). Also

Porter (1990) writes that factor inputs themselves have become less valuable in a global economy – rather, a nation's prosperity depends on a business environment that enables the nation to productively use and upgrade its inputs.

Lall (1992) notes that competition – both inside the country but also from firms abroad – is the most efficient incentive for capability development of firms. Increasing costs usually force companies to review their operations and become more efficient over the longer term (Vehmas et al 1999), (Porter 1990). Barker and Johnstone (1998) highlight cases of Singapore, Hong Kong and Japan to prove that high energy prices brought about by high taxes or lack of domestic energy supplies are not an obstacle to industrialisation, innovation and/or rapid economic growth. Vehmas et al (1999) also state that IMD's competitiveness reports constantly rank the Nordic countries among most competitive economies in Europe, whereas these countries have been forerunners in implementing different types of taxes, including on energy use. Indeed: taxing CO_2 emissions and encouraging research and development in abundantly available wind resources has led Denmark to become one of the World's powerhouses in wind power utilisation. At the same time, ample reserves of low-cost oil, gas and coal – as is the case e.g. in Nigeria, Iran or Zimbabwe – have not proven to be sufficient guarantors of success in international trade (Barker & Johnstone 1998). Thus the key lies in creating a sustainable business environment that allows the country's companies to innovate while not imposing a too high tax burden.

Herrring (2006) notes that national energy consumption in most of the world's industrial countries has continued to rise over the past 25 years, despite advancement in technical efficiency. Haas et al (2008) refer to this as the take-back or rebound effect in economics (ref. Figure 9).

As per Haas et al (2008), if a technology's efficiency would be enhanced from η_0 to η_1 it should result in a theoretical energy consumption of E_{1TH}, down from E_0. But due to the fact that technical efficiency improvements lead to cheaper services, it will result in an increase in demand from S_0 to S_1. The practical level of energy consumption at η_1 is then E_{1PR}. Technical efficiency improvements may lead to an increase in long-term energy service demand, resulting in new and more end-use technologies emerging and a higher saturation of these appliances, and finally an increase in energy demand E_{1agg}.

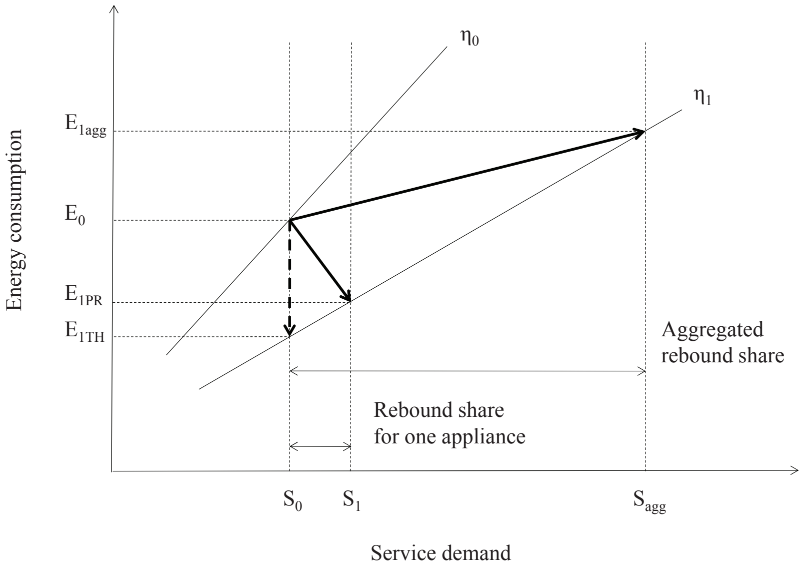

Figure 9. Rebound effect for technological advancement and aggregated effect on economy. Source: Haas et al (2008)

Haas et al (2008) demonstrate that improving fuel efficiency of passenger cars has in fact led to more customers buying larger cars which today consume as much fuel as small cars a few decades ago; and the average level of consumption has therefore not decreased. Similarly, if lower prices of electricity make electricity cost share much lower than that among direct rivals then companies will not find it relevant to address them and dealing with electricity consumption will not be seen as a key priority affecting the companies' core competence development. As a result several companies in several industries are much more energy intensive than they could be (Thollander & Ottosson 2010).

Electricity is used inefficiently in several countries and often for purposes where other forms of energy would be more appropriate from an environmental point of view (Nørgaard et al 1994). Haas et al (2008) note that increased efficiency in energy services is one of the most cost-effective and environmentally friendly means of achieving more with less per unit of corresponding primary energy required; and it is often also the least well-understood means. Friedrich et al (2009) calculate that if energy efficiency improvements were made instead of setting up new electricity supply, cost savings could amount up to $^1/_3$ of new energy supply. Such calculations hold for both conventional fossil-fuelled and renewable energy sources, as the cost of energy efficiency has remained very consistent over time.

Some governments have imposed energy saving targets and award «white certificates» for reaching these targets. Participants are then free to trade the certificates based on how well they are meeting their energy efficiency goals (Bye

& Amundsen 2012). In 2001 in California consumers received bonus payments for lower energy consumption: Californian customers were given a 20% rebate on the commodity proportion of their electricity bill in June–September for a 20% minimum reduction in monthly consumption in the same months compared to last year (ESMAP 2011). Imposing energy efficiency targets might also be involuntary, such as the energy savings targets enforced in Brazil in 2001 where market participants were obliged to cut their power usage or face fines for not meeting the baseline (as the country experienced generation shortcomings)[42]. In practice, consumption restrictions are generally imposed on distribution companies or energy suppliers, who invest in energy efficiency measures on behalf of end-users and charge the latter a fee (Bye & Bruvoll 2008).

A number of issues need to be considered when discussing energy efficiency measures. Huntington (2011) lists the flaw of using averages (indicating heterogeneity of populations, meaning that new technology adoption rate might often be overstated), slow diffusion process (indicating that even the best new technologies might not achieve 100 per cent penetration rate), rebound effect (indicating that new technology might be used more intensively because it is energy efficient and hence cheaper to operate), the fallacy of composition (collective decisions of many actors – e.g. to consume less energy – might reduce the profitability of the original opportunity to each investor – e.g. lower demand will reduce energy prices), and policy costs (governments need to invest in new standards and monitoring mechanisms). Thollander and Ottosson (2010) highlight asymmetric information as one of the reasons why energy efficiency measures are not always implemented. Henriksson et al (2012) discuss the same as the principal-agent problem.

Controversy also remains over how effective energy efficiency initiatives have been to reduce electricity intensity as there is no uniformly agreed formula to calculate savings. Arimura et al (2012) put the cost of kWh saved through energy efficiency measures from USD 0.01 to USD 0.20 in real 2007 values for studies carried out in the United States. The difference is explained by perspective taken: ex-post econometric analysis usually returns higher costs per unit of electricity saved than ex-ante engineering-based costing approach.

Interestingly, research by Krishnapillai and Thompson (2012) concluded that at least with empirical data from the USA, economic growth leads to higher increase in price of electricity than real wages and interest rates. This implies that energy conservation policies – which promote savings in physical capital or increased labour productivity – will in the long run not be a better solution than policies promoting development and commercialization of new energy sources.

[42] In Brazil the overall energy consumption declined more than planned with residential customers saving up to 25% electricity, industrial reductions between 15–20% and commercial savings between 10–25% (ESMAP 2011).

Also Backlund et al (2012) note that energy efficiency should be combined with other activities, such as investments in energy-efficient technologies with continuous energy management practices. Accordingly, countries should strive for regulation where market participants would be encouraged to develop energy efficiency measures, yet having some security that a selection of price risks is absorbed by the state (Kopsakangas-Savolainen & Svento 2010). Alternatively, Bjertnæs and Fæhn (2008) suggest to remove any preferential treatment of electricity-intensive producers but at the same time compensate for the losses of electricity-intensive company profits. They argue that this can be welfare improving, because the former outweighs the latter: the costs associated with compensating energy-intensive exporters are modest because of high dependence on world market and little scope for shifting tax burdens onto demanders.

1.3.2. Establishment of study framework and research propositions

This dissertation posits that a country's overarching goal is to maximise welfare; and one aspect of this is establishment of a fostering business environment that firms use to produce superior goods for international markets in free and fair competition, so that successful industries develop. This is done best if all resources are used most efficiently: including electricity.

Availability of natural resources has historically played an important role in determination of electricity generation technology and is important also at present day: hydropower can only be exploited in regions with rapidly flowing rivers or streams; coal is typically more often used for generation in locations with abundant coal deposits (or proximity to these) etc. Owing to recent advancements in new generation technologies, availability of natural resources for electricity generation has obtained a new meaning. Ample agricultural waste and/or forest is increasingly used for electricity generation from biomass, solar power is increasingly popular means of electricity generation as one moves closer to the equator, and wind turbines have been erected to generate electricity in windy areas onshore and offshore. This has shaped electricity generation costs – and price of electricity supply – in every country differently.

Paraphrasing Lall (1992), efficient resource allocation for electricity production is dependent on well-functioning flexible factor markets and correct relative factor prices. This lowers entry barriers and thereby increases competition as well as transparency, since market participants have a motivation to become more efficient (both as electricity generators and as consumers). Accordingly, investments are made to reduce operating costs. It has been shown in section 1.1.2 of this dissertation that liberalised electricity markets ensure production efficiency, exchange efficiency and optimal product mix efficiency (ref. Boettke

2010, Nielsen et al 2011, Pikk & Viiding 2013). It has also been argued in section 1.2.2 that in this context, governments' initial preoccupation to raise productivity may be replaced with a focus on capacity-building and capacity-utilisation. Market imperfections stipulate that in many liberalised markets historic incumbents still control a large (if not the largest) share of generation capacity and especially smaller producers may struggle to remain profitable (ref. Begg 1999, Burinskiene & Rudzkis 2010, Moreno et al 2012).

Thus, in order to avoid potential price manipulation, governments should ensure adequate interconnector capacity to facilitate greater cross-border trading. As pointed out in section 1.1.1 in most cases electricity market liberalisation coincides with building inter-connectors to neighbouring countries (or significantly expanding the capacity in existing inter-connectors), which in turn has converted electricity from a local commodity to a regionally tradeable one. As shown in section 1.1.2, managing infrastructure development – such as improvements in transmission capacity and building more inter-connectors – can significantly improve predictability of the business climate in a country. Accordingly the relative advantage of lower electricity supply prices decreases, as electricity supply prices adjust to changes in demand and potential cross-border electricity trade. For industrial end-users, aggregated electricity demand will depend on the different consumption profiles of firms and industries in a given country, whereas aggregated supply will be a combination of domestic supply and supply from generators abroad (given that there are inter-connectors to neighbouring countries). This is a prime example of a case where governments can indirectly shape location-specific determinants, if they cannot control them directly (ref. Barney 1991, Porter et al 2007).

Indeed, as shown in section 1.1.3 with reference to Erdogdu (2014), reduction of cost-price margins has been one of the primary objectives in electricity market liberalisation and inter-connection to neighbouring countries. Similarly, it was shown with reference to Steiner (2001) that liberalisation and greater inter-connectivity eventually contribute to better capacity utilisation and lower reserve margins.

Therefore, building inter-connectors to neighbouring countries increases demand and supply by reaching out to more market counterparts. Given that there are no bottlenecks in the supply chain, this in turn should then result in electricity supply price convergence across neighbouring countries.

The first research proposition of this dissertation is accordingly phrased as follows:

P1: Liberalisation of electricity markets in neighbouring countries, along with adequate inter-connector capacity between these countries, will lead to convergence of electricity supply prices.

As was shown in equation (3) in section 1.1.2, there are three components in the total price of electricity – in addition to electricity supply price one also has to pay for electricity transport and taxes. There are least differences in price-setting of electricity transport (i.e. grid fees for DSOs and the TSO) in regulated vs liberalised electricity markets – the main difference being degree of transparency as in regulated markets the grid operator(s) is/are often part of a vertically integrated utility (and might benefit from cross-subsidisation). Typically, the (in any case, regulated) electricity grid fees are a product of needed operating costs, needed (re)investment costs and reasonable profit for the operator, whereas efficiency in the former contributes positively to the latter. Grid operating and re-investment costs are however often not directly comparable across countries, as they depend among other things on geographical and climatic conditions of the electricity grid (e.g. greater exposure to moisture in coastal areas may necessitate more frequent monitoring and a faster equipment replacement cycle). Reinvestment needs are also determined by historical grid developments and thus the present day condition of grid (e.g. how many km of power lines reach end of lifetime each year, owing to when they were first built). Investments into new grid capacity – both in distribution and transmission, including interconnectors abroad – are often based on macroeconomic analysis of assumed changes in aggregated supply and demand.

Thus the third electricity price component – taxation of electricity use – becomes an important instrument for government policy-making in liberalised electricity markets. In section 1.3.1 it was acknowledged that generally free markets determine the most efficient resource allocation (ref. Haltom 2011), but it was also argued that electricity markets have several unique market failures owing to the special physical characteristics of electricity (ref. Badcock & Lenzen 2010), and this justifies government intervention. With the taxation component, governments have levers to regulate the actual cost burden of different market participants, e.g. by re-distributing some of the weight from larger consumers (where electricity costs and cost share has a noteworthy size) to smaller consumers (where electricity costs are both small in absolute terms and as a share of total costs). This would apply in addition to differences from economies of scale, where larger consumers that buy in bulk are offered a lower price per kWh for both electricity supply as well as electricity transport.

Some electricity-intensive users might approach the government directly or through an industry association for an agreement to allow for tax-free use of electricity or negotiate electricity prices. It was shown in section 1.1.2 that the European Commission (2011) has acknowledged importance of the manufacturing industry as centrepiece in advancing future technical development of the EU. This includes electricity-intensive manufacturing industries, which might affect a significant part of workforce and exports in some countries. Reference was also made to OECD (2011) and Commins et al (2011), arguing that in some countries negotiated tax rates might be justified also on the ground of environmental concerns – e.g. if moving electricity-intensive industries abroad would likely result in countries that use more-polluting technologies both for electricity generation and production of output from the electricity-intensive industries.

Thus, in liberalised electricity markets the governments' main lever for controlling the total price of electricity – and competitiveness – is taxation of electricity use, with level of taxation often being a blended result of both economic as well as political rationale. The second research proposition of this dissertation is accordingly phrased as follows:

P2: In liberalised electricity markets, firm and industry-level competitiveness is influenced by governments' decisions on pricing of electricity taxes and fees to various consumer segments.

In section 1.1.1 it was summarised that cost of energy (including electricity) is a determinant for cost of doing business similarly to capital, labour and other resources (ref. Varian 1992, Haas et al 2008). Firms use electricity as an input factor similar to all other resources, whereas the share of electricity costs in total cost of purchased goods and services is larger in the more electricity-intensive industries.

This means that in regulated markets, countries with ample low-cost electricity generation capacity should engage in manufacturing of electricity-intensive products, as such industries thrive better than they would elsewhere, and can export larger shares of their production abroad. Governments of such countries should then maintain a preferable total price of electricity for the more electricity-intensive industries, so as to support further growth of such industries, create more added value, generate more income and ultimately cater to greater welfare of the society. Thus, the price of electricity becomes a location-specific advantage that defines relative competitiveness levels of countries and lures firms to set up electricity-intensive production in one country over another.

In section 1.2.2 it was summarised that recent trends indicate on the one hand importance of costs as an element of competitiveness – since prices are set globally for an increasing list of goods and services. However, on the other hand also product and process innovation are more important, so as to differentiate a firm's offering and rely less on costs (ref. Carlin et al 2001, Porter 2004).

Indeed, in liberalised markets prices are more volatile, governments cannot act in isolation and activities of neighbouring countries' governments influence others' decision-making. If one country decides to impose low electricity taxes to its large-scale consumers, then it inevitably also influences a neighbouring country's government in design of its electricity taxes to its large-scale consumers. Also activities of some supranational governing bodies such as the European Union or others with significant influence (e.g. World Bank, International

Monetary Fund, European Central Bank) might impose mandatory activities on country governments[43].

Therefore, government activities will in the long run have only a limited effect on competitiveness. In section 1.3.1 it was shown that due to the rebound effect several companies are more electricity-intensive than they could be (ref. Haas et al 2008, Thollander & Ottoson 2008). Instead of governments shielding selected companies from market forces, free competition should provide the incentive for capability development of firms, so that they review their operations and implement efficiency measures (ref. Porter 1990, Lall 1992, Vehmas et al 1999). Firms decide to internalise electricity-intensive production if the price of electricity is acceptable. If prices start to rise, companies must either take steps to reduce power requirements per unit of output or take steps to lower the cost of power per kWh (ref. Davis et al 2008) – otherwise production of electricity-intensive products needs to be outsourced and/or left for other companies in the supply chain, possibly abroad.

This stipulates that ultimately the firms themselves – e.g. the electricity-intensive manufacturing industry – should take steps to boost their performance: such companies' competitiveness is partly dependent on cost-competitiveness but possibly also focus on improved efficiency and innovation both in processes and products. This is also in line with Porter (2008) recommendations for competitive strategies: by developing a unique product and/or process, companies can ultimately move away from cost-based competition.

The third research proposition of this dissertation is accordingly phrased as follows:

P3: Firms can boost their competitiveness through increased efficiency and/or innovation, so that output per kWh increases.

In section 1.2.2 it was argued that exports are a testament to attractive goods and services, and allow firms to match and exceed activities of rivals in other countries (ref. Waheeduzzaman & Ryans 1996, Siggel 2006). In section 1.2.1 reference was also made to Melitz (2003), who showed how only most productive firms enter the export market and as industries' exposure to trade further increases, inter-firm allocations enable aggregate industry productivity growth and overall gain in welfare.

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[43] In situations where governments have borrowed money from e.g. the IMF, the latter may dictate government spending, and thereby indirectly influence electricity tax levels. Another example is the 20–20–20 goals of the European Union (ref. European Commission 2011), where the EU's leaders committed to a reduction of greenhouse gas emissions by at least 20% below 1990 levels; 20% of EU energy consumption to come from renewable sources; and a 20% reduction in primary energy use from higher energy efficiency – all by the year 2020.

As per microeconomics, production of greater volumes allows firms to exploit economies of scale – i.e. the relative unit costs decrease (ref. Varian 1992). This means that it is possible to absorb some cost increases – e.g. increased electricity prices – without significant impact. However, the possibility to reach economies of scale might be limited by the small size of the domestic market – there is not enough demand for the firm's products. Given that the goods produced by a firm are desirable (and/or cost-competitive), they will also have export potential. Thus, increased exports can significantly increase the aggregated demand for the firm's (and industry's) output; and provide the needed economies of scale. This allows the firm to earn increased profits, or to produce at (somewhat) higher marginal costs, including price paid for electricity.

Indeed, in section 1.2.1 it was also argued that pattern of trade is associated with economies of scale and market structure, and impact a country's comparative advantage (ref. Krugman 1980, Das 1982). Thus, whereas only more successful firms can export, the export activity itself also impacts firm performance at home. The fourth research proposition of this dissertation is accordingly phrased as follows:

P4: In countries with small domestic markets, increased exports allow for increased economies of scale, which in turn allows firms to absorb electricity price increases.

In this dissertation competitiveness is seen as means of increasing welfare to the society; and increased welfare is the ultimate aim of any country. In section 1.2.1 it was concluded that the pursuit of competitiveness is a country's long-term dedicated choice that necessitates a combination of strategic activities from the government (ref. Porter 1990, Rugman et al 2012). Predictability of government activities is key to long-term success – in section 1.3.1 it was argued that long-term business planning and firm development are highly reliant on the government's activities which set the scene (ref. Lall 1992, Boettke 2010). In section 1.2.2 reference was made to Porter (1990) and Aiginger (2006), concluding that countries should search for resources that create a competitive advantage and then develop processes that sustain them.

In section 1.1.2 it was shown that cost of electricity per output depends on price paid for each kWh consumed – which in turn is a product of electricity supply price, electricity transport price and electricity taxes (and/or subsidies) as summarised in equation (3). As shown in section 1.1.2 electricity costs are one out of several input factors in firms' production function; in some industries their relative share is higher than in others.

In regulated markets, governments control all three price components; whereas in liberalised electricity markets price of electricity supply is determined by open competition – which increases when electricity markets are inter-connected across countries (ref. research proposition #1). Price of electricity transport usually remains regulated, but so that it encourages greater efficiency from the grid operator. Therefore, governments' main lever for adjusting total price of electricity in liberalised electricity markets is the taxation component with possible variation in tax levels across end-users (ref. research proposition #2).

In section 1.3.1 it was shown that efficiency and innovation are also important contributors to relative competitiveness of firms and industries (ref. research proposition #3) – in addition to lower costs per output. The same underlying idea is presented in section 1.2.2, which concludes that firms should use a favourable business environment to efficiently develop valuable goods and services (ref. Krugman 1994, Dunning 2001, Porter et al 2007).

If governments execute competitive policies and provide sustainable location-specific advantages that firms can use as basis for developing attractive products, then eventually successful industries develop. The same idea is found in Trabold (1995) as he lists various «abilities» that governments need to address (ref. section 1.2.2). Successful firms and industries create more value added and earn higher revenues, with export as an important contributor for smaller countries (ref. research proposition #4).

Figure 10 below provides a visualisation of the study framework for this dissertation – on how electricity prices in liberalised electricity markets impact competitiveness of industries and thereby contribute to welfare creation in countries. It is acknowledged that such a framework is likely to be one out of many possible alternatives – it has been shown in this dissertation that there is more than one way to define competitiveness and there are many ways to manage cost of electricity as production input factor. However, it is argued that such a clear mapping of relationships between variables is not to be found in most literature reviews on similar topics, and is thus addressing the research gap. The robustness of this study framework is tested empirically by validating the research propositions further in chapter 3.

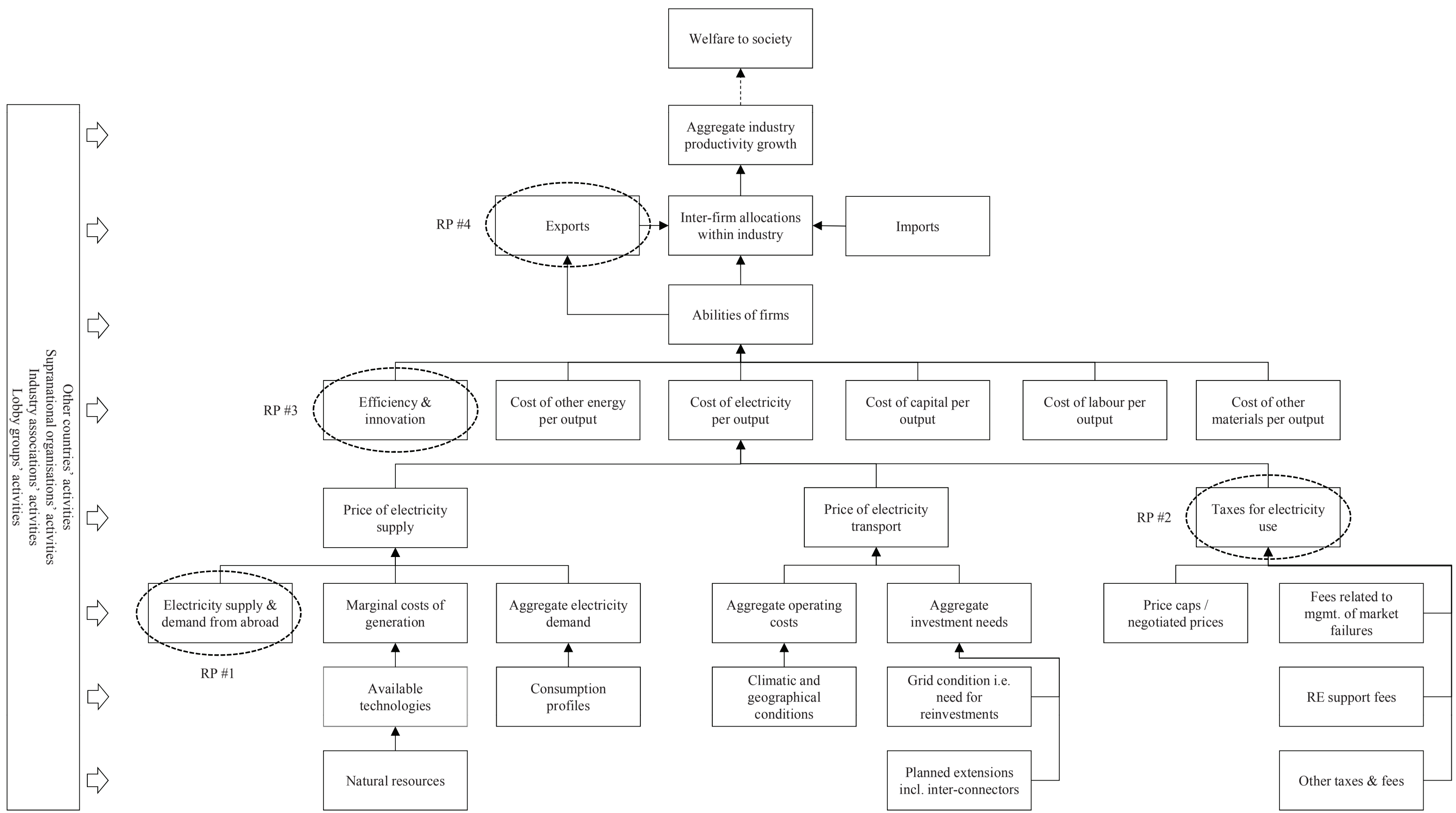

Figure 10. Framework on the relationship between electricity prices and firm and industry competitiveness in liberalised electricity markets. Variables addressed by research propositions are shown as circles. Author's drawing.

Chapter summary

Uniqueness of electricity markets stipulates that government intervention is in certain cases justified to mitigate market failures. Part of this mitigation can be done through setting of taxes and subsidies. However, there are clear limits to it, as rational economic agents always adjust their behaviour based on government activities and market regulators never have full information. Thus government activities help firms only half-way: for market actors to maximise use of their resources, they must innovate and implement efficiency gains. Indeed, energy efficiency is often seen as an underused resource.

Four research propositions have been developed to address the aim of this dissertation and describe how electricity prices shape competitiveness of firms and industries in liberalised electricity markets, and thereby impact welfare creation in countries. Validity of these propositions – and the framework – is to be tested in the second half of this dissertation.

2. METHODOLOGY FOR EMPIRICAL ANALYSIS

This chapter discusses the methodology for testing the research propositions that were set up in section 1.3.2. Section 2.1 provides an explanation of the general structure of the empirical analysis and provides an overview of used data sources. Section 2.2 introduces the relevant definitions and specifications, such as the reasoning for limitation of analysis to the manufacturing sector, as well as classification and identification of electricity intensive industries in the context of this dissertation.

2.1. Characteristics of empirical research

2.1.1. Structure for data analysis

A starting point for arriving at quantitative logical models is plotting the data. Keeping things simple makes it easier to combine simpler building blocks to arrive at complex constructions (Taagepera 2009), thus in this dissertation different variables are first compared graphically to identify any relationships between them as means of preliminary descriptive analysis. Several of these are also summarised in section 3.2.1.

It was earlier (ref. section 1.2.3) concluded that for measuring changes in industry competitiveness, it makes sense to use value added, production value and exports as dependent variables. More specifically, measurement of value added per electricity expenditure probably acts as one of best means for measuring competitiveness in the context of this dissertation, since Davis et al (2008) have used it as «electricity productivity», the European Commission (2014a) has used it as «real unit energy costs», and as Hourcade et al (2007) and Graichen et al (2008) have used it as «value added at stake». As follows from Davis et al (2008) and European Commission (2014a) the relationship between the two sub-components, electricity intensity (or efficiency, depending on how one wishes to define it) and electricity price, is also relevant. While production value is self-explanatory, export performance is observed through trade intensity as a proxy for international attractiveness of the manufactured goods and hence a testament of sustainable competitiveness.

Generally, the more data is available, the more complex econometric models can be constructed. Typically, a linear regression analysis is either observational or experimental (Shmueli 2010). In observational analysis, the causal relationship between predictor variables and response variable is examined. Observational data are collected from historical records, which means that they are objective i.e. cannot be influenced by the modeller. However, it also means that the modeller has no control over possible sources of (systematic) errors. It is therefore critical that the relationship between response variable and predictor variables are validated with regards to the cause-and-effect-relationship (Mendenhall & Sincich 2003). As a rule, it is difficult to find proof for causality in regression analyses. In this dissertation, preliminary validation of the cause-and-effect-relationship is attempted by plotting of data (ref. Taagepera 2009).

In experimental analysis the values for predictor variables are determined by the experimenter, and measures are made to reduce sources of systematic error, by randomization, and to isolate effects in the experiment. In that case the aim is to build a prediction model on how the response variable can be predicted by a set of variables (Mendenhall & Sincich 2003). One of this dissertation's research tasks is synthesis of general recommendations for economic policy-making towards electricity-intensive industries. Naturally, for this purpose a predictive model would assist better than an observational one. However, limited time-series of data impedes from building a predictive model in this dissertation, and consequently conclusions are drawn from the observational analysis only.

A popular means of regression is use of pooled ordinary least squares. This means that the regression assumes same intercept and slope for all seven NordPool countries and all industries. The OLS regression takes the following form:

$$\log Y_i = \beta_0 + \sum_{j=1}^{k} \beta_j \log X_{ij} + \varepsilon_i \tag{18}$$

…where Y represents a dependent variable, β_0 is the intercept, X_{ij} represent various independent variables with β_j as coefficients, so that $(i = 1 \dots n)$ represents total population and $(j = 1 \dots k)$ represents explanatory variables; and ε is the error term. Owing to the fact that there may be large differences in absolute values (e.g. costs, value added, exports etc) in same industries across different countries and also different industries within a country, it makes sense to use logarithmic values instead of linear data for the regressions. An added benefit is the fact that when using logarithmic values, the coefficient indicates elasticity.

In total four sets of regressions are run in section 3.2.2 and all are effectively modelled as shown in equation (18). As was highlighted in section 1.2.3, the European Commission (2014a) suggests to measure energy cost levels over time and/or between countries as inputs and choose e.g. gross production, value added or other indicators as outputs. In section 1.1.1 it was summarised that cost of energy (including electricity) is a determinant for cost of doing business similarly to capital, labour and other resources (ref. Varian 1992, Haas et al 2008). Consequently, in the first regression the two sub-components of value added per electricity expenditure (as the preferred competitiveness indicator) are regressed so that value added per kWh (as a measure of energy intensity / efficiency) is regressed as a dependent variable and electricity payments together with several production function components as independent variables.

This effectively relates to the Augmented Solow Model discussions that date back to Mankiw et al (1992). Accordingly, in a classical approach modelling of output depends on only two factors: capital and labour. In the Augmented Solow Model, it is argued that these two factors cannot comprehensively capture the more complex background to the production function and hence additional variables are needed, such as e.g. human capital (see e.g Temple 1998, McDonald & Roberts 2001). In this dissertation, the typical production function variables capital and labour are complemented with cost of materials as a third frequently used variable (ref. Varian 1992), and specifically electricity expenditure as a focus variable relevant for this dissertation. Also, a variable for cost of all other energy (apart from electricity) is included.

In the second regression, value added per total electricity expenditure (i.e. what Davis et al (2008) call electricity productivity and reciprocal of what the European Commission (2014a) calls real unit energy cost) – is regressed with electricity cost share in total purchased goods and services for each industry. This is inspired by a related test by Davis et al (2008), who found that rising electricity costs affect electricity-intensive manufacturers more than others. Given that Davis et al (2008) had access to firm-level data, they were first able to calculate an estimated elasticity of efficiency with respect to price for each industry, and use this for regression analysis. In this dissertation such elasticity is assumed to be constant due to lack of firm-level data, thus a simpler regression – as described above – is used instead.

Davis et al (2008) also found that there is a tradeoff between price paid for electricity and implemented efficiency measures; and a similar logic postulates research proposition #3 in this dissertation. Thus in the third regression value added per kWh is regressed with electricity price per kWh for each industry to identify possible correlation and relationship of the two variables.

Finally, the first regression is repeated by replacing value added with trade intensity to introduce an element of success in foreign markets. Augmented production function components – including electricity expenditure – remain unchanged so as to test validity of research proposition #4.

Already in the introductory chapter it was highlighted that the seven countries differ from each other, as do the same industries across the countries. Hence, country (γ_i) and industry (δ_i) level dummies are introduced to the pooled OLS to detect these differences, as shown in equation (19) below.

$$\log Y_i = \beta_0 + \sum_{j=1}^{k} \beta_j X_{ij} + \gamma_i + \delta_i + \varepsilon_i \tag{19}$$

In order to better interpret the relationships, regressions are also re-run without dummies but with decreased sample sizes, as follows (refer to section 3.2.2 for more details): (1) only electricity-intensive industries; (2) only non-electricity-intensive industries; (3) only Denmark as an energy-efficient economy; (4) only the three most electricity-intensive Nordic countries; and (5) only the Baltic countries.

2.1.2. Available datasets and used variables

There are effectively three different ways to gather relevant data for the 7 NordPool member countries. The first option is to download available data from the individual countries' national statistical bureaus. The second option is to access available data from Eurostat, i.e. the statistical bureau of the European Union which requests data from all its 28 member states, and several other non-EU countries (including Norway, which is the only non-EU country among the 7 NordPool member countries). The third option is to access data from global organisations that have their own statistics databases – such as the UN, World Bank, OECD etc.

The first option is the most flexible one: given that there are only 7 countries, it is possible to review each country's statistical bureau's website – all of them have English-language versions in addition to the local language – and also contact these institutions for clarifications and/or additional information. For these reasons, the author of this dissertation chose to exercise this option first. However, it soon became evident that different countries' statistical bureaus have chosen to put different emphasis on which data is collected: whereas it is possible to find data on the most common variables such as population, GDP, aggregated export value etc, there is far less information collected for electricity pricing components, industry-level consumption patterns etc. Indeed, in several countries electricity prices, generation and consumption are only reported on aggregated levels, which is insufficient for industry-level analysis that is the focus of this dissertation. Follow-up phone calls to the national statistical bureaus confirmed that in several countries more detailed data is not collected. Thus, even if industry-level information is collected and published by one or two countries' statistical bureaus and one can use it to study patterns within these countries, they are of no use for a 7-country comparison due to lack of similar data in other countries.

This suggests that the second option – data from Eurostat – is more preferential. Eurostat sends standardised questionnaires to all EU member states' statistical bureaus – and a few other countries such as Norway[44] – with commonly agreed due dates. Thus, data published by Eurostat is cross-comparable across all countries in the Eurostat database, and whenever new data becomes available (e.g. for the past year), it is published simultaneously for (almost) all countries. On several occasions one finds more detailed data (e.g. on industry level) from Eurostat than from the websites of the respective countries' own statistical bureaus, which again points to the large differences in how different countries' statistical bureaus prioritise different data.

On some occasions, this can and has led to problems in cross-comparability of data: although Eurostat's guidelines for data reporting are rather clear, there is only limited quality control by Eurostat of the data that is delivered by the national statistical bureaus. An example of this is reporting of electricity prices on three different levels: price of generated electricity, all taxes and fees for electricity consumption (excluding value-added-tax, i.e. VAT) and total price paid by different consumer groups (excluding VAT), whereas the first two combined lead to the third. Although the second group (all taxes and fees excluding VAT) may sound straight-forward, different countries interpret this differently. In some countries subsidies for renewable electricity are collected as a public service obligation (PSO) and included in the first group, i.e. price of generated electricity. At the same time in some countries the PSO includes both subsidies for renewable electricity and financing of future transmission grid investments, and is reported in the second group i.e. taxes and fees of electricity consumption. As a result prices reported in the first group – price of generated electricity – become incomparable, although the differences level out for total price of electricity (i.e. the first two groups combined). Where inconsistent data was detected, the author called the country's national statistical bureau for clarifications.

The third option is to use data collected and published by large global organisations. The advantage of choosing this option is the fact that standardised data is collected and reported for nearly every country in the World, thus cross-country comparisons can be made not only on regional but also global level; and timeseries usually are available for several decades. The disadvantage of using data from global organisations such as the UN, World Bank etc is the fact that full data is for several variables reported 3–4 years later. Also, because of their global coverage, more detailed data is missing for several countries; and specifically within electricity pricing, generation and consumption data is reported on aggregated country levels only. However, particularly for trade-related indicators these global databases include equally detailed information as Eurostat: it is possible to extract export and import data per commodity from both the United

[44] For more information, see http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM&StrGroupCode=LEX_MANUAL&StrLanguageCode=EN

Nation's Comtrade database as well as from Eurostat. Since data in Comtrade is reported in USD whereas data in Eurostat is in EUR, in this dissertation Eurostat data has also been used for trade analysis to avoid currency conversions.

In light of the above, most of the data used in this dissertation has been sourced from Eurostat, and complimented with national-level data sources and/or global data sources were applicable. The limitations in making conclusions from such data are further elaborated in the chapter «Limitations and Future Research» at the end of this dissertation.

Eurostat's dataset for structural business statistics («sbs_na_ind_r2») has been used to retrieve most industry-level variables – gross investments, production value, value added, wages paid, total purchases of goods and services, payments for energy. Purchases of energy products, including electricity, are also reported in multi-yearly enterprise statistics («sbs_pu_4l_02»), although not regularly updated. Electricity generation, transmission and consumption data is available from annual dataset «nrg_105a», whereas pricing can be retrieved from datasets «nrg_pc_205_h» and «nrg_pc_205_c». Data on industry-level trade (exports and imports) is available from detailed data tables for international trade in goods (such as «DS-018995» and «DS-058471»). Consequently for each variable there are altogether up to 378 observations, i.e. by observing nine grouped industries in seven countries over a period of 6 years. Due to the need to omit some data points on the ground of unreliable or incomplete data[45], the number of actual observations is somewhat lower – as specified further under regression results in section 3.2.2.

2.2. Relevant definitions & specifications

2.2.1. Manufacturing sector as focus of empirical studies

When comparing value added from various sectors of the economies of the 7 NordPool countries it can be seen that the manufacturing industry[46] has a high share in all countries except for Norway, which receives most of its revenues from mining (ref. Figure 11 below). However, value added from the manufacturing sector in Norway amounted to 24.7 billion EUR in 2014, which is roughly the same as the total manufacturing value added of 24.5 billion EUR in Finland and 29.4 billion EUR in Denmark. Value added from mining in other countries is

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[45] Some countries choose not to disclose certain data for certain industries, if it is deemed sensitive. This can be the case e.g. due to very few companies in a specific industry.

[46] For all seven countries, manufacturing industry is defined as NACE rev.2 categories 10–33 except for #12 (tobacco manufacturing) and #19 (petrochemicals processing), for which there is limited information available.

much lower than value added from manufacturing in Norway: Denmark has the second-highest value added in mining after Norway, but it stands at only 5.6 billion EUR. Given this, it is relevant to focus further comparative analysis on the manufacturing industries which (unlike the also large retail sector) have direct links to a country's export performance, i.e. means for measuring international competitiveness.

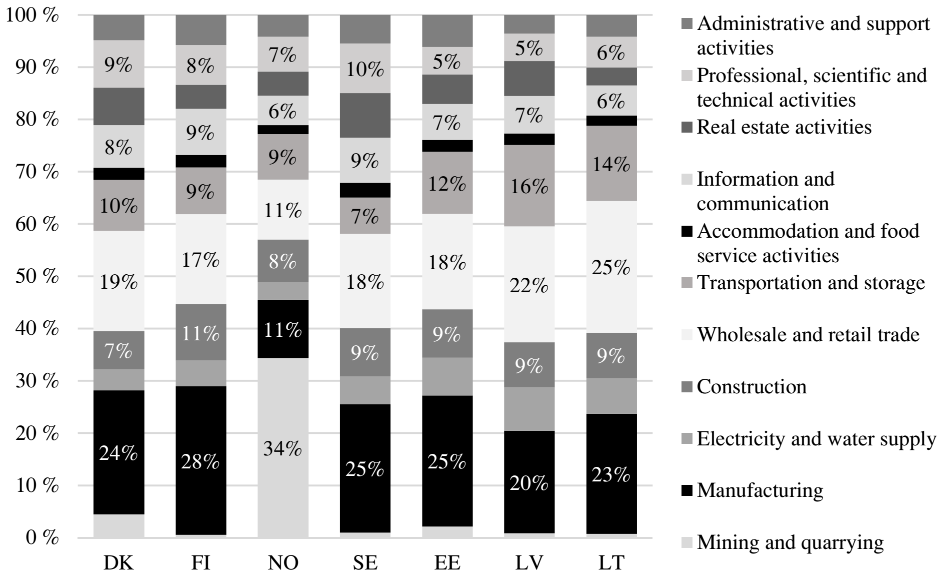

Figure 11. Value added to the economy in the NordPool member countries in 2014. Source: author's calculations based on Eurostat table «sbs_na_sca_r2».

2.2.2. Electricity-intensive industries in the 7 NordPool countries

Similarly to lack of a common definition for competitiveness, there is no commonly accepted threshold for energy intensity nor electricity intensity in the OECD or in the International Energy Agency. The European Commission has come up with a specification of energy intensity to be used within the EU: as per the Commission's article 17.1(a) of the Energy Taxation Directive (2003/96/EC), energy intensive industries are those where purchases of energy products (incl. electricity) amount to at least 3% of production value or where national energy tax payable amounts to at least 0.5% of added value.

Using the 3% benchmark, the following manufacturing industries qualify as energy-intensive in the 7 NordPool countries as per data from Eurostat in 2013 (see Table 1):

(1) food processing (NACE #10);
(2) manufacturing of textiles and leather products (NACE #13 & #15);

(3) wood processing and manufacturing of wood products (NACE #16);
(4) manufacturing of pulp and paper products (NACE #17);
(5) chemicals manufacturing (NACE #20);
(6) manufacturing of non-metallic minerals (NACE #22–23); and
(7) manufacturing of basic metals (NACE #24).

Table 1. Share of energy costs (%) in production value in manufacturing industries of the seven NordPool member countries in 2013. Tobacco and oil refining industries (NACE #12 and #19) are omitted due to poor data availability. Source: author's calculations based on Eurostat table «sbs_na_ind_r2».

Manufacturing industry (NACE rev.2)	DK	FI	NO	SE	EE	LV[c]	LT
10. Food products	1.9	2.0	1.7	2.7	3.3	5.4	3.4
11. Beverages	2.6	2.3	0.9	1.6	2.9	3.8	3.7
13. Textiles	2.0	4.2	1.8	4.3	2.6	6.3	5.3
14. Wearing apparel	0.2 [b]	1.5	0.8	4.2	2.3	3.9	2.0
15. Leather & related products	0.3	1.2 [b]	1.5	4.2	4.5	5.2	3.7
16. Wood & wood products	2.2	3.0	2.3	2.8	3.5	11.1	5.6
17. Paper & paper products	3.8	9.2	13.8	9.3	13.8	4.7	6.6
18. Printing & related products	1.7	1.8	1.3	1.0	2.2	4.0	2.5
20. Chemicals & related products	2.8	7.2 [b]	8.7	4.1	6.1	7.6	3.0
21. Pharmaceutical products	0.6	0.7 [a]	1.3	0.7	1.4	N/A	1.4
22. Rubber & plastic	1.6	2.9	2.4	3.2	3.4	4.2	3.7
23. Other non-metallic minerals	5.1	4.7	4.3	4.4	9.3	13.4	12.5
24. Basic metals	4.2	5.6	13.2	5.8	3.9	7.7	3.0
25. Fabricated metal products	1.7	1.3	1.3	1.8	2.2	4.2	3.1
26. Computer, electronics & optical equipment	0.4	0.3	0.3	0.2	0.2	1.2	1.2
27. Other electrical equipment	0.8	0.6	0.6	0.9	1.3	2.1	1.5
28. Other machinery & equipment	0.7	0.7	0.4	0.8	2.1	3.9	1.8
29. Motor vehicles & trailers	1.4	1.3	2.0	1.0	1.7	2.0	0.7
30. Other transport equipment	1.3	1.8	0.4	0.9	1.0	6.1	1.5
31. Furniture	1.3	1.1	1.4	1.5	3.4	5.9	2.2
32. Other manufacturing	0.5	0.6	0.9	0.7	2.3	N/A	2.0
33. Repairs & machinery installation	1.0	2.7	0.9	0.9	1.9	20.2	1.3

[a] Year 2013 data missing, year 2012 used.
[b] Year 2013 and 2012 data missing, year 2011 used.
[c] Data for Latvia is visibly inconsistent with all other countries, i.e. most likely a different methodology has been used. There is not enough information to draw any conclusions.

The European Commission's approach generalises all energy costs, which also include heat, petroleum products and other energy purchases in addition to electricity. As can be seen from Figure 12 grid-supplied electricity was the largest source of total energy used in the manufacturing industry in 2014 and significance of electricity increases if one considers that category «renewable energies» also includes a share of locally co-generated electricity (in addition to heat). Thus it is likely that electricity intensive industries are also energy intensive industries, i.e. there is a degree of overlap.

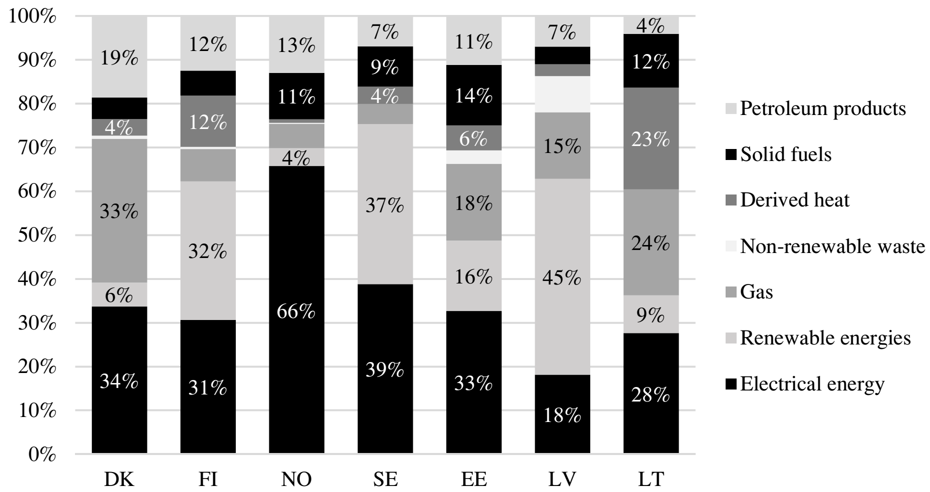

Figure 12. Sources for final energy consumed in the manufacturing industry in 2014. Source: author's calculations based on Eurostat table «nrg_100a».

Whereas it was earlier noted that larger institutions have not set boundaries for electricity intensity nor have specified electricity-intensive industries, this has been done by the Statistical Bureau of Norway (SSB). Accordingly, electricity-intensive industries could be identified in one of the following three ways: (1) electricity use divided by production value; (2) electricity use divided by gross output; or (3) electricity costs divided by production costs. It is noteworthy that the first option is similar to the efficiency of electricity use as proposed by Davis et al (2008) and a sub-component in European Commission's (2014b) real unit energy cost formula: value added divided by amount of kWh used in each industry (ref. section 1.2.3). The former two result in kWh/EUR ratio whereas the latter indicates cost share in per cent. SSB argues that the first alternative is the most useful one: calculation of gross output depends on both production value and input value, which might change in variable speeds; and use of production costs ignores capital costs that may vary greatly across industries (SSB 2010). When measuring electricity use divided by production value, SSB concludes that in Norway producers of pulp and paper (NACE #17), chemical manufacturing (NACE #20) and basic metals processing (NACE #24) should be regarded as electricity intensive industries.

Whereas the Statistical Bureau of Norway reports consumption data for each industry in Norway, in Eurostat it is reported by industry groups, where similar industries are grouped together: e.g. food processing, beverages manufacturing and tobacco manufacturing are shown as one industry group (NACE #10–12); although some groups only contain one industry, e.g. wood processing (NACE #16)[47]. However, it is possible to identify more-electricity-consuming industries within these industry groups by (1) observing energy purchases as a share of total purchases of goods and services, which is reported for each industry in Eurostat for the years 2008–2013; and (2) observing electricity purchases as a share of total energy purchases, which is reported for each industry in Eurostat for the years 2003, 2005 and 2007. This is effectively similar to the third option proposed by SSB. The resulting average electricity cost shares in total purchased goods and services are summarised in Table 2 below.

Moving forward, it is therefore assumed/generalised in this dissertation that within NACE group #10–12, the food processing industry (NACE #10) is more electricity intensive[48]; in NACE #13–15 it is generally textiles manufacturing (NACE #13)[49]; in NACE #17–18 it is manufacturing of pulp and paper (NACE #17); in NACE #20–21 it is manufacturing of chemicals (NACE #20); in NACE #22–23 it is generally manufacturing of non-metallic minerals other than rubber and plastic (NACE #23)[50]; and in NACE #25–28 it is generally manufacturing of

[47] Electricity consumption data is available for the following industries / industry groups: food and beverages (NACE #10–12); textile, clothing and leather (NACE #13–15), wood processing (NACE #16), paper, pulp and printing (NACE #17–18), chemicals and pharmaceuticals (NACE #20–21), non-metallic minerals (NACE #22–23), basic metals (NACE #24), machinery and equipment (NACE #25–28), transport equipment (NACE #29–30), furniture and other manufacturing, installation and repairs (NACE #31–33).

[48] Although it emerges from Table 2 that electricity cost share in total purchases of goods and services is higher in manufacturing of beverages than it is in manufacturing of food products, the turnover from beverage manufacturing (NACE #11) is equal to only 10–15% of the turnover from food and beverage manufacturing industries combined (NACE #10 + NACE #11).

[49] Although it emerges from Table 2 that in Sweden and Estonia leather manufacturing (NACE #15) is more electricity-intensive, it is equal to only 5–10% of the turnover from manufacturing of textiles, wearing apparel and leather combined (NACE #13 + NACE #14 + NACE #15).

[50] Although it emerges from Table 2 that cost share of electricity (in total purchased goods and services) in Norway and Sweden is higher for manufacturing of rubber and plastic products (NACE #22), the difference with manufacturing of other non-metallic minerals (NACE #23) is not large, hence NACE #23 is used for generalisation purposes moving forward.

fabricated metal products (NACE #25)[51]. In NACE #29–30 and NACE #31–33 it is harder to generalise, as one needs to also consider production volumes.

Table 2. Electricity cost shares (%) in total purchased goods and services, shown as average values for 2008–2013. Bold figures represent higher value within the groups of industries that are bundled together for consumption data in Eurostat (ref. footnote 47); the groups are also separated by horizontal divider lines for better overview. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2» and «sbs_pu_4l_02».

Manufacturing industry (NACE rev.2)	**DK**	**FI**	**NO**	**SE**	**EE**	**LV**	**LT**
10. Manufacture of food products	1.0	1.0	1.4	1.0	**1.7**	**2.8**	1.6
11. Manufacture of beverages	**1.8**	**1.1**	**1.8**	**1.2**	1.4	1.8	**1.9**
13. Manufacture of textiles	**1.3**	**1.9**	**1.9**	1.0	2.0	**4.1**	**3.2**
14. Manufacture of wearing apparel	0.2	0.8	0.7	0.5	2.1	2.7	2.0
15. Manufacture of leather	0.4	0.6	1.2	**1.3**	**4.5**	3.7	2.5
16. Manufacture of wood	1.4	1.3	2.2	1.7	2.1	5.6	3.0
17. Manufacture of pulp and paper	**2.9**	**4.2**	**14.3**	**8.3**	**8.5**	**2.8**	**4.0**
18. Printing and reproduction of media	1.3	1.1	1.9	1.1	1.5	2.6	1.5
20. Manufacture of chemicals	**2.3**	**3.1**	**5.5**	**3.4**	**2.7**	**4.7**	**1.3**
21. Manufacture of pharmaceuticals	0.5	0.6	1.6	0.7	0.9	2.5	1.0
22. Manufacture of rubber and plastic	2.1	1.3	**2.4**	**1.9**	2.6	2.2	1.8
23. Manufacture of other non-metallic minerals	**2.5**	**2.8**	2.2	1.5	**4.4**	**7.8**	**5.1**
24. Manufacture of basic metals	2.1	2.3	8.1	2.3	2.4	4.8	1.8
25. Manufacture of fabricated metal products	**1.4**	**0.7**	**1.8**	**0.7**	1.3	2.5	**1.6**
26. Manufacture of computers and optical instruments	0.5	<0.0	0.4	0.1	0.2	0.8	0.6
27. Manufacture of electrical equipment	0.7	0.3	1.0	0.5	0.9	1.5	1.1
28. Manufacture of machinery and equipment	0.5	0.3	0.5	0.4	**1.4**	**3.0**	1.2
29. Manufacture of motor vehicles and trailers	**1.5**	0.5	**2.1**	0.4	**1.1**	1.1	0.5
30. Manufacture of other transport equipment	0.7	**0.7**	0.5	**0.5**	1.0	**3.1**	**1.2**
31. Manufacture of furniture	**1.2**	**0.6**	**1.6**	**1.1**	**2.0**	3.0	**1.2**
32. Other manufacturing	0.8	0.4	1.3	0.3	1.4	N/A	1.2
33. Repair and installation of machinery	0.8	0.4	0.9	0.8	1.2	N/A	1.0

[51] Although it emerges from Table 2 that cost share of electricity (in total purchased goods and services) in Estonia and Latvia is higher for manufacturing of machinery and equipment (NACE #28), the difference with manufacturing of fabricated metal products (NACE #25) is not large, hence NACE #25 is used for generalisation purposes moving forward.

Using SSB's identification method (1) with Eurostat data for all seven countries results in similar conclusions to SSB's calculations for Norway. However in absolute terms this calculation method seems to work less well for identifying electricity-intensive industries in Denmark and the Baltic States, where the kWh used for EUR production value seems to be much lower than in other Nordic countries. Thus, the values were re-calculated with production value replaced with value added, in line with calculation from Davis et al (2008) and European Commission (2014b) to check for differences (for comparison, an inverse calculation was used). Figure 13 A and B visualise the outcome, shown separately for Nordic and Baltic countries.

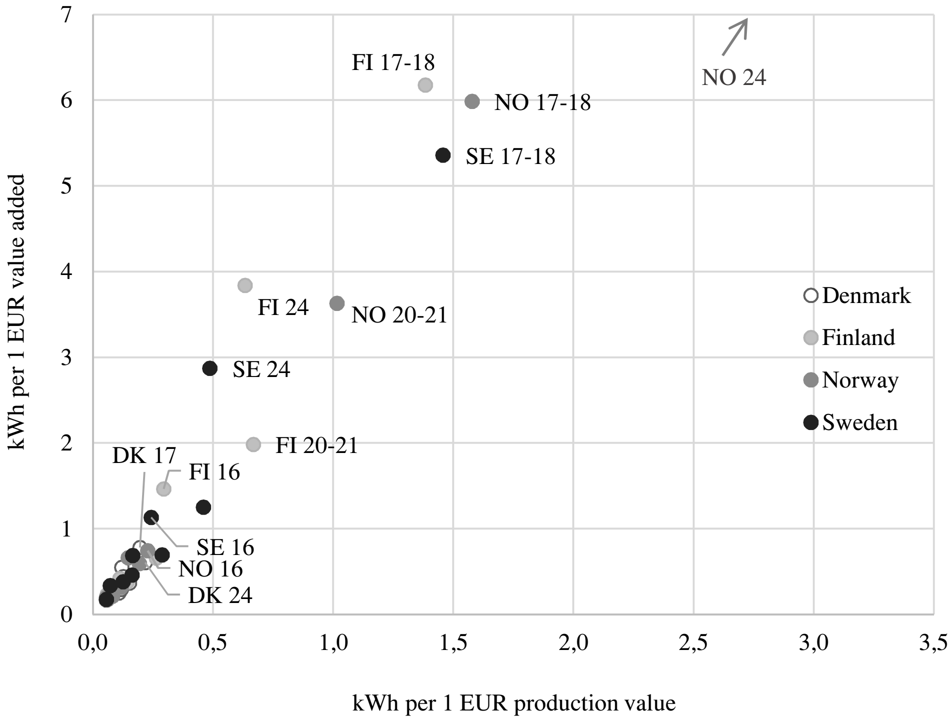

Figure 13A. Electricity intensive industries (shown as NACE rev.2 codes) in the Nordic countries, calculated based on 2008–2013 average values, showing kWh used for 1 EUR production value and kWh used for 1 EUR value added. NO 24 not shown as its values on both X and Y scale are much larger. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2», «nrg_105a» and «sbs_pu_4l_02».

Accordingly, it is worthwhile to add wood processing (NACE #16) to the pulp and paper manufacturing (NACE #17), chemical manufacturing (NACE #20) and basic metals processing (NACE #24) as electricity intensive industries in Finland, Norway and Sweden. In Sweden, manufacturing of furniture (NACE #31) also seems to be more-electricity-consuming, but the industry is not important in other countries, hence ignored in cross-country comparison. In Denmark, much less kWh are needed to produce 1 EUR production value or value added: pulp and paper manufacturing and basic metals processing as two of the country's most electricity-consuming industries consume less than 0.8 kWh per 1 EUR value added and less than 0.25 kWh per 1 EUR production value, which is on par with some of the least electricity-intensive industries in the other Nordic and Baltic countries. Nevertheless, of the most electricity-intensive industries within Denmark, the four aforementioned sectors are also valid for Denmark.

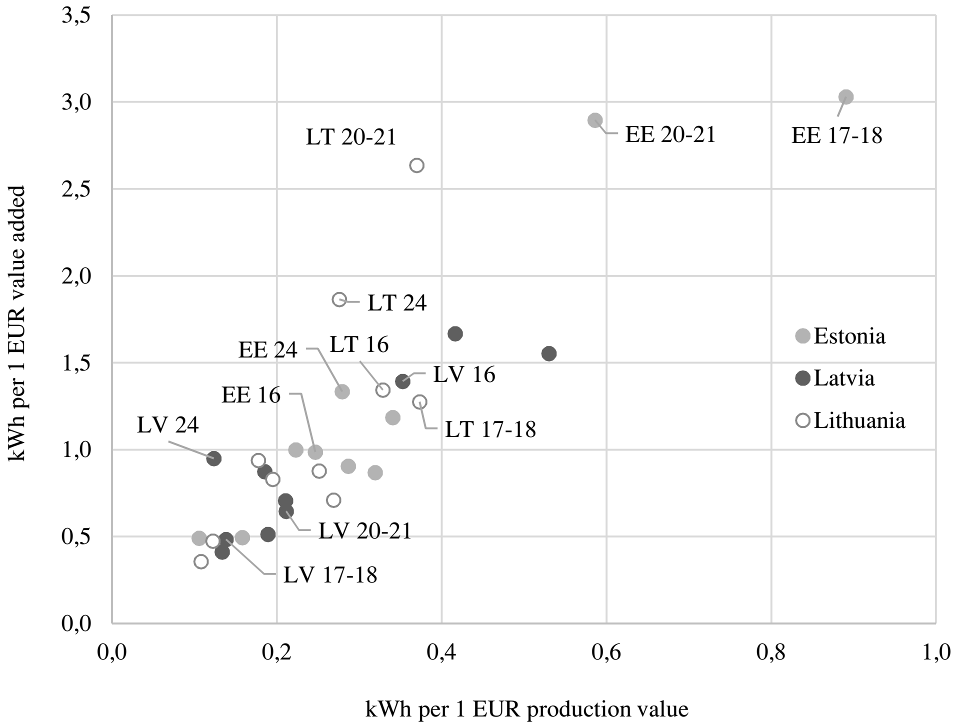

Figure 13B. Electricity intensive industries (shown as NACE rev.2 codes) in the Baltic countries, calculated based on 2008–2013 average values, showing kWh used for 1 EUR production value and kWh used for 1 EUR value added. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2», «nrg_105a» and «sbs_pu_4l_02».

Comparing Finland, Norway and Sweden to the Baltics shows that generally, the latter consume less kWh to produce 1 EUR value added and 1 EUR production value. Nevertheless, the same four industries (NACE #16, #17, #20, #24) also stand out in the Baltics. It is however worthwhile to add manufacturing of non-metallic minerals (NACE #22–23) to the electricity-intensive industries' group within the Baltics, which can further be narrowed down to manufacturing of non-metallic minerals other than rubber and plastic (i.e. NACE #23) as per Table 2. Similarly to Sweden, Latvia also has a relatively higher kWh to production value and value added ratio in the furniture manufacturing industry (NACE #31), but since this is not the case in the other two Baltic countries, the industry is dismissed from further analysis. For a cross-7-country analysis, manufacturing of non-metallic minerals other than rubber and plastic (i.e. NACE #23) is also dropped.

Chapter summary

It has been shown that the manufacturing sector is responsible for a significant share of value added to the seven countries' national economies. The importance of the manufacturing sector is somewhat lower in Norway vis-à-vis the other 6 countries, but size of value added in Norwegian manufacturing is comparable to that in Denmark and Finland. This justifies choice of the manufacturing industry as focus of empirical studies.

Even though the European Commission has issued guidelines for classification of energy intensive industries, there are no commonly agreed parameters for classifying electricity intensive industries. This dissertation has used the calculation formulas offered by the Statistical Bureau of Norway and Davis et al (2008) to identify and cross-check electricity intensive industries within the seven NordPool member countries. As a result, it is concluded that among the NordPool 7 countries, wood manufacturing (NACE #16), pulp and paper manufacturing (NACE #17), chemical manufacturing (NACE #20) and basic metals processing (NACE #24) industries can be regarded as electricity-intensive; although the level of intensity somewhat varies.

3. EMPIRICAL ANALYSIS OF THE ROLE OF ELECTRICITY PRICE IN COMPETITIVENESS

3.1. Electricity price at the 7 NordPool members

3.1.1. Country profiles in the context of NordPool

NordPool is Europe's first liberalised regional electricity market, where power from different technologies – hydro, wind, biomass, nuclear and thermal – from different countries enters the same inter-connected grid. This makes NordPool the leading regional power market in Europe, with its seven members managing both day-ahead market coupling as well as trading cross-border electricity on an hourly basis intra-day (NordPool Spot 2014a). Figure 14 provides a visualisation of the regional inter-connectivity within NordPool countries and beyond.

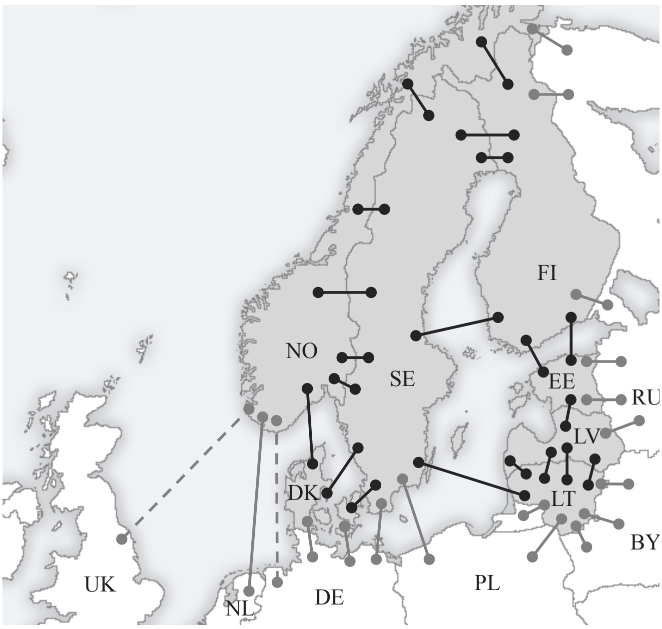

Figure 14. The NordPool common electricity market in 2016. The seven NordPool member countries are highlighted in light grey. Interconnectors between the NordPool members are shown in black, interconnectors to neighbouring countries are shown in dark grey (geographical location for each interconnector is approximate, capacity of interconnectors is not shown). Dashed lines represent interconnectors that are planned or under construction. Source: author's drawing based on Statnett (2014), AST (2014) and Litgrid (2014).

The seven NordPool member countries vary in terms of size, population, terrain and climatic conditions, natural resources as well as historic legacy. All these variables have an impact on electricity generation, size of the transmission network and consumption patterns. The countries' power generation mix varies from mainly hydro-based production in Norway to mainly oil shale burning in Estonia (see Table 3). Sweden and Finland rely on a balanced mix of hydropower and nuclear power, with additionally thermal powered generation in Finland. Denmark has been building up wind generation capacity, but is still reliant on imported coal for thermal generation; Latvia and Lithuania use a mix of imported natural gas and hydropower.

Table 3. Gross electricity generation sources (% of total) in the seven countries and NordPool average in 2014. Difference in net electricity production vs gross production shows energy used in the generation process. Source: Author's calculations based on Eurostat table «nrg_105a».

	DK	**FI**	**NO**	**SE**	**EE**	**LV**	**LT**	**NordPool (weighted)**
Peat	0	5	0	<1	<1	0	<1	**1**
Waste	5	1	<1	2	1	0	2	**1**
Biofuels	11	17	<1	6	6	13	8	**6**
Natural gas	7	8	2	<1	1	45	40	**4**
Other combustible fuels	35	13	<1	1	87	0	4	**8**
Hydro	<1	20	96	42	<1	39	25	**52**
Wind	41	2	2	7	5	3	15	**7**
Solar	2	<1	0	<1	0	0	2	**<1**
Nuclear	0	35	0	42	0	0	0	**21**
Other sources	0	<1	0	0	0	0	6	**<1**
Total gross production	100	100	100	100	100	100	100	**100**
Total net production	96	96	100	98	88	92	94	**97**
Share of net production in NordPool	**8**	**16**	**35**	**37**	**3**	**1**	**1**	**100**

Generation portfolio (along with technology/fuel for generation) and transmission capacity are important when evaluating each country's potential to supply enough electricity to its population and economy, i.e. guarantee easy and affordable access to electricity as a location-specific advantage. Figure 15A and B compare net electricity generation to final consumption in the seven countries from 1995 – 2014, shown as kWh per capita. The 45-degree diagonal line splitting the graph relates to balance of supply and demand. Countries to the left of the line consume more than they produce; and countries to the right of the line produce more electricity than they need. Apparently, Latvia and Finland have historically consumed more than they produce. This may be explained by the fact that importing electricity from neighbouring countries might be less costly than importing generation fuels and using existing capacity at home (Elering 2014).

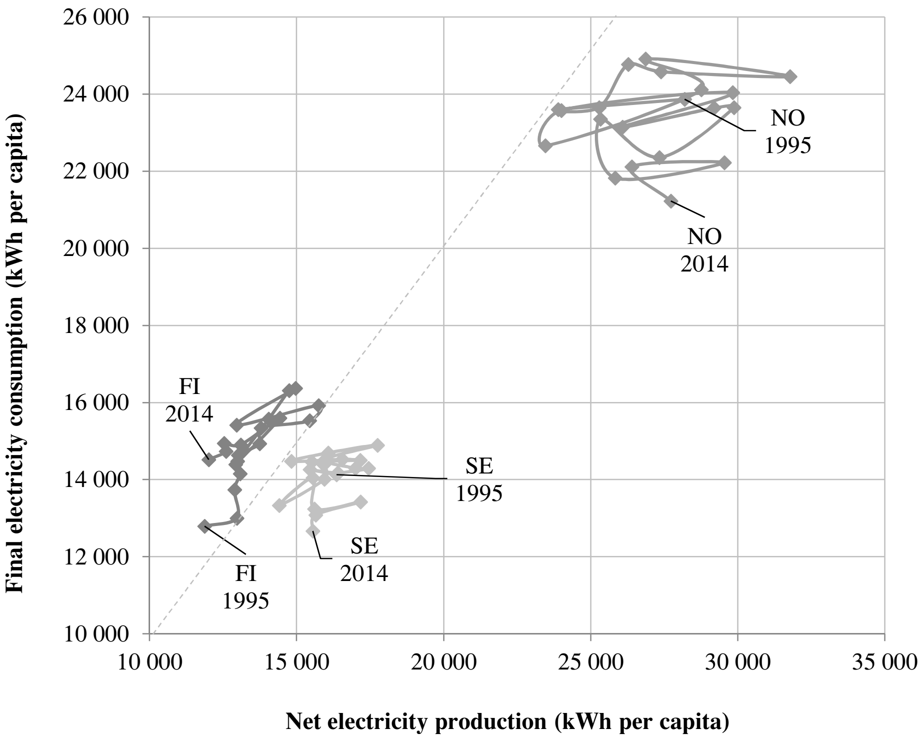

Figure 15A. Electricity generation / consumption ratio dynamics in Finland, Norway and Sweden in 1995–2014. Yearly production fluctuation is Norway is to a large degree explained by variation in rainfall/snowfall. Dashed line represents a balanced generation and consumption. Source: author's calculations based on Eurostat tables «nrg_105a» and «demo_pjan».

As Lithuania shut down its nuclear generation in 2010, it needs to import fuel (primarily natural gas) for 67% of its generation capacity whereas it might be worthwhile to import electricity instead[52]. 21% of electricity generation in Finland relies on imported fuels (excluding the occasional need to import nuclear fuel), thus it makes sense to import lower-priced electricity from neighbouring Sweden

[52] This logic holds at least in the summer period, when heat demand is low – co-generation of heat and electricity might be worthwhile in the winter period, as heat cannot be transported over long distances without considerable losses.

instead; and in Latvia the import equivalent is 33%. Other countries use fuel that is abundantly available at home (including oil shale for thermal generation in Estonia), have production surplus and export energy that is not consumed domestically. Although 49% of electricity generation from Denmark relies on imported fuels, the country has Europe's largest installed wind generation capacity per capita, so with favourable weather conditions Denmark produces more electricity than it can consume.

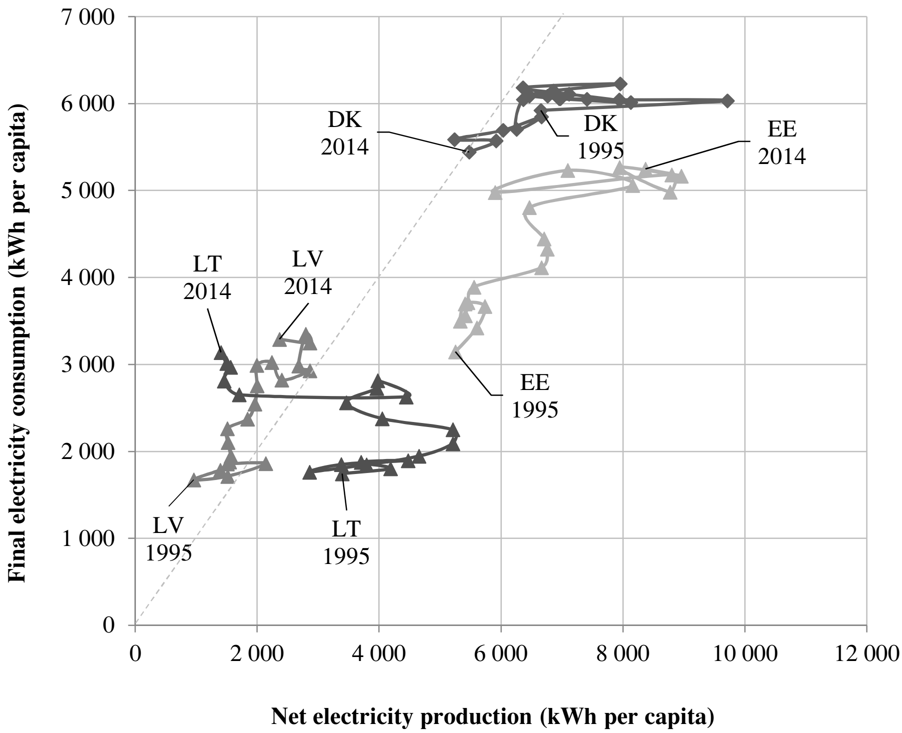

Figure 15B. Electricity generation / consumption ratio dynamics in Denmark, Estonia, Latvia and Lithuania in 1995–2014. Dashed line represents a balanced generation and consumption. Source: author's calculations based on Eurostat tables «nrg_105a» and «demo_pjan».

As per the factor abundance theory, in the long run countries with electricity supply surplus can choose to encourage development of more electricity-intensive industries and services at home and export goods from such industries with higher value added. The opposite holds for deficit countries that are more vulnerable to any changes in their existing electricity supply chains: even with long-term supply contracts, any unplanned generation stops would lead to more imports at market price (which is usually higher than in forward contracts) as in the short run electricity demand is price inelastic (see Appendix 2).

With careful planning relying on imports is not necessarily a problem, especially if importing implies that total cost of electricity will be lower than generating itself. Sweden and Norway and to a lesser degree also Estonia and Denmark must anyway export produced electricity to balance their electricity system, hence liberalised electricity markets (via the NordPool power exchange platform) effectively allow for flexibility and security to both the surplus and deficit countries. Furthermore, long-term forecast by several market analysts (cf. SKM Market Predictor, Markedskraft etc) based on studies of national policies and development plans predict the generation surplus in Denmark, Norway and Sweden to grow further (ref. Figure 16).

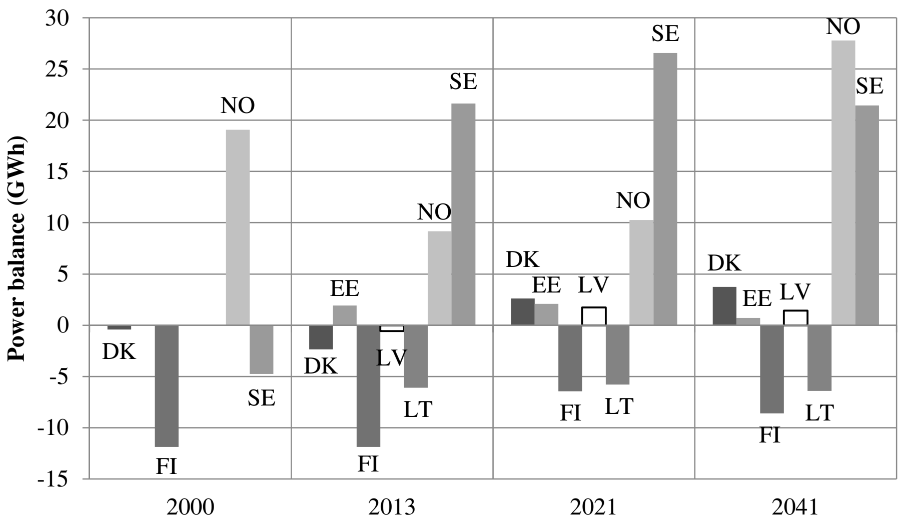

Figure 16. Historic and projected electricity demand-supply balance in NordPool. Source: author's calculations based on SKM Market Predictor (2013)

Part of the reasoning why surplus should grow further is slowing consumption growth. Some authors (e.g. Lee 2005, Warr et al 2010) have argued that the relative importance of energy consumption for economic growth has changed over time as several industrialized economies have shifted their production structure from energy intensive manufacturing to less energy intensive service activities. This suggests that having an electricity generation surplus and high levels of electricity consumption might not be necessary for welfare creation. Indeed, at first glance Figure 17 reaffirms that throughout 1995–2014 Estonia has consumed more kWh per capita than neighbouring Latvia and Lithuania; and the country's GDP per capita has also been higher every year. Yet Estonia's electricity consumption levels are now approaching those in Denmark, whereas the difference in two countries' GDP per capita remains 4-fold. As can be seen from Figure 17 for the past 20 years Denmark has persistently kept a higher GDP per capita than Finland or Sweden, while consuming at the same time 2–3 times less electricity.

Figure 17 also reveals that Finland, Norway and Sweden – that consume 3–4 times more electricity per capita than Denmark – have in recent years grown their economies (per capita) while actually decreasing electricity consumption (per capita).

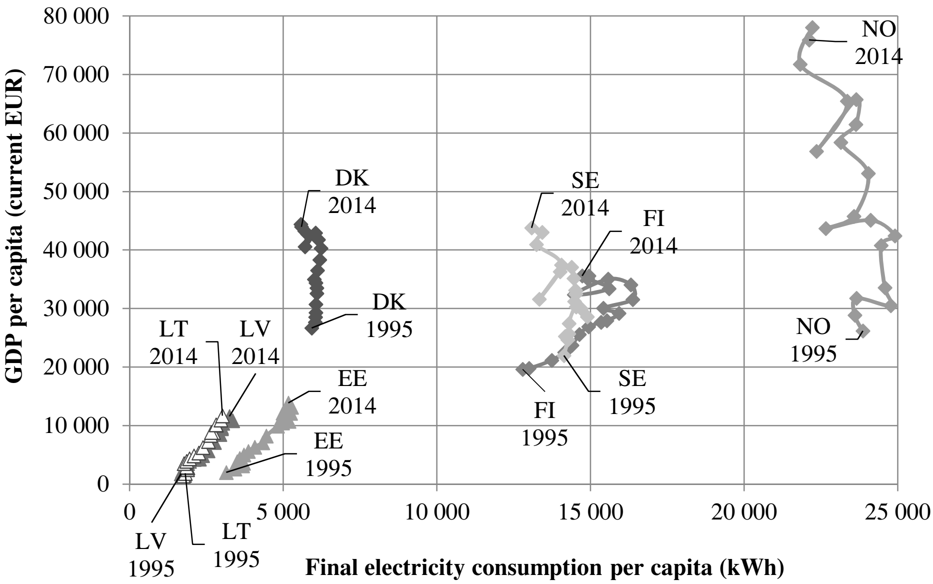

Figure 17. Relationship between GDP per capita and electricity consumption per capita for the seven countries 1995–2014. Source: author's drawing based on Eurostat tables «nrg_105a», «nama_gdp_c» and «demo_pjan».

This is more clearly evident from Figure 18: whereas between 1995 and 2014 the Baltic countries increased their final energy consumption (in terms of total MWh used) by some 40–50%, in three of the four Nordic countries the increase was only 2–5% (although Finland's growth reads 24%, the country has witnessed a decreasing trend in the past years). This proves that measurement of GDP per capita as a viable indicator of competitiveness from electricity price change is not justified in this dissertation (cf. section 1.2.3).

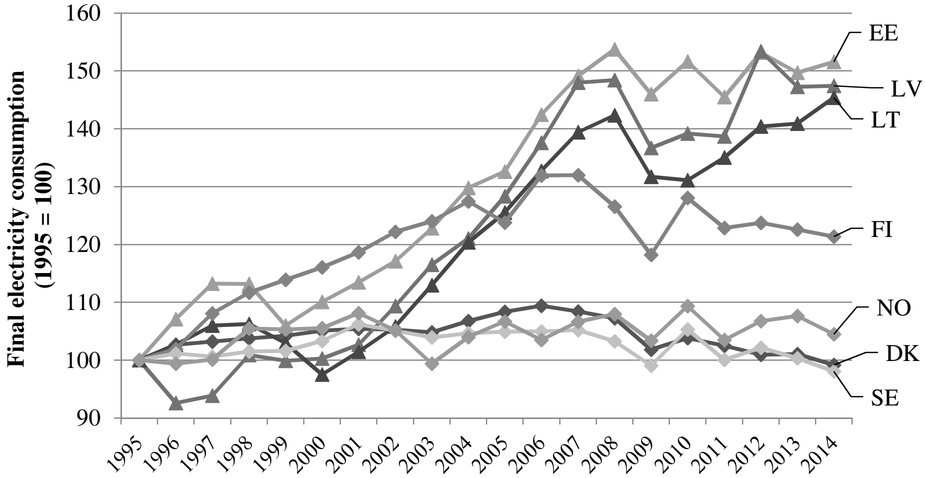

Figure 18. Indexed final electricity consumption in 1995–2014 (total MWh consumed in a country), 1995 = 100. Author's calculations based on Eurostat table «nrg_105a».

Based on Figure 15A and B one might claim that there appears to be more surplus electricity than is demanded within the NordPool countries. Indeed, some of the power is sold to neighbouring countries outside NordPool (as can be seen from Figure 14 all NordPool member countries have inter-connectors to third countries, including Belarus, Germany, Netherlands, Poland and Russia; and soon to the UK). Similarly, some electricity might occasionally be imported from third countries – so total demand and supply in the system is always balanced.

As per research proposition #1 liberalisation of electricity markets increases supply and demand and lowers entry barriers, leading to price convergence. Figure 19 A and B visualise development of electricity supply prices over the course of 6 years in the periods 1995 – 2001 and 2008 – 2014 respectively. As can be seen from Figure 19A, establishment of a common market between Sweden and Norway in 1996 has seemingly resulted in converged prices for both countries, although part of the price development is likely to be explained by amount of rainfall in these years, as both countries are heavily reliant on hydropower (ref. Table 3). It can also be seen that when Finland joined the common market in 1998 the price convergence continued further. Hence, at first glance empirical data of Nordic countries supports research proposition #1, i.e. the idea of price convergence as a result of market liberalisation and inter-connectivity (there is insufficient data about Denmark post-1999 in order to conclude).

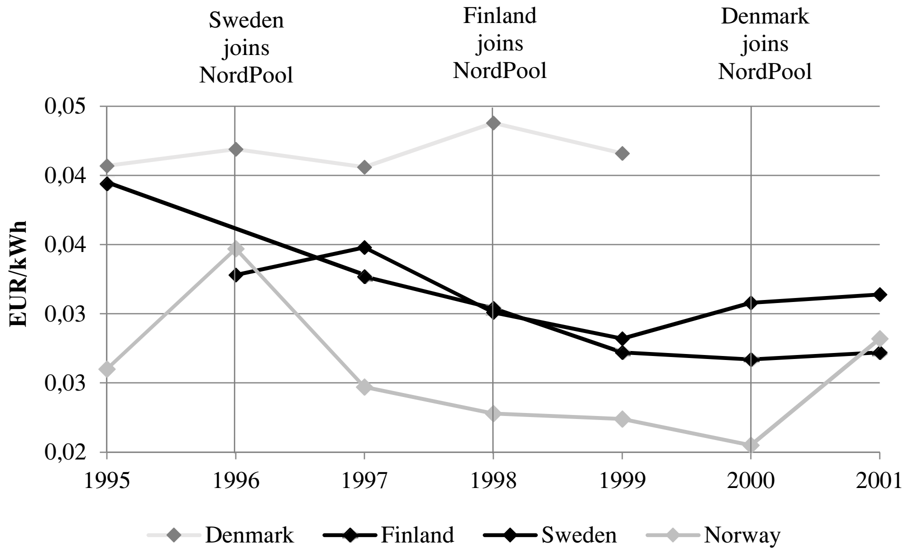

Figure 19A. Changes in electricity supply price for Nordic consumers of 24 GWh annually in 1995–2001. Incomplete data available for Denmark. Source: author's drawing based on Eurostat table «nrg_pc_205_h».

Figure 19B additionally supports research proposition #1: price convergence also seems to be taking place between Estonia (a net exporter of electricity, with lower prices) and Finland (a net importer of electricity, with higher prices). After Estonia joined NordPool in 2010 Finnish prices were lowered while Estonia's prices increased. There is insufficient data to conclude on the effect of Latvia's and Lithuania's NordPool membership, as the two countries joined the common market fairly recently. Visual changes should be expected in post-2016 when an interconnector between Sweden (a net exporter, with lower prices) and Lithuania (a net importer, with higher prices), has been operational for more than a year[53] – in addition to the recent commissioning of an interconnector between Poland and Lithuania. This contributes to a more diversified import portfolio for both Latvia and Lithuania (until 2016 both countries could only import electricity from Estonia; and Russia and Belarus as non-NordPool countries).

[53] The so-called NordBalt interconnector was commissioned in the first half of 2016. For more information see
http://ec.europa.eu/energy/eepr/projects/files/electricity-interconnectors/nordbalt-01_en.pdf

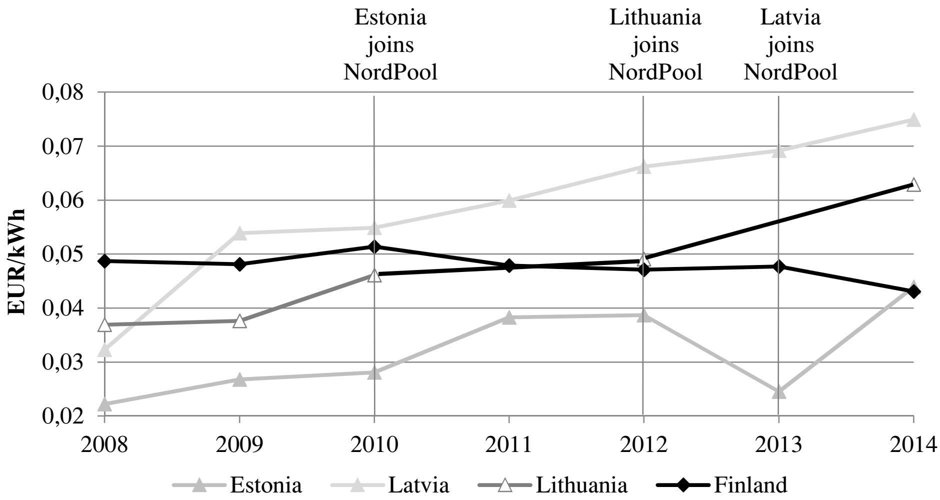

Figure 19B. Changes in electricity supply price for Finnish and Baltic consumers of 20–70 GWh annually in 2008–2014. Source: author's drawing based on Eurostat table «nrg_pc_205_c».

It has been shown that the seven NordPool member countries have very different generation portfolios, and different levels of aggregated consumption. It emerges that Norway, Sweden and Finland both produce and consume more electricity per capita than Denmark and the three Baltic States, i.e. their economies are much more electricity-intensive. However, in Finland the consumption has for several years exceeded net production, meaning that only Sweden and Norway have electricity as an abundant resource that could qualify as source for relative competitiveness. Judging by the consumption vs production axes (ref. Figure 15B), Estonia could be added to that group too, albeit at much lower levels in both relative and absolute terms. This means that foremost Norway, Sweden and Estonia should support development of electricity-intensive industries as basis for relative competitiveness, if one were to follow the factor abundance theory. Finland, Latvia and Lithuania as net importers would seemingly be better off with relatively lower levels of electricity-intensive industry; Denmark's position in the middle of the axes leaves room for conclusions both ways.

These conclusions change if one considers the interconnectivity of the electricity grids among these seven countries, and the need to balance demand and supply. In that light Finland's position seems less vulnerable, since it can purchase deficit electricity from neighbouring Sweden and support its electricity-intensive industry. Similarly, Latvia and Lithuania can turn to Estonia and Sweden as well as non-NordPool members for power imports. If the cost of imported electricity is relatively low and supply levels are guaranteed then deficit countries could still sustain electricity-intensive industries. Indeed, empirical evidence – albeit somewhat limited – supports the fact that after joining NordPool, neighbouring countries' electricity supply cost levels seem to have converged. Next section provides further insight to the role of the electricity-intensive industries in the seven countries.

3.1.2. Background for electricity-intensive industries in NordPool

As shown in section 2.3.1 value added from the manufacturing industry ranges primarily between 20–30% across the 6 NordPool member countries (with Norway's manufacturing contributing less in relative terms but equally much in absolute terms, given its large mining sector). As is visible from Figure 20 the 7 NordPool countries can be divided into two groups when comparing final electricity consumption of the manufacturing industry as a share of the country's total electricity consumption. The industrial electricity consumption ranges between 40–50% of the country's total for Finland, Norway and Sweden and between 25–35% for Denmark and the three Baltic countries.

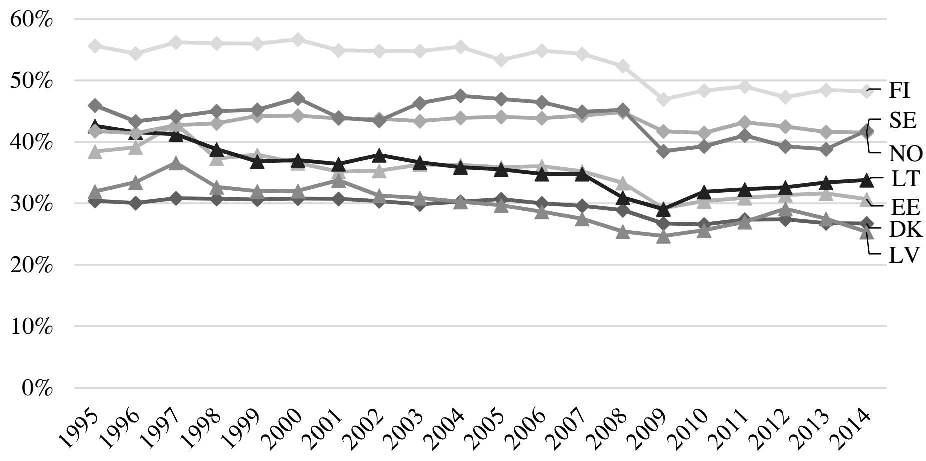

Figure 20. Final electricity consumption of the manufacturing industry as of total electricity consumption in the country in 1995–2014. Source: author's drawing based on Eurostat table «nrg_105a».

It is further visible from Figure 21 that the four industries that were identified as electricity-intensive – i.e. wood processing (NACE #16), pulp and paper manufacturing (NACE #17), chemical manufacturing (NACE #20) and basic metals processing (NACE #24) – account for a large share of the countries' total industrial electricity consumption. The four most electricity-intensive industries account for 70–85% of the manufacturing sector's total electricity consumption in

Finland, Norway and Sweden. In Denmark the spread of various manufacturing industries is much greater and the equivalent share for the four more electricity-intensive industries is below 30%. This indicates that the electricity-intensive industries have a lesser role in the Danish economy, in line with much lower electricity consumption and production levels per capita for the country. It also suggests that the intra-industry composition of the more electricity-intensive industries in Denmark is likely to be somewhat different from the other three Nordic countries.

In the three Baltic countries the four electricity-intensive industries account for around 50–65% of total electricity consumption of the countries' manufacturing sector. Thus, compared to Finland, Norway and Sweden electricity consumption among various manufacturing industries in the Baltic economies is more evenly spread; however the share of the more electricity-intensive industries in the countries' total manufacturing sector's electricity consumption still clearly stands out, and is twice as high as in Denmark. This indicates intermediate levels of electricity intensity in the Baltic countries, despite these countries having lower per capita levels of electricity consumption and production than Denmark.

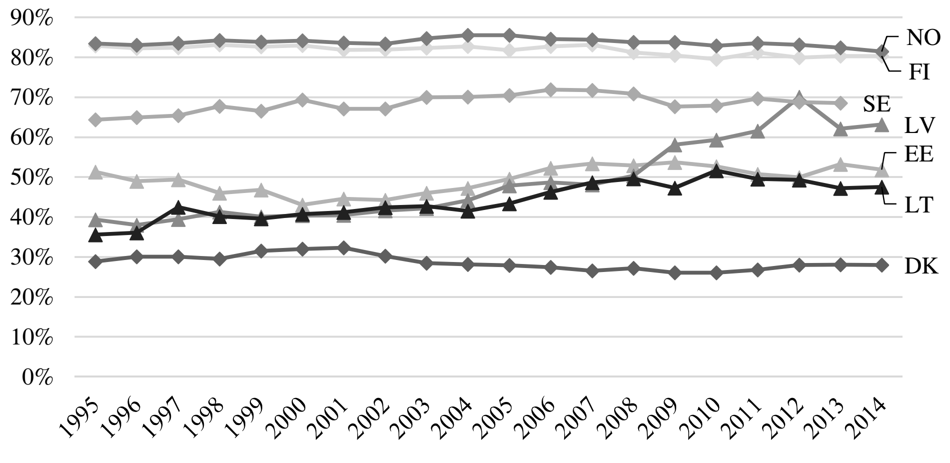

Figure 21. Final electricity consumption of the 4 electricity-intensive industries (NACE #16, #17, #20 and #24) as a share of the total electricity consumption of the countries' industrial sector in 1995–2014. Source: author's drawing based on Eurostat table «nrg_105a».

With the exception of Denmark the electricity-intensive industries play an important role in all countries' economies, if one observes the share of production value, paid wages, and employment as a share of the respective countries' total manufacturing sector (ref. Table 4). The shares vary from 20% to 40% of the manufacturing sector's total, thus implying that the industries are vital for the Nordic and Baltic countries' economic health.

Table 4. Comparative overview of the four electricity-intensive industries' contribution to the national economy (as a share of manufacturing total) in 2005–2014. Source: author's calculations based on Eurostat table «sbs_na_ind_r2».

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark										
Production value	10	10	10	10	9	10	9	8	9	9
Salaries	10	11	11	11	10	10	10	10	10	10
Employment	9	10	10	10	10	10	10	10	10	10
Finland										
Production value	31	33	32	29	27	32	31	30	31	32
Salaries	N/A	N/A	N/A	24	22	24	23	22	22	22
Employment	24	24	23	23	22	22	22	21	21	N/A
Norway										
Production value	N/A	N/A	27	24	25	25	26	22	20	20
Salaries	N/A	N/A	N/A	17	17	18	17	16	15	14
Employment	N/A	N/A	18	17	17	17	17	16	15	N/A
Sweden										
Production value	27	26	25	26	25	25	24	24	23	24
Salaries	21	19	19	20	19	20	20	20	19	19
Employment	21	18	18	20	19	20	19	19	19	N/A
Estonia										
Production value	31	31	32	28	26	27	25	25	26	28
Salaries	N/A	N/A	N/A	23	22	23	23	24	24	25
Employment	23	23	23	23	21	22	22	23	23	N/A
Latvia										
Production value	39	38	39	36	35	41	42	40	39	39
Salaries	N/A	N/A	N/A	30	29	31	31	31	30	30
Employment	30	30	30	29	29	30	30	30	30	N/A
Lithuania										
Production value	16	19	24	22	20	21	22	21	20	21
Salaries	N/A	N/A	N/A	22	20	20	21	20	21	21
Employment	19	20	21	21	20	20	20	20	20	20

Although Eurostat has a dedicated table for reporting exports from separate industries in the manufacturing sector (table DS-058471), for 6 of the 7 NordPool countries such data is available only for 2011–2013. For earlier periods, it is possible to get an impression of exports from the manufacturing sector from trade categorised by SITC (Standard International Trade Classification), a categorisation developed by the United Nations[54]. SITC is product-based and hence not directly convertible to manufacturing industries (i.e. the NACE classification). In parallel to SITC, trade statistics are also reported by HS (Harmonized Commodity Description and Coding System)[55], which is also product not industry-based. Thus the challenge with both SITC and HS is in identifying products/commodities that have been processed and hence have most of their value added from the manufacturing industry rather than the primary sectors of the economy (agriculture, forestry, fishing, mining etc). However, by using several conversion tables[56], it is possible to ultimately identify which exported goods originate from which manufacturing industry. Table 5 summarises exports from the four electricity-intensive industries – proving that the electricity-intensive industries are also significant contributors to their countries' exports.

Table 5. Comparative overview of electricity-intensive industries' contribution to exports in 2007–2013 (shown as a % share of the country's manufacturing sector's total). Source: author's calculations based on Eurostat tables «sbs_na_ind_r2», «sbs_pu_4l_02» and «DS-018995».

	2007	2008	2009	2010	2011	2012	2013
Denmark	12	12	11	12	12	11	11
Finland	36	33	34	41	42	39	40
Norway	51	46	41	48	49	45	43
Sweden	26	26	26	26	26	26	26
Estonia	26	27	25	25	24	23	22
Latvia	42	39	35	38	36	35	32
Lithuania	21	24	21	21	24	23	21

Thus it is clear that the identified electricity-intensive industries play an important role in their countries' economies, accounting for 20–40% of total value added, employment and wages paid from the respective countries' manufacturing sector, as well as contributing to exports in the same range. Given this, it is relevant to

[54] For more information on SITC, see http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=14
[55] For more information on HS, see http://unstats.un.org/unsd/tradekb/Knowledgebase/Harmonized-Commodity-Description-and-Coding-Systems-HS
[56] For conversion tables, see http://unstats.un.org/unsd/cr/registry/regdnld.asp?Lg=1

analyse performance of these industries in light of cost changes. The following chapter focuses on how different countries have controlled the total price of electricity within industrial users as means of influencing competitiveness; and how the role of electricity-intensive industries has been taken into consideration.

3.1.3. Electricity price levels among NordPool member countries

All seven Nordic and Baltic countries are members of NordPool, which means that industrial consumers in all seven countries have the opportunity to purchase their electricity from the market or negotiate a deal with preferred suppliers and/or retailers. As can be seen from Table 6, in all countries except Lithuania (where no data is available for large consumer groups) the largest electricity-intensive users (i.e. those in consumption band IF, consuming more than 70 GWh of electrical energy annually) pay a discounted price relative to the average spot market area price[57]. This is natural as largest electricity users buy in bulk and many of them lock the price in forward contracts; whereas less-consuming users usually buy from retailers that charge a premium to the market price.

Table 6. Price of supplied electricity for industrial consumers in 2013 (EUR/MWh), excluding grid fees and taxes. For reference the average NordPool area spot price for each country is also shown. Source: Eurostat table «nrg_pc_205_c», (NordPool Spot, 2014), (Energimyndigheten, 2014).

Consumption band (MWh/year)		**DK**	**FI**	**NO**	**SE**	**EE**	**LV**	**LT**
IA	< 20	45.60	55.02	39.56	48.34	50.80	50.50	49.40
IB	20 – 500	41.10	49.75	39.36	45.74	46.20	47.60	49.80
IC	500 – 2 000	39.80	47.97	38.26	43.84	45.50	46.60	50.00
ID	2 000 – 20 000	39.30	46.37	37.66	43.64	44.90	45.80	54.40
IE	20 000 – 70 000	39.30	43.34	37.16	43.04	43.90	47.10	N/A
IF	> 70 000	39.30	43.15	34.66	40.74	42.80	44.90	N/A
Average spot price		39.29	41.16	38.17	39.44	43.14	47.82	48.93

Although summarised-country-prices in Figure 19A and B indicated supply price convergence, Table 6 highlights that until interconnector capacity remains limited, bottlenecks between different regions will continue to contribute to different electricity supply prices. Thus, both with or without supply price convergence, electricity taxes become an important consideration topic for governments in determining the total price of electricity. From the point of view of

[57] The fact that the most electricity-intensive consumers in some countries seem to be paying more than the spot price equivalent might be explained by rounding differences in reporting to Eurostat and differences in used exchange rate.

competitiveness, the lower the price of supply compared to neighbouring countries, the greater the flexibility to determine appropriate size of taxes.

Grid fees can generally be broken down to fees payable to the TSO and the DSO. Within both the TSO and DSO, fees further depend on the type of connection to the customer. As was further explained in section 1.1.2 some large-scale consumers are generally connected directly to the transmission grid (at high voltage levels) with own transformers, hence they only pay TSO fees. Most customers get their power from the distribution network, with grid payments usually depending on both time of connection (day/night) and the connection type (kVA/MVA). Economies of scale and scope also apply, with less-consuming users paying in some countries more than 10 times as much as large-scale users for the same MWh used (see Table 7).

It can be seen from Table 7 that the grid fees are generally higher in the Baltics. As was further explained in section 1.1.2 one of the key drivers of grid fees is the need for (re-)investments in infrastructure – which is highest in the Baltic States due to underinvestments in the 1980ies and 1990ies (Elektrilevi 2015). Yet grid fees also reflect the overall approach to customer segmentation: in Sweden the fee difference between consumers of <20 MWh/year and >70 000 MWh/year is 12-fold, in Finland it is 6-fold, in Latvia it is 3-fold and in Denmark most electricity-intensive users only pay 50% less than households (i.e. 2–3 times as much as in other Nordic countries).

Table 7. Average grid fees in the NordPool region in 2013 (EUR/MWh), excluding taxes & public service obligation. Source: Eurostat table «nrg_pc_205_c», (Lithuanian National Commission for Energy Control and Prices, 2014); (Energiamarkkinavirasto, 2014); (Energinet.dk, 2014); (Statistisk Sentralbyrå, 2014).

Consumption band (MWh/year)		**DK**	**FI**	**NO**	**SE**	**EE**	**LV**	**LT**
IA	< 20	40.31	32.32	32.80	93.90	54.50	67.80	74.72
IB	20 – 500	32.01	30.85	32.90	36.30	44.60	49.70	58.82
IC	500 – 2 000	24.81	18.39	32.90	26.20	38.30	40.70	51.72
ID	2 000 – 20 000	24.81	16.27	18.30	18.80	31.70	32.90	38.02
IE	20 000 – 70 000	15.71	5.92	7.70	11.20	23.30	32.00	N/A
IF	> 70 000	15.71	5.74	6.00	7.40	15.00	23.20	N/A

The European Commission requires that all EU member countries charge electricity excise taxes from all users. The minimum excise duty on electricity – as adopted by the Council with directive 2003/96/EEC – is set at 0.50 EUR/MWh for business users[58]. Sweden and Lithuania have set their excise taxes close to the allowed minimum, and the same holds for non-EU member country Norway (ref. Table 8). In fact most EU member states charge a tax that is in the range of 0.50–

[58] Proposed to be increased to 0.54 EUR/MWh (European Commission 2014b).

1.50 EUR/MWh. In this regard, Estonia and Finland stand out in a negative sense. However, EU member states are also free to regulate how much they charge from different consumer groups: in Denmark the tax difference between industrial and domestic users is up to 50 EUR/MWh, whereas there is no difference in excise tax for residential and business users in Estonia. Therefore, it is not evident from Table 8 that all Nordic countries charge several times higher excise taxes from domestic consumers and the less-consuming service sector in order to compensate for the more favourable treatment of the manufacturing industries.

In addition to the electricity excise tax, all 7 countries also charge their end-users a fee that is used to support renewable electricity generation (the RES fee). In several countries, this is referred to as the «public service obligation» (PSO), although e.g. in Lithuania the PSO also includes compensation for other strategically relevant projects, such as funding of the NordBalt sub-marine interconnector cable between Sweden and Lithuania. Sweden and Norway operate a market-based renewable energy support scheme where consumers pay for «green certificates» that are ultimately used to compensate new renewable electricity generation. Hence from the point-of-view of consumers, «green certificates» are effectively also a RES fee.

Whereas it was earlier highlighted that Estonia and Finland stand out as charging more electricity excise tax than their neighbours, in terms of RES/PSO the opposite holds. One has to further investigate how much of the RES/PSO payments are forwarded to producers and how the governments spend the money collected from electricity excise tax in order to speculate which split (more electricity excise and less RES/PSO tax or vice versa) makes more sense. From the point-of-view of total taxes payable by end-users Norway clearly stands out as charging least, followed by Sweden and Finland (ref. Table 8).

Table 8. Taxes and fees payable by the manufacturing industry in the NordPool member countries (EUR/MWh) in 2013, excluding VAT. Source: Energinet.dk (2014), Konkurentsiamet (2013), Sadales Tīkls (2014), Energiamarkkinavirasto (2014), Lithuanian National Commission for Energy Control and Prices (2014), European Commission (2014c), Statistisk Centralbyrå (2014); Energimyndigheten (2014) and Eurostat table «nrg_pc_205_c».

Consumption band (MWh/year)		**DK**	**FI**	**NO**	**SE**	**EE**	**LV**	**LT**
Electricity excise & other related taxes								
IA	< 20	69.20	7.03	0.52	0.58	4.47	1.01	0.52
IB	20 – 500	12.80	7.03	0.52	0.58	4.47	1.01	0.52
IC	500 – 2 000	12.60	7.03	0.52	0.58	4.47	1.01	0.52
ID	2 000 – 20 000	10.50	7.03	0.52	0.58	4.47	1.01	0.52
IE	20 000 – 70 000	9.80	7.03	0.52	0.58	4.47	1.01	0.52
IF	> 70 000	9.00	7.03	0.52	0.58	4.47	1.01	0.52
RES/PSO fee								
IA	< 20	28.44	- [b]	1.04 [c]	4.16 [c]	8.70	26.79	20.68
IB	20 – 500	28.44	- [b]	1.04 [c]	4.16 [c]	8.70	26.79	20.68

IC	500 – 2 000	28.44	- [b]	1.04 [c]	4.16 [c]	8.70	26.79	20.68
ID	2 000 – 20 000	28.44	- [b]	1.04 [c]	4.16 [c]	8.70	26.79	20.68
IE	20 000 – 70 000	28.44	- [b]	1.04 [c]	4.16 [c]	8.70	26.79	20.68
IF	> 70 000	6.97[a]	- [b]	- [c]	- [c]	8.70	26.79	20.68
Total taxes and fees								
IA	< 20	91.79	7.03	1.56	4.76	13.17	27.80	21.20
IB	20 – 500	35.39	7.03	1.56	4.76	13.17	27.80	21.20
IC	500 – 2 000	35.19	7.03	1.56	4.76	13.17	27.80	21.20
ID	2 000 –20 000	33.09	7.03	1.56	4.76	13.17	27.80	21.20
IE	20 000 – 70 000	32.39	7.03	1.56	4.76	13.17	27.80	21.20
IF	> 70 000	15.97	7.03	0.52	0.58	13.17	27.80	21.20

[a] Users above 100 GWh annually pay a lower RES fee in Denmark
[b] In Finland renewable energy is supported from the electricity tax, no separate RES/PSO fee exists
[c] Norway and Sweden have a market-based el-certificate system[59]. Users pay a certain share of the market price for each MWh consumed[60]. In both countries energy-intensive manufacturers are exempt (see footnotes 14 and 15).

Generally, there is no preferential treatment for specific industries in the seven countries: this means that e.g. the food processing industry (NACE #10) pays the same amount of non-recoverable electricity taxes per each kWh consumed as does e.g. the transport equipment manufacturing industry (NACE #29). Hence, the difference in paid taxes will be determined by the difference in total kWh consumed. However in some countries some exceptions exist. In Norway, Sweden and Finland the entire manufacturing industry (together with horticulture) is subject to lower electricity taxes than other business users – as opposed to the Baltic States where industrial users pay the same amount of tax per kWh as do e.g. households or commercial users. In Finland electricity excise tax payable by industries is capped to € 50 000, after which 85% is refunded. Both in Sweden and in Norway some industries are further exempt from paying some or all electricity consumption taxes[61] [62]. In Denmark, under the Green Tax Package

[59] Elcertificate market prices can be seen at http://certifikat.svk.se/WebPartPages/SummaryPage.aspx
[60] The annual quotas for elcertificates can be seen at https://lovdata.no/dokument/NL/lov/2011-06-24-39
[61] In Sweden energy-intensive manufacturers are defined as «using on average at least 190 MWh per million SEK added value of the industry's production or industries that consume electricity in chemical reduction and electrolytic processes, in the production of energy products or in metallurgical processes or for in manufacturing of mineral products» (Energimyndigheten 2014).
[62] In Norway industries in NACE rev.2 categories 17.1 (the paper & pulp industry), 20.1 (the chemical industry, 24.1 and 24.4 (basic metals processing industry) are exempt from paying for elcertifiates (NVE 2015).

scheme, energy intensive industries[63] are completely exempt from energy taxes. Existence of such differentiation confirms validity of research proposition #2.

Another reason for imposing lower electricity taxes to some industrial users lies in the fact that several large-scale electricity users are also subject to CO_2 taxes through the EU emissions trading scheme (ETS) due to environment-polluting nature of their production processes. As shown in Kleesmaa et al (2011), in Estonia the biggest electricity producers, cement, glass and brick manufacturers as well as wood processors and pulp/paper producers are all subject to EU ETS, while several of them are also spending over 20% of production costs on energy – up to 62% in one wood tile producing company. Hence paying both for CO_2 emissions and paying high electricity taxes might significantly increase overall tax burden of such companies and harm their overall international competitiveness. Whereas effect of EU ETS on electricity prices (due to CO_2-intensive electricity generation) is relatively modest both in Estonia (Kleesmaa et al 2011) as well on a pan-European level in general (European Commission, 2014c), the combined impact can be significant for several manufacturing industries. Kleesmaa et al (2011) demonstrated that in Estonia the CO_2 intensive mineral industries would see their variable costs increase by 68% if the CO_2 price increased from 15 to 25 EUR/tonne and by more than 340% if the increased price amounted to 50 EUR/tonne. As existing production technologies for e.g. cement or bricks cannot be easily upgraded or replaced, these industries could face considerable price increase and thereby loss of competitiveness if the governments failed to address the issue – in Estonia and also elsewhere.

One has to add the grid fees and taxes together in order to understand how much has to be paid additionally to the price of electricity supply in the 7 countries. This is presented in Table 9. It can be seen that in general, grid fees and taxes of electricity are highest for Latvian and Lithuanian industrial consumers, with less-consuming users paying some 30% more than in neighbouring Estonia. For consumers up to 2000 MWh/year, total cost of grid fees and taxes is highest in Lithuania, with Latvia close behind. The payments per kWh are rather similar in Denmark and Estonia, with Estonian consumers generally better off at higher than 2000 MWh/year levels.

[63] The ratio of the electricity costs to gross value added must exceed 15% and electricity demand must exceed 10 GWh/year at a certain delivery point; in which case the added costs to the client cannot exceed 0.05 eurocents per kWh. Alternatively if the ratio of the electricity costs to gross value added is below 20% and the electricity demand is below 100 GWh the limitation of the added cost will only apply to 90% of the electricity purchased in the previous year. Those that participate in voluntary agreements that commit them to energy efficiency improvements are eligible for a rebate of 100% on their energy tax and 97% on their carbon tax (European Commission, 2014c).

Table 9. Total price of electricity (excluding recoverable taxes) for industrial users in the NordPool region in 2013 (EUR/MWh). Sum of Table 6, Table 7 and Table 8.

Consumption band (MWh/year)		DK	FI	NO	SE	EE	LV	LT
Total network fees and taxes								
IA	< 20	132.10	39.55	34.36	98.66	67.67	95.60	95.92
IB	20 – 500	67.40	37.88	34.46	41.06	57.77	77.50	80.02
IC	500 – 2 000	60.00	25.42	34.46	30.96	51.47	68.50	72.92
ID	2 000 – 20 000	57.90	23.30	19.86	23.56	44.87	60.70	59.22
IE	20 000 – 70 000	48.10	12.95	8.22	15.96	36.47	59.80	N/A
IF	> 70 000	31.68 [a]	12.77	6.52	8.00	28.17	51.00	N/A
Total price of electricity (supply, network fees and taxes)								
IA	< 20	177.70	94.37	73.92	147.00	118.50	146.10	145.10
IB	20 – 500	108.50	87.63	73.82	86.80	104.00	125.10	129.60
IC	500 – 2 000	99.80	73.38	72.72	74.80	97.00	115.10	122.60
ID	2 000 – 20 000	97.20	69.67	57.52	67.20	89.80	106.50	113.40
IE	20 000 – 70 000	87.40	56.30	45.38	59.00	79.90	106.90	N/A
IF	> 70 000	86.60 [a]	55.92	41.18	48.74	69.80	95.90	N/A

[a] For users above 100 GWh/annually

Whereas large subsidies on oil, gas, nuclear power and (in the case of China) even coal use are in place in emerging markets (World Economic Forum 2013), European electricity consumers have witnessed the opposite trend. A study by Eurelectric (2014) found that even if electricity supply prices have been shrinking over the past years, the share of taxes and levies in total electricity price has continued to increase. Between 2008 and 2012, share of taxes moved on average from 12% to 23% of total price among the 24 Eurelectric member countries (i.e. most EU member states plus Norway and Switzerland).

As can be seen from Figure 22A and B, this trend is similar in Northern Europe: increase in electricity supply prices has generally been lower than increase in total prices. In Denmark and Norway supply prices for consumers in band IE (20–70 GWh/annually) were in fact in 2014 slightly lower than in 2007, so total price only increased (also slightly) due to increased taxes (ref. Figure 22A). In Sweden supply price stayed roughly the same, whereas total price of electricity increased slightly due to increase in grid fees. Finnish consumers of 20–70 GWh/annually saw an increase both in supply price as well as taxes; but the total price remained comparable to peers in Norway and Sweden. Most dramatic total price increase has taken place in Estonia, where large electricity consumers have seen both electricity supply prices increase (ca 2-fold) as well as a close to 3-fold increase in grid fees and electricity taxes. Indeed, during 2007–2013 electricity taxes alone rose close to 10-fold in Estonia. Similar conclusions hold for largest consumer group IF (i.e. consumers of above 70 GWh), except for a sharp supply price increase in Norway due to ending of subsidies in 2008[64] – see Figure 22B. Latvia and Lithuania are missing from comparison due to limited information for pre-2010 years.

Figure 22A and Figure 22B visualise Nordic governments' strong intention to keep total price of electricity for the largest user groups on par with that in neighbouring countries, and a clear effort to maintain that total price of electricity remains at predictable levels. This is in support of research proposition #2.

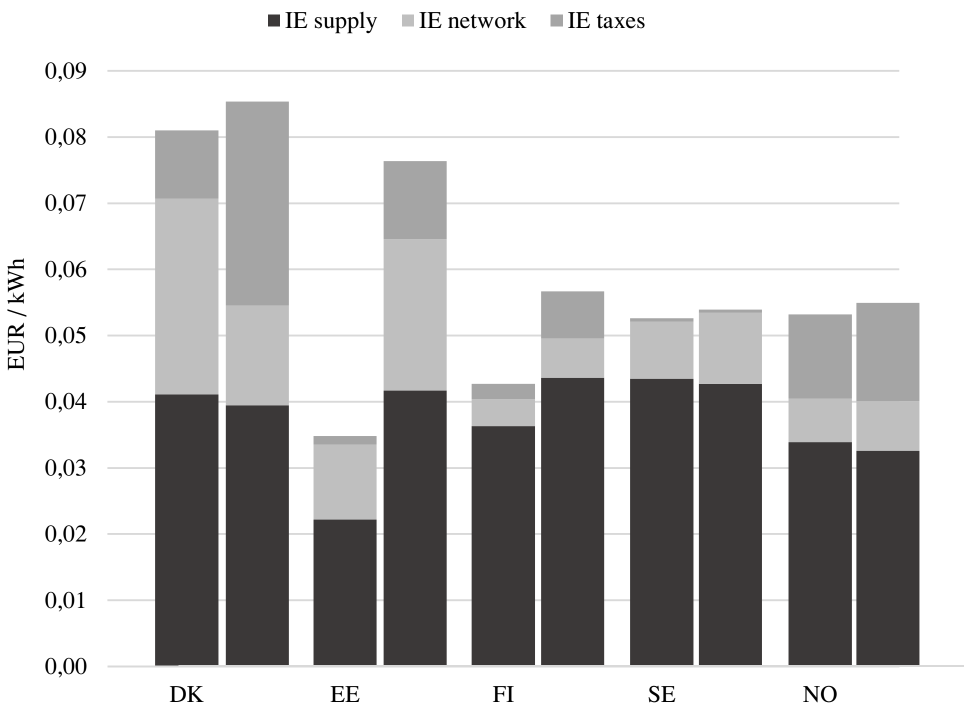

Figure 22A. Electricity price sub-components for consumption band IE (20–70 GWh) in 2007 (left column) and 2014 (right column) in Estonia and the Nordic countries. Latvia and Lithuania are not shown due to insufficient data. Source: author's calculations based on Eurostat table «nrg_pc_205_c».

[64] For more information on this, see e.g. Bye & Holmøy (2010).

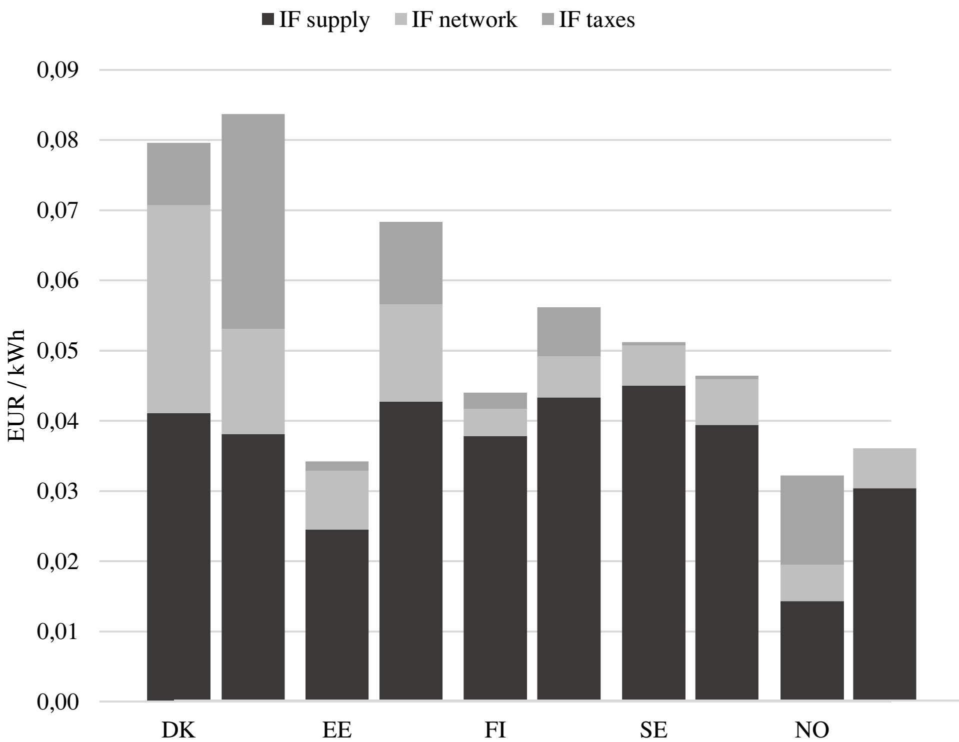

Figure 22B. Electricity price sub-components for consumption band IF (above 70 GWh) in 2007 (left column) and 2014 (right column) in Estonia and the Nordic countries. Latvia and Lithuania are not shown due to insufficient data. Source: author's calculations based on Eurostat table «nrg_pc_205_c».

Figure 23A and B offer a better insight into annual changes in total electricity prices. As can be seen from Figure 23A the total electricity prices for Danish users have stayed relatively stable (except for a hike in 2008). In Norway and Sweden total electricity prices have increased ca 10–15% from 2007 levels, having actually decreased post-2010 for all consumers except the most energy-intensive band IF (annual consumption >70 GWh) in Norway. This means that within the Nordic countries, competitiveness of the electricity-intensive manufacturing sector may not have been impacted due to (lack of) changes in electricity prices.

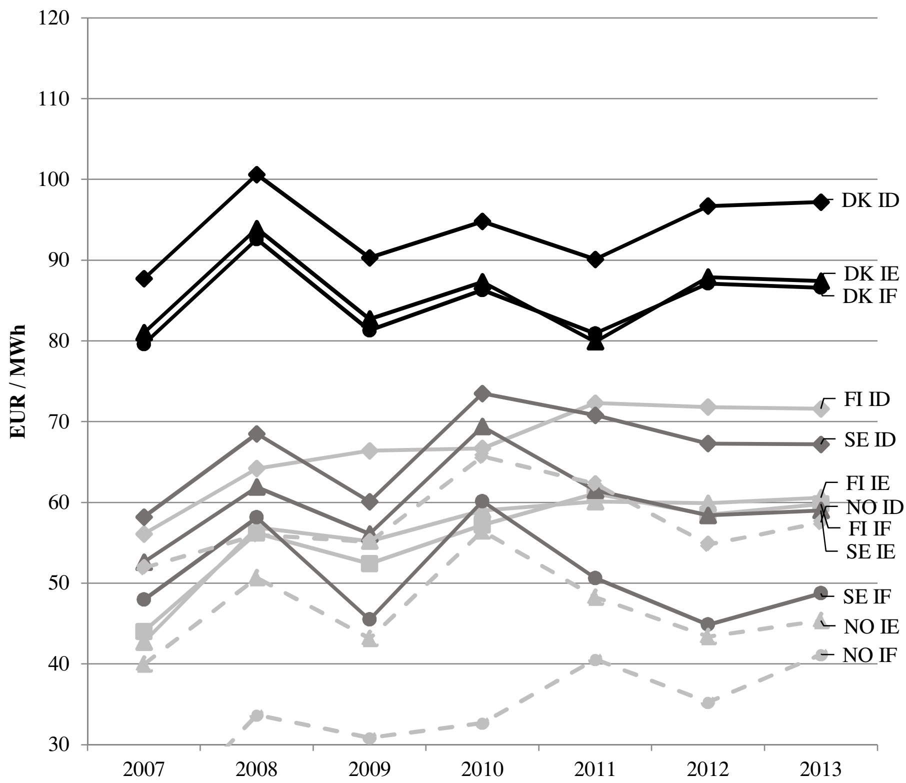

Figure 23A. Development of total price of electricity (supply price + grid fees + taxes) for industrial consumer bands ID-IF in the Nordics in 2007–2013. Diamonds indicate band ID (2000–20 000 MWh/year), triangles indicate band IE (20 000–70 000 MWh/year) and dots indicate band IF (over 70 000 MWh/year). Countries can be identified as follows: Denmark – solid black lines; Finland – solid light grey lines; Norway – dashed light grey lines; Sweden – solid dark grey lines. Source: author's calculations based on Eurostat table «nrg_pc_205_c».

Estonian electricity consumers not only witnessed a doubling of total electricity prices between 2007–2013 (ref. Figure 23B), the country also moved from being the least costly location for electricity-intensive manufacturing to being more costly than Finland, Norway and Sweden and closer to Denmark's levels (cf. Figure 23A). In 2007 Estonian consumers in band ID (2000–20 000 MWh/annually) paid some 20–30% less than their counterparts in Finland, Norway and Sweden and some 50% less than in Denmark. By 2013 the Estonian businesses paid 25%–35% more than Finns, Norwegians and Swedes and only 8% less than their Danish competitors. This means that from the point-of-view of total electricity price as a driver of competitiveness, position of Estonia's manufacturing sector as a whole is likely to have drastically worsened vis-à-vis all its Nordic counterparts, including Denmark. Price information for Latvia and

Lithuania comes with limited reliability (the author was not able to verify historic price levels) but based on available information, the increase in prices has been even higher in Latvia and total levels are higher still in Lithuania.

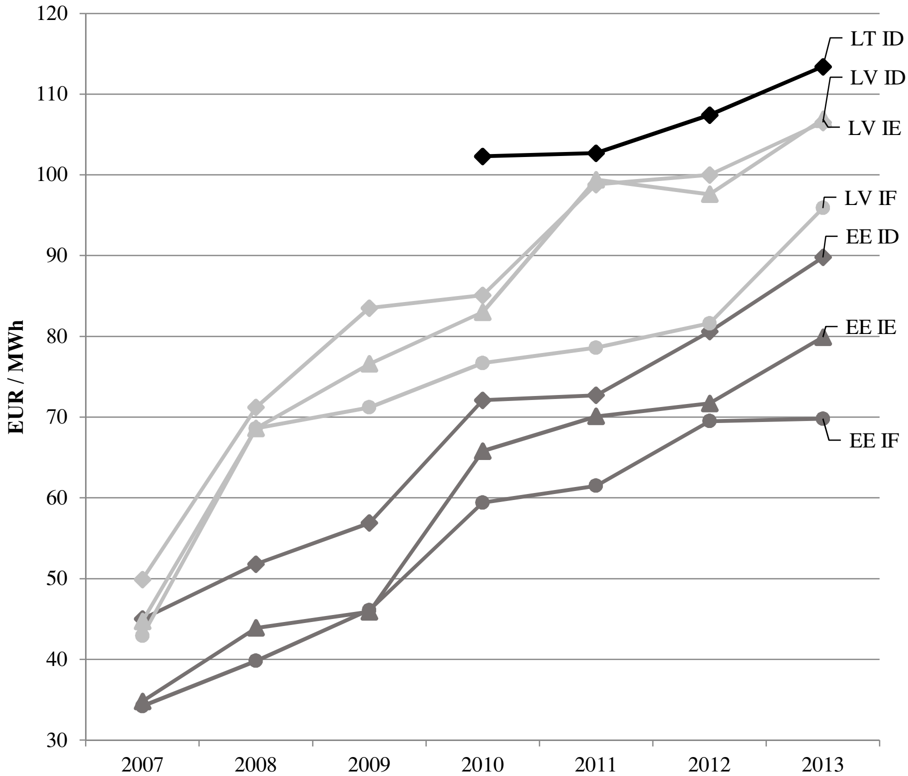

Figure 23B. Development of total price of electricity (supply price + grid fees + taxes) for industrial consumer bands ID–IF in the Baltics in 2007–2013. Diamonds indicate band ID (2000–20 000 MWh/year), triangles indicate band IE (20 000–70 000 MWh/year) and dots indicate band IF (over 70 000 MWh/year). Countries can be identified as follows: Estonia – solid dark grey lines; Latvia – solid light grey lines; Lithuania – solid black lines. Data for Latvia and Lithuania is not verifiable due to limited information availability and is presented for reference purposes only. Source: author's calculations based on Eurostat table «nrg_pc_205_c».

Analysis of electricity supply price (i.e. price of supply excluding grid fees and taxes, shown on Figure 24) development in 2007–2013 allows one to conclude that part of the increase of Estonia's total electricity prices can be explained by the trend of supply price convergence (cf. research proposition #1): in 2007 only the very electricity-intensive users in Norway paid less than the Estonian manufacturing industries and there were large differences between Estonia and its neighbours; whereas by 2013 price of electricity supply in Estonia was higher than for all Norwegian and Danish competitors, yet the price differences were much smaller. However it should be reminded that the slope of the Estonian manufacturers' electricity supply price curves (68%, 98% and 75% increase for bands ID, IE and IF respectively) is smaller than the slope of total electricity price curves (200%, 230% and 204% respectively), meaning that increase in grid fees and taxes (that are both ultimately controlled by the government) has been the actual driver of price increase (cf. research proposition #2), as was also visualised on Figure 22. It is likely that the same conclusions hold for the other Baltic states (which have more limited information).

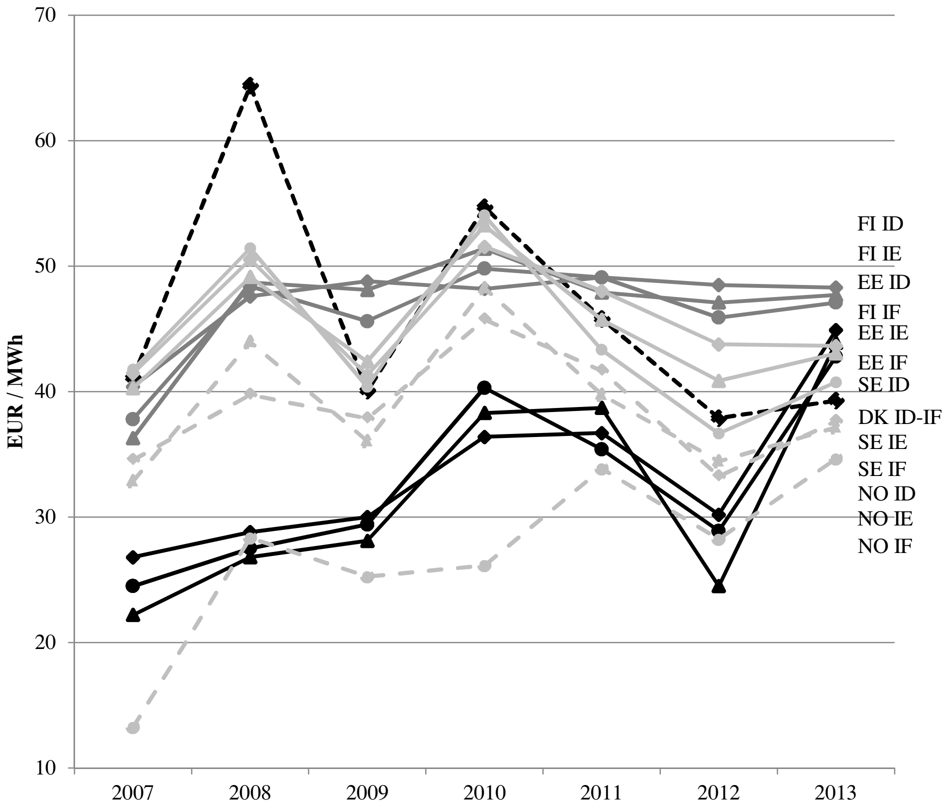

Figure 24. Development of electricity supply price for industrial consumer bands ID–IF in 2007–2013. Diamonds indicate band ID (2000–20 000 MWh/year), triangles indicate band IE (20 000–70 000 MWh/year) and dots indicate band IF (over 70 000 MWh/year). Countries can be identified as follows: Denmark – dashed black lines; Finland – solid dark grey lines; Norway – dashed light grey lines; Sweden – solid light grey lines; Estonia – solid black lines. Data not presented for Latvia and Lithuania due to limited information availability. Source: author's calculations based on Eurostat table «nrg_pc_205_c».

Chapter summary

When comparing the countries' total consumption of electricity, it emerges that the manufacturing sector is responsible for 30–60% of total; and that the four electricity-intensive industries in Finland, Norway and Sweden account for 70%–85% of total manufacturing electricity consumption. This is in line with the generally higher kWh per capita consumption ratios in these countries, confirming that the three economies are electricity-intensive. Norway and Sweden have large and relatively low-cost electricity generation surpluses, which – in line with the factor abundance theory and path dependency – explains greater electricity-intensity of these economies. Even though Finland has a net electricity generation deficit, its proximity and good connectivity to neighbouring Sweden (that has a generation surplus) provides background for an equally electricity-intensive economy. In Denmark the electricity consumption is spread much more evenly across all industries, indicating that the Danish economy is significantly less electricity intensive. The Baltic States position between Denmark and the other Nordics, with their electricity-intensive industries accounting for 45%–65% of total electricity consumption in the countries' manufacturing sector. There appears to be no significant difference in electricity intensity between the three Baltic countries, although Estonia is the only country with net electricity generation surplus (possibly because all three Baltic countries are very well inter-connected to each other and non-NordPool countries).

Whereas electricity-intensive industries account for a sizeable share of total electricity consumption, they also play an important role in their countries' economies. The industries' contribution to production value, salaries paid, employment and exports ranges between 20 and 40% in 6 of the 7 NordPool member countries – only in Denmark are the shares about two times lower.

Empirical evidence supports research proposition #1, i.e. that market liberalisation and better interconnectivity converges electricity supply prices. Although all seven NordPool members are interconnected, the limited interconnector capacities (e.g. the Baltics are currently connected to the Nordics via two cables from Estonia to Finland; and via one cable from Lithuania to Sweden) and different production mixes ensure that electricity supply prices nevertheless remain somewhat different across countries. Empirical evidence supports research proposition #2, i.e. that government-controlled electricity taxes have an important role in setting total electricity prices in the seven countries. The total electricity-related tax burden tends to be generally higher in the Baltics and Denmark, whereas Finland, Norway and Sweden charge lower grid fees and taxes from their industrial electricity consumers, with very low fees and taxes for the most electricity-intensive users. In Sweden and Norway the most electricity-intensive users are altogether exempt from certain fees. This creates a significant locational advantage for electricity-intensive industries in the three Nordic countries: compared to e.g. Latvia and Lithuania, differences in total price of electricity per kWh were in 2013 more than two-fold. Estonia's example shows that on top of the doubling of electricity supply prices between 2007–2013, the government has raised electricity taxes 10-fold in the same period – meaning that the government has actually contributed to a potential decrease of location-based advantages for Estonia's most intensive electricity users.

3.2. Observed relationship between changes in electricity price and competitiveness

3.2.1. Preliminary descriptive analysis

In section 1.2.3 it was concluded and in section 2.1.1 it was further elaborated that in the context of this dissertation, it makes sense to analyse the relationship between value added, kWh consumed and price of electricity in various forms (total electricity expenditure, electricity cost share etc) to identify changes in competitiveness of the electricity-intensive industries. Indexed changes to the above mentioned indicators over the period 2008–2013 have been summarised in Figure 25A and B below for the Nordic and Baltic countries respectively.

As is evident from Figure 25A value added per electricity expenditure – chosen as primary indicator for measuring changes in competitiveness in this dissertation – has been decreasing in 12 of the 16 industries covering four electricity-intensive industries in four Nordic countries. The indicator has decreased for all electricity-intensive industries in Sweden, and in three of the four industries both in Denmark and Norway. In Finland, value added per electricity expenditure was in 2013 lower than in 2008 in two of the four observed industries. Accordingly, it appears that such industries in Finland have been hurt least, with Norway and Sweden following before Denmark. In all instances, the basic metals processing industry (NACE #24) was significantly worse off in 2013 vis-à-vis 2008. Value added per electricity expenditure has also decreased in every Nordic country's wood processing industry (NACE #16), however much less so. With the exception of Denmark, there seem to have been least changes to the competitiveness of Nordic pulp and paper manufacturing industries (NACE #17).

Much of the reasoning why value added per electricity expenditure has decreased in 12 out of 16 industries may be covered by the fact that payments for each kWh consumed electricity have increased in 14 out of 16 industries (although the increase is smaller than in the Baltics, as visible on Figure 25B). Generally, in indexed terms, the price increase has been most visible in Denmark, Sweden and Norway, in Finland this is visible to a lower degree.

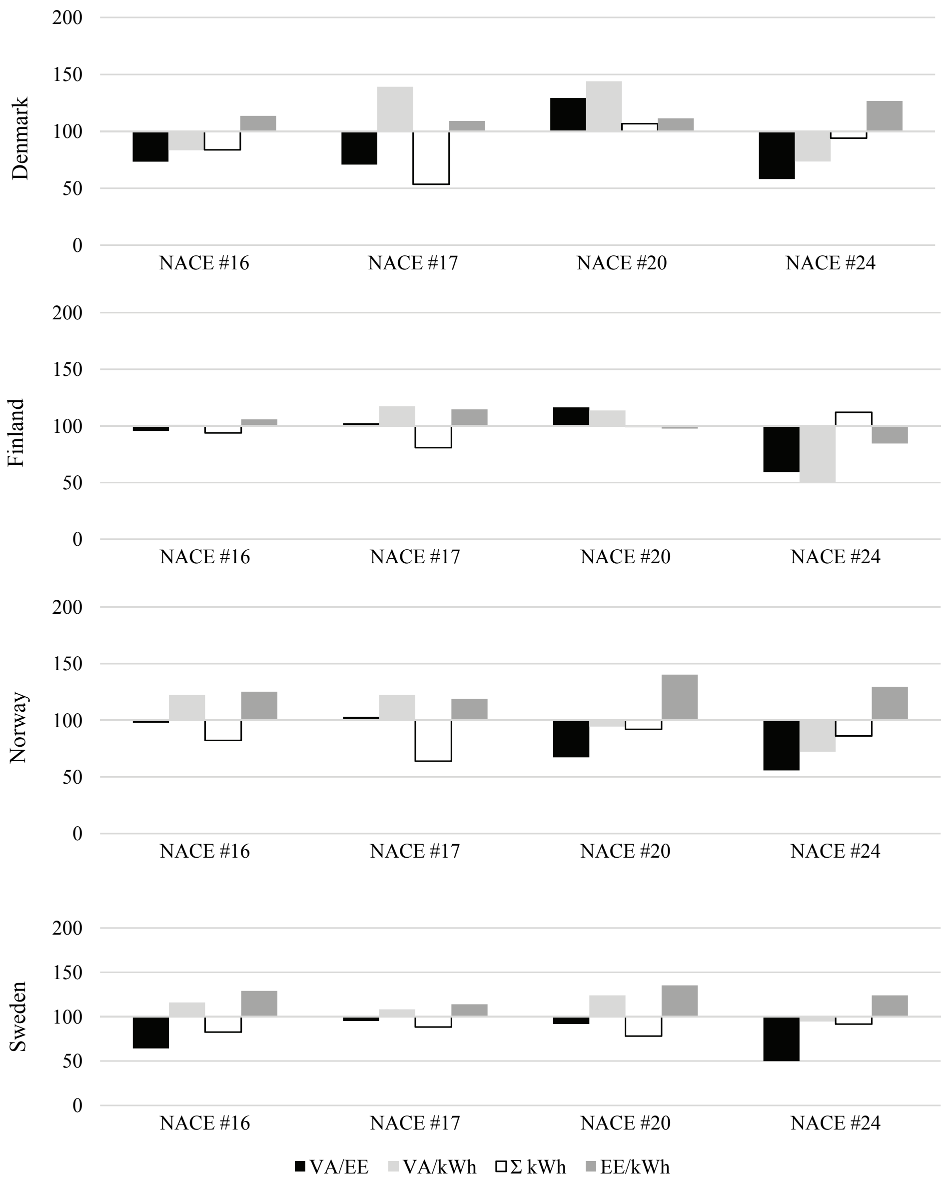

Figure 25A. Indexed change in electricity price per kWh (dark grey), total electricity consumption (white), value added per kWh (light grey) and value added per electricity expenditure (black) in the Nordic countries over the period 2008–2013, with 2008=100. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2», «nrg_105a» and «sbs_pu_4l_02».

Interestingly, the indexed rate of price increase is different for each country's each industry – e.g. the basic metals processing industry (NACE #24) has witnessed a larger price increase in three out of four countries, whereas in Finland there has actually been a small price reduction; in wood processing (NACE #16) there has been a noticeable increase in Sweden and Norway. Such differences may be explained by the fact that this analysis uses aggregated industry-level data, which may be influenced by larger differences across firms within the same industry in the same country.

In the context of rising prices total consumption of electricity has also decreased in 14 out of 16 industries: the two exceptions being Danish chemical manufacturing (where price increase has been modest, and consumption increase has also been relatively small) and Finnish basic metals processing (where prices somewhat decreased). Analysis of annual data indicates that the increase in Denmark is negligible; in Finland consumption increased beyond year 2008 levels only in 2012–2013.

Given that value added per electricity expenditure is influenced both by changes in electricity price and changes in consumption, it is interesting to observe changes in value added per kWh as an indicator of changes in intensity/efficiency. As seen from Figure 25A it has increased in 9 out of 16 industries, whereas the opposite trend can be observed in the rest. Generally, Finland and Sweden stand out with less changes to the indicator, in line with less change in prices and consumption. In Norway and Denmark the results are more mixed. Across the four countries, value added per kWh consumed has decreased in the basic metals processing industry (NACE #24), and there is a slight increase in the pulp and paper manufacturing industry (NACE #17).

Summing up the above, there is a clear relationship between increased electricity prices per kWh and decreased value added per total electricity expenditure. Increased electricity price has generally lead to decreased consumption, which in turn has contributed to increased value added per kWh – in support of research proposition #3. There are generally least changes in the above described indicators in Finland; somewhat more in Norway and Sweden, and largest indexed change has taken place in Denmark. Across the four-country sample, basic metals processing industry stands out in negative terms; suggesting that applicability of research proposition #3 – i.e. that price increase forces firms to innovate and become more efficient – may be more limited in the more electricity-intensive industries, such as basic metals processing.

Trends in the Baltic countries over the period 2008–2013 are captured in Figure 25B. Accordingly, value added per electricity expenditure has decreased in 11 of the 12 industries covering the four electricity-intensive industries in the three Baltic countries. In indexed terms, decrease has been largest in Lithuania, with Estonia and Latvia following. Across the three Baltic countries, particularly the chemical manufacturing (NACE #20) stands out with largest decreased values in 2013 vs 2008, although in all countries the pulp and paper manufacturing (NACE #17) has also experienced a noticeable reduction.

Price increase is clearly visible across all three Baltic countries. In Estonia, all four industries seem to have experienced a similar price increase, whereas it is visibly higher (in indexed terms) in Latvian and Lithuanian wood manufacturing (NACE #16) and pulp and paper manufacturing (NACE #17). Smaller price increases in e.g. Latvian chemicals manufacturing (NACE #20) and Lithuanian basic metals processing (NACE #24) industries may be explained by the fact that this analysis uses aggregated industry-level data, which may be influenced by larger differences across firms within the same industry in the same country. The general deviation between price increases in the Baltic countries is in line with findings in section 3.1.3.

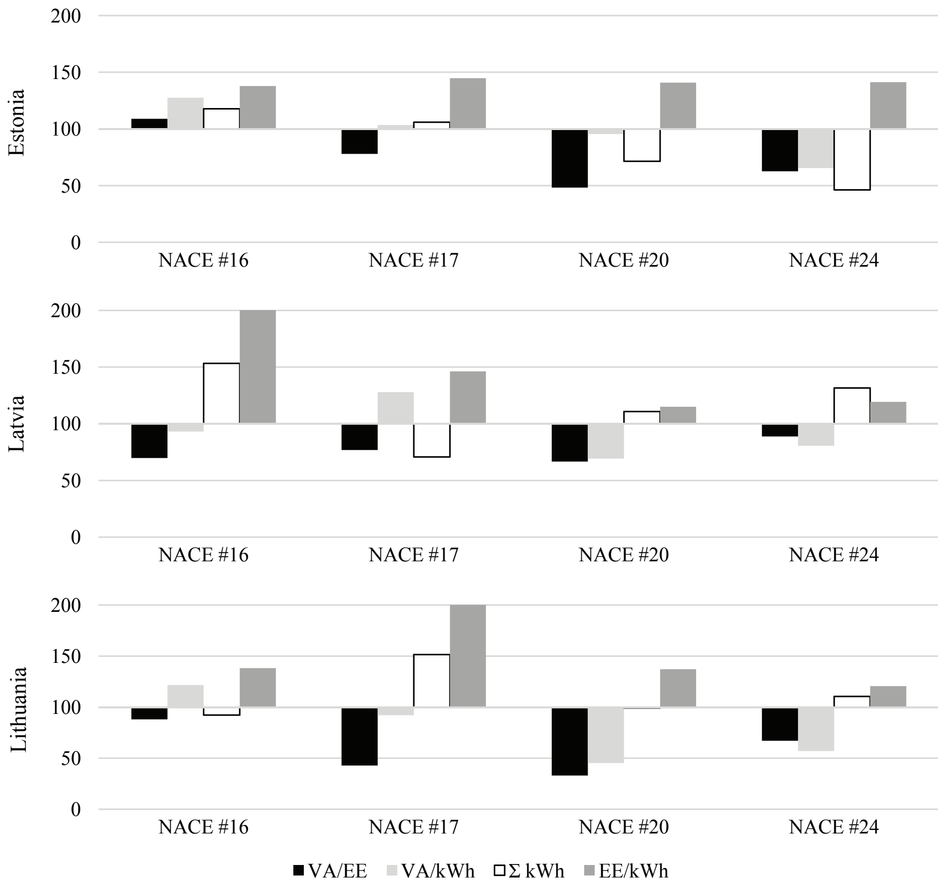

Figure 25B. Indexed change in electricity price per kWh (dark grey), total electricity consumption (white), value added per kWh (light grey) and value added per electricity expenditure (black) in the Baltic countries over the period 2008–2013, with 2008=100. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2», «nrg_105a» and «sbs_pu_4l_02».

Interestingly, consumption of electricity has decreased only in 4 industries; and not necessarily in those industries where prices have increased significantly: e.g. in Estonian and Latvian wood processing sector (NACE #16), prices have increased, but so has consumption; the same holds in e.g. Lithuanian pulp and paper manufacturing (NACE #17). There are no clear patterns in indexed change in consumption neither across the three Baltic countries nor across the Baltic electricity-intensive industries.

Consequently, there are almost no clear patterns for changes in value added per kWh: in each Baltic country there are industries where it has increased and where it has decreased; only in all Baltic basic metals processing industries (NACE #24) has the indicator decreased noticeably, together with price increase as highlighted above (cf. validity of research proposition #3 in the Nordics). This suggests that compared to the Nordics, there are less clear relationships between changes in various indicators across the Baltic electricity-intensive industries. This is not suprising, given that the Baltic countries are less energy-intensive than their Nordic neighbours (ref. section 3.1.1); also the Baltic electricity-intensive industries are less energy-intensive than their counterparts in the Nordics (ref. section 3.1.2).

The above conclusions for both Nordic and Baltic electricity-intensive industries are further validated by observing indexed changes in each country's industry's share of value added in European total, and indexed change in total value added from each country's each respective industry (ref. Figure 26).

As can be seen, on a 7-country level generally wood processors (NACE #16) and pulp and paper manufacturers (NACE #17) seem to be doing better than chemical manufacturers (NACE #20) and basic metals processors (NACE #24), although some exceptions exist. On an inter-country comparison, generally the Baltic countries seem to have performed better than their Nordic counterparts.

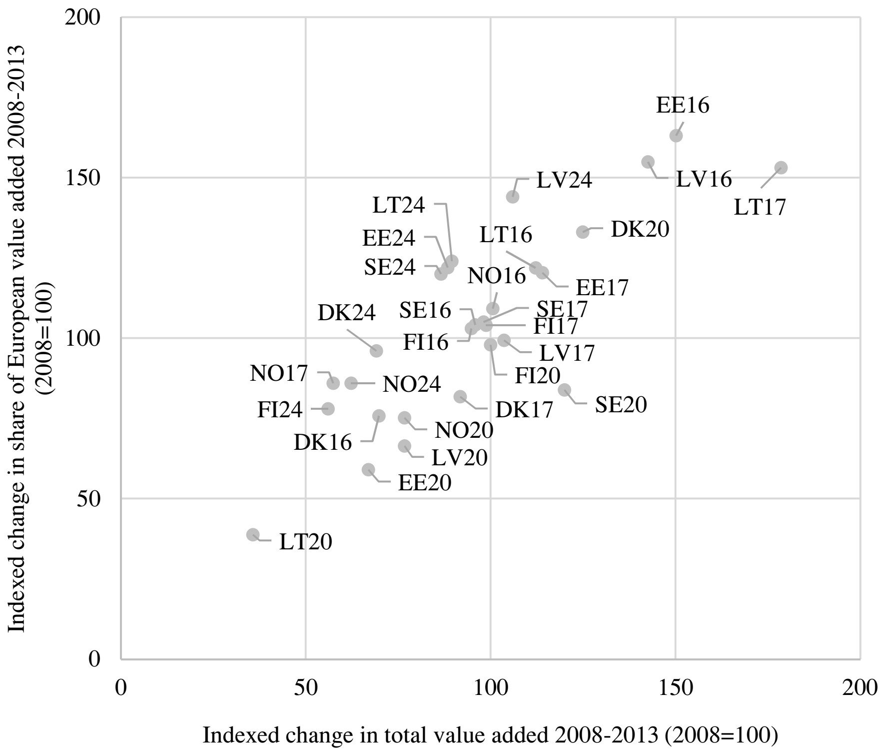

Figure 26. Indexed visualisation of changes in total value added of each electricity-intensive industry in each country (on X-axis) and share of value added of the same industry on aggregated European level[65] (on Y-axis) for the period 2008–2013, with 2008=100. Source: author's calculations based on Eurostat table «sbs_na_ind_r2».

Review of changes in export performance was earlier identified as another way of analysing industry competitiveness; and as per research proposition #4 export markets can boost economies of scale (foremost if domestic market size is small) and help absorb cost increase to preserve or boost competitiveness. Figure 27 below plots changes in export performance by using changes in trade intensity (i.e. the ratio of export value to the sum of production value and import value, ref. equation (17)) as well as change in Balassa's RCA index value (ref. equation (6)) for all of the electricity-intensive industries in the 7 NordPool member countries.

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[65] Aggregated European level is calculated from the following countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

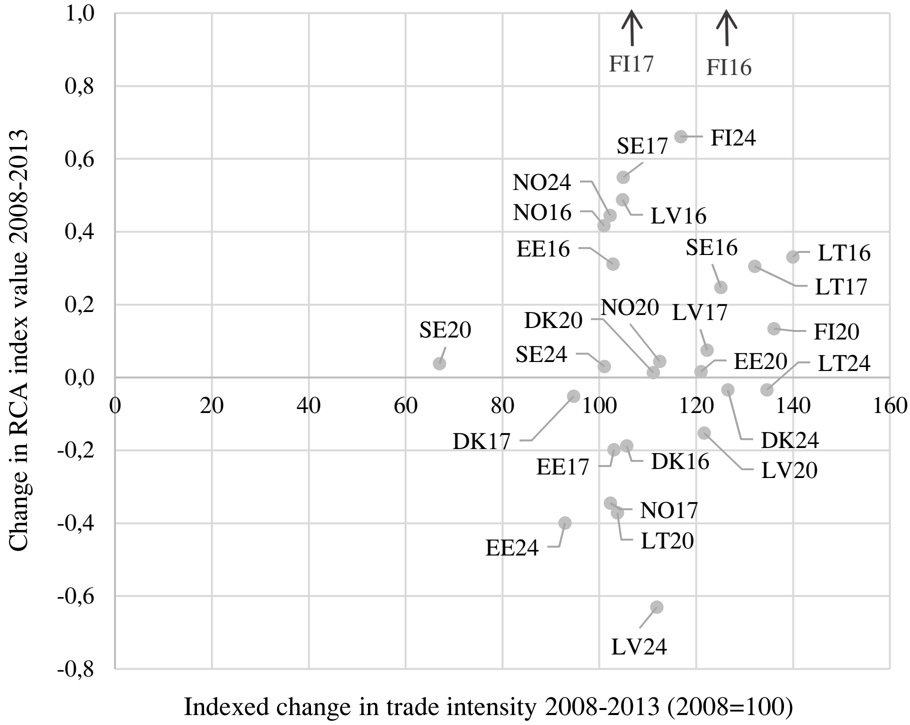

Figure 27. Indexed visualisation of changes in trade intensity of the electricity-intensive industries in each country (on X-axis) and change in RCA index value (on Y-axis) for the period 2008–2013, with 2008=100. Source: author's calculations based on Eurostat tables «sbs_na_ind_r2» and «DS-058471».

As is visible from Figure 27 there is more ambiguity in export-related performance vis-à-vis changes in value added. Especially the calculated RCA index has both increased and decreased for similar industries in different countries, and for different industries within the same country. However, trade intensity has generally increased or remained the same (with the exception of three industries in three separate countries), which indicates strong export performance in most of the electricity-intensive industries. This hints at potential validity of research proposition #4, i.e. that increased exports could have provided additional economies of scale to absorb cost increases from e.g. rising electricity prices.

3.2.2. Econometric analysis

In order to validate how competitiveness of the electricity-intensive industries in the 7 NordPool member countries has changed over the period 2008–2013, four separate regressions were run with different variables. Accordingly, value added per electricity expenditure and per kWh (ref. equations (7), (8) and (9)) were chosen as dependent variables; together with trade intensity (ref. equation (17)), while electricity price was directly and indirectly (e.g. as total electricity expenditure, share in total costs etc) chosen as the independent variable. Background and methodology for each of the four regressions was further explained in section 2.1.1.

In the first regression, logarithm of value added (per kWh of consumed electricity) was regressed with typical production function components (logarithms of cost of labour, cost of capital, cost of materials other than energy, electricity costs, and all other energy costs) in order to establish the relationship between the previously discussed components of the preferred competitiveness indicator: value added, kWh consumed and payments for electricity.

An OLS regression returned a relatively high description of the model (R^2=0.66), great significance of electricity expenditure (P>|t| is 0.000) and – as expected – a negative coefficient for the electricity expenditure component (see column (2) in Table 10). This proves the argumentation put forward in this dissertation that as firms have to pay more for the same amount of consumed electricity, it negatively impacts value added and hence, broadly speaking, their competitiveness. Introduction of country dummies further increased the adjusted R^2 to 0.72 while significance of electricity expenditure stayed unchanged, and it remained negatively correlated to value added – as shown in column (3). Denmark acted as a reference group, thus it is not surprising that dummies for the three other very electricity-intensive Nordic countries are negative. Replacement of country dummies with industry dummies in column (4) also resulted in a high adjusted R^2=0.75 and P>|t|=0.000 for electricity expenditure, with a slightly lower coefficient value. The less-electricity-intensive food processing industry acted as a reference group; nearly all industry dummies had a negative coefficient. It is evident that the coefficient is larger for the more electricity-intensive sectors.

When consolidating electricity-intensive industries together into one group and leaving the rest into another group; and running the same regression with both country and (modified) industry dummies, the adjusted R^2 increased close to 0.80. P>|t|=0.000 for electricity expenditure, which remained negatively associated with value added per kWh (see column (5) in Table 10). Dummies for all electricity-intensive industries in all seven countries were significant in at least 10% level, and had a negative coefficient when referenced to Danish non-electricity-intensive industry. By grouping countries into (i) the electricity-intensive Nordics, (ii) the Baltics and (iii) Denmark as a separate group, it is also evident that all dummies are negative; and those for the more electricity-intensive groups are higher – with the three electricity-intensive Nordic countries as highest (see column (6) in Table 10). This is in line with findings from section 2.2.2, i.e. that value added per kWh is generally lower for electricity intensive industries and countries – and payments for electricity have a higher impact.

Despite use of dummies, regressions with all industries and countries pooled together do not allow to observe change in the coefficient for electricity expenditure in different industries and countries. Therefore, separate regressions were conducted for all electricity-intensive industries in one sample (column (2) in Table 11) and for non-electricity-intensive industries in another sample (column (3) in Table 11); as well as for different country groups (columns (4), (5) and (6) in Table 11). The large difference between the two industry groups is evident in statistical significance of electricity expenditure, which was respectively P>|t|=0.000 and P>|t|=0.525. The coefficient indicates that value added per kWh in electricity-intensive industries decreases by 0.81% for every 1% increase in electricity expenditure, which is a noticeable change. Among the three country groups, electricity expenditure was statistically significant at 1% level in the Baltics and electricity-intensive Nordics, and at 5% level in Denmark. In all cases, the coefficient was negative. As expected the value of the coefficient is higher in the Nordics than in the Baltics, owing to different level of electricity-intensity as shown in sections 3.1.1 and 3.1.2.

In summary, the first set of regressions has established a negative link between value added per kWh and electricity expenditure, and it has been shown that this link is stronger for the more electricity-intensive industries and the more electricity-intensive countries. According to both Davis et al (2008) and European Commission (2014a), the relationship between these two components ultimately defines changes in value added per electricity expenditure, the preferred measure of competitiveness in the context of this dissertation. Thus, the first set of regressions indicates that as firms have to pay more for consumed electricity, it leads to lower value added for the same kWh, and thereby decreased competitiveness.

Table 10. Summary of OLS regressions for value added per kWh and typical production function components. All variables are in logarithms.

	Pooled OLS		OLS with country dummies[a]		OLS with industry dummies[b]		OLS with el.intensive industry dummies[c]		OLS with el.intensive industry and country group dummies[c]	
(1)	(2)		(3)		(4)		(5)		(6)	
Capital	0.153	(0.06)**	-0.049	(0.07)	0.032	(0.06)	0.001	(0.06)	0.078	(0.06)
Labour	1.056	(0.07)***	1.219	(0.08)***	1.046	(0.09)***	0.940	(0.09)***	0.910	(0.09)***
Materials	-0.404	(0.09)***	-0.261	(0.08)***	-0.520	(0.10)***	-0.258	(0.08)***	-0.343	(0.08)***
Electricity	-0.747	(0.05)***	-0.607	(0.07)***	-0.550	(0.05)***	-0.376	(0.07)***	-0.394	(0.06)***
Other energy	-0.084	(0.05)	-0.181	(0.07)***	-0.091	(0.05)*	-0.214	(0.06)***	-0.155	(0.05)***
EE			0.076	(0.06)						
FI			-0.189	(0.05)***						
LT			0.110	(0.05)**						
LV			0.302	(0.06)***						
NO			-0.194	(0.05)***						
SE			-0.204	(0.05)***						
NACE C13–C15					-0.244	(0.06)***				
NACE C16					-0.201	(0.05)***				
NACE C17–C18					-0.385	(0.05)***				
NACE C20–C21					-0.147	(0.05)***				

	Pooled OLS	OLS with country dummies[a]	OLS with industry dummies[b]	OLS with el.intensive industry dummies[c]	OLS with el.intensive industry and country group dummies[c]
(1)	(2)	(3)	(4)	(5)	(6)
NACE C22–C23			-0.045 (0.05)		
NACE C24			-0.371 (0.05)***		
NACE C25–C28			0.075 (0.05)		
NACE C29–C30			-0.162 (0.06)***		
Non-el.intensive in EE				-0.084 (0.06)	
Non-el.intensive in FI				-0.098 (0.05)*	
Non-el.intensive in LT				0.047 (0.06)	
Non-el.intensive in LV				0.062 (0.06)	
Non-el.intensive in NO				-0.101 (0.06)*	
Non-el.intensive in SE				-0.186 (0.05)***	
El.intensive in DK				-0.136 (0.05)**	-0.149 (0.06)**
El.intensive in EE				-0.126 (0.07)*	
El.intensive in FI				-0.546 (0.07)***	
El.intensive in LT				-0.178 (0.07)**	
El.intensive in LV				0.135 (0.08)*	
El.intensive in NO				-0.636 (0.07)***	
El.intensive in SE				-0.401 (0.06)***	

	Pooled OLS	OLS with country dummies[a]	OLS with industry dummies[b]	OLS with el.intensive industry dummies[c]	OLS with el.intensive industry and country group dummies[c]
(1)	(2)	(3)	(4)	(5)	(6)
Non-el.intensive in Baltics					-0.024 (0.05)
El.intensive in Baltics					-0.108 (0.07)
Non-el.intensive in Nordics					-0.117 (0.04)**
El.intensive in Nordics					-0.540 (0.05)***
R^2 / adjusted R^2	0.66 / 0.66	0.72 / 0.72	0.75 / 0.74	0.80 / 0.79	0.76 / 0.75
No. of observations	361	361	361	361	361

The following reference groups are used for dummies: [a] Denmark [b] Food and beverage manufacturing industry (C10–C11) [c] Danish non-electricity-intensive industry. Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error. *** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Table 11. Summary of OLS regressions for value added per kWh and typical production function components (with smaller samples instead of dummies). All variables are in logarithms.

(1)	Pooled OLS for electricity-intensive industries (2)		Pooled OLS for non-electricity-intensive industries (3)		Pooled OLS for all industries in Denmark (4)		Pooled OLS for all industries in Estonia, Latvia and Lithuania (5)		Pooled OLS for all industries in Finland, Norway and Sweden (6)	
Capital	0.357	(0.09)***	-0.096	(0.06)*	-0.202	(0.11)*	0.159	(0.07)**	-0.118	(0.12)
Labour	1.073	(0.11)***	0.636	(0.07)***	1.354	(0.16)***	0.833	(0.10)***	1.675	(0.19)***
Materials	-0.609	(0.14)***	-0.160	(0.08)*	-0.300	(0.14)**	-0.301	(0.10)***	-0.641	(0.19)***
Electricity	-0.810	(0.07)***	-0.045	(0.07)	-0.781	(0.32)**	-0.299	(0.09)***	-0.700	(0.08)***
Other energy	-0.143	(0.08)*	-0.235	(0.06)***	0.158	(0.23)	-0.286	(0.07)***	-0.072	(0.07)
R^2 / adjusted R^2	0.67 / 0.66		0.64 / 0.63		0.77 / 0.75		0.53 / 0.51		0.76 / 0.75	
No. of observations	156		205		54		161		146	

Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error. *** Significant at 1% level ** Significant at 5% level * Significant at 10% level

The second set of regressions set out to validate conclusions from the first regression by examining the importance of electricity expenditure cost share. Accordingly, the relationship between value added per electricity expenditure and electricity cost share in total purchased goods and services was observed. An OLS regression of the logarithm of value added per electricity expenditure and electricity cost share returned a relatively high description of the model ($R^2=0.56$), great significance of electricity cost share ($P>|t|$ is 0.000) and also a negative coefficient (see column (2) in Table 12). This indicates that as the importance of electricity expenditure in total procurement costs increases, it decreases the relative share of value added.

When consolidating electricity-intensive industries together into one group and leaving the rest into another group; and running the same regression with both country and (modified) industry dummies, the adjusted R^2 rose to 0.68, while $P>|t|=0.000$ and the value of the negative coefficient for electricity cost share remained similar (see column (3) in Table 12). Dummies for both the electricity-intensive industries in the Baltics and electricity-intensive Nordics were significant at 1% level, and had a negative coefficient. Given that the Danish non-electricity-intensive industry acted as a reference group, the dummies reveal that the negative relationship is stronger for the more electricity-intensive industries – in line with findings in sections 2.2.2 and 3.2.1.

Separate regressions for all electricity-intensive industries in one sample (column (4) in Table 12) and for non-electricity-intensive industries in another sample (column (5) in Table 12) further confirmed negative relationship between value added and electricity cost shares. Adjusted R^2 was 0.67 and 0.44 in the two groups, and conclusions were statistically significant at 1% level in both cases.

However, it is also possible to prove that increasing electricity prices encourage efficiency – to support research proposition #3. This is shown by regressing value added per kWh with electricity price per kWh, as further discussed below and summarised in Table 13.

Table 12. Summary of OLS regressions for (logarithm of) value added per electricity expenditure and electricity cost share (as of total purchased goods and services).

(1)	Pooled OLS (2)	OLS with el.intensive industry and country group dummies[a] (3)	Pooled OLS for non-electricity-intensive industries (4)	Pooled OLS for electricity-intensive industries (5)
Electricity cost share	-15.922 (0.72)***	-12.267 (0.76)***	-10.818 (0.95)***	-24.598 (1.19)***
El.intensive in DK		-0.030 (0.06)		
Non-el.intensive in Baltics		-0.180 (0.05)***		
El.intensive in Baltics		-0.362 (0.05)***		
Non-el.intensive in Nordics		0.048 (0.05)		
El.intensive in Nordics		-0.262 (0.05)***		
R^2 / adjusted R^2	0.57 / 0.56	0.68 / 0.68	0.67 / 0.67	0.44 / 0.44
No. of observations	375	375	210	165

[a] Danish non-electricity-intensive industry is used as reference for dummies. Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error. *** Significant at 1% level ** Significant at 5% level * Significant at 10% level

In the third set of regressions, the relationship between value added per kWh consumed and payments for each kWh consumed electricity was examined. As the argument goes, when prices increase, firms tend to consume less and this positively affects relative value added. An OLS regression of the logarithm of value added per kWh and electricity price per kWh returned a relatively low description of the model (R^2=0.20), yet high significance (P>|t| is 0.000) and a positive coefficient for the electricity price (see column (2) in Table 13), thus confirming the argumentation. This finding is in line with Davis et al (2008) and proves research proposition #3.

When consolidating electricity-intensive industries together into one group and leaving the rest into another group; and running the same regression with both country and (modified) industry dummies, the adjusted R^2 rose to 0.65, P>|t|=0.000 and electricity price remained positively associated to value added per kWh (see column (3) in Table 13). Dummies for the electricity-intensive industries in the Baltics and Nordic countries were significant at 1% level, but with a negative coefficient. This is expected, since Danish non-electricity industries acted as a reference group, and it has been shown in section 3.1.3 that the more electricity-intensive industries pay less per kWh and as shown in section 2.2.2, also produce less value added per kWh.

Preliminary descriptive analysis in section 3.2.1 revealed that especially in the basic metals processing industry, efficiency measures seem to be harder to implement. This is backed up by results in the OLS regression: when introducing industry-specific dummies to the regression, the coefficient for the dummy for the basic metals processing industry has the highest negative value (ref. column (4) in Table 13). In fact coefficients for all electricity-intensive industries have a negative value because the non-electricity-intensive food manufacturing industry served as reference group.

Separate regressions for all electricity-intensive industries in one sample (column (5) in Table 13) and for non-electricity-intensive industries in another sample (column (6) in Table 13) further confirmed positive relationship between value added per kWh and electricity prices and therefore support research proposition #3, i.e. that when prices increase, it encourages efficiency measures.

Table 13. Summary of OLS regressions for (logarithm of) value added per kWh and payments for each kWh consumed electricity.

(1)	Pooled OLS (2)		OLS with el.intensive industry and country group dummies[a] (3)		Pooled OLS with industry dummies[b] (4)		Pooled OLS for non-electricity-intensive industries (5)		Pooled OLS for electricity-intensive industries (6)	
Electricity price per kWh	6.093	(0.63)***	3.192	(0.46)**	4.552	(0.47)***	1.200	(0.53)**	9.130	(0.96)***
El.intensive in DK			-0.129	(0.07)*						
Non-el.intensive in Baltics			-0.321	(0.05)***						
El.intensive in Baltics			-0.648	(0.06)***						
Non-el.intensive in Nordics			-0.019	(0.05)						
El.intensive in Nordics			-0.789	(0.06)***						
NACE C13–C15					0.181	(0.06)***				
NACE C16					-0.075	(0.06)				
NACE C17–C18					-0.362	(0.06)***				
NACE C20–C21					-0.244	(0.06)***				
NACE C22–C23					-0.072	(0.06)				
NACE C24					-0.476	(0.06)***				

(1)	Pooled OLS (2)	OLS with el.intensive industry and country group dummies[a] (3)	Pooled OLS with industry dummies[b] (4)	Pooled OLS for non-electricity-intensive industries (5)	Pooled OLS for electricity-intensive industries (6)
NACE C25–C28			0.451 (0.06)***		
NACE C29–C30			0.321 (0.06)***		
R^2 / adjusted R^2	0.20 / 0.20	0.65 / 0.65	0.64 / 0.63	0.02 / 0.02	0.35 / 0.35
No. of observations	375	375	375	209	166

The following reference groups are used for dummies: [a] Danish non-electricity-intensive industry [b] Food and beverage manufacturing industry (C10–C11).
Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error.
*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

As per research proposition #4, especially in countries with smaller domestic markets – as is the case in NordPool member countries – exports might provide increased economies of scale and hence help absorb cost increase, e.g. increase in electricity expenditure. Thus regressions were also run by replacing value added with trade intensity, which captures export performance (ref. equation (17)).

OLS regression of trade intensity over cost of capital, labour, materials, electricity expenditure and other energy payments did not return statistical significance of electricity expenses (P>|t| was 0.717 and R^2 was 0.16), but results changed when country and industry dummies were introduced, as shown in Table 14 below.

Accordingly, electricity expenditure was statistically significant at 1% level with country dummies (ref. column (3) in Table 14) and at 5% level with industry dummies (ref. column (4) in Table 14). The coefficient for electricity expenditure was positive in both cases, although it indicated low elasticity. Country dummies for the Baltics suggest a higher significance of trade intensity in these countries compared to Denmark, which served as reference. This is logical, since the Baltic countries have much smaller domestic market size than their Nordic neighbours. Nearly all industry dummies were statistically significant and had a positive coefficient, although with generally lower values for the electricity-intensive industries (using food manufacturing industry as reference group).

Results for regressions for trade intensity by grouping industries and countries into smaller samples (similar to the grouping in previous regressions for value added) are presented in Table 15 below. Despite relatively low R^2 values electricity expenditure was found to be statistically significant for both industry groups, with a positive coefficient for electricity-intensive industries (ref. column (2) in Table 15) and with a negative coefficient for the rest (ref. column (3) in Table 15). Similarly, the coefficient was positive for all Nordic countries and negative for the Baltics. With such ambiguous results, validity of the research proposition #4 is only partially supported by regression analysis.

Table 14. Summary of OLS regressions for trade intensity and logarithmic values of typical production function components.

	Pooled OLS		OLS with country dummies[a]		OLS with industry dummies[b]	
(1)	(2)		(3)		(4)	
Capital	-0.022	(0.04)	-0.074	(0.04)	0.044	(0.03)
Labour	-0.159	(0.05)***	-0.102	(0.05)**	-0.210	(0.05)***
Materials	0.064	(0.05)	0.102	(0.05)**	-0.057	(0.05)
Electricity	0.012	(0.03)	0.196	(0.04)***	0.069	(0.03)**
Other energy	0.036	(0.03)	-0.124	(0.04)***	0.153	(0.03)***
EE			0.111	(0.03)***		
FI			-0.023	(0.03)		
LT			0.052	(0.03)		
LV			0.131	(0.04)***		
NO			-0.239	(0.04)***		
SE			-0.056	(0.04)**		
NACE C13–C15					0.266	(0.03)***
NACE C16					0.112	(0.03)***
NACE C17–C18					0.106	(0.03)***
NACE C20–C21					0.190	(0.03)***
NACE C22–C23					0.027	(0.03)
NACE C24					0.215	(0.03)***
NACE C25–C28					0.328	(0.03)***
NACE C29–C30					0.350	(0.03)***
R^2 / adjusted R^2	0.17 / 0.15		0.34 / 0.32		0.50 / 0.48	
No. of observations	362		362		362	

The following reference groups are used for dummies: [a] Denmark [b] Food and beverage manufacturing industry (C10–C11). Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error.
*** Significant at 1% level ** Significant at 5% level * Significant at 10% level.

Table 15. Summary of OLS regressions for trade intensity and logarithmic values of typical production function components (using smaller samples instead of dummies).

(1)	Pooled OLS for electricity-intensive industries (2)	Pooled OLS for non-electricity-intensive industries (3)	Pooled OLS for all industries in Denmark (4)	Pooled OLS for all industries in Estonia, Latvia and Lithuania (5)	Pooled OLS for all industries in Finland, Norway and Sweden (6)
Capital	-0.000 (0.04)	0.020 (0.05)	0.020 (0.09)	-0.042 (0.05)	-0.155 (0.06)**
Labour	-0.359 (0.06)***	0.080 (0.07)	-0.574 (0.13)***	0.117 (0.06)*	-0.203 (0.10)**
Materials	0.124 (0.07)*	-0.075 (0.08)	0.617 (0.11)***	-0.074 (0.06)	0.268 (0.10)***
Electricity	0.116 (0.04)***	-0.193 (0.06)***	0.803 (0.26)***	-0.125 (0.06)**	0.069 (0.04)*
Other energy	0.116 (0.04)***	0.026 (0.05)	-0.812 (0.19)***	0.026 (0.05)	0.097 (0.04)**
R^2 / adjusted R^2	0.39 / 0.37	0.29 / 0.28	0.49 / 0.44	0.14 / 0.12	0.29 / 0.26
No. of observations	157	205	54	162	146

Heteroskedasticity consistent estimators.
Figures in brackets indicate standard error.
*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Chapter summary

Using value added per electricity expenditure as primary indicator of competitiveness in this dissertation, it has been shown that most electricity-intensive industries in the Nordics (12 out of 16) and in the Baltics (11 out of 12) have lost competitiveness over the period 2008–2013. Across the seven countries, particularly the basic metals processing industry (NACE #24) has experienced steepest decline.

Much of the reasoning for decreased value added per electricity expenditure has may be covered by the fact that payments for each kWh consumed electricity have increased in all seven countries – less in the Nordics and more so in the Baltics.

In the context of rising electricity prices, most Nordic industries have decreased total consumption of electricity. Interestingly, this has not been the case for several industries in the Baltics (there is no visible correlation between unit price increase and change in total consumption).

The above has resulted in increased value per kWh – as an indicator of increased efficiency – in the Nordics, thus confirming research proposition #3. In the Baltics, more than half of the electricity-intensive industries have also increased value added per kWh consumed. Across the four-country sample, basic metals processing industry stands out in negative terms; suggesting that applicability of research proposition #3 – i.e. that price increase forces firms to innovate and become more efficient – may be more limited in the more electricity-intensive industries.

Altogether four different sets of regressions were conducted to more closely examine relevant time-series of data. The first set of regressions proved the argumentation put forward in this dissertation that as firms have to pay more for the same amount of consumed electricity, it negatively impacts value added and hence, broadly speaking, their competitiveness. Namely, the first set of regressions established a negative link between value added per kWh and electricity expenditure, and it was shown that this link is stronger for the more electricity-intensive industries and the more electricity-intensive countries. Hence, as firms have to pay more for consumed electricity, it leads to lower value added for the same kWh, and thereby decreased competitiveness.

In the second set of regressions, it was shown that as the importance of electricity expenditure in total procurement costs increases, it decreases the relative share of value added. Such findings are in line with earlier observations in sections 2.2.2 and 3.2.1 and support conclusions from the first regression.

In the third set of regressions the relationship between value added per kWh consumed and payments for each kWh consumed electricity was examined. As per research proposition #3, when prices increase, firms tend to consume less and this positively affects relative value added. Regression results confirmed this, but industry and country dummies also hinted that this effect is weaker for the more electricity-intensive countries and dummies.

The fourth set of regressions aimed to establish a positive relationship between export performance and electricity expenditure, in line with research proposition #4. Positive correlation was detected, with country dummies for the Baltics suggesting a higher significance of trade intensity in these countries compared to Denmark, which served as reference. This is logical, since the Baltic countries have much smaller domestic market size than their Nordic neighbours. Nearly all industry dummies were statistically significant and had a positive coefficient, although lower values for the electricity-intensive industries weaken applicability of research proposition #4.

DISCUSSION OF RESULTS

This dissertation builds on the statement that competitiveness of countries depends on competitiveness of the firms that are set up in these countries. Therefore, a country needs to take measures for its firms and industries to prosper by developing location-specific advantages that set the basis for relative competitive advantage. Firms utilise the advantages created by governments to develop attractive products. If the products are desirable then they are also valuable and have an export potential. Exported goods allow for additional revenues, since the firms' offering is no longer limited to the demand from domestic consumers. Successful firms pay more taxes and hire more people, and thus contribute to greater welfare of a country – which is the ultimate aim of competitiveness.

The dissertation focuses on the role of electricity price as a location-specific enabler of firm and industry-level performance, particularly in liberalised electricity markets. Electricity is a unique good that has almost no substitutes (except for lighting and heating): nearly all businesses need electricity to operate. Whereas electricity is imperative, for many companies electricity costs make up a small share of total costs – access to electricity is taken for granted and paid attention to only when it is missing. Given the complex nature of modern economies, it is easy to argue that competitiveness – and the path to greater welfare – depends on a range of factors, and all need to be considered in economic policy-making. Indeed when one speaks about production costs one foremost considers cost of materials, labour and capital. In interconnected markets (such as the European Union with its European Economic Area member countries) cost of (traded) materials and cost of capital are likely to be the same or very similar: the key production cost differentiator is probably the cost of labour. However, in this dissertation it has been shown that within the manufacturing industry there are several industries where the role of electricity costs is significant. Four industries specifically stand out: the wood processing industry (NACE rev.2 #16), pulp & paper manufacturing industry (NACE rev.2 #17), chemicals manufacturing industry (NACE rev.2 #20) and basic metals processing industry (NACE rev.2 #24). It is argued that within these industries – although to a lesser degree also in other industries – electricity cost is an important factor of success.

The Nordic and Baltic countries that are in focus in this dissertation – Denmark, Finland, Norway, Sweden, Estonia, Latvia and Lithuania – have all different electricity generation sources, dictated by differences in geography, geology, climate and history. Thus the availability of electricity generation sources and the respective cost of electricity generation in these countries historically provided governments with different levers in utilising electricity as output to economic growth.

Electricity-intensive industries developed in all countries except Denmark, with the level of intensity being highest in Finland, Norway and Sweden. A high importance of the wood processing and/or paper & pulp manufacturing sectors in the economies is natural, given that all Nordic and Baltic countries (except for Denmark) are rich in forests (but Denmark also has a smaller wood processing and pulp & paper manufacturing industry). Basic metals processing is important for mountainous countries with ore deposits, such as Finland, Sweden and Norway. Chemical industry plays an important role in all countries: it is not directly dependent on minerals as several components can be artificially manufactured.

Today the four electricity intensive industries have an important role in the economies of all the 7 focus countries. Production value, wages paid, employment and also exports from the four electricity-intensive industries make up 20–40% of the 7 focus countries' manufacturing sectors' total equivalents. The fact that electricity costs make up a noteworthy share in such industries' total costs means that any change in electricity prices will much more dramatically influence total cost levels of these manufacturing firms. Given that prices of such industries' end-products are set by open markets, higher costs mean lower profits and this accordingly means a lower contribution to welfare creation, as per argumentation above.

A country's policy-making should ensure efficient use of all resources, which is most probable if markets are liberalised. Thus liberalisation of electricity markets has made sense for the Northern/Northeastern European countries – which are small both by physical parameters as well as domestic market size – by interconnecting their electricity grids and trading electricity with each other. All seven countries are members of NordPool and engage in cross-border electricity trade on a daily basis. Given ever closer integration of the countries' economies, uncoordinated activities would likely be suboptimal – hence the need to cooperate regionally. Inter-connected electricity grids allow for pooling of all generated electricity and thus lead to more stable prices, as countries are no longer dependent on technology-specific temporary price hikes (e.g. no wind, depleted hydropower reservoirs due to dry season etc).

In such a setup – where (nearly) all electricity is traded through the same interface (the NordPool power exchange) and countries are well inter-connected – research proposition #1 argued that the supply prices are likely to converge. Empirical evidence supports this: whereas some area differences remain due to constraints in inter-connector capacities, market liberalisation levels the playing field between all actors (including foreign-based firms) and the most efficient firms win at the expense of least efficient / more costly ones.

Empirical evidence proves that with grid-interconnectors, countries which have experienced very low electricity prices due to abundantly available low-cost generation sources have seen their price levels increase towards neighbouring countries' higher price levels, whereas the latter have experienced price reduction. For example, price levels of Finland and Estonia converged after Estonia fully liberated its market and increased inter-connector capacity. Even though Estonian consumers experienced supply price increase as a result of market liberalisation, price-setting is now fully transparent and regulated by market demand. Estonia's electricity generation is to a large degree based on burning of (locally available but not globally traded) oil-shale; prior to market liberalisation the electricity supply price was set artificially by the regulator. From the point-of-view of the country's welfare burning of oil shale for electricity generation now has a reference – market price of electricity, which is higher than the previously regulated price – meaning that use of the mineral has become more valuable. As the state collects revenues from oil shale mining and most of oil shale burning is overseen by the state-owned utility, the country's government collects more revenues from this process than it used to. This ultimately benefits the nation and thus contributes to greater welfare. In another example, electricity supply cost levels of Finland and Sweden did not change significantly after Finland moved from being a net exporter of electricity to being a net importer of electricity (for several past years, Finland has been importing significant volumes of electricity from Sweden, a net exporting country). Fully liberalised markets with good inter-connectivity helped to ensure that Finnish consumers saw no price difference even after domestic electricity supply levels decreased.

The Danish-Norwegian symbiosis visualises how market liberalisation and greater inter-connectivity has brought about better utilisation of capacity: Denmark, which has a windy Western coastline, has installed more wind power capacity than it needs, and Norway, which has mountainous terrain with glaciers, has installed more hydropower capacity than it needs. Both countries can afford to do so because of good inter-connectivity and well-functioning markets. At times of high wind Denmark can export its surplus electricity to Norway, which can avoid operating hydropower plants with reservoirs (provided there is no need to spill water); and at times of low wind Denmark can import (lower-priced) electricity from hydropowered plants in Norway.

Importance of good inter-connectivity to neighbouring countries is also evident in the Baltics. Whereas Estonia is the only Baltic country with net surplus electricity generation, Latvia and Lithuania have equally electricity-intensive industries as Estonia. Both countries rely on good interconnectivity for imports from neighbouring countries, which is in many cases less costly than generating the deficit electricity locally.

Theoretical argumentation suggests that market liberalisation weakens applicability of the factor abundance theory: as markets are liberalised, costs converge and the relative competitive advantage weakens. As per research proposition #2, this is not the case with electricity: in liberalised electricity markets total electricity costs are eventually determined by the governments who set the level of taxes, so that the total cost of electricity and thus the relative competitive advantage still remains different across countries.

As greater interconnectivity converges electricity supply prices and increases their predictability, it also makes it easier for governments to calculate how different tax levels affect different industries. Optimal taxation of electricity is important for finding a balance between supporting a competitive business environment for electricity-intensive industries yet not nurturing them from market risks. Norway, Sweden and Finland (all of which have historically had ample low-cost electricity supply) have relatively large pulp & paper manufacturing, chemicals manufacturing and basic metals processing industries (i.e. the most electricity-consuming industries), supported by a more favourable taxation of electricity use compared to less electricity-intensive industries. All Nordic market participants (even in Denmark, which has one of the least energy-intensive economies among the OECD countries) pay differentiated taxes depending on their electricity consumption needs and importance in the national economies. As Nordic electricity markets were liberalised earlier, the governments have had more time to fine-tune an appropriate level of add-on costs. In the Baltic countries electricity markets were liberalised only recently and governments' full trust in market mechanisms has resulted in no additional focus on the electricity-intensive industry. Accordingly the Baltic countries – which also host several electricity-intensive industries – do not offer any preferential taxation mechanisms to the larger consumers. This means that the Baltic governments do not seem to prioritise development of electricity intensive industries the way Nordic governments do.

It is tempting to argue that if one trusts in markets, then all prices will self-adjust. Accordingly, governments should not exercise preferential treatment of certain industries, especially since there are no commonly accepted rules for electricity intensity and a fair discount to the tax rate. Thus one might argue that any preferential treatment in taxation leads to lower taxes and ultimately to lower welfare creation; and potentially distorts market power. Yet there is also supporting argumentation for the opposite view. According to the factor abundance theory countries with ample resources (e.g. low-cost electricity supply) should engage in manufacturing of products that use such resources (e.g. electricity-intensive products), so as to leverage the country's relative competitive advantage best, and capture international markets. Based on this, one could counter-argue that if such conditions exist and such industries have historically developed then the aim of governments should be to keep the total price of electricity lower, which would allow for the country's electricity intensive industries to have a relative cost advantage and export electricity-intensive products abroad. Thus, if the state chooses to charge all actors the same taxes it will collect higher tax revenues from electricity consumption in the short run, but it will likely lose potentially higher tax revenues in the long run, as growth opportunities of the electricity-intensive industries may remain limited.

The total price of electricity has increased in the observation period 2008–2013 in all 7 countries, but the extent of increase differs between the Nordics and the Baltics. In the Nordic countries, total price increase – both in absolute and relative terms – has been lower than in the Baltics. This can primarily be explained by the fact that there have been almost no changes in price of supply, so total electricity price increase in the Nordics is driven by increase in grid fees and electricity taxes; with the more electricity-intensive industries eligible for a preferential tax treatment. At the same time, in the Baltics all three electricity price components have increased – at higher rates than in the Nordics, and with no special attention to the more electricity-intensive consumers. Hence empirical evidence proves validity of research proposition #2, and consequently (cost-based) competitiveness of electricity-intensive industries in the Baltic countries has worsened vis-à-vis their Nordic counterparts.

In liberalised electricity markets governments need to be wary of decision-making in other countries. This is especially relevant in taxation: countries might change their tax regime as a result of changes in taxation regulation in their neighbouring country. International coordination – or at least being aware of steps taken abroad – is also relevant in overall economic policy-making, as government decisions need to be made with long-term focus. Not least, decision-making and activities of supranational organisations (such as the EU) should be kept in mind – cf. the EU's 20–20–20 targets that commit governments to enforce energy efficiency and install more renewable energy – and thereby indirectly influence the add-on costs to electricity supply price.

Keeping costs low is not the governments' only possibility for enhancing competitiveness. As per Michael Porter (1990), companies should also be encouraged to compete on know-how rather than lowest price. Thus, companies within electricity-intensive industries should use their (location-specific) cost advantages to develop into internationally successful actors that can later base their competitive offering also on historically accumulated know-how and innovation. Porter (2008) refers to this as movement from cost-based competition to innovation-based competition. Indeed within several electricity-intensive industries in the Nordics a favourable business environment has enabled continuous research and development, thus the companies are today able to offer high-quality products even if lower-priced competitors have appeared from other countries (e.g. outside the EU). Such is the case in e.g. the Swedish and Finnish paper and pulp industry; which specialise in high-quality paper products. In Norway some electricity-intensive manufacturers from the metal processing industry have altogether moved up in the value chain to developing high-tech products for the defence industry.

As per research proposition #3, market participants should boost their competitiveness by improving efficiency so as not to be fully reliant on beneficial costs (and cost-based competitiveness). As increased energy efficiency is also one of the European Union's binding 20–20–20 targets, energy efficiency targets are on the agenda of all seven country governments. Denmark has for years intentionally pursued a low-energy-intensity programme, with its most electricity-intensive industries consuming same amount of kWh per 1 EUR value added as the least electricity-intensive industries in other Nordic neighbours. As Danish firms consume less kWh, they are also less vulnerable to changes in total price of electricity. It has been shown that the price of electricity in the Baltics is now approaching Danish levels, whereas the Baltic countries need to consume (and pay for) more kWh to produce the same level of output. This is a clear disadvantage to the Baltic industrialists vis-à-vis their Danish competitors.

It has been shown that electricity prices have changed least for electricity-intensive users in Finland and Sweden. This has acted as a competitive advantage in these two countries. However, small price increases seem to have also discouraged efficiency gains in these industries: the two countries have least (or no) growth in value added per kWh for several of their industries. As an opposite example, higher electricity prices for wood producers in all the seven countries coincide with increased value added per kWh, which supports research proposition #3.

Efficiency gains will not offset electricity price increase for all industries in all countries. Especially in basic metals processing, value added per kWh is one of the lowest in both relative and absolute terms – owing to the nature of the production process. Consequently, only limited gains are possible – if any – and in almost all seven countries the industry seems to have lost competitiveness due to increasing electricity prices. Too high costs lower the firms' profit margin, and will hence ultimately also lead to lower wealth creation. If production is significantly less costly abroad, electricity-intensive industries will experience loss of domestic market shares due to growing imports. This will also contribute negatively towards wealth creation. Thus – while efficiency gains are important, electricity pricing through appropriate tax-levels still plays a vital role in liberalised electricity markets too.

Manufacture of desirable products paves the way for increased exports so that firms are no longer restricted to competition in domestic market, and profits associated with exports can be higher than revenues earned at home. Increased exports will allow for economies of scale; as unit costs will decrease and profitability will increase, electricity costs as such (as a share of total costs) will become less significant – as captured in research proposition #4.

Empirical evidence proves that all electricity-intensive industries in the seven sample countries are export-oriented. In both preliminary descriptive analysis as well as econometric tests, there is mixed evidence about export performance in a situation where electricity prices have increased in all industries (albeit at different levels of increase). On the one hand, this means that research proposition #4 is partially supported, since some of the electricity price increase is likely to have been absorbed by increasing economies of scale from increased exports in several industries in several countries. On the other hand, export performance depends on a much broader set of political instruments and variables; and its relationship to electricity prices cannot be captured as straightforwardly.

CONCLUSIONS

This dissertation set out to assess the role of electricity price in competitiveness of the manufacturing industry in liberalised electricity markets. In order to reach the aim of the dissertation a number of research tasks were set up. The first research task ordered discussion of differences for electricity price setting in regulated markets and liberalised electricity markets. In chapter 1.1 it was shown that components of electricity price – as seen from the perspective of the electricity consumer – are the same in both regulated and liberalised markets. Namely, electricity price can be split into price of supply, price of electricity transport (grid fees) and a product of taxes and subsidies. It was shown that in regulated markets, especially the first two components are less transparent, since they are determined based on «best guess» by the regulators that try to find an optimal fit for producers' real costs and reasonable profit. Accordingly, prices are more exposed to political influence and governments have a tighter grip over all components of electricity pricing. In economies with low electricity generation costs this has historically encouraged development of energy-intensive industries, cf. factor abundance theorem. In liberalised markets electricity supply prices are determined based on available supply and demand. Grid fees remain regulated, dependent on re-investment needs and operating costs. Thus taxation of electricity use becomes the main lever for government policy-making. In a situation where governments can no longer dictate who pays how much for electricity supply, several countries have chosen to exercise differentiating electricity taxation as means of influencing total price of electricity for different consumer groups, e.g. the electricity intensive industries. Thus, also in liberalised electricity markets governments have the opportunity to preserve and foster historically developed electricity-intensive industries – provided that they remain important constituents of the economy and produce desirable output, e.g. high-quality paper, valuable chemicals, high-end-loghouses etc.

On a parallel track, the second research task in this dissertation set out to clarify how firms, industries and countries achieve and maintain competitiveness, and how to measure it. In chapter 1.2 it was shown how the theory of competitiveness has evolved over time, from earliest Mercantilist trade theories to a separate field of research that covers a wide span from firm to industry to country level. It was also shown that there is in fact no commonly agreed definition for competitiveness – it is context-dependent. Consequently, it was defined that in this dissertation, competitiveness is a means of fostering development of firms and industries that can sustainably compete internationally and thereby create welfare to the society over long-term. This definition is based on presentation of prior research on firm, industry and country level competitiveness, concluding that country competitiveness depends on competitiveness of the firms active within that country, and this shapes success in industries. However, through regulation of markets and competition, ultimately countries set the business environment which firms then need to use as a catalyst to develop and thrive. Several ways to measure competitiveness were presented, concluding that both qualitative as well as quantitative measures are applicable. In the context of this dissertation – i.e. focus on electricity prices – quantitative measures were deemed as better; and several single-variable measures as well as composite measures and ratios were pinpointed, many of them explicitly in the context of electricity use. Based on prior research, it was concluded that value added, production value and exports serve as suitable indicators of firm and industry-level competitiveness; in this dissertation they are measured per kWh electricity consumed or relative to total electricity expenditure.

The third research task in this dissertation necessitated development of a study framework on how electricity pricing affects competitiveness of industries in countries with liberalised electricity markets. By building on this dissertation's definition of competitiveness, in chapter 1.3 it was shown how firms as electricity users and governments as managers of the entire electricity market work together towards greater value creation by complimenting each other. Firm-level success is dependent on several country-specific factors as well as how well governments manage these (e.g. availability and affordability of electricity, considering path-dependency of historical industries in a given country); yet ultimately firms themselves also need to be efficient and innovative to maximise productivity, boost revenues and contribute to welfare of societies. In the process of developing and visualising a suggested study framework (ref. Figure 10), four research propositions were set up to verify the proposed context and structure: (1) that inter-connectivity of neighbouring electricity markets converges electricity supply price; (2) that even with market-driven supply prices, governments can still differentiate total electricity price by managing taxes; (3) that ultimately no firm is shielded from cost increase, so firms themselves need to become more efficient; and (4) that in countries with small domestic markets, development of attractive products that can be exported abroad increases economies of scale and thereby helps absorb some (electricity) cost increases.

The fourth research task in this dissertation set out to identify electricity-intensive industries in the NordPool region. In chapter 2.2 it was shown that whereas there is no commonly agreed classification for electricity intensity, it can be measured in several ways. Specifically, it was shown that electricity-intensity of industries can be determined by analysing electricity cost share in total purchased goods and services, or electricity use per value added, or electricity use per production value. Accordingly, based on these measures a list of electricity-intensive industries was derived, concluding that within the 7 NordPool member countries four electricity-intensive industries exist. These are wood processors (NACE rev.2 #16), pulp and paper manufacturers (NACE rev.2 #17), chemical manufacturers (NACE rev.2 #20) and basic metals processors (NACE rev.2 #24).

The fifth research task in this dissertation entailed providing an overview of electricity pricing and historical price developments in the 7 NordPool member countries. In chapter 3.1 it was shown that NordPool comprises of a heterogeneous set of countries. Size of the economy and population, geography, geology, natural resources and historical political-economic developments have played a substantial role in shaping electricity supply and demand levels in the seven focus countries. It was shown that due to historical reasons all countries – except for Denmark – have large electricity-intensive industries, with Finland, Norway and Sweden more electricity-intensive than the Baltics. Composition of total electricity price for different consumer groups (referring to their electricity-intensity) was broken down to show inter-country differences within the three components (supply, grid fees and taxes); and historical changes in electricity supply price were shown, with reference to building interconnectors and liberalising electricity markets. Electricity supply price convergence in neighbouring countries was identified, offering strong support for research proposition #1. Research proposition #2 was also supported by showing how the three Nordic governments (and in fact also the Danish government) allow for differentiated electricity pricing – through differentiated taxation – for their electricity-intensive industries, whereas the Baltic governments do not. It was shown that total price of electricity has risen sharply in the Baltic countries, vis-à-vis moderate increase in the Nordics. Whereas there are several reasons for the Baltic price increase, in summary this means that the Baltic electricity-intensive industries have lost competitiveness vis-à-vis their Nordic competitors.

The sixth research task in this dissertation aimed at verifying the proposed study framework with empirical data. In chapter 3.2 a series of preliminary descriptive analyses and econometric regressions were conducted, showing how changes in electricity price, electricity expenditure and electricity cost share have impacted value added and exports (as means of measuring changes in competitiveness[66]) from the electricity-intensive industries. It was concluded that increasing electricity expenditure and growing electricity cost share have negatively impacted competitiveness of the 7 countries' electricity-intensive industries, whereas increasing electricity prices to a degree have stimulated efficiency measures and thereby eased reliance on low costs. Thus, research proposition #3 was supported. Empirical data for impact from exports was less conclusive, leading to partial support for research proposition #4.

The last research task in this dissertation aimed at providing general recommendations for economic policy-making towards electricity-intensive

[66] Earlier, it was concluded that production value should also be used to measure competitiveness. However, through empirical analysis it emerged that changes in production value closely correlate with changes in value added, hence production value was dropped from further analysis.

industries. As acknowledged in the introductory chapter, one of the attributes of the NordPool regional power exchange is that it comprises of different countries with different profiles. In this dissertation, it emerged that from the point-of-view of electricity-intensity of their economies, the seven NordPool countries can be grouped into three: (i) the electricity-efficient Denmark; (ii) the three very electricity-intensive Nordic countries Finland, Norway and Sweden; and (iii) the three Baltic countries Estonia, Latvia and Lithuania with intermediate-to-high levels of electricity-intensity. Changes to composition of economies take time; path-dependency helps explain why historical roles of industries in these countries have not been changing significantly over the 6 years that are under observation in this dissertation. It is likely that intra-industry composition has changed somewhat during the observation period, however absence of firm-level data has not allowed to observe such changes[67]. Yet to a large degree changes are still consistently visible across the three country groups. In this light, it is not possible to define the «right way forward» that would be applicable for all seven focus countries, rather one should draw conclusions from the development of the three country groups.

It makes sense to group Denmark separately because it is radically different from the other six countries in several ways. The country has few minerals; ample farmland across the flat terrain also replaces much of forest that is found more abundantly in the other six countries. Accordingly, Denmark does not have the same prerequisites for development of electricity-intensive industries. Its close historical ties to neighbouring Norway and Sweden – both of which have plentiful low-cost electricity generation from hydropower and/or nuclear power – have also discouraged the country from developing large electricity generation capacity (although this has now changed, with installation of intermittently available wind power capacity that can be used to trade electricity with neighbours, rather than just buy).

Given these circumstances, it is not surprising that the Danish economy is much less electricity intensive; and it would be unfair to use Denmark as a benchmark to the other Nordic and Baltic countries. However, Denmark is a good role model for the pursuit of energy efficiency. Policy-making by the Danish government – e.g. heavy taxation of CO_2 emissions in almost all sectors, from manufacturing to transport to electricity generation – has boosted eco-innovation[68]

[67] It is likely that such changes might somewhat explain lack of unity in changes in industries across different countries (e.g. in the chemical manufacturing industry, which includes a large variety of firms manufacturing different types of products using different types of production technologies).

[68] As one example, Denmark has long been pioneering development of wind turbines and is today one of global R&D centres for wind energy research.

and helped the country to become one of the most energy-efficient countries in OECD, while also being among those with highest welfare.

It has been shown in this dissertation that very electricity-intensive industries need to consume more kWh per value added owing to the nature of their business and production processes. Sunk costs, e.g. investments into machinery, may also limit efficiency improvements. Whereas no firm should be shielded from international competition nor receive unfair competitive advantages from governments, empirical evidence from the three electricity-intensive Nordic countries shows that differentiating taxation levels for electricity consumption might be justified as means of creating, sustaining and/or boosting competitiveness of such industries in these countries[69]. It is noteworthy that the differentiating taxation levels only apply to electricity consumption and not other business activities, e.g. employment, cost of capital etc. It has been shown that these countries' electricity-intensive industries have historically played an important role in the three countries' economies and have a favourable business outlook for this to continue, as the industries have become more efficient, are innovative and deliver high quality products.

Equally important is the fact that electricity prices in the Nordics have remained relatively stable across several years – no significant increase or decrease is visible in historical development of prices of electricity supply; add-on taxes have grown modestly. Stability of business environment is an obvious catalyst to firm and industry-level developments; and this applies equally to predictability of the price of electricity.

The Baltic countries have embraced market liberalism ever since regaining their independence in 1991. When the electricity markets opened about 5 years ago – after improved interconnectivity – the Baltic governments seem to have applied the same degree of market liberalism to it, i.e. have effectively left it to free market forces to ascertain the dividing lines among market participants. Consequently, electricity market liberalisation has led to the increase of the previously undervalued electricity supply price in Estonia. In Lithuania – and to a certain degree in Latvia – the Lithuanian government's long-term inability to decide on the way forward after de-commissioning of the Baltic countries' only (Lithuanian-government-owned) Soviet-era nuclear power plant has had a significant role in sharply increasing electricity supply prices. Accordingly,

[69] It is to be reminded that this dissertation has intentionally not investigated government policies' compliance with international competition best practices, EU and WTO rules etc. Legitimacy of differentiating electricity taxation is evidenced by the fact that the European Commission – nor other international bodies – have to the author's knowledge not ruled this as unfair; nor have the Nordic governments received wide international criticism about unfavourable treatment of their electricity-intensive industries. Furthermore, the three Nordic countries have applied differentiating electricity taxation for years.

Lithuania and Latvia are now dependent on imported electricity from Russia, Belarus, Estonia – and more recently, also from Sweden and Poland[70]. The Baltic governments have also kept raising electricity taxes and grid fees, year-on-year. This too is partly a result of short-sighted government policies in the past: after years of underinvestment in the (government-owned) electricity grids, several re-investments are overdue and necessitate increased grid fees to fund this; compliance with EU-rules to increase share of renewable electricity generation has led to increased electricity taxes for funding installation of such generation capacity.

Empirical results prove that despite rapid electricity price increases and almost lacking support from the Baltic governments, the countries' electricity-intensive industries have done well over the 6 years under observation: both value added and exports have generally increased (in absolute terms). This can partly be explained by the fact that the Baltic electricity-intensive industries are less electricity-intensive than their Nordic competitors, thus electricity plays a smaller role in total costs. Labour costs – an important element for cost-based competitiveness in nearly all manufacturing industries – remain significantly lower in the Baltics, despite a rapid increase in absolute terms. And, partly due to regulatory requirements (cf. the EU's 20–20–20 goals) as well as increasing prices and increasing competition in international markets, efficiency improvements have been made, which all have helped to decrease the negative impact of rising electricity expenditure.

Yet it is clear that compared to their Nordic neighbours the Baltic countries are still new to liberalised electricity markets, and more time is needed to find an optimal balance between market forces and fair government activity. Baltic governments are yet to learn that electricity supply price convergence does not lead to convergence of competitiveness in use of electricity. An indifferent policy towards all electricity consumers may appear as free and fair, yet fails to consider industry specifics and may in the long run hurt performance of several key industries in a country.

It remains to be seen whether the Baltic electricity-intensive industries can maintain and further increase their competitiveness through added improvements in efficiency and without differentiating support from their governments. Nordic experience suggests that any changes in government energy policies have to be gradual and allow for lead time.

[70] Reference is made to chapter 3.1.1 – Latvia and Lithuania can produce electricity from gas, but gas also needs to be imported, thus importing of electricity might be preferred instead.

LIMITATIONS AND FUTURE RESEARCH

As was mentioned earlier, a large variety of research exists on both competitiveness and electricity costs, given the popularity and depth of the two topics. Whereas the latter is relatively straightforward, especially research boundaries for the former are much harder to draw. Already in the introductory chapter it was acknowledged that activities of other firms intra-industry have an impact on firm and industry performance, but these impacts are not considered in this dissertation. Firm-level data – such as used in Davis et al (2008) for the U.S. manufacturing industries – would allow to measure true impact from electricity prices to firm-level competitiveness and performance, and filter reasons for the more successful firms within the same industry. Whereas e.g. the Amadeus database collects and stores ample firm-level-data for nearly all businesses across the European Union, use of electricity and payments for electricity are not reported. If such data – across industries and across countries – becomes available, it sets the basis for a more detailed future research on the same topic.

The dissertation has observed changes in performance of the manufacturing industry in connection with changes in total payments for electricity, ceteris paribus. It is acknowledged that especially international trade and wealth creation is impacted by several other factors which arise from interaction of the industries with other industries and other sectors – services, agriculture, forestry, fishing, mining, as well as consumer and government activities. This helps explain the ambiguous results for research proposition #4 that attempted to measure the link between exports and electricity prices. Such holistic effects are attempted to be modelled in the GEM-E3 model developed jointly by the European Commission's Joint Research Centre. For purpose of future research, it is worthwhile to investigate how the GEM-E3 modelling could be better tied to changes in electricity prices and components thereof.

Already in the introductory chapter it was made clear that this dissertation is not discussing appropriate legal solutions for governments to assist firms and/or industries in becoming and staying competitive – e.g. principles of state aid, compliance with EU directives, WTO rules, etc. Whereas this dissertation has pointed out how the 7 countries apply different electricity taxes to different industries, future research might include a pan-European study of «best practices» from 28+ countries.

Petroleum refining (NACE #19) holds significant importance (turnover, exports, employment, taxes paid, electricity consumed) in several of the 7 NordPool member countries, but most of associated data is listed as classified in Eurostat – hence the sector has been excluded from analysis. It is generally accepted that the sector suffers in several countries from energy inefficiency and therefore has great potential for lower consumption. This should be studied by researchers with greater access to data from this specific industry. Likewise, little data is available for tobacco processing (NACE #12) in the 7 NordPool member countries, although presumably for a different reason: namely, there are very few manufacturers of tobacco products in these countries.

Although all data is sourced from Eurostat for maximum comparability, there is no immediate overlap between data values from different Eurostat tables. Whereas Eurostat sends out the same questionnaires to all European countries, there seems to be no immediate quality assurance on how each country interprets the questionnaire. Consequently there might be differences in some values (e.g. energy costs in each industry) reported to Eurostat and those reported in the countries' own statistical office's websites. For some branches some participating countries have chosen not to disclose any data, as is the case in most countries' petroleum refining sector (ref. paragraph above), but also e.g. purchased energy in Latvian and Lithuanian food processing sector or number of employees in the Swedish pharmaceutical industry. The author has mitigated this problem by cross-checking values across different data tables, and using averages or datasets that relate most. National statistics databases of all seven countries have also been studied and in some cases (e.g. for Norway) data missing from Eurostat has been substituted with data from local statistical bureaus. However, the data collected by national statistical bureaus – and the level of detail – vary greatly. In recent years Eurostat has started to collect more information on industry level for both energy/electricity and international trade. Once time-series become longer, it will ultimately be possible to better study the relationships between different variables – such as electricity prices and value added – and also develop predictive econometric models for future estimates of industry performance.

It is argued that the total cost of electricity includes total cost of supply (to be determined by the market), grid costs and all applicable taxes – however in empirical analysis VAT is excluded from total costs on the grounds that it is recoverable. It is acknowledged that such a limitation holds on general level, whereas VAT is not to be added to cross-border sales and thus cannot be deducted if a given firm is not VAT-liable. This might be the case for some companies that export nearly all production and invoice VAT-free, but pay VAT for utilities (electricity, water etc) procured in their host countries. It is assumed that very few such companies exist; and given that data is available on industry not firm level inclusion of VAT in total electricity costs would likely be suboptimal. However, future research might revisit this topic if firm-level data becomes available.

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APPENDICES

Appendix 1. List of manufacturing industries by NACE rev.2 categorisation

NACE rev.2 category	Description
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment

Appendix 2. Price elasticity of electricity demand

Comparison of changes in total cost of electricity (unweighted average total cost across all industrial consumer segments excluding recoverable taxes and VAT) and final electricity consumption (excluding consumption in the energy sector) in 2007–2012. Author's calculations based on Eurostat tables «nrg_105a» and «nrg_pc_205».

∆ Electricity cost	**2007–2008**	**2008–2009**	**2009–2010**	**2010–2011**	**2011–2012**
Denmark	0.14	0.11	0.04	0.00	0.05
Estonia	0.15	0.09	0.19	< 0.00 [a]	0.09
Latvia	0.20	0.11	0.03	0.19	< 0.00 [a]
Lithuania	0.15	0.04	0.30	0.06	0.05
Finland	0.17	< 0.00 [a]	0.03	0.09	0.01
Sweden	0.19	0.10	0.24	0.04	0.02
Norway	0.16	0.09	0.20	0.03	0.07
∆ Electricity consumption	**2007–2008**	**2008–2009**	**2009–2010**	**2010–2011**	**2011–2012**
Denmark	0.01	0.05	0.03	0.01	0.02
Estonia	0.03	0.05	0.04	0.04	0.05
Latvia	0.00	0.08	0.02	0.00	0.11
Lithuania	0.02	0.07	0.00	0.03	0.04
Finland	0.04	0.07	0.08	0.04	0.01
Sweden	0.02	0.04	0.06	0.05	0.02
Norway	0.01	0.04	0.06	0.05	0.01
Price elasticity of demand	**2007–2008**	**2008–2009**	**2009–2010**	**2010–2011**	**2011–2012**
Denmark	0.07	0.47	0.66	3.73	0.33
Estonia	0.21	0.59	0.20	29.45 [a]	0.56
Latvia	0.02	0.70	0.68	0.02	38.32 [a]
Lithuania	0.14	1.85	0.02	0.46	0.86
Finland	0.25	18.96 [a]	2.37	0.47	0.82
Sweden	0.10	0.42	0.26	1.19	1.09
Norway	0.08	0.49	0.29	1.55	0.19

[a] Abnormally high price elasticity in Finland in 2008–2009, Estonia in 2010–2011 and Latvia in 2011–2012 can be explained by less than 1% change in electricity cost and relatively much higher change in consumption in the same periods.

Appendix 3. Comparison of production value per kWh vs value added per kWh

Total value added and total production value from various manufacturing industries, divided by total consumption of electricity in these industries in 2008–2013. Author's calculations based on Eurostat tables «sbs_na_ind_r2» and «nrg_105a».

Denmark: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.79	1.86	1.87	1.74	1.81	1.85
Textiles & leather	2.52	2.33	2.13	2.19	1.97	2.10
Wood processing	2.63	2.31	2.28	2.09	2.16	2.19
Paper & pulp	1.79	1.85	1.72	1.73	2.45	2.49
Chemical & pharmaceutical	3.24	3.40	4.01	4.07	4.39	4.67
Non-metallic minerals	3.50	3.48	3.43	3.62	3.33	3.54
Basic metals	1.02	0.96	1.21	1.08	0.74	0.75
Machinery	6.49	5.74	5.79	6.37	6.63	7.02
Transport equipment	2.75	1.79	2.45	3.53	4.63	4.54

Denmark: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	8.2	7.9	7.9	8.2	9.0	9.8
Textiles & leather	8.2	7.5	7.0	7.4	6.4	7.3
Wood processing	7.5	6.9	6.6	6.2	6.5	6.2
Paper & pulp	4.9	5.0	4.8	4.9	7.1	7.2
Chemical & pharmaceutical	7.9	8.2	9.3	9.5	9.7	10.4
Non-metallic minerals	8.5	8.1	8.1	9.9	8.4	8.8
Basic metals	3.9	4.1	4.5	4.6	2.9	2.9
Machinery	19.4	17.6	16.3	19.0	20.5	19.6
Transport equipment	9.9	8.1	8.1	10.2	16.0	13.7

Finland: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.83	1.26	1.42	1.42	1.56	1.51
Textiles & leather	2.99	1.72	2.83	2.23	1.40	2.05
Wood processing	0.75	0.54	0.74	0.67	0.73	0.76
Paper & pulp	0.15	0.13	0.18	0.17	0.17	0.17
Chemical & pharmaceutical	0.46	0.48	0.51	0.50	0.53	0.52
Non-metallic minerals	2.42	2.45	1.17	2.46	2.65	2.41
Basic metals	0.39	0.16	0.29	0.25	0.19	0.20
Machinery	5.89	3.98	4.22	4.05	3.74	3.97
Transport equipment	2.75	2.23	1.68	2.69	2.92	2.96

Finland: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	7.9	5.0	5.6	6.0	6.7	6.5
Textiles & leather	7.8	4.7	7.7	5.5	4.0	5.8
Wood processing	3.7	2.9	3.5	3.3	3.7	3.7
Paper & pulp	0.7	0.7	0.7	0.8	0.8	0.8
Chemical & pharmaceutical	1.5	1.5	1.4	1.4	1.4	1.4
Non-metallic minerals	7.0	7.1	3.7	7.7	8.2	7.6
Basic metals	1.8	1.2	1.6	1.7	1.5	1.3
Machinery	20.5	15.7	15.3	17.0	17.8	15.9
Transport equipment	10.7	9.0	6.3	9.2	10.6	11.3

Norway: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.14	1.37	1.38	1.65	1.84	1.78
Textiles & leather	2.31	2.83	3.75	4.05	3.76	3.94
Wood processing	1.25	1.34	1.21	1.49	1.55	1.53
Paper & pulp	0.17	0.15	0.17	0.14	0.21	0.21
Chemical & pharmaceutical	0.32	0.27	0.27	0.29	0.28	0.30
Non-metallic minerals	0.44	1.79	1.57	1.85	1.95	1.83
Basic metals	0.07	0.07	0.07	0.07	0.07	0.05
Machinery	4.66	5.22	4.40	6.41	6.63	6.13
Transport equipment	4.23	4.59	4.69	5.99	6.35	6.21

Norway: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	5.3	6.3	6.0	7.5	8.4	8.1
Textiles & leather	6.4	7.5	9.8	10.8	9.9	9.9
Wood processing	4.1	4.3	4.0	4.9	5.0	4.9
Paper & pulp	0.6	0.6	0.6	0.7	0.6	0.6
Chemical & pharmaceutical	1.0	0.9	1.0	1.1	1.1	1.0
Non-metallic minerals	1.4	5.2	4.7	5.8	6.1	5.7
Basic metals	0.3	0.4	0.3	0.4	0.3	0.3
Machinery	14.5	16.1	12.9	17.4	18.6	18.5
Transport equipment	16.8	17.8	14.6	19.7	22.6	22.2

Sweden: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.34	1.34	1.45	1.58	1.58	1.74
Textiles & leather	1.63	1.96	2.18	2.73	2.83	3.01
Wood processing	0.87	0.79	0.92	0.92	0.92	1.01
Paper & pulp	0.18	0.17	0.18	0.20	0.19	0.20
Chemical & pharmaceutical	1.17	1.50	1.45	1.56	1.59	1.45
Non-metallic minerals	2.22	2.19	2.52	3.06	3.21	3.28
Basic metals	0.35	0.24	0.52	0.33	0.34	0.33
Machinery	12.29	6.40	4.25	3.88	5.16	5.61
Transport equipment	2.92	1.95	3.30	3.40	3.30	3.19

Sweden: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	5.9	5.5	5.7	6.4	6.9	7.2
Textiles & leather	4.7	5.7	6.0	7.7	8.0	8.6
Wood processing	4.0	3.5	4.0	4.6	4.7	4.7
Paper & pulp	0.7	0.6	0.7	0.8	0.7	0.8
Chemical & pharmaceutical	2.9	3.6	3.4	3.7	3.8	3.6
Non-metallic minerals	6.8	6.8	7.8	9.3	9.6	10.3
Basic metals	2.0	1.7	2.9	2.0	1.9	1.7
Machinery	39.4	21.1	12.8	11.4	15.8	16.2
Transport equipment	15.2	11.0	13.5	15.5	14.1	14.2

Estonia: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	0.96	1.13	0.95	1.03	0.96	1.14
Textiles & leather	1.22	1.05	1.04	1.16	1.28	1.32
Wood processing	0.86	0.91	1.03	1.14	1.09	1.10
Paper & pulp	0.33	0.31	0.32	0.36	0.33	0.34
Chemical & pharmaceutical	0.36	0.20	0.34	0.55	0.36	0.35
Non-metallic minerals	0.89	0.58	0.74	1.00	1.00	1.07
Basic metals	1.19	0.89	0.62	1.06	0.78	N/A
Machinery	2.29	1.77	1.67	2.19	2.24	2.77
Transport equipment	2.07	1.46	2.35	2.50	1.78	1.58

Estonia: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	4.3	4.6	4.3	5.0	4.3	5.4
Textiles & leather	3.2	2.9	2.9	3.2	3.6	3.7
Wood processing	3.7	3.4	4.1	4.6	4.3	4.6
Paper & pulp	1.1	1.1	1.1	1.2	1.1	1.2
Chemical & pharmaceutical	1.4	1.0	1.5	2.7	2.8	2.3
Non-metallic minerals	3.1	2.2	2.6	3.3	3.4	3.7
Basic metals	3.9	2.7	3.0	4.2	4.0	10.2
Machinery	8.5	6.3	7.8	11.8	12.2	13.8
Transport equipment	5.8	4.5	7.4	8.2	5.8	5.0

Latvia: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.22	1.11	1.13	0.98	1.28	1.12
Textiles & leather	1.67	1.43	2.17	2.20	2.65	2.43
Wood processing	0.74	0.48	0.81	0.80	0.75	0.69
Paper & pulp	2.47	1.26	2.12	2.21	2.53	3.16
Chemical & pharmaceutical	0.67	0.66	1.06	0.53	0.50	0.47
Non-metallic minerals	0.84	0.47	0.45	0.59	0.64	0.74
Basic metals	0.57	0.29	0.34	0.33	0.46	N/A
Machinery	2.00	2.12	2.13	2.55	2.93	2.98
Transport equipment	1.26	0.86	1.55	0.88	1.01	1.23

Latvia: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	5.2	5.0	5.0	5.4	6.6	5.5
Textiles & leather	4.2	3.7	5.6	6.4	8.0	7.4
Wood processing	3.1	2.0	2.8	3.3	3.0	2.9
Paper & pulp	7.1	4.6	7.7	8.5	9.5	11.9
Chemical & pharmaceutical	2.6	2.3	2.9	3.0	3.4	2.9
Non-metallic minerals	3.4	2.0	1.9	2.3	2.4	2.6
Basic metals	3.5	2.5	3.1	2.7	3.3	2.2
Machinery	5.7	6.1	6.9	8.3	9.4	9.7
Transport equipment	4.2	3.1	5.3	3.1	3.3	4.3

Lithuania: Value added in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	1.09	1.19	1.02	1.02	1.03	1.00
Textiles & leather	1.64	0.94	1.29	1.71	1.61	1.77
Wood processing	0.71	0.73	0.72	0.91	0.69	0.87
Paper & pulp	1.17	0.80	0.44	0.78	1.11	1.07
Chemical & pharmaceutical	0.40	0.25	0.46	0.49	0.28	0.18
Non-metallic minerals	1.30	1.20	1.07	1.13	1.28	1.22
Basic metals	0.90	0.24	0.47	0.61	0.51	0.73
Machinery	3.13	2.71	2.90	2.96	2.39	2.71
Transport equipment	2.42	1.66	2.39	1.84	2.20	2.94

Lithuania: Production value in EUR per kWh

Manufacturing industry	2008	2009	2010	2011	2012	2013
Food & beverages	5.9	5.1	5.4	5.8	5.9	5.9
Textiles & leather	4.3	2.4	3.5	4.5	4.4	4.9
Wood processing	2.8	2.7	2.9	4.0	3.0	3.5
Paper & pulp	3.7	2.6	1.6	2.8	3.9	3.8
Chemical & pharmaceutical	2.8	2.0	2.5	3.2	2.9	2.7
Non-metallic minerals	5.1	4.7	4.7	5.5	5.5	5.1
Basic metals	4.3	2.3	3.4	4.2	4.0	4.5
Machinery	10.3	8.9	9.5	10.1	7.8	8.5
Transport equipment	8.6	4.8	7.5	8.0	14.9	18.0

SUMMARY IN ESTONIAN – KOKKUVÕTE

Elektrihinna roll tööstusettevõtete konkurentsivõimes liberaliseeritud elektriturgudel – NordPooli kaasus

Töö aktuaalsus

Viimased aastakümned on olnud tunnistajaks massilisele deregulatsioonile ja turgude liberaliseerimisele, mis on hüppeliselt kasvatanud rahvusvahelist kaubandust. See on tõstnud fookusesse uuringud, kuidas soodustavad riigid eri ettevõtete ja tööstusharude kasvu – millised on konkurentsivõime tegurid. Liberaliseerima on hakatud ka elektriturgusid – kui varem oli elekter kohalik hüvis, siis nüüd on seda võimalik transportida kaugete vahemaade taha ja see on muutnud elektri väärtuslikumaks.

Riikides, kus elektri tootmise omahind on ajalooliselt olnud madal, on arenenud ka energiamahukamad tööstusharud. Enamikes tootmisettevõtetes jääb elektri osakaal kogukuludest 2–3% vahele, kuid puidu, paberi- ja tselluloosi, keemia- ning metallitööstuses on see märkimisväärselt kõrgem, ulatudes 10–20%-ni ja teatud juhtudel veel kõrgemalegi.

Reguleeritud elektriturgudel kontrollivad riigid kõiki elektrihinna komponente: tootmishinda, võrgutasusid ning makse. Olukorras, kus elektriturud on liberaliseeritud, ei ole riikidel enam võimalust tootmishinda reguleerida, mis seab fookusesse maksud kui riikide põhilise instrumendi elektri hinnastamisel.

Kuigi nii konkurentsivõimet kui elektrihinda ja –kulutusi on varasemates teadusuuringutes palju käsitletud, on küllaltki vähe uuritud seda, kuidas riikide energiapoliitika mõjutab ettevõtete ja tööstusharude konkurentsivõimet. Autorile teadaolevalt ei ole uuringuid, mis seostaks elektri hinnastamise aspektid otseselt ettevõtete ja tööstusharude konkurentsivõime muutustega.

Töö eesmärk ja uurimisülesanded

Käesolevas töös analüüsitakse, kuidas elektrihinna muutus mõjutab NordPooli seitsme liikmesriigi (Taani, Soome, Norra, Rootsi, Eesti, Läti ja Leedu) töötleva tööstuse konkurentsivõimet. Selleks on esitatud seitse uurimisülesannet:

1. Näidata ära elektri hinnastamise erinevused reguleeritud ja liberaliseeritud elektriturgudel.
2. Arutleda, kuidas ettevõtted, tööstusharud ja riigid saavutavad ja hoiavad konkurentsivõimet – ning kuidas seda mõõta.

3. Läbi konkreetsete uurimisväidete sünteesida raamistik/mudel, mis näitab kuidas elektri hinnastamine mõjutab liberaliseeritud elektriturgudel tööstusharude konkurentsivõimet.
4. Identifitseerida elektri-intensiivsed tööstusharud NordPooli liikmesriikides.
5. Anda ülevaade elektri hinnastamisest ja ajaloolistest hinnamuutustest NordPooli liikmesriikides.
6. Testida töös esitatud uurimisväiteid ja raamistikku/mudelit, kasutades empiirilisi andmeid.
7. Koostada üldised soovitused majandus- ja energiapoliitika elluviimiseks elektrienergiamahukaid tööstusi silmas pidades.

Käesolev töö panustab teaduskirjandusse vähemalt kolmel erineval moel:

1. Töö tähtsaimaks panuseks on raamistiku/mudeli loomine, mis näitab, kuidas liberaliseeritud elektriturgudel elektri hind kujuneb ning kuidas see mõjutab ettevõtete ja tööstusharude konkurentsivõimet.
2. Antud töös analüüsitakse, millised on riikide võimalused reguleeritud ja liberaliseeritud elektriturgudel elektrihinna eri komponentide mõjutamiseks.
3. Töös näidatakse, kuidas võiks mõõta muutuseid elektrienergiamahukate tööstusharude konkurentsivõimes.

Dissertatsioonil on vähemalt neli praktilist väljundit:

1. Töös antakse ülevaade sellest, millised on NordPooli erinevate liikmesriikide eri tööstusharude kulutused elektrile ja kuidas see on ajalooliselt muutunud.
2. Käesolevas töös identifitseeritakse NordPooli liikmesriikide elektrienergiamahukad tööstusharud.
3. Töös antakse ülevaade kõikide NordPooli liikmesriikide eri tarbijagruppide elektrihinna erinevatest komponentidest.
4. Antud töös jälgitakse elektrihinna muutumist ning analüüsitakse, kuidas see on mõjutanud elektrienergiamahuka tööstuse käekäiku kõikides NordPooli liikmesriikides.

Töö ülesehitus

Töö esimese osa esimeses alapeatükis tutvustatakse elektri tarne- ja väärtusahelat ning elektrituru osalisi. Seejärel näidatakse, millised on elektrihinna komponendid ning kuidas elektrihind kujuneb; selgitatakse hinnastamise erinevusi liberaliseeritud ja reguleeritud elektriturgudel.

Käesoleva töö esimese osa teises alapeatükis vaadeldakse konkurentsivõime ajaloolist kujunemist ning lähtuvalt asjaolust, et konkurentsivõimele pole üheselt aktsepteeritud definitsiooni, defineeritakse konkurentsivõime antud töö kontekstis. Peatükis vaadeldakse ka konkurentsivõime saavutamise ja hoidmise meetmeid – nii ettevõtte, tööstusharu kui riigi tasandil – ning analüüsitakse konkurentsivõime mõõtmise võimalusi. Lähtuvalt töö eesmärgist ja fookusest pannakse paika konkreetsed konkurentsivõime mõõdikud.

Esimese osa kolmandas alapeatükis sünteesitakse elektri hinnastamise olulisus konkurentsivõime kontekstis. Analüüsitakse riigi rolli turu reguleerimisel ning koostatakse raamistik/mudel koos uurimisväidetega, et neid töö empiirilises osas kontrollida.

Töö teises osas selgitatakse läbiviidava analüüsi metoodikat ning põhjendatakse, miks ja milliseid andmeid analüüsil kasutatakse. Samuti selgitatakse, miks on töö fookus just töötleval tööstusel ning identifitseeritakse NordPooli riikide elektrienergiamahukad tööstusharud.

Töö kolmanda osa esimeses alapeatükis tutvustatakse esmalt NordPooli riikide elektritootmist ja –tarbimist ning nende riikide majanduste elektrimahukust; seejärel näidatakse elektrimahukate tööstusharude tähtsus iga NordPooli liikmesriigi majanduses. Lõpetuseks vaadeldakse elektrihindade muutumist läbi aja kõigi kolme hinnakomponendi – tootmishind, võrgutasud ja maksud – lõikes. Seejärel selgitatakse, kuidas erinevad riigid on rakendanud elektritarbijate maksustamist ning milliseid erandeid tehakse.

Kolmanda osa teises alapeatükis viiakse esmalt läbi kirjeldav analüüs, kus vaadeldakse elektrienergiamahukate tööstusharude elektrihinna muutumist ning samaaegselt erinevaid konkurentsivõime mõõdikuid. Seejärel viiakse läbi ökonomeetriline analüüs, kasutades elektrihinda või sellega seonduvaid mõõdikuid ning erinevaid konkurentsivõimet kajastavaid muutujaid.

Töö viimases osas diskuteeritakse empiirilise analüüsi tulemuste üle ning tehakse kokkuvõtvaid järeldusi ja soovitusi edasiseks poliitikakujundamiseks.

Teoreetiline taust

Elekter on eriline hüvis, sest selle tootmine ja tarbimine peavad olema samaaegselt pidevas tasakaalus. Ajalooliselt oli elektri tootmine riigi omanduses olevate elektrijaamade pärusmaa, mistõttu reguleerisid riigid kõiki elektri väärtusahela hinnakomponente. Liberaliseeritud elektriturgudel kujuneb elektri tootmishind hetkepakkumise ja nõudluse tulemusena. Nõudlus on suurem päeval ja talvel ning väiksem öösiti ja suvel. Elektritootjad pakuvad müügihinna marginaalkulude järgi, mis on madalam ennekõike erinevates taastuvenergiat kasutavates jaamades, aga ka tuumaenergial genereeritud elektril. Tulenevalt oma tootmistehnoloogiast ei ole sellised jaamad suutelised oma pakkumist kiiresti alandama, mistõttu sisenevad suurema nõudluse juures turule ka kõrgemate marginaalkuludega tootjad, kes kasutavad näiteks kütteõli või maagaasi. Kuivõrd turg on dünaamiline, siis on elektriturul kujunev tootmishind alalises muutuses ja pidevalt kooskõlas nõudlusega.

Elekter kantakse tootjatelt tarbijateni eri pinget kasutavate ülekandevõrkude kaudu. Ülekandevõrkude näol on tegemist loomulike monopolidega, sest paralleelsete võrkude ehitamine on majanduslikult ebaotstarbekas. Sellest tulenevalt on võrgutasud reguleeritud ka liberaliseeritud elektriturgudel – peamiseks erinevuseks on asjaolu, et tihti on just reguleeritud elektriturgudel tootmine ja transport koondatud ühte ettevõttesse ning eri tegevusharude läbipaistvus on väiksem. Liberaliseeritud turgudel määrab turu regulaator võrgutasud, võttes arvesse vajalikud reinvesteeringud ning igapäevased võrgu käitamiskulud. Mida efektiivsemalt võrguoperaatorid töötavad, seda suurem on (reguleeritud) kasum.

Elektri tarbimise maksustamine on liberaliseeritud elektriturgudel riikide ainus otsene väljund lõpliku elektrihinna mõjutamiseks. Üldiselt loob maksustamine täiendava tulubaasi riigieelarvesse, kuid seda kasutatakse ka erinevate turutõrgete reguleerimiseks. Samuti võivad riigid kehtestada eri tarbijagruppidele erinevaid maksumäärasid, neid maksustamisest täielikult vabastada või ka tarbimist otseselt subsideerida.

Konkurentsivõime kui termin tuli akadeemilises kirjanduses kasutusele alles viimase sajandi viimasel veerandil, kuigi seda edasikandvat mõtet – s.o. kuidas riigid saavad luua suuremat heaolu – on kajastatud juba varaseimates kaubandusteooriates. Konkurentsivõimet on käsitletud erinevatel tasanditel, kuid kõik autorid viitavad asjaolule, et konkurentsivõime loomine ja hoidmine on pidevalt jätkuv protsess, milles on oluline roll nii riikidel, kes loovad soodsa keskkonna; kui ka ettevõtetel, kes peavad keskkonda ära kasutades looma väärtuslikke tooteid, mis omakorda väljendub vastavate tööstusharude kasvus. Käesolevas doktoritöös defineeritakse konkurentsivõime kui «ärikeskkond, mis soodustab ettevõtete ja tööstusharude arengut nii, et need saaksid jätkusuutlikult ja edukalt konkureerida rahvusvahelistel turgudel ja seeläbi panustada ühiskonna suurenevasse heaolusse».

Konkurentsivõimet saab mõõta nii kvantitatiivsete kui kvalitatiivsete näidikutega. Akadeemilises kirjanduses viidatakse mitmele populaarsele kvalitatiivsele mõõdikule, kuid antud töö kontekstis on asjakohasem kasutada kvantitatiivseid mõõdikuid. Konkurentsivõimet saab mõõta nii üksikute näitajate baasil – näiteks SKP elaniku kohta – kui ka erinevate suhtarvudena, millest tuntuim on Bela Balassa RCA-indeks. Kirjanduses on defineeritud mitmeid konkurentsivõime näidikuid, mis sobivad kasutamiseks elektritarbimise ja elektrihindade kontekstis. Enamik neist koosneb suhtarvudest, kus üheks osapooleks on lisandväärtus, tootmisväärtus või ka ekspordiväärtus, ning teises osapooleks tarbitud kilovatt-tunnid või kogukulutused elektrile. Antud näidikuid kasutatakse ka käesolevas töös.

Joonisel 11 on toodud käesolevas töös loodud raamistik/mudel, millelt nähtub, kuidas elektrihinna kolm komponenti mõjutavad ettevõtete kulutusi elektrile ning kuidas viimane koos muude kuludega – aga samuti läbi innovatsiooni ja pidevate efektiivsusparenduste – määrab ära ettevõtete võimekuse edukalt konkureerida ja luua lisandväärtust. See omakorda loob eeldused rahvusvaheliselt edukate tööstusharude tekkeks, mis kokkuvõttes viib ühiskonnas jätkusuutliku heaolu kasvuni.

Vastavalt uurimisväitele #1 ühtlustuvad turgude liberaliseerimisel ja riikidevaheliste elektrikaablite ehitamise tagajärjel elektri tootmishinnad, mis suurendab turu läbipaistvust ja tugevdab kõikide osapoolte konkurentsi.

Vastavalt uurimisväitele #2 on elektrihind riigiti sellegipoolest erinev, sest riigid otsustavad tarbijate maksumäärad ning selle, kas ja kuidas need eri tarbijagruppides erinevad.

Vastavalt uurimisväitele #3 peavad ettevõtjad pidevalt püüdlema suurema efektiivsuse poole ja olema innovaatilised, et mitte sõltuda ainult kulueelistest (sh madalast elektrihinnast tulenevast konkurentsieelisest).

Vastavalt uurimisväitele #4 aitavad eksportturud kaasa mastaabisäästu tekkele just väiksemates riikides asuvatel ettevõtjatel – ning seeläbi väheneb elektrikulude osakaal ja samuti ka elektrihinna olulisus.

Uurimismetoodika ja kasutatavad andmed

Käesolevas töös analüüsitakse elektrihinnast tulenevat mõju tööstusharude konkurentsivõimele kahel erineval viisil. Esmalt viiakse läbi kirjeldavad analüüsid, kus võrreldakse eri muutujate omavahelisi seoseid. Seejärel viiakse läbi regressioonanalüüs. Viimane saab olla kas vaatlev või eksperimentaalne/ ennustav. Antud doktoritöös on olemasolevaid aegridasid liiga vähe, et luua ennustav regressioon, mistõttu on otsustatud vaatleva OLS-regressiooni kasuks. Kõik regressioonid on modelleeritud ühel kujul – vt valemit (18) – samas on erinevates regressioonides kasutatud erinevaid muutujaid.

Saadaolevad andmed pärinevad põhiliselt Eurostatist. Avalikuks kasutamiseks mõeldud tabelites ei ole otseselt välja toodud eri riikide eri tööstusharude elektrikulutusi, kuid neid on võimalik erinevaid andmeid kombineerides välja arvutada. Varaseimad andmed, mis on kättesaadavad kõigi 7 NordPooli liikmesriigi 9 töötleva tööstuse kohta, on aastast 2008 ning hiliseimad andmed aastast 2013 – kokku 6 aastat. Seega on töös olnud võimalus analüüsida kuni 378 vaatlust iga muutuja kohta. Tegelik vaatluste arv on olnud mõnevõrra väiksem, sest mõne tööstusharu andmed on mõnel aastal jäänud avaldamata. Mitme riigi statistikaametis on vastavad andmed saadaval ka varasemate perioodide kohta, samas kui mitmes riigis ei avaldatagi elektri tarbimise ja kulutustega seotud statistikat. Kuivõrd antud töö eesmärgiks on NordPooli riike omavahel võrrelda, siis on lähtutud Eurostatis asuvatest andmetest. Töös on peamiselt kasutatud tabeleid «sbs_na_ind_r2», «sbs_pu_4l_02», «nrg_105a», «nrg_pc_205_h», «nrg_pc_205_c», «DS-018995» ning «DS-058471».

Euroopa Komisjon on kehtestanud energiaintensiivsete tööstuste piirmäärad, samas puudub üheselt aktsepteeritud klassifikatsioon elektrimahukate tööstuste määratlemiseks. Võttes aluseks Norra Statistikaameti pakutud kriteeriumid, on antud töös leitud, et 7 NordPooli riigi kontekstis on elektrienergiamahukad tööstusharud puidutööstus (NACE rev.2 klassifikaator #16), paberi- ja tselluloositööstus (NACE #17), keemiatööstus (NACE #20) ning metallitööstus (NACE #24).

Empiirilised tulemused

Norra ja Rootsi elektri tootmishinnad on turgude avanedes lähenenud; hinnakonvergents on veel paremini täheldatav Rootsi ja Soome vahel. Samuti on näha, kuidas Eesti ja Soome hinnatase on pärast Eesti turu liberaliseerimist ja Soome ühenduskaablite rajamist ühtlustunud. See tõestab uurimisväite #1 paikapidavust.

Töös antakse ka ülevaade sellest, kuidas erinevad riigid maksustavad elektritarbimist. Näidatakse, et kõikides Põhjamaades – kaasa arvatud Taanis – rakendatakse elektrimahukamatele tööstusharudele soodsamaid maksumäärasid, mis tõestab uurimisväite #2 paikapidavust. Baltimaades diferentseeritud maksustamist ei ole; elektritarbijate jaoks on tõusnud kõik kolm elektrihinna komponenti: tootmishind (sest konvergentsi hinnatase on kõrgemal), võrgutasud (sest vananev elektrivõrk vajab mahukaid investeeringuid) ning ka maksud (mis on regiooni ühed kõrgeimad).

Kirjeldava analüüsi käigus nähtub, et lisandväärtus elektrikulutuste kohta – mõõdik, mida antud töös kasutatakse elektri hinna muutusest tuleneva konkurentsivõime muutuse peamise näitajana – on perioodil 2008–2013 vähenenud 12-s tööstusharus Põhjamaade 16-st elektrimahukast tööstusharust (st 4 tööstusharu 4 riigis) ning 11-s tööstusharus Baltimaade 12-st tööstusharust (st 4 tööstusharu 3 riigis). Kõigis seitsmes NordPooli riigis paistab silma metallitööstus (NACE #24), kus vastav näitaja on langenud kõige rohkem.

Samuti on pea kõikides tööstusharudes vaatlusperioodil elektri ühikuhind tõusnud (Põhjamaades mõnevõrra vähem, Baltimaades rohkem). Enamik Põhjamaade eletrimahukatest tööstustest on elektri kogutarbimist vähendanud, samas kui Baltimaades on trend olnud vastupidine. Tulemusena on lisandväärtus kilovatt-tunni kohta Põhjamaades enamasti suurenenud, mis tõestab uurimisväidet #3. Baltimaades jagunevad tööstusharud enam-vähem võrdselt. Kõikide Põhja- ja Baltimaade metallitööstustes (mis on üks elektrimahukamaid tööstusharusid) on lisandväärtus kilovatt-tunni kohta langenud, mis annab alust arvata, et efektivisuse kasv vastavalt uurimisväitele #3 on elektrimahukamates harudes raskendatud.

Töö ökonomeetrilises osas viidi läbi neli regressioonanalüüsi. Esimeses regressioonis vaadeldi lisandväärtust kilovatt-tunni kohta sõltuva muutujana ning laiendatud tootmisfunktsiooni erinevaid komponente sõltumatute muutujatena – sealhulgas kogukulutusi elektrile. Negatiivne seos kahe muutuja vahel tõestas antud töö põhiteesi, et suurenevad elektrikulutused sama tarbimise juures vähendavad lisandväärtust ning mõjuvad negatiivselt konkurentsivõimele. Suuremad negatiivsed koefitsientidid olid elektrimahukamates riikides ja –tööstustes. Teise regressiooni eesmärk oli esimese regressiooni järeldusi kontrollida. Vaadeldes lisandväärtust elektrikulutuste kohta sõltuva muutujana ning elektrikulutuste osatähtsust sõltumatu muutujana leiti, et nendevaheline seos on negatiivne. Kat eises regressioonis olid suuremad negatiivsed koefitsientidid elektrimahukamates riikides ja –tööstustes. Kolmandas regressioonis näidati, et eksisteerib positiivne seos elektri ühikuhinna ja lisandväärtuse kilovatt-tunni kohta, mis tõestab uurimisväite #3 paikapidavust. Samas leiti, et see seos on nõrgem elektrimahukamates riikides ja –tööstustes. Neljandaks korrati esimest regressiooni, asendades lisandväärtuse ekspordiga (vt kaubanduse intensiivuse valemit (17)). Ekspordi ja elektrikulutuste vahel täheldati positiivset seost, mis kinnitab uurimisväite #4 paikapidavust. Seos oli suurem Baltimaades, mille majandused on väiksemad, kuid mille majandused on vähem elektrimahukad kui Põhjamaades.

Järeldused

NordPooli liikmesriigid võib tinglikult jagada kolme eri gruppi: (1) Taani, mille majandus on kõikidest teistest oluliselt energiaefektiivsem; (2) ülejäänud kolm Põhjamaad, mis on väga elektrienergiamahukate majandustega; ning (3) Baltimaad, mis asetuvad elektrimahukuses Taani ja Põhjamaade vahele. Arvestades, et elektrienergiamahukad tööstusharud on puidutööstus, paberi- ja tselluloositööstus, keemiatööstus ning metallitööstus, on lihtsam mõista, miks Taanis – kus pole metsa ega rauamaake – on selliseid tööstusettevõtteid vähem ning miks neid on omakorda palju rohkem Põhjamaades ja ka Baltimaades. Kõikides riikides peale Taani on elektrienergiamahukatel ettevõtetel oluline roll riigi majanduses – neis sektorites töötab 20–40% kogu tööstussektori töövõtjatest, samas suurusjärgus on ka tootmisväärtus ning eksport.

Liberaliseeritud elektriturud ja hea ühenduvus lubab mitmetel NordPooli riikidel tarbida rohkem elektrit kui riigis toodetakse, sest mitmes naaberriigis on olukord vastupidine ning mõlemal poolel on huvi kaubelda. Pudelikaelte puudumine ühendustes loob aluse stabiilseteks riigiülesteks tootjahindadeks.

Hoolimata asjaolust, et Taani majanduses on elektrimahukatel tööstustel oluliselt väiksem osakaal, maksustavad kõik Põhjamaad – s.h. Taani – erinevate tööstusharude elektritarbimist erinevalt. Oluline on märkida, et erinevaid maksumäärasid rakendatakse ainult elektritarbimisele, mitte muudele maksuliikidele (tööjõumaksud, tulumaks jne). Samal ajal ei ole Balti riikide elektrienergiamahukatel tööstustel mingeid eeliseid mitte-elektrimahukate tööstuste ees, v.a. mastaabisäästelektri tootmishinna ja võrgutasude puhul. Veelgi enam, kui Põhjamaades on elektri hind tõusnud suhteliselt vähe, siis Baltikumis on kõik kolm hinnakomponenti teinud läbi mitmekordse kasvu – eriti just riigi poolt kontrollitavad võrgutasud ja maksud. Joonistel 25, 26 ja 27 toodud graafikutelt nähtuv hüppeline hinnakasv annab aluse arvata, et Balti elektrimahukate tööstuste konkurentsivõime on valitsuste tegevuse tagajärjel kannatanud.

Nii kirjeldav analüüs kui regressioonanalüüs kinnitavad, et tõusvad elektrihinnad mõjutavad negatiivselt elektrienergiamahukate tööstuste konkurentsivõimet, mis väljendub pidurduvas lisandväärtuse kasvus. Samas on näha, et kasvavate elektrikulutuste taustal otsivad ettevõtjad võimalusi oma tegevuse efektiivsemaks muutmiseks. Elektrienergiamahukamates tööstusharudes on see aga raskendatud – tulenevalt spetsiifilisest tootmistehnoloogiast, pöördumatutest investeeringutest põhivarasse jne.

Soovitused edasisteks uuringuteks

Antud doktoritöös kasutatakse tööstusharu-taseme andmeid, sest elektrikulutused ettevõtete kaupa ei ole kättesaadavad. Asjaolu, et töös ei saa võtta arvesse ettevõtete-vahelist konkurentsi tööstusharu sees, seab järeldustele mitmed piirangud, sest edukad ja vähem edukad ettevõtted võetakse kokku harukeskmisteks näitajateks. Näiteks Amadeusi andmebaasis kajastatakse erinevaid ettevõtte-taseme andmeid s.h. erinevad kululiike, kuid kulutusi elektrile avaldatud ei ole. Tulevikus ettevõtte-tasandil läbiviidav analüüs lubaks teha konkreetsemaid järeldusi.

Euroopa Liidus on konkurentsivõime modelleerimiseks välja arendatud GEM-E3 mudel, mis lubab modelleerida eri teguritest tulenevaid muutusi. GEM-E3 mudeli haldamiseks ja kasutamiseks luuakse mitmeid ülikoole kaasavaid töörühmi; tulevikus võiks kaaluda ka GEM-E3 mudeli kasutamist NordPooli liikmesriikide elektrikulutuste modelleerimiseks.

Samuti võib kaaluda antud analüüsi laiendamist NordPooli liikmesriikidest üle-euroopaliseks analüüsiks, kus kaasatakse kõik riigid, kus elektriturud on juba täielikult liberaliseeritud ja omavahel ühendatud. Seda saab teha nii GEM-E3 mudeliga kui ka – lihtsamas vormis – ilma.

Töös kasutatakse Eurostatist pärinevaid andmeid, mida on kogutud alates 2008. aastast, st. käesolevaks hetkeks on kättesaadav 6 aasta jagu andmeid. Aastate möödudes muutuvad aegread pikemaks, mistõttu muutub eri riikide eri tööstusharude konkurentsivõime muutus ka paremini analüüsitavaks – nii et lisaks kirjeldavale mudelile saab luua ka eksperimentaalseid / ennustavaid mudeleid, mis on energiapoliitika kujundamisel suuremaks abiks.

CURRICULUM VITAE

Marko Viiding

Nationality	Estonian
Place & date of birth	Tallinn, 30.05.1982
Marital status	Married
Address	Liblika 12/10, Tallinn 13426
Phone	(+372) 5209 907
E-mail	marko.viiding@gmail.com

Education

2010–2016	Ph.D. in Economics, University of Tartu, Faculty of Economics and Business Administration
2006–2007	CEMS Master in International Management, Copenhagen Business School & Stockholm School of Economics
2005–2007	M.Sc. in International Business, Copenhagen Business School
2001–2005	B.A. in Business Economics, University of Tartu, Faculty of Economics and Business Administration
1989–2000	Tallinn English College / Tallinn Secondary School No 7

Professional Employment

2010–…	Energy Economics Advisor Renewable Energy, Multiconsult ASA, Norway
2009–2010	Project Manager, Business Analysis Group Finance, Vestas Wind Systems A/S, Denmark
2009	Business Consultant Repair & Spare Parts, Vestas Wind Systems A/S, USA
2008–2009	Project Consultant Project Operations, Vestas Wind Systems A/S, China
2007–2008	Sales Analyst Sales & Marketing, Vestas Wind Systems A/S, Poland

Lecturing

- Environmental Economics
- EU Energy & Climate Policy
- Strategic Management
- Change Management

Languages

- Estonian (native)
- English
- German
- Norwegian/Danish
- Russian
- Finnish

Main Research Interests

- Electricity pricing
- Electricity market regulation
- Renewable energy policy

ELULOOKIRJELDUS

Marko Viiding

Rahvus	Eesti
Sünnikoht ja -aeg	Tallinn, 30.05.1982
Perekonnaseis	Abielus
Aadress	Liblika 12/10, Tallinn 13426
Telefon	(+372) 5209 907
E-post	marko.viiding@gmail.com

Hariduskäik

2010–2016	Ph.D. Majandusteadus, Tartu Ülikool, Majandusteaduskond
2006–2007	CEMS Rahvusvahelise Juhtimise Magister, Copenhagen Business School & Stockholm School of Economics
2005–2007	M.Sc. Rahvusvaheline Ärikorraldus, Copenhagen Business School
2001–2005	B.A. Ettevõttemajandus, Tartu Ülikool, Majandusteaduskond
1989–2000	Tallinna Inglise Kolledž / Tallinna 7. Keskkool

Erialane teenistuskäik

2010–…	Energiaökonoomika nõunik Taastuvenergeetika, Multiconsult ASA, Norra
2009–2010	Ärianalüüsi projektijuht Kontserni rahandus, Vestas Wind Systems A/S, Taani
2009	Ärikonsultant Varuosad ja parandus, Vestas Wind Systems A/S, USA
2008–2009	Projektikonsultant Ehitus, Vestas Wind Systems A/S, Hiina
2007–2008	Müügianalüütik Müük ja turundus, Vestas Wind Systems A/S, Poola

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Keeleoskus

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