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THE PROFITABILITY OF ELECTRICITY COMPANIES IN FINLAND

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LIST OF ABBREVIATIONS

A = Amper

CHP = Combined Heat and Power

DSO = Distribution System Operator

GWh = 1000 MWh

kW = kilowatt = 1000 W, the watt (symbol: W) is a derived unit of power

kWh = Kilowatt hour, is a derived unit of energy

MW = Megawatt

MWh = Megawatt hour = 1000 kWh

TSO = Transmission System Operator

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The purpose of this study is to analyze the key factors affecting the profitability of Distribution System Operator (DSO) and electricity companies. Until this date, there has have been studies about the electricity prices and the electricity networks in Finland but less research specifying their profitability related factors.

The theoretical parts for this study contain information such as the way of production of energy, the transmission and the distribution of electricity and energy legislation. The Finnish Energy Authority and the Finnish Energy have been the vital sources of important statistical information.

The electricity distribution is a monopoly type of business by nature and it is highly regulated in Finland. The Finnish Energy Authority is responsible for looking after the companies so that their pricing structures and operational principles are reasonable. Even though the Authority makes sure these companies are all profitable, there are still significant differences between companies due to the different locations of companies. In addition, the costs structures between the DSO companies are varying causing tariff variations per transmitted energy unit.

The main factors, which have an effect on the profitability of the DSOs, include for example the length of electricity grid, the amount of end users and the geographical operating area of the electricity distribution company. Secondly, the effect of electricity origin or number of different energy sources on the profitability of electricity companies will be studied. The selected companies are reviewed in order to analyze this linkage.

KEY WORDS: Delivery Obligation, Legislation, Electricity Distribution, Profitability, Energy, DSO

1. INTRODUCTION

This study focuses on the key factors affecting the profitability of electricity distributing companies and electricity production companies. The electricity distribution is a monopoly type by the nature and these companies are strictly regulated in Finland. All of the electricity distributing companies are under surveillance of the Finnish Energy Authority and it ensures that the companies' performance and profits stay reasonable.

Even though the electricity distribution business is of a monopoly type, some of these distribution companies are more cost efficient and profitable compared to the other ones. This study will look under the key elements of why some companies are operating financially better and analyze what could be the most important factors affecting their cost efficiency, business performance and profitability.

A natural monopoly can be explained as a situation where the investment cost structure of a certain industry creates an obstacle towards competition. The benefits of economies of scale can be seen as an important reason to explain the existence of natural monopoly to benefit the society. In order to have scale benefits there needs to be fixed costs such as big investments so the market becomes monopolistic rather than competitive. If only a small amount of the end product is produced with high fixed costs, the final cost for each product becomes high because the original investment cost is divided to these functions. An important reason for economies of scale benefits is to be able to produce a large quantity of products with the same fixed costs so that until a certain point the cost towards one unit will decrease when the total costs are divided between multiple products. In case the scale benefits are not reached can the cost for each product be too high resulting in a situation where there will not be enough demand for the product and the business will become unprofitable. When the operational demand is large enough and the market cannot offer conditions for multiple companies' operations, the company will be operating in a natural monopoly condition.

The challenge with a monopoly market compared to a competitive market is the pricing power a monopoly has. Because a monopoly company is the only company offering a certain product on the market in a certain area, it can define the prices by itself. In a competitive market a single seller needs to follow the market cost structure but in a monopoly situation the quantity of the product is reflected on the cost; the cost of each product will decrease once more products are produced. If the company would increase its producing quantity, the product cost would decrease which would at a certain point result in a normal competitive market situation because the product cost would be normal.

Electricity market and especially the electricity distribution market is a good example of a natural monopoly since the construction costs for the infrastructure are high but when the people in a certain area are connected to this grid connection, will the end costs be divided between all the end consumers and the final cost for each consumer decrease. Because the construction costs of an electricity grid are high, would another grid be an unprofitable investment because in the electricity market the economies of scale benefits are the precondition of the whole market. Also from optimal use of the expensive infrastructure, it is economical to use one dedicated system.

The other focus in this study is to analyze the effect of electricity origin and the number of different energy sources to the profitability of electricity company. Large distribution companies are typically part of utility company consisting of other related business units. The selected utility companies will be reviewed and studied the effect of the energy sources to the profitability. These selected companies have various forms of own electricity production sources, they have various size of ownerships in production companies or they are purchasing various amounts of electricity from markets.

2. THE ELECTRICITY MARKETS IN THE NORDIC COUNTRIES

The supply of electricity can be seen as one of the key issues of society structures all over the world. Most people need electricity in order to enable several functions and responsibilities in their daily lives, which makes electricity an important part of countries' infrastructure. According to Hongyan Liu (2014) there has been deregulation in the electricity market since the 1980s, meaning that markets have wanted to transform the hierarchical production process including generation, transmission, distribution and supply by purely establish a new wholesale electricity market and retail electricity market. This adaptation has brought openness to competition and different kinds of market mechanisms to the electricity generation and supply. Even though this new deregulation is a part of the electricity market, the processes of electricity transmission and distribution are still subject to natural monopoly (Liu, 2014).

The liberalization of the electricity market began also in a few other countries in addition to Finland in the early 1990s. It started in Norway in 1991, followed by Finland in 1995 and Sweden in 1996. The deregulation ment that generation and retail of electricity became open for competitive business, whereas the transmission and distribution stayed regulated. After this, the Nordic countries including Norway, Finland, Sweden and Denmark established an electricity market called Nord Pool to be able to trade electricity. At the present time it is known as Nord Pool Spot. This spot market is owned by the national grid companies Statnett, Fingrid, Svenska Kräftnät and Energinet.dk.

Electricity markets can be divided into following elements; electricity production, sales, electricity distribution and export and import of electricity. The price of electricity consists of three elements: the price of electricity energy itself, its distribution and taxation. The electricity energy share is nowadays free for the competition (Liu, 2014).

There is also cross-border energy selling involved in the Finnish electricity market and this seems to be growing as in 2013 the total net import of electricity was 18,7 percent and in

2014 the similar rate being 21,6 percent of total electricity consumption in Finland during those years (Energia Uutiset, 2015). Finland is part of the Nord Pool Exchange System, where Nordic countries can exchange electricity. The main trading partner countries of Finland at the moment are Russia, Sweden, Norway and Estonia (Energiateollisuus, 2014).

Figure 1. The operation area of Nord Pool Spot markets. Source: Nord Pool Annual Report (2014).

2.1. Electricity production and sales in Finland

In Finland, there are around 120 companies which produce energy and they own 400 power production units, power stations. Even though the number of companies can be quite high, the large-scale energy production is basically divided into two groups, Fortum Oyj with 40 percentage and Pohjolan Voima with 20 percentage of the electricity production. Some distribution companies with their combined heat and power (CHP) production units and manufacturing industry like pulp and paper industry in general are also key players in the energy production.

Various different sources of energy are used to produce electricity and also diverse forms of production are utilized. Nuclear power, coal, natural gas, hydro, peat and biomass could be identified as the most important sources of energy. The share of wind energy is also growing, even though its share is still quite small compared to the others but it is rapidly growing globally and in Finland as well. The utilization of fossil fuels for the electricity production depends a lot on how much hydroelectric power is available from Norway and Sweden to the Nordic electricity market. Norway and Sweden have abundant hydropower capabilities and have typically surplus of electricity to export neighbor countries (Appendix 4. Fortum, 2016). Hydropower is less expensive and the use of coal in condensing power plants is depending on the market situation. The main production principle generally is to produce electricity with the most efficient and economic way. Compared to the other European countries, the structure of Finnish electricity production is quite decentralized. The positive point of this is that a varied production ways of electricity increases the certainty of the delivery (Finnish Energy Industries, 2014).

The transmission of electricity begins from the power station where the electricity energy is produced. After this, the electricity will be transferred to the end customers via the main grid and local distribution system. Consumers can buy electricity from whichever electricity supplier they would prefer. The grid operators are responsible for transferring the electricity produced in the power station safely and without interruptions to the end user.

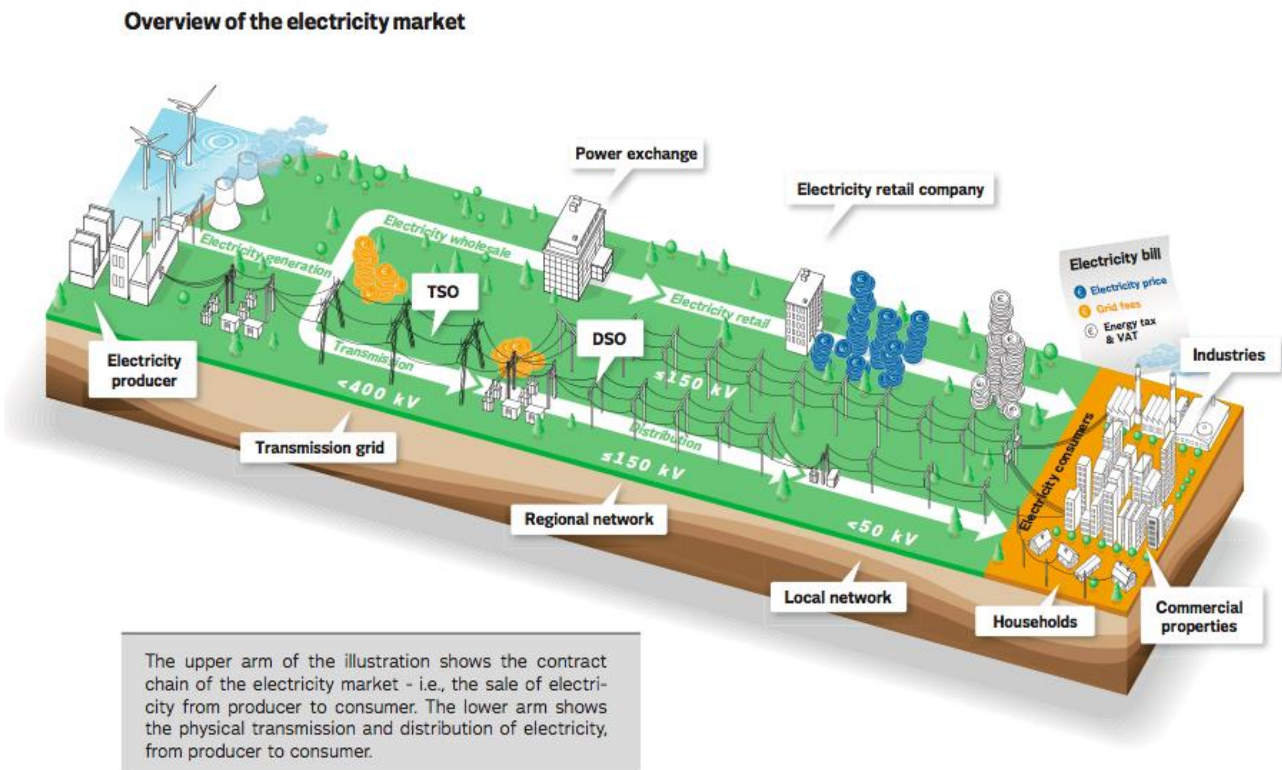

Figure 2. Illustration of the electricity markets and contract chain from the power production plant and distribution network up to end user. Source: Vattenfall (2011).

Nord Pool Spot Exchange is a place where companies can exchange raw material, in this case, electricity. Only members can use this exchange system for trading purposes. The system can be divided into three parts; spot exchange, derivatives market and Elbas – market.

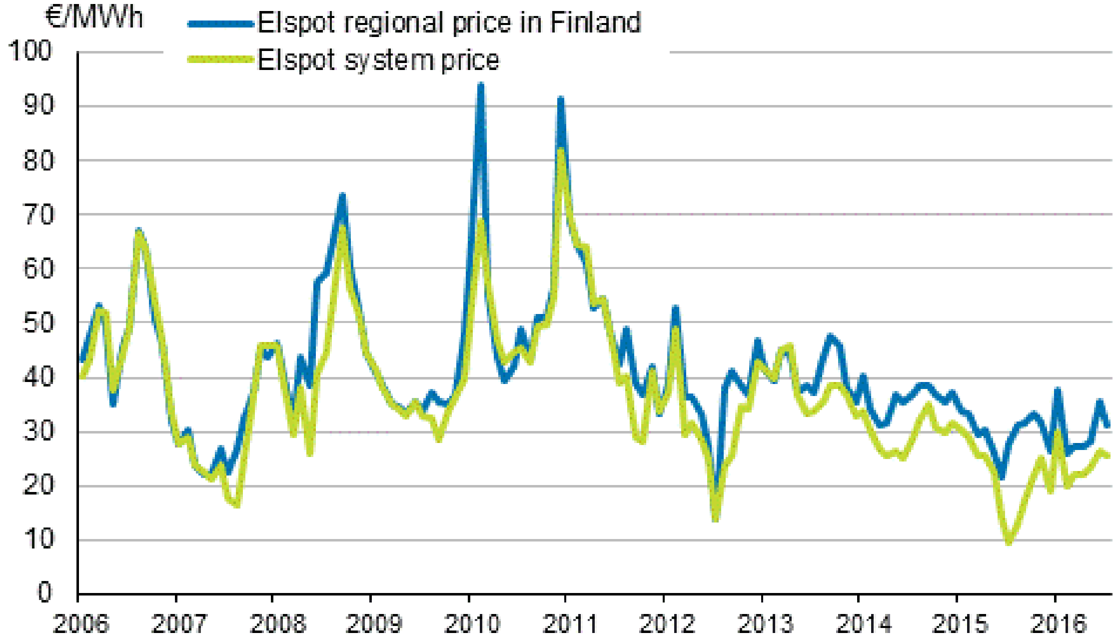

Figure 3. Average monthly spotprices at the Nord Pool Spot power exchange. Source: Statistics Finland (2016).

In spot exchange, the price of electricity is determined according to the demand and supply. Each day at noontime, the companies will give their offer for how much and for what price they would be willing to either sell or buy electricity. The final rate will be at the intersection where these two meet and this point is called the spot rate. The main players in the spot market are large energy intensive companies, manufacturers and other big consumers like electricity distribution companies to complement their possible own production or sell their excess electricity production (Energy Industry 2014). Spot price variations in the years 2006 – 2016 are shown in the Figure 3 as monthly average prices.

In derivatives market, the exchange happens with instruments which are linked with the electricity price. These are known as futures, termini’s and options. The basic idea of derivatives market is to create trust for the future. In the spot market the price of electricity is available only for the next day but most of the companies would like to make their plans to for example income, expenditures and cash flows for a much longer period of time. In the derivatives market it is possible to make trading agreements to the future with fixed prices. The trading periods are from weeks, months, a quarter all the way up to years, the most common ones being a quarter of a year and the next year. The exchange of derivates does not necessarily mean an obligation to buy or sell actual physical electricity because they are pure financial instruments. This way, the Nord Pool Exchange market is open for other companies from the financial market as well, as the trading does not include any non-financial instruments. The fact that large financial sector companies enter the derivatives market increases its liquidity (Energiateollisuus, 2014).

The trading on Elbas-market is considerably smaller compared to spot exchange and derivatives market. Elbas-market is ment more for exceptional situations with problems in electricity production. For example if a power plant’s electricity, which has earlier been traded on the spot market is interrupted, the same amount can be bought from the Elbas-market. This way the trade and delivery of electricity stays normal and balanced (Energiateollisuus, 2014). The Nordic power market trading places are illustrated in Appendix 5. (Fortum, 2016).

The electricity trading companies can decide to buy their electricity from Nord Pool Exchange system or they can choose to negotiate trade agreements directly with other selling companies. Companies can also decide to produce electricity for consumers by themselves. In the end, the electricity is then transferred to consumers by the transmission grid. The Nord Pool Exchange System forms one of the basis for the economic success of electricity production companies as well as electricity retail companies and the end-customers.

2.2. Electricity distribution

The electricity grid includes the national grid, regional networks and local distribution grids which are owned and operated by local electricity distribution companies. The main grid covers the whole country of Finland and it transfers electricity to regional networks and local distribution grids. The approximately eighty companies behind regional networks and distribution companies transfer the energy to the end consumers. Usually the distribution companies can serve both electricity transfer and electricity energy as products but the only cost item which the consumer can affect by his choice, is the electricity energy. The distribution company invoices a charge for the use of electricity grid used for the electricity transfer.

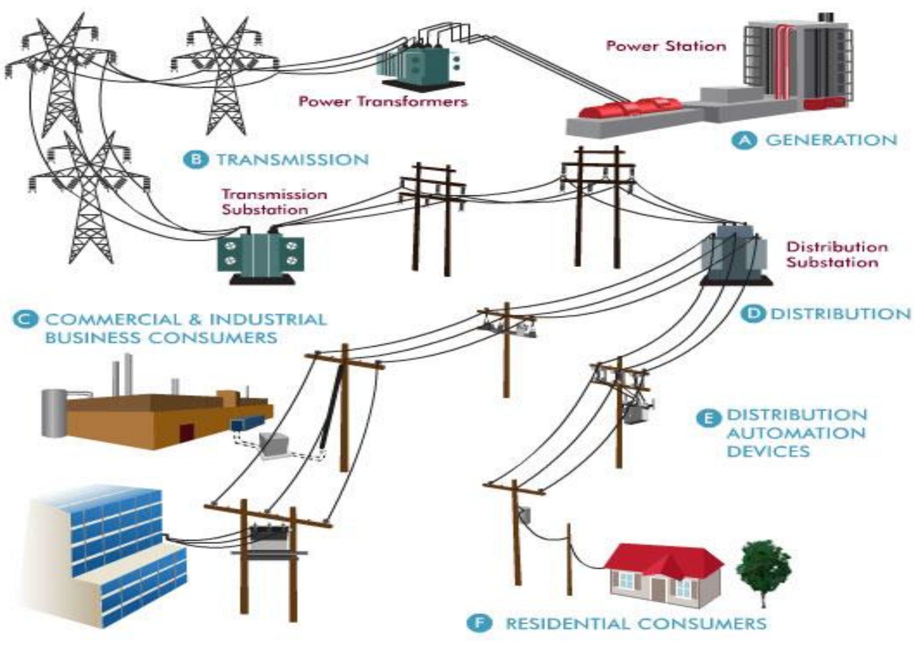

Figure 4. Typical distribution system. Source: The Common European Energy Market, Vattenfall (2011).

Fingrid Oyj is the developer and main supervisor or the Finnish main grid. The company was established in 1996 to combine electric transmission lines owned by multiple operators. Both the State of Finland and some big insurance company groups own the company. Fingrid Oyj is responsible for the functionality of the main grid and it is basically the body of the whole electricity network as the distribution companies, power stations and other big users of power are connected to it. The main grid is in between of the electricity producers and the DSOs and makes it possible for these two to interact inside Finland and having grid connections to neighbor countries. Fingrid Oyj is responsible for the monitoring of the grid, designing and planning the use of grid, maintaining the network, executing different kind of constructions, balancing electricity service operation and also promoting the operations done in the electricity market (Fingrid Oyj, 2014).

Fifteen largest regional distribution companies are covering around seventy percent of Finland’s distribution networks. Small municipalities with a few thousand inhabitants are served by small electricity network companies. Majority of Finland’s around eighty distribution companies are owned by either companies controlled by municipalities or municipalities themselves.

2.3. Electricity distribution system operation (DSO)

When the electricity network market was renewed, it became possible for electricity companies to provide both the producing of electricity and selling it in the same company. In order to control and clarify the electricity industry business conditions better the ownership of the network and the production of the electricity need to be divided into separate business functions: the network, production and selling electricity (Liu, 2014).

According to the legislation and regulation it is mandatory that especially the network company needs to be able to show its own balance sheet and income statement for the network part of business in the accounting records of the company. The Finnish Energy Authority will use the financial and other business information of the companies on business units which have been differentiated from the main business, when evaluating the reasonable profitability of the network business and its price formations.

Vertical integration in the electricity market means that one company can provide the producing of electricity, selling it and is taking part in the network business. The Finnish electricity markets have been vertically integrated already for a long period. From the endcustomer’s point of view the vertical integration can be seen as positive with affordable pricing and well-organized service. It can naturally be also seen as negative if the prices are high and the seller has a monopolistic position. This all depends on how the electricity company is structured and what the markets are like at a certain period. Of course, when the electricity markets are decent on all of the production levels, it decreases the possible negative side effects of vertical integration (Liu, 2014).

In Finland a well-structured and functioning electricity markets require the operating companies to be profitable and that they are not supported with any kind of monopolistic functions. This is why the legislation entails that the electricity companies need to have a separate network, production and selling functions. Also in the local companies the electricity functions need to be differentiated from other services offered in the municipality.

The electricity distribution system operation (DSO) companies take care of the distribution system operation and its maintenance and development. In Finland the DSO business is strictly regulated due to its monopoly type nature. DSOs must report both technical and financial consolidations and status on the annual basis to the Energy Authority.

2.4. The Finnish electricity production and distribution

There is a variety of different kind of company structures and organizations among Finnish electricity companies. The way of organizing the company operation is typically related to the size of the company’s business and the number of different business segments. One example of organizing the business of a small size locally operating distribution company is

Jylhän Sähköosuuskunta, which is operating locally in the South Ostrobothnia area. Its revenue is around 12 - 15M€ and it has a lean organization for the operation, construction and management as it is shown in the Figure 5.

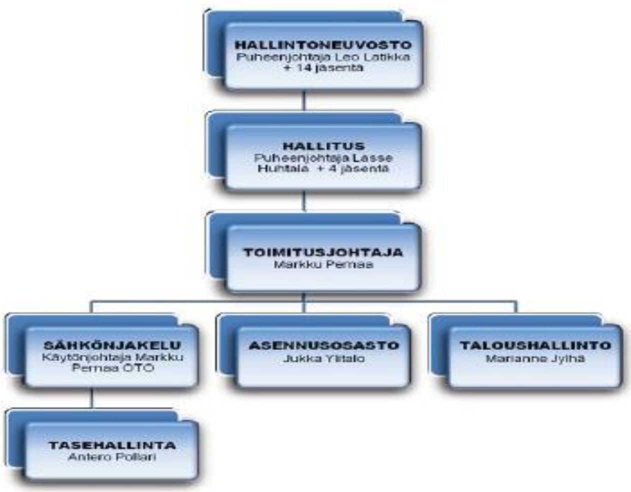

Figure 5. Organization of Jylhän Sähköosuuskunta. Source: Annual report (2013).

Another example is the organization of a large municipal electricity company having multiple operative units. Tampereen Sähkölaitos Oy is owned by the city of Tampere, organization chart of company structure is presented in Figure 6. It can be seen that the main business segments are placed under own dedicated organizations. The total revenue in Tampereen Sähkölaitos Oy is around 300 M€ (Tampereen Sähkölaitos Annual report, 2014).

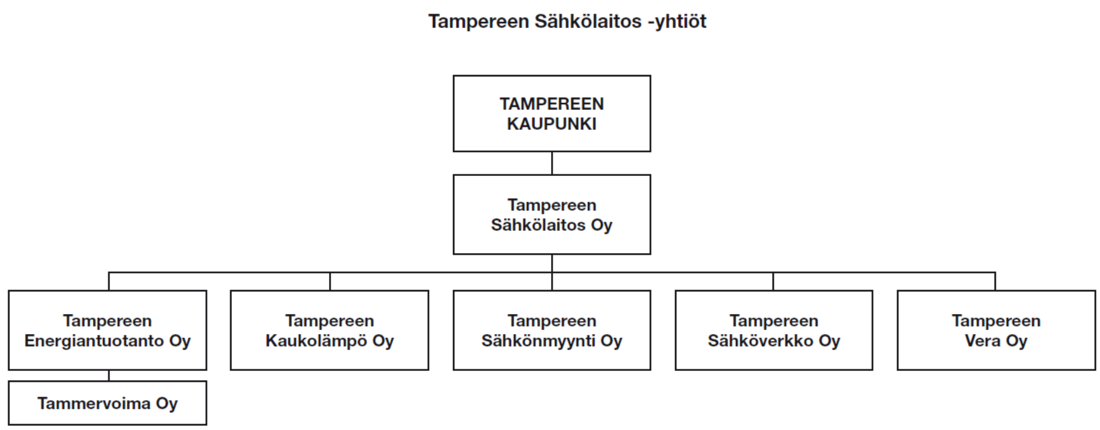

Figure 6. The structure of Tampereen Sähkölaitos Oy. Source: Annual Report (2013).

Another example is the city of Vaasa, where the company Vaasan Sähkö Oy is located. It has five subsidiaries; Vaasan Sähköverkko Oy, Ravera Ab, VS Tuulivoima Oy and associated companies EPV Energia Oy and Smedsby Värmeservice AB. The total revenue is about 140 M€ (Vaasan Sähkö Annual Report, 2014).

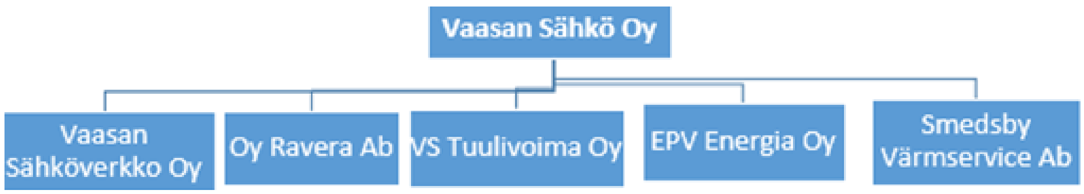

Figure 7. The structure of Vaasan Sähkö Oy. Source: Annual Report (2014).

It can be noted that there are alternative ways to organize the operations of large utility company having multiple business units and ownerships in other companies.

2.5. The position of the electricity end user

The consumer of the electricity is responsible for making a contract with an electricity company. It can be either a one contract for the electricity and distribution or separate contracts for electricity energy and for the distribution. The electricity contract can be done with any electricity seller company in Finland, but the electricity distribution contract needs to be arranged with the local distribution company. If the contract for both electricity and the distribution are done with the same local supplier, only one contract including both of these is needed (Finnish Energy, 2014).

The electricity bill is an important part between the end user and the energy company and is acting as one key of customer service from the company side. There are alternative ways of how the energy bill can be paid. The bill can either be made according to an estimated usage of electricity and it can be done separately for each period. The consumer may also choose to pay according to when the electricity is used including day or night and summer or winter times. The method of payment will vary depending on the ways the local company is offering. What also affects this is how the use of electricity is measured at the consumer end (Finnish Energy, 2014).

An estimation bill has been a traditional way of paying for the electricity usage. In this method the charge has been calculated according to previous consumption. For example if a period is one year, a customer will get a bill or compensation after 11 months depending on the actual electricity usage. Another option is a bill for each period where the consumer will be charged according to the actual electricity metering (Finnish Energy, 2014).

Depending on the various options the electricity seller and the distribution companies' offer, it may also be possible to choose an electricity tariff. For example in the time tariff the consumer will pay a different price for electricity whether it is used at daytime or night. A seasonal tariff is another one where the prices vary depending on the time of year. The idea of tariff is that electricity is less expensive on times when there is less usage.

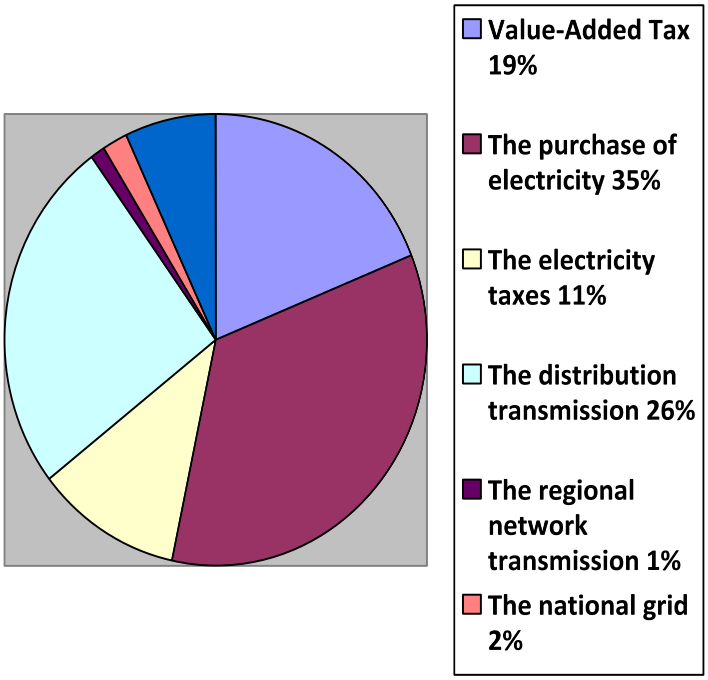

Figure 8. The comprise of household electricity price. Source: Energy Authority in Finland (2015).

One interesting factor is also the development of electricity price for household customers where the total share of taxation has increased along the time as shown in the Figure 9. It can be noted that the share of tax amount has increased in last years while the relative shares of transfer and energy have decreased.

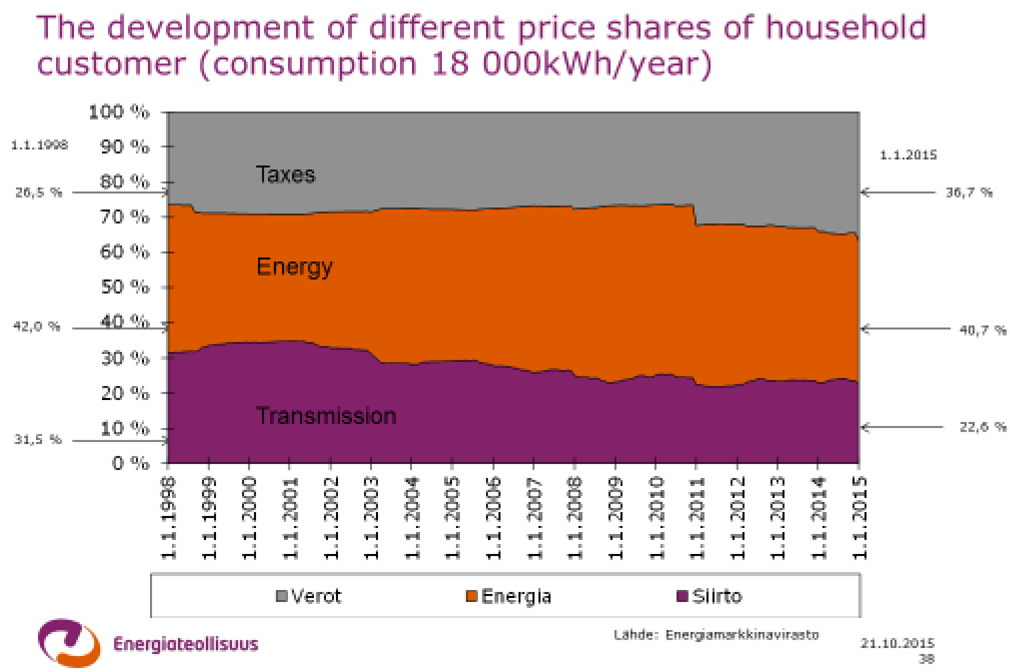

Figure 9. Change of electricity price shares for heating customers (consumption 18000kWh/a), Energy year 2014, Electricity, development. Source: Finnish Energy (2015).

2.6. The origin of distributed energy

The Energy Authority (Energiavirasto) is a specialist organization under the Ministry of Economic Affairs and Employment and it consists of six parts, which are the market, electricity networks, natural gas network, emission trading, renewable energy and energy efficiency. The Electricity network –group and the Market –group both supervises the price of the electricity. The Electricity network – group is responsible for supervising that the price of electricity is reasonable but also the tasks of the Market –group relates closely to the pricing. The Energy Authority in Finland is responsible for ensuring that legislation is followed, which means that the distribution companies are required to notify the origin of the energy, i.e. is it made based on the renewable energy, fossil fuels or by nuclear energy.

The Authority also looks after the activities executed in the department of evaluation and is the holder of registry (Energy Authority, 2014). In order to carry out the required actions it is allowed to collect information from the power station owners and further prepare statistics and evaluate the execution of the distribution companies. Certain financial support and subsidies for renewable energy production are based on this information and therefore this precise follow-up and data gathering is extremely important. Financial supports and subsidies have large economical affect and value to all involved stakeholders.

If the electricity seller informs that a part of the electricity produced is from renewable energy sources, the seller is required to specify the origin of them. A guarantee system is known as a way which the Energy Authority uses to assure the origin of the energy. The origin needs to be guaranteed through the system if the electricity company reports renewable energy sources being used in other business segments. The purpose of this guarantee system is to ensure that renewable energy sources are used if said so and also to promote renewable sources. The guarantee of origin can only be granted to electricity produced with renewable energy sources. There are also various support or taxation benefit system for renewable electricity production. Additionally, there are also trade involved in the EU (European Union) and EEA (European Economic Area) countries' guarantee system, as the electricity sellers can sell their guarantees even separately from the electricity itself (Energy Authority, 2014).

In order to possibly receive this guarantee of origin, the owner of the power station needs to inform the amount of electricity to which the guarantee is intended for and the months and year when that electricity has been produced. Only the department of registry can confirm these guarantees. The measurement unit used for this is one megawatt hour (MWh) equalizing 1000 kilowatt hours (kWh). The guarantee is awarded on a monthly basis and the charges involved in these services need to be rational. The guarantees of origin are listed in the EEX (European Energy Exchange) stock market (Energy Authority, 2014). The guarantee can also be awarded to electricity produced with effective co-operation but not to electricity which has been produced only to power stations own equipment (Finlex

2§ 14.6.2013/445). In some companies DSO is one of the business segments and they have other business segments like electricity sales to customers, distribution system construction, district heating sales and system construction etc. These multibusiness operation company structures make the evaluation and real analysis of these companies more complex due to the inter-company businesses and transactions.

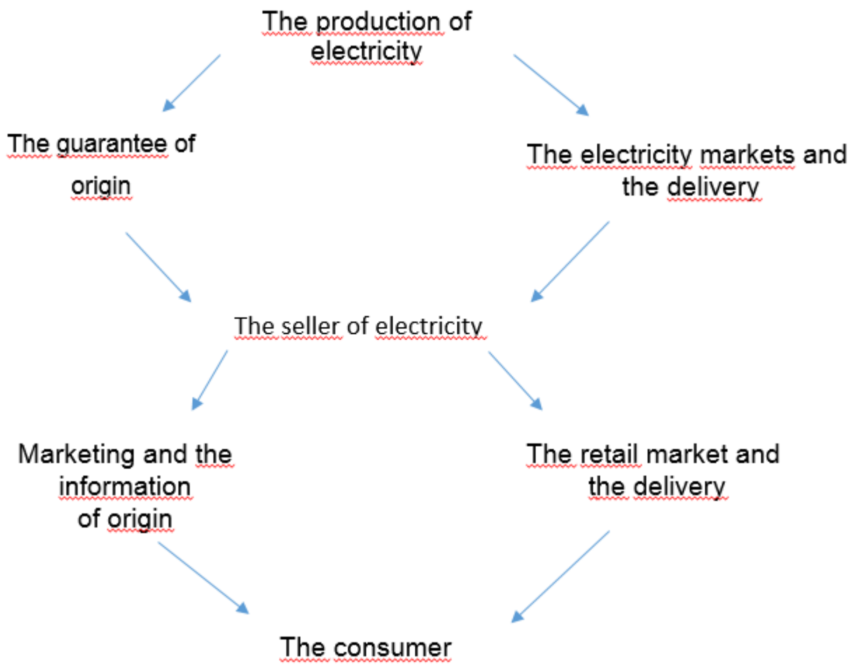

Figure 10. The guarantee of origin and the structure of electricity market. Source: Energy Authority (2014).

3. PROFITABILITY FACTORS OF ELECTRICITY DISTRIBUTION COMPANIES

Efficient operation in electricity distribution business is an important factor although it is monopoly type by nature and under strict control by authorities. Different kind of comparison and benchmarking studies have been carried out in many studies in Finland and internationally in order to establish methods to follow and control the business performance, cost structures and its operational quality aspects from the customer point of view.

The comparison between the distribution company operational efficiency is challenging in order to have a fair and compatible analysis. Companies are operating in very different conditions e.g. rural or urban area, dense or sparsely populated areas and large or small electricity capacity users.

In the literature, the following variables have been selected for comparisons in order to have numerical indicators for evaluations: network length, number of users, amount of distributed energy, operating costs, number of employees, electricity interruption times and transformer capacities (International benchmarking of electricity distribution utilities, D. Edvarsen, F. Forsund, Resource and Energy Economics 24, 2003. On Advancing Business Intelligence in the Electricity Retail Market, H. Liu, Dissertation at Åbo Akademi (2014).

The local DSO company's operational efficiency determines the network tariff charged from the customers.

3.1. Definition of operation principles and obligation to deliver

Distribution companies can either produce the electricity by themselves in the same company group, buy it from the stock market or it can focus only on the distribution. Currently there are just fewer than 100 electricity-selling companies in the country. In

Finland there is no need for a license to sell electricity commodity which means that anyone is allowed to do it. At the same time, the retail sellers no longer have a single dealership right in their local area, which means that they might not be the only company selling electricity in the area, but then again they do not have an obligation to sell electricity around the country.

In order to meet small distribution companies' and consumers' rights there exists legislation which obligates the most powerful distribution company in one area or province to sell electricity to consumers in that specific place. This distribution company is usually the company, which already sells the biggest amount of electricity to consumers, and other companies in the area. This is also known as an obligation of delivery. The use of distribution and electricity needs to be publicly available information and the charge that will be taken reasonable. The delivery of obligation legislation is set in the electricity law (Finlex 588/2013).

The purpose of this law is to take care that an end-customer and other industries receive the electricity they need, with the power 3x63 Ampeer and up to capacity of 100 000 kWh in year. In case there is no distribution network, which could be seen as the biggest in an area, the largest retail seller of electricity has an obligation to sell to the users of energy. If the electricity seller leaves the market for example because of a bankruptcy etc., the distribution company is still obligated to sell energy to consumers. The distribution company needs to transfer electricity until the Energy Authority decides a new seller. This is also the case where the original company was the main or the biggest seller in the area.

The whole distribution system is a monopoly type business by nature due to its big investments, being part of society's infrastructure and therefore has the large-scale benefits. The State of Finland strictly follows the business execution of those distribution system operators (DSO). The distribution company invoices for the use of electricity grid used for electricity transfer. For a typical consumer, the electricity distribution costs including taxes are around 45 percentages of the overall electricity cost. The same distribution charge excluding the taxes would be around 30 percentages of the total electricity cost. This will point to an acknowledgement that the structure of the electricity company can affect the charge quite a lot. (Finnish Energy Authority, 2011)

3.2. Profitability factors

It is the responsibility of the Energy Authority to supervise the DSO companies and their pricing structures. Because the electricity distribution is a monopolistic business by its nature, the Authority needs to make sure that the pricing structures of these companies are reasonable. The operation income should cover the maintaining of the distribution network, operation, and construction costs and ensure sufficient return on investment. Return of investment calculation is complicate by its nature and the aim is to have an equal way to handle the companies and their complete pricing. The evaluation takes into account also the electricity delivery interruptions as a quality factor in network operation (Energiavirasto, 2014).

Monopolistic way of business is also one of the reasons why all of the DSO companies are profitable on the long term as average but annual variations are however possible. The society will benefit that this kind of infrastructures are well maintained.

In this study around eighty Finnish DSO companies will be studied and analyzed regarding selected profitability related factors and comparing them to their unit costs per each electricity unit (kWh) transmitted. DSO companies are obliged to report on the detail level both their technical and financial performance on the annual basis and this information is public.

First all DSO companies will be studied, then 30 largest and 30 smallest by revenue will be separately studied accordingly. Then this study will explore some of the biggest electricity companies in Finland and will then focus on the key reasons, why some of these DSO companies are more profitable and cost effective compared to the other ones and what are the reasons behind this. The companies are first examined at the distribution system level in order to understand the structure of the companies and electricity network.

After the DSO companies, this study will focus on the selected electricity companies in order to learn more about the key elements affecting their profitability. Special point of interest is whether the origin of electricity has effect on the profitability.

4. THE STUDY OF THE SELECTED LARGE ELECTRICITY COMPANIES

The second part of this study contains an analysis of the selected electricity producing companies owned by large municipalities. These energy companies are typically consisting of many business segments like electricity and district heating production, district heating distribution, electricity distribution, electricity sales, electricity network construction and also other utility service related units. The companies, which have been included for this study, are located around Finland and are owned by the municipalities and have different kinds of original sources of energy. Companies for this analysis have been chosen based on their geographical location and on the alternative ways of energy productions.

The interest is to analyze whether the origins of electricity categories like nuclear, fossil fuels, renewables including hydro, bio fuels and wind or share of purchased electricity from markets will have linkage to the financial success of those large companies. In the Figure 11 the electricity supply by various energy sources is shown and the figure shows how nuclear, hydro, renewables and the imported electricity are the most important sources for the Finnish electricity system in year 2014. The companies in the analysis have own production, own shares in other production companies or are purchasing electricity from the markets and have different kind of production portfolio compared to Finnish average electricity supply shares as on Figure 11.

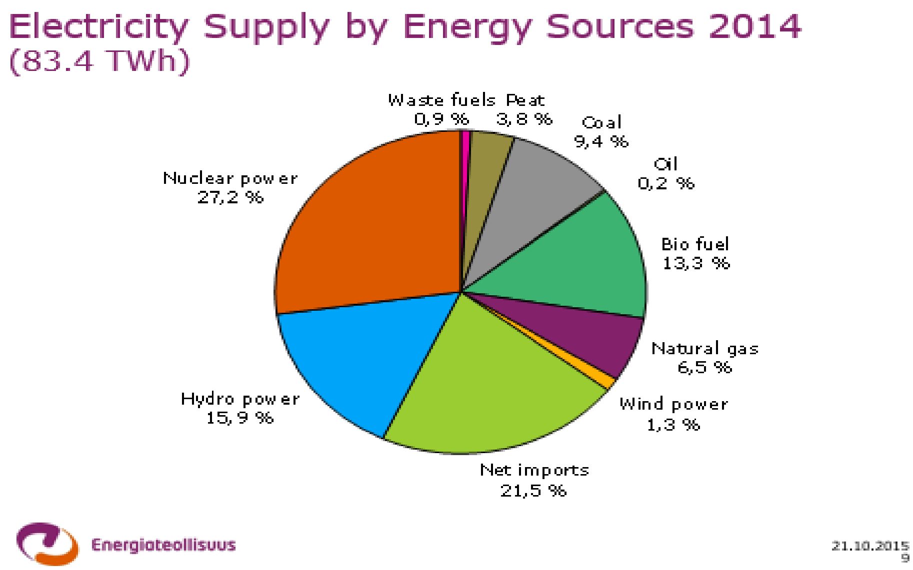

Figure 11. Electricity supply by energy source in Finland, year 2014. Source: Finnish Energy (2015)

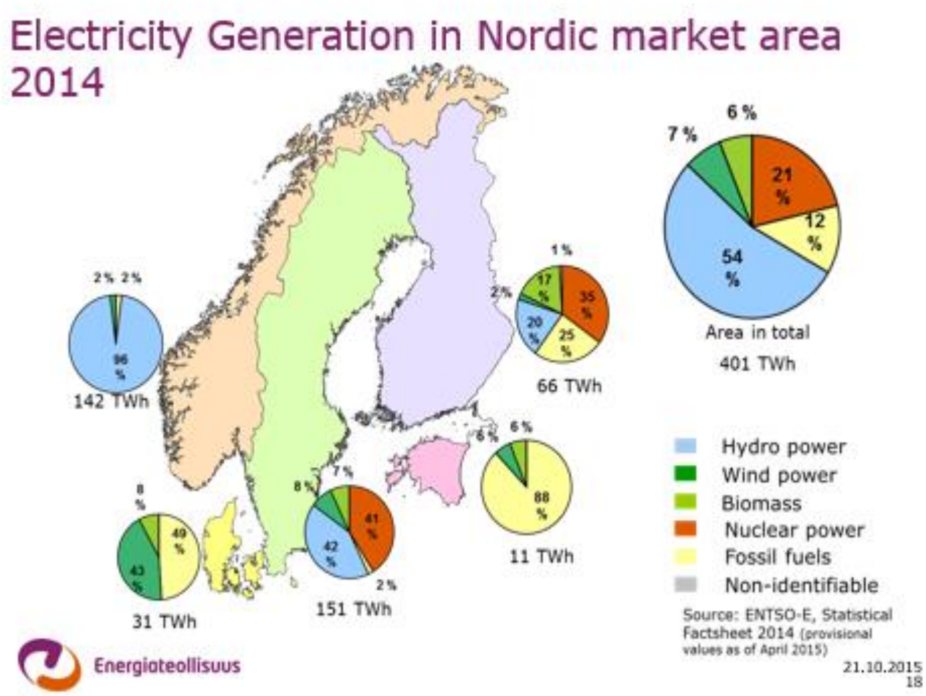

Figure 12. Electricity generation in Nordic market area. Source: Finnish Energy, (2015).

The electricity generation amount differences and the origins in the Nordic countries in year 2014 can be seen in Figure 12. In Norway hydropower is the main source, in Sweden hydropower has a major role as well and both of these countries are exporting surplus electricity. In Denmark and in Estonia there is no own hydropower available. The Nordic system including Nord Pool electricity trading has an effect on the Finnish system and the price levels while securing the continuous supply and optimal operation.

5. DATA MINING

The data for this study were gathered from the Finnish Energy Authority's statistics, the companies' annual reports and their financial figures statements as well as the key facts from the Statistics Finland.

For the electricity distribution companies the data were gathered using a spreadsheet made by the Energy Authority. On the table all of the essential information for companies was drawn together. In order to find key aspects about the profitability factors, certain parameters were selected for four separate years and a Pearson Correlation analysis was made.

5.1. Research methods: Pearson correlation coefficient and self-organizing maps

This study will use two different approaches towards the profitability analysis of distribution system operators. The first method is the Pearson Correlation Coefficient, which analyzes the possible dependences between variables (Mellin, 2006) and the second one is the Self-Organizing Map (SOM), which is known as one of the most popular neural network models (Hollmen, 1996).

Pearson correlation theory is a useful statistical measurement to study the correlation between two variables. This theory examines the strength of linear regression between the variables. The correlation coefficient varies between -1 and 1; when the correlation is 1 it means a linear relationship and it being -1 means negative linear correlation. When the correlation is close to either -1 or 1 it means that the variables have a strong correlation (Yhteiskuntatieteellinen tietoarkisto, 2004).

The Self-Organizing Maps are non-linear regression techniques founded by Teuvo Kohonen in the 1980s. In this method regression techniques can be trained to learn to find relationships between the inputs and outputs set into the model (Deboek & Kohonen, 1998). The method can be clustered into the competitive learning network category and it can be said to be useful as it does not need any humans for supervising the learning which gives it an advantage that little information and basic data needs to be known when inputting data in (Hollmen, 1996).

Self-organizing map is able to convert complex figures, charts and statistical relationships into more simple and easier to read and understand maps with geometric relationships. The SOM requires two layers of units for processing; first, one is the input layer for processing all of the units in the input vector and the second layer, also known as the output layer, which consists of processing units that are already fully connected with units in the input layer. The user of the map can decide how many units to put on the output layer, according to what kind of map in the end is desired. SOM does not consist of any hidden units or layers as some other network models (Deboek & Kohonen, 1998).

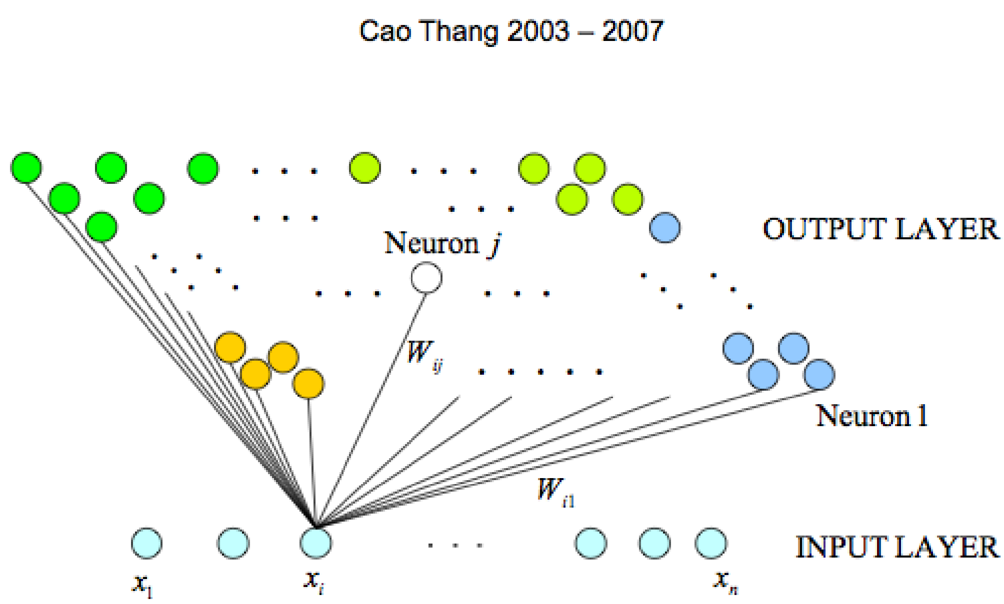

Figure 13. Self-organizing Map. Cao Thang 2003-2007. Source: Spice-SOM Users' Guide (2011).

Self-Organizing Map usually consist of a two-dimensional grid of nodes and it is automatically arranged into a meaningful order so that the similar grids are closer to each other than the dissimilar ones. It could be said that SOM is a good tool for clustering objects and also a similarity graph where similarities and dissimilarities of certain points are shown. (Kohonen, 1998)

One key detail of SOM is that it will try to find different structures from complex empirical research data. If there were many different variables, normal statistical methods would probably be unable to find similarities in the empirical data and then be unable to cluster the results correctly. The Self-Organizing Map will be created so that many dimensions of the map are set on flat board and the similarities and dissimilarities can then be seen as distances between points on the map. All points on the map can be taken to a closer examination, but observations can be made already in the very beginning of the learning. The different shades on the map will identify areas where targeted points have spread out. If categories from other models are set on the same map, the positive and negative sides can be seen straightforward.

According to Kohonen (1998), one way of explaining the method of SOM is how flowers can be dried so that they appear as a two-dimensional picture of themselves. Humans are capable of picturing an item as a three-dimensional version, but for a four-dimensional version a systematical approach, for example a SOM method, is approachable.

For this research it was important to choose a technique, which is clear and will visualize the outcome so that conclusions can be made. Some other techniques such as decision tree would have probably created quite complex figures, which could have produced more information than wanted and therefore be riskier to interpret.

Another technique called K-mean could also have been chosen. K-mean belongs to the non-hierarchical type of clustering. In this method the number of clusters would have been set to the program and it would then pick the correct points, which are enough long distance apart from the data, to be the class centers for the first period. The main disadvantage of the K-mean program is the fact that the results weaken when there are many different variables. This is also a key reason why it was not selected for this research project. Also the fact that it was important to make sure the K-mean would not emerge, which would happen if there were many different kinds of clusters (Kohonen, Debeck, 1998). Some information would have been needed in advance; for example, the amount of clusters was not yet in known, made it clearer that this was not approachable in this research (Selkälä, 2013).

Probably the most important aspects of why the SOM method was chosen, was the fact that the amount of clusters were unknown in advance and for the good visualization expected (Länsiluoto, 2014). It appeared that the SOM method has not been as familiar in the field of accounting before as it has been in the field of engineering where it has been more commonly used. In accounting it has been used for example to measure socioeconomic data, measuring the economic situation of certain companies to predict bankruptcies, customer profiling, clustering nations according to their welfare and poverty (Länsiluoto, 2014).

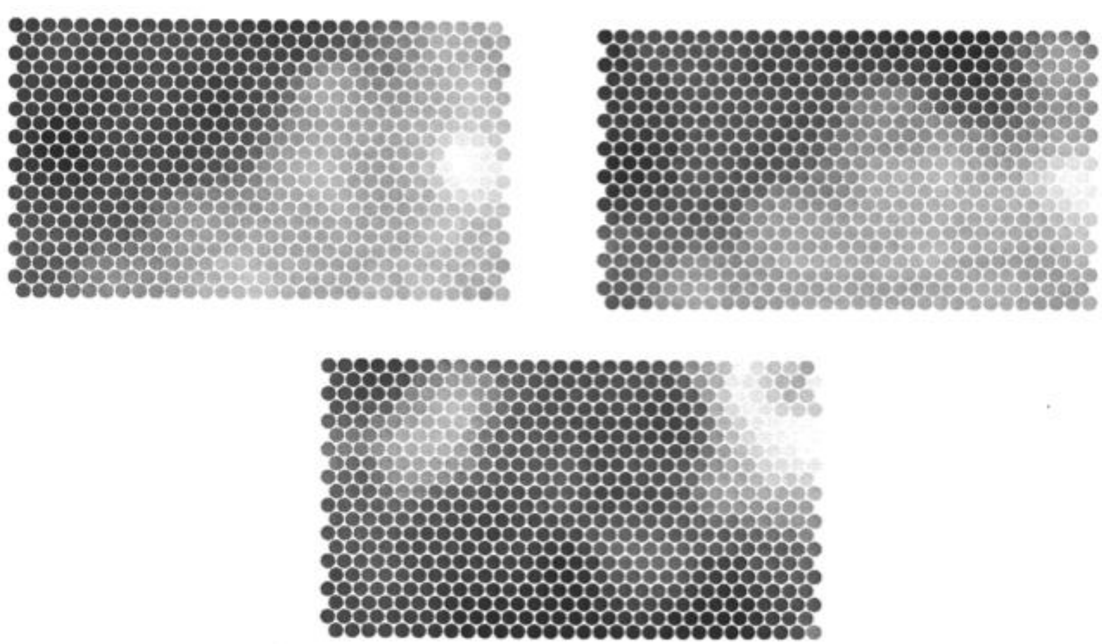

Figure 14. Self-Organizing Map. Source: Werner (2001)

6. HYPOTHESIS

In the beginning of this study the key elements, which were assumed to affect the DSO companies' profitability, are the network length, number of customers, the amount of annual electricity sales and the size of peak capacity. These are all elements which are related to the distribution of electricity but do not require a special source of energy. The first hypothesis will be followed by this.

H1: The number of customers and the length of transmission lines have an effect on the profitability of a DSO company and the unit cost of the transferred electricity.

The number of customers and the length of transmission lines are reflecting the population density of the company's geographical operational area and then have an effect on the distribution company's business operation. There may be differences between the DSO companies operating on the rural areas or on the area having big towns or cities. These factors affect also on the amount of electricity consumed and the peak capacity.

On the dense populated areas the effectiveness of a system should be higher compared to the rural areas with less dense population on larger areas providing services with lower unit costs while maintaining reasonable profit level.

H2: Using only a few energy sources risks the profitability of a company in the constantly changing energy market.

Weather conditions are a key player in the energy production both in Finland, in the Nordic countries and around the world. On a rainy year along with domestic production, it might be an affordable option for Finnish electricity production companies to buy more energy from Nord Pool Spot market because of the abundant amount of hydropower electricity and thus lower prices.

Another key factors affecting profitability are assumed to be the energy sources that the companies are using to produce electricity. Fossil fuels, nuclear power and renewable energy are the most commonly used sources. Electricity production with thermal power generation is possibly designed to use only certain fuels e.g. bituminous coal, natural gas or biomass etc. Due to market variations and changes in fuel prices, this may cause risks to the production costs. It is also possible for one company to produce energy with a combination of these fuels meaning that for example both fossil fuels and renewable energy can be used. If a company uses more than one source of energy to produce electricity, will it be enough to secure its profitability in the market?

H3: Diverse source including renewable energy will secure the profitability of a company

The proportion of different energy sources in the production structure have an effect on the profitability of the company. Various energy sources and ownerships in other energy companies spread the risks and then decreases financial risks. Those aspects will be analyzed in this study.

7. REVIEW OF THE SELECTED ELECTRICITY COMPANIES

This study will focus first on the selected electricity distribution companies and their parent companies. The companies are the distribution companies in various cities in Finland representing various company sizes and locations having also different production forms of electricity. The following companies will be analyzed: Helsingin Energia, Kuopion Energia Oy, Oulun Energia, Tampereen Sähkölaitos Oy, Vaasan Sähkö Oy, Seinäjoen Energia and Kotkan Energia. Kotkan Energia has not distribution system, only heat and power production and district heating operation.

7.1. Description of the selected companies

Helsingin Energia, Helen Oy

The company is located in Helsinki, the capital city of Finland and the share capital of the company is fully owned by the city. The main products of this company are the combined production of heat and power in power stations and the distribution to public and private customers. The main sources for electricity production are coal, natural gas, hydropower and ownerships in other production companies.

All businesses of Helsingin Energia were transferred at the end of the year 2014 to the company Helen Oy, which was formed to replace Helsingin Energia. The company structure in year 2012 is shown in the Figure 15.

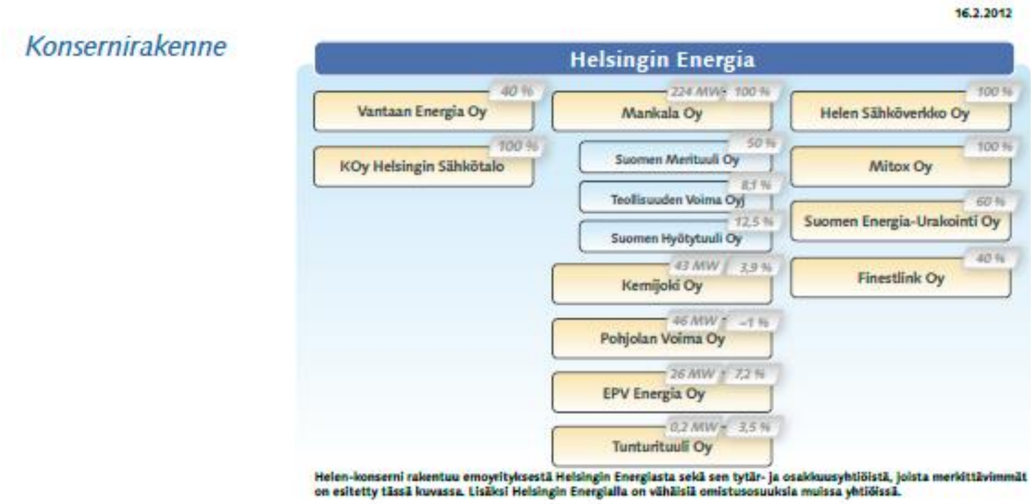

Figure 15. The structure of Helsingin Energia. Year 2012, Source: Annual report (2012).

The structure of Helsingin Energia including various ownerships in energy production companies and the number of own subsidiary companies are multiple as can be seen in the Figure 15. Helsingin Energia is the largest utility company in Finland owned by municipality and its electricity production capacity with own production and through ownership shares is the biggest.

The revenue in the year 2012 of the whole Helsingin Energia consisted of sales in electricity (41%), district heating (39%), electricity distribution (13%) and other income (7%). This is illustrated in the Figure 16.

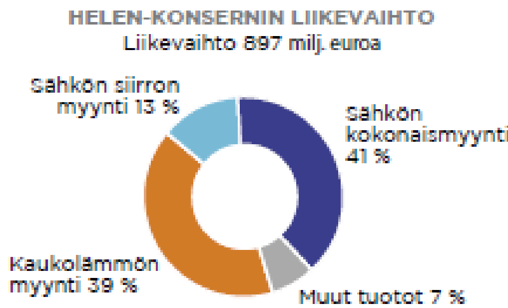

Figure 16. The revenue split of Helsingin Energia Concern in 2012. Source: Annual report (2012).

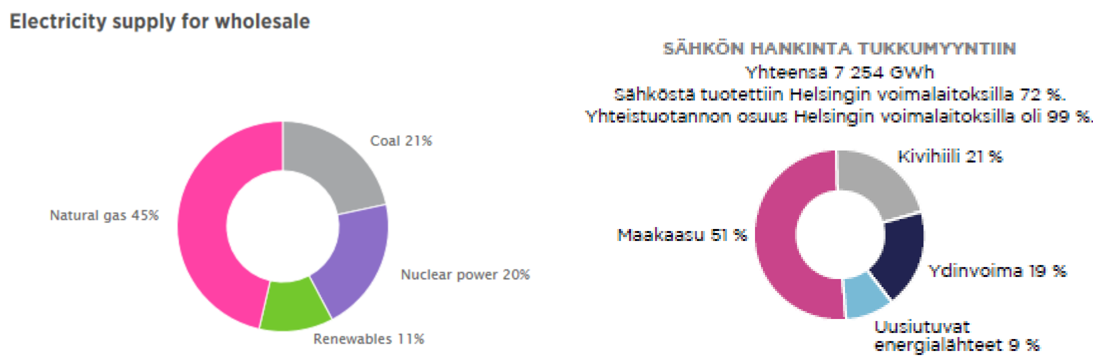

Figure 17. The origin of electricity for wholesale in Helen Oy. On the left year 2014 and on the right side year 2012. Source: Helen annual reports 2012 and 2014

The distribution company Helen Sähköverkko Oy is a subsidiary and is focused on the transmission and distribution of electricity in Helsinki area. It is completely owned by its parent company.

Kuopion Energia Oy

The company is located in central Finland and is owned by the city of Kuopio. Its focus is to produce electricity energy and district heating with combined heat and power in power stations. The main fuels in thermal power generation are peat and biomass. The company has one subsidiary, which concentrates on the distribution of energy. The utility has been divided in to two areas; the other is Kuopion Energia Oy having energy production consisting of electricity and district heat. The other part of utility consists of electricity distribution and district heating businesses. Those two sections form Kuopion Energia Liikelaitos. The structure is shown in Figure 18.

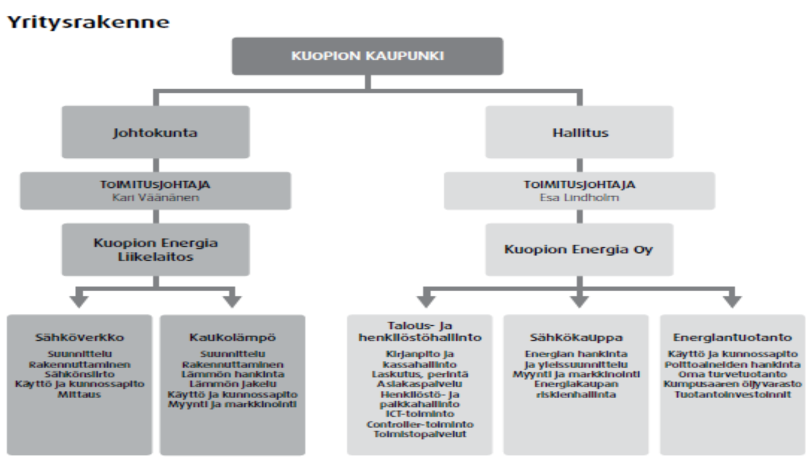

Figure 18. The structure of Kuopion Energia Oy. Source: Kuopion Energia Liikelaitos. Source: Annual report (2014).

The energy production and the fuel shares are shown in the Table 1.

Table 1. Energy production and fuel usage at Kuopion Energia CHP power plant Haapaniemi, Source: Annual report (2014).

The energy production and fuels usage at Haapaniemi power plant.				
Unit / Year	Unit	2014	2013	2012
Electricity production, back pressure	GWh	402	386	427
Electricity production, condensing	GWh	3	6	2
District heat production	GWh	933	923	999
Fuel consumption	GWh	1673	1702	1759
Fuel share of peat	%	43	52	62
Fuel share of biofuels	%	57	44	33
Fuel share of coal	%	0,1	2,5	3
Fuel share of oil	%	0,1	1,5	2

Oulun Energia Oy

Company is located on the western coast of Finland as well. In addition to the parent company, Oulun Energia Oy, the group consist of power sales company Oulun Sähkönmyynti Oy, network operator Oulun Energia Siirto ja Jakelu Oy, network construction company Oulun Energia Urakointi Oy and peat production company Turveruukki Oy. The parent company is owned by the city of Oulu, and the subsidiaries-with the exception of the Oulun Sähkönmyynti Oy for the electricity trade, of which Oulun Energia holds approximately 60,4%. Businesses were transferred from the public utility Oulun Energia to limited liability company Oulun Energia Oy at the beginning of the year 2014 (Oulun Energia Annual report, 2014).

The shares of various forms of electricity procurement and the shares of fuels used at Oulun Energia power plants are shown in the Figures 19 and 20. The shares of electricity purchased from markets is steadily increasing between 2011 and 2014 and at the same time the share of fossil fuel peat is decreasing while wood share is increasing.

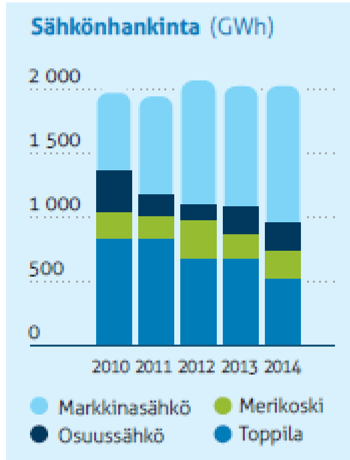

Figure 19. The shares of electricity procurement in the year 2010 – 2014. Merikoski hydropower, Toppila CHP plant, Shares from ownerships, purchased from markets. Source: Annual report (2014).

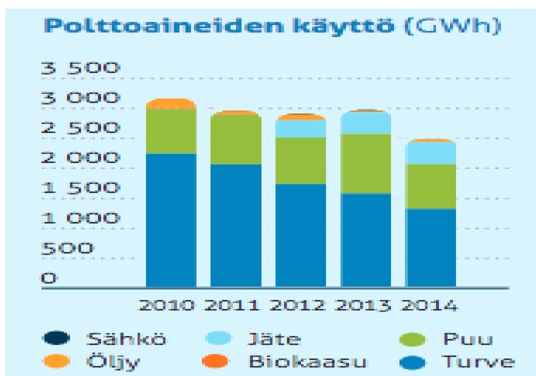

Figure 20. The origin of fuels used for electricity production in Oulun Energia power plants. Fuels peat, wood, waste, oil, biogas and electricity. Source: Oulun Energia annual report (2014.)

Tampereen Sähkölaitos Oy

The company is located in Southern Finland and it includes parent company with five subsidiaries. The main company is parent company for the subsidiaries the energy production, district heating, electricity sales, electricity network operation and electricity network construction company. The company delivers electricity, district heating, cooling, and natural gas to both public and private customers in its operating area. Fuel sources in own production are mainly natural gas, peat, biomass and some hydropower.

The organization chart is shown in the Figure 6.

The main sources of energy that were used in the years 2012/2014 are natural gas 72/ 64 %, wood fuels 12/ 17 % and peat 15/ 14 %. Figure 21. The share of natural gas is decreasing while wood fuel share and wind energy shares are increasing.

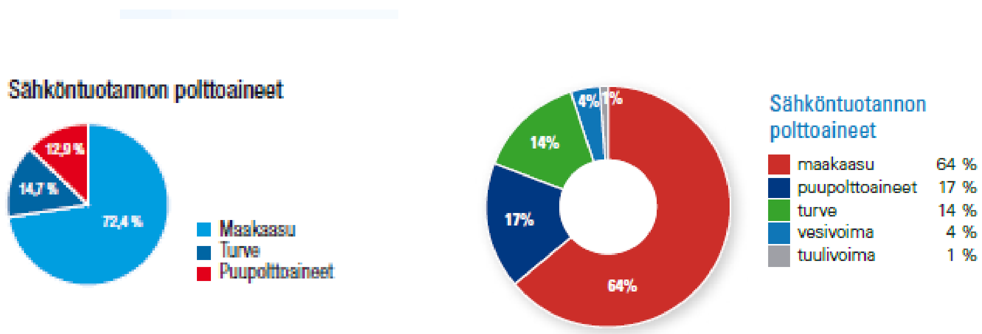

Figure 21. The fuels/origins shares of electricity production in Tampereen Sähkölaitos, Fuels: natural gas, wood, peat, hydropower, wind. Source: Tampereen Sähkölaitos Annual reports (2012 and 2014).

Vaasan Sähkö Oy

The company is located in the western coast of Finland. The parent company has three subsidiaries operating in the same area as the parent company. Most of the energy is produced through ownerships in various production companies having very diversified energy sources. The shares in EPV Energia Oy and its ownerships in various other electricity generation companies form solid basis for Vaasan Sähkö Oy’s electricity supply, Figure 22. Electricity production in own power plant is in minor role. In ownership 99, 9 percentages of the share capital of this company is owned by the city of Vaasa.

Vaasan Sähköverkko Oy is a subsidiary of Vaasan Sähkö Oy and it is owned by its parent company. Its key responsibilities are the transmission and distribution of electricity.

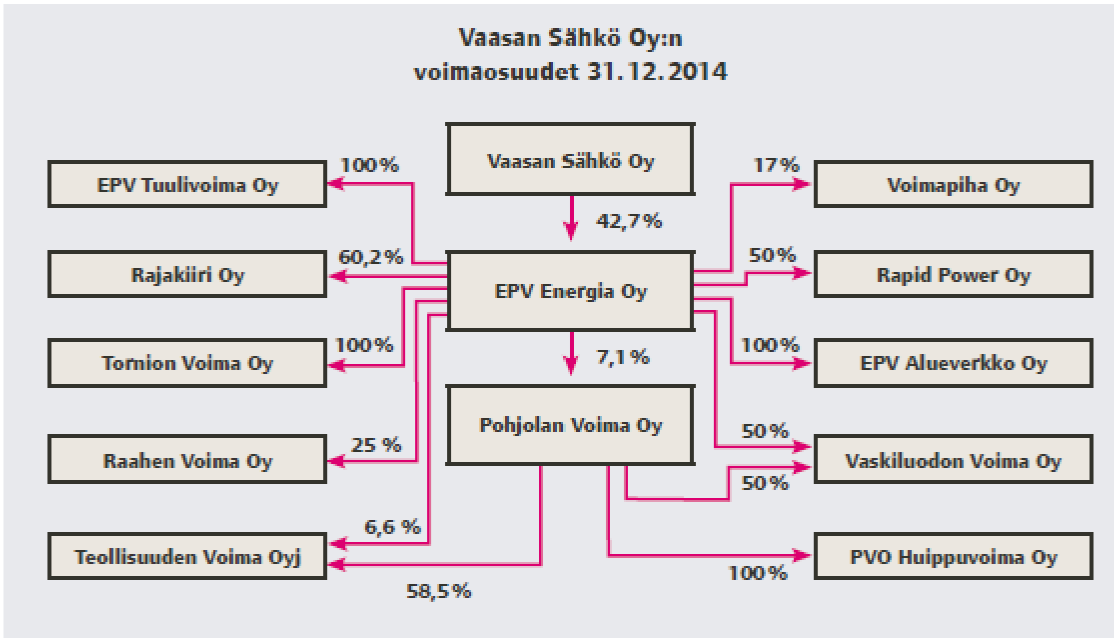

Figure 22. The ownership shares of Vaasan Sähkö Oy in various electricity companies. Source: Annual report (2014).

Vaasan Sähkö Oy has a wide variety of fuels and energy sources in electricity production through ownerships. Additional purchasing from markets is securing cost efficiency in business, Figure 23.

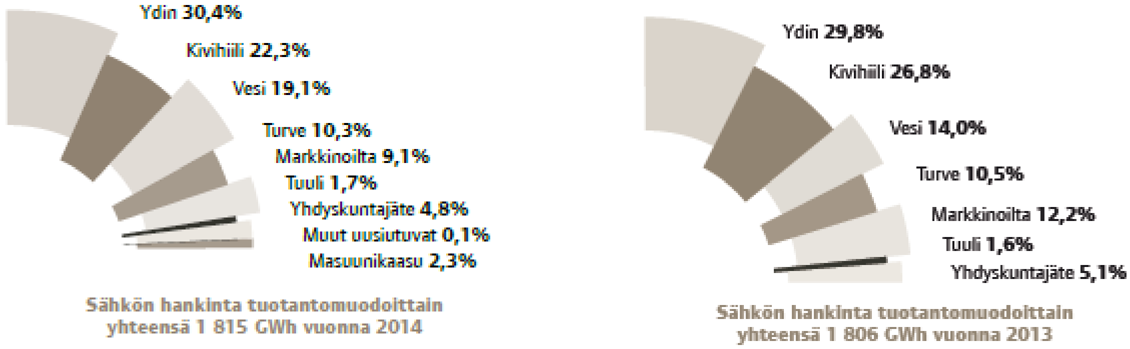

Figure 23. The shares in electricity supply of various fuels including purchasing from markets in Vaasan Sähkö. Source: Annual report (2013 and 2014).

Seinäjoen Energia Oy

The company is located in the Southern Ostrobothnia of Finland and it consists of Seinäjoen Energia Oy, Seiverkot Oy and Seinäjoen Vesi Oy, which all are owned by the city of Seinäjoki. The businesses of parent company are energy production, electricity network operation (Seiverkot Oy), water business (Seinäjoen Vesi Oy), district heat and electricity businesses. The company structure is shown in Figure 24.

Figure 24. The structure of Seinäjoen Energia Oy. Source: Annual report (2014).

Seinäjoen Energia is a substantial share owner in EPV Energia Oy, which has large ownerships in various energy production companies and which delivers electricity to its shareowners. The majority of Seinäjoen Energia's electricity is supplied by EPV Energia and the sources of its electricity production are shown in Figure 25.

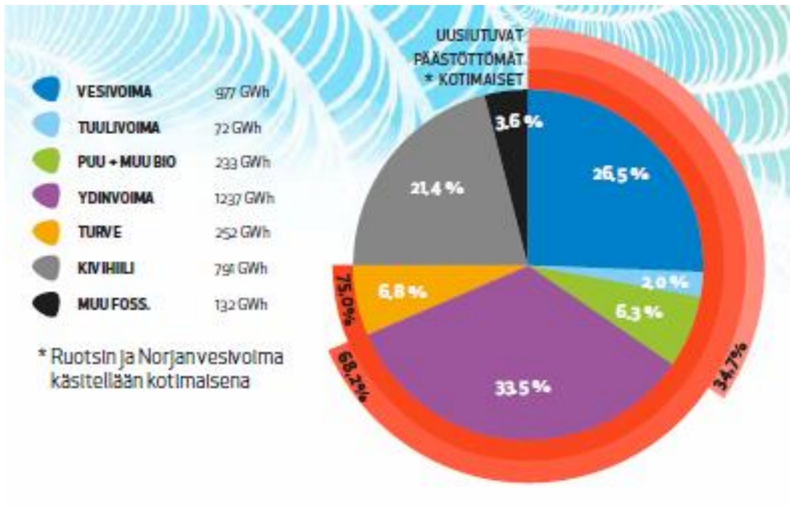

Figure 25. The electricity production shares in EPV Energia. Source: Annual report (2013).

Kotkan Energia Oy

Kotkan Energia Oy is a production company in the city of Kotka and the company is owned by the city. The company has power plants for electricity and district heating production and the business covers district heating network and its operation. Energy sales are divided in to three categories, district heat, process steam and electricity sales as shown in the Figure 26. Kotkan Energia has no other business functions.

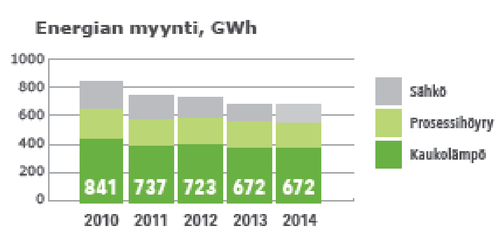

Figure 26. The shares of different energy sales, electricity in Kotkan Energia. Source: Annual report (2014).

The shares of biofuels and waste have increased at Kotkan Energia since 2010 as shown in Figure 27.

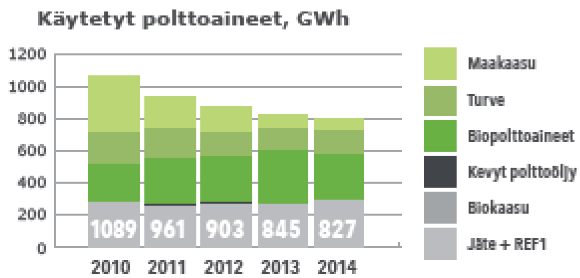

Figure 27. The shares of different fuels in Kotkan Energia between the years 2010 - 2014. Fuels natural gas, peat, bio, oil biogas and waste. Source: Annual report (2014).

The second part of this study contains analysis of the selected electricity producing companies which were mentioned above. The aim is to look at the key factors affecting the profitability of these companies with the original source of energy as the key point. The companies which have been chosen for this study, are electricity producing companies that are located around Finland. The main idea has been to select companies from different geographical areas, different sizes, different company structures and different kinds of energy sources.

8. RESULTS AND EVALUATION OF THE COMPANIES

8.1. Introduction for the DSO evaluation

In the beginning of this study, there were prior assumptions of the key factors, which would have the biggest effect on the profitability of the distribution companies. The key elements were expected to be the network length, number of customers, amount of transmitted electricity and size of peak capacity all those describing the size of the company.

Pearson Correlation calculation is made for all of the electricity distribution companies listed by the Energy Authority for the years 2011, 2012, 2013 and 2014. Only few companies with insufficient information were left out from this evaluation. Information is publicly available at the Energy Authority data base systems. The number of the companies varies on an annual basis and is around 80 during this evaluation period. This study focuses on analyzing the profitability factors of the companies, the year 2012 was selected for detailed evaluation, and other evaluation years will be compared to year 2012.

8.2. The DSO company evaluation for the year 2012

First, all of the chosen companies with sufficient information in the database will be studied, then the 30 largest and then the 30 smallest companies according to revenue will be taken separately under closer evaluation in order to find out the possible differences based on the company sizes.

The key variables, which were assumed to correlate with the profitability of the companies, were the revenue, the total number of end users and the length of the grid. The amount of users and the length of the grid were chosen as variables because they would express the geographical area of the distribution companies and how it affects the profitability. The variables, which have been chosen for this study are revenue, profit or loss before the appropriations and taxes, the amount of electricity transmitted to end users (GWh) describing the volume of operations, total length of grid (km), largest hourly electricity capacity (MW) describing the size of the user's momentary electricity needs, total number of users by voltage levels, return of equity for network operations and the cost for DSO per each transmitted energy unit (Eurocent/kWh) describing the cost structure and effectiveness of the company and having linkage to the charged price from the customers per electricity unit. The table of DSO companies including selected data is in appendix 1.

Table 2. Year 2012, Correlations of all DSO companies for selected variables.

Year 2012, 84 DSO Companies	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GWh	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Revenue, 1000€	1,000								
Profit before extraordinary items %	0,390	1,000							
Profit before appropriations and taxes %	0,266	0,726	1,000						
The amount of electricity transmitted to end-users, GWh	0,978	0,396	0,263	1,000					
Total length of grids, km	0,937	0,346	0,250	0,861	1,000				
Largest hourly electricity capacity, MW	0,971	0,350	0,255	0,981	0,890	1,000			
Total number of users by voltage levels	0,969	0,405	0,257	0,988	0,832	0,950	1,000		
Return on equity for network operations	0,147	0,188	0,007	0,092	0,178	0,084	0,123	1,000	
Costs of DSO operation per each transmitted energy unit, cent/kWh	-0,164	-0,437	-0,313	-0,269	-0,049	-0,206	-0,253	0,099	1,000

Key findings in the correlation analysis off all 84 DSO companies as shown in the table 2: All variables clearly correlate well with the revenue, profit, the electricity amount and capacity and except return of equity and cost per each kWh. The correlation between profit and total length of the grids and the number of users is substantial. The cost per transmitted kWh is negatively correlating with other variables describing that the volume of operation, i.e. the size of the company will produce lower unit cost when the cost/ kWh decreases by the increase in the size of the business, called the economy of scale. The return of equity correlates weakly with other variables.

Table 3. The correlations of 30 largest DSO companies based on the revenue in 2012.

Year 2012, 30 Largest DSO Companies	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GWh	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Revenue, 1000€	1,000								
Profit before extraordinary items %	0,425	1,000							
Profit before appropriations and taxes %	0,507	0,546	1,000						
The amount of electricity transmitted to end-users, GWh	0,970	0,432	0,511	1,000					
Total length of grids, km	0,927	0,397	0,472	0,831	1,000				
Largest hourly electricity capacity, MW	0,963	0,367	0,479	0,978	0,865	1,000			
Total number of users by voltage levels	0,958	0,448	0,513	0,984	0,794	0,937	1,000		
Return on equity for network operations	-0,076	-0,105	-0,197	-0,158	0,017	-0,135	-0,126	1,000	
Costs of DSO operation per each transmitted energy unit, cent/kWh	-0,109	-0,426	-0,240	-0,287	0,029	-0,191	-0,266	0,430	1,000

The main interest is to find possible differences in the correlation analysis between all and the 30 largest DSO companies.

Key findings in the 30 largest DSO companies compared to all company groups shown in the table 3 are as follows. There is a stronger correlation between revenue and profit before appropriations and taxes meaning that there is higher profit in larger size companies. There is also a stronger correlation between profit and the amount of electricity transmitted which means that bigger volumes result in better profits and stronger correlation between profit and total length of grids and number of users than in the group of all companies. There is a weaker, even negative correlation between revenue, profit versus return of equity. This means that the bigger the company is, the lower the return of equity is. There is the same level of correlation factor between the revenue, profit and the cost of electricity unit transmitted.

Table 4. The correlations of the 30 smallest DSO companies in 2012 based on the revenue.

Year 2012, 30 smallest DSO Companies	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GWh	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Revenue, 1000€	1,000								
Profit before extraordinary items %	0,218	1,000							
Profit before appropriations and taxes %	0,353	0,849	1,000						
The amount of electricity transmitted to end-users, GWh	0,881	0,063	0,235	1,000					
Total length of grids, km	0,301	-0,001	-0,133	0,183	1,000				
Largest hourly electricity capacity, MW	0,884	0,041	0,114	0,894	0,361	1,000			
Total number of users by voltage levels	0,758	0,176	0,051	0,624	0,575	0,821	1,000		
Return on equity for network operations	0,120	0,528	0,453	0,039	-0,050	0,152	0,134	1,000	
Costs of DSO operation per each transmitted energy unit, cent/kWh	-0,166	-0,316	-0,353	-0,416	0,418	-0,304	-0,031	-0,237	1,000

Key findings in the 30 smallest DSO companies as shown in the table 4 compared to all or the 30 largest companies are as follows. The correlation between the revenue and profit before extraordinary items is lower compared to the other groups. In addition, the correlation between the profit and the amount of the transmitted electricity is very low which means that the volume does not secure the profit.

Correlations between profit and grid length, largest capacity and number of customers are very low compared to the two other groups. The group of small companies is heterogeneous by nature and the companies are different which explains this result. The correlation between the length of grid and the cost of electricity transmitted is strong which describes the wide geographical area and smaller population on the served area. The correlation between the revenue profits and unit costs is more negative describing higher unit costs due to the smaller business units and wider operation areas.

From the correlation analysis of the year 2012 DSO companies' performance can be noted that the profit is correlating with the number of users and grid lengths in the group of all DSO companies and among 30 largest companies. However, in the group of 30 smallest DSO companies the correlation between these parameters is very small. The correlation between profit and unit cost has negative values showing that with higher profit there is lower unit cost. This correlation is weaker in the small company group.

In the evaluation of large company group the return of equity had a slight negative correlation to all the main variables used in the analysis. This means that the large size of the company is not giving better return of equity. This was not the case with smallest companies, in which group return for equity was positively correlating with the size and the volume of the company.

In the smaller size group the grid length has positive correlation to unit cost, i.e. increasing unit cost. In the larger company group the grid length has neutral correlation to cost, i.e. no affect. In practice this means moderate grid lengths with large number of customers.

Smaller companies are serving in rural areas on the larger geographical areas having longer grids causing higher cost structures and thus higher unit costs.

8.3. Comparison of the results of the year 2012 to the other years' in evaluation.

The years 2011, 2013 and 2014 were also analyzed using the same correlation methods for all listed DSO companies and the 30 largest and 30 smallest companies were analyzed separately and the results are explained in the following chapters.

Based on the correlation analysis it can be found out that the year 2011 is similar in all comparison groups compared to the year 2012. There is a bigger change in the results of the year 2013 compared to 2012. Key finding is that the profit has neutral or even small negative correlation with size of the company by revenue, transmission volume and other indicative variables. It especially indicates that the larger companies profit percentage has decreased compared to 2012. The profit percentage is higher in the lower volume companies. In the smaller company group, this was not the case and they were maintaining their performance and profit level more stable than larger companies were.

In the year 2014 the correlation analysis reveals that also the same phenomena continued and in the range of smaller company group. It means that the performance and the profit of the companies varied more regardless of the size of the company.

The parameters in the Hypothesis 1, the profit dependence on the length of the grid and number of users and the profit vs. the costs per unit of transmitted electricity and their correlations will be presented in the table 5.

Table 5. The correlations between the profit before extraordinary items, the length of the grids, the number of users and the unit costs for the years 2011 – 2014 in different company categories.

	Year 2011			Year 2012			Year 2013			Year 2014		
Correlations between profit and grid length, number of users and unit costs	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.
Profit before extraordinary items	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Total length of grids	0,163	0,182	0,102	0,346	0,397	-0,001	-0,062	-0,264	0.232	-0,085	-0,229	0,030
Total number of users by voltage levels	0,272	0,358	0,165	0,405	0,448	0,176	0,007	-0,216	0,332	-0,095	-0,301	-0,096
Cost of DSO operation per each transmitted energy unit, € cent/ kWh	-0,422	-0,503	-0,483	-0,437	-0,426	-0,316	-0,346	-0,402	-0,233	-0,160	-0,154	0,011

It can be noted that the profit correlates with the length of the grid and the number of users strongest in the year 2012 in the group the 30 largest companies informing that wider service area with a large number of users are positively connected to profit. In the years 2013 and 2014 this correlation is slightly negative informing that the bigger the profit is, the smaller the length and number of customers are especially in the group of the 30 largest companies.

The correlation between the profit and unit cost is quite stable in the years 2011, 2012 and 2013 informing that the bigger the profits are, the lower the unit costs are especially in the group of the 30 largest companies. However, in the year 2014 there is a substantial change in the group of all companies and the correlation decreases substantially informing that the most profitable companies are not having lowest cost per electricity unit transmitted.

Table 6. The correlations between the length of the grid and the unit costs and the correlation between the number of users and the unit costs for the years 2011 – 2014 in different company categories.

	Year 2011			Year 2012			Year 2013			Year 2014		
Correlations between the grid length, number of customers and the unit costs	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.	All DSO companies	30 Largest DSO comp.	30 Smallest DSO comp.
The grid length	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Cost of DSO operation per each transmitted energy unit, € cent/ kWh	-0,063	-0,080	0,196	-0,049	0,029	0,418	0,070	0,155	-0,219	0,126	0,284	0,440
Number of users by voltage levels	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Cost of DSO operation per each transmitted energy unit, € cent/ kWh	-0,203	-0,315	-0,012	-0,253	-0,266	-0,031	-0,077	-0,037	-0,297	-0,086	-0,015	-0,106

It can be noted from the table 6 that the grid length and unit cost correlates only in the category 30 smallest DSO companies in the years 2012 and 2014 informing that small DSO companies are mostly locating on the rural areas having long distribution grid in ratio to company business size causing higher unit costs. The year 2013 is an exception having a negative correlation meaning that the longer the grid length is, the lower the unit cost is.

Other correlation evaluation is the number of users vs. the unit costs. The ratio is typically negative informing that the higher the number of users (customers) is, the lower the unit cost is. This is the case in the years 2011 and 2012 with group of large companies, in the group of 30 smallest DSO companies correlation is small. In the year 2014 the situation changed and the correlation is very weak in all categories.

8.4. Other notes from the DSO company comparisons

The statistics and yearly financial analysis also reveal that there are differences between the reported unit costs/ kWh and profits. The following figures are from the year 2012.

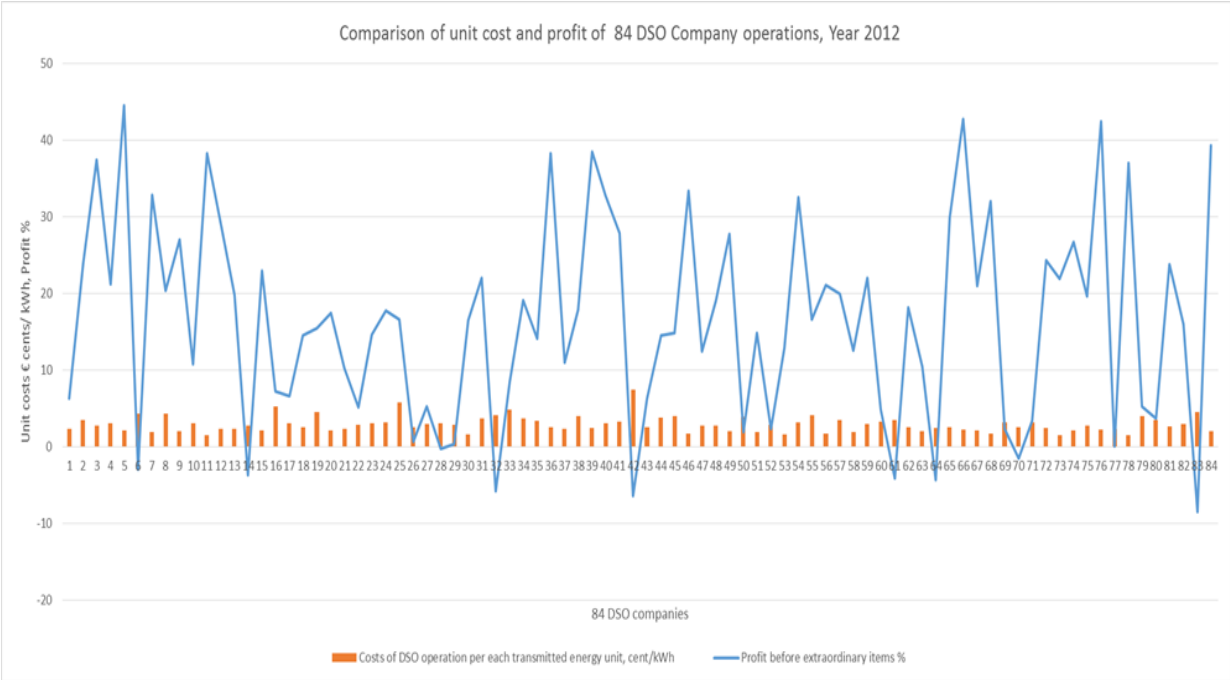

Figure 28. Comparison of profit and unit costs/kWh. All DSO companies in 2012.

In the group of all DSO companies the variations between profit percentage and unit costs are wider when compared to the group of the 30 largest companies.

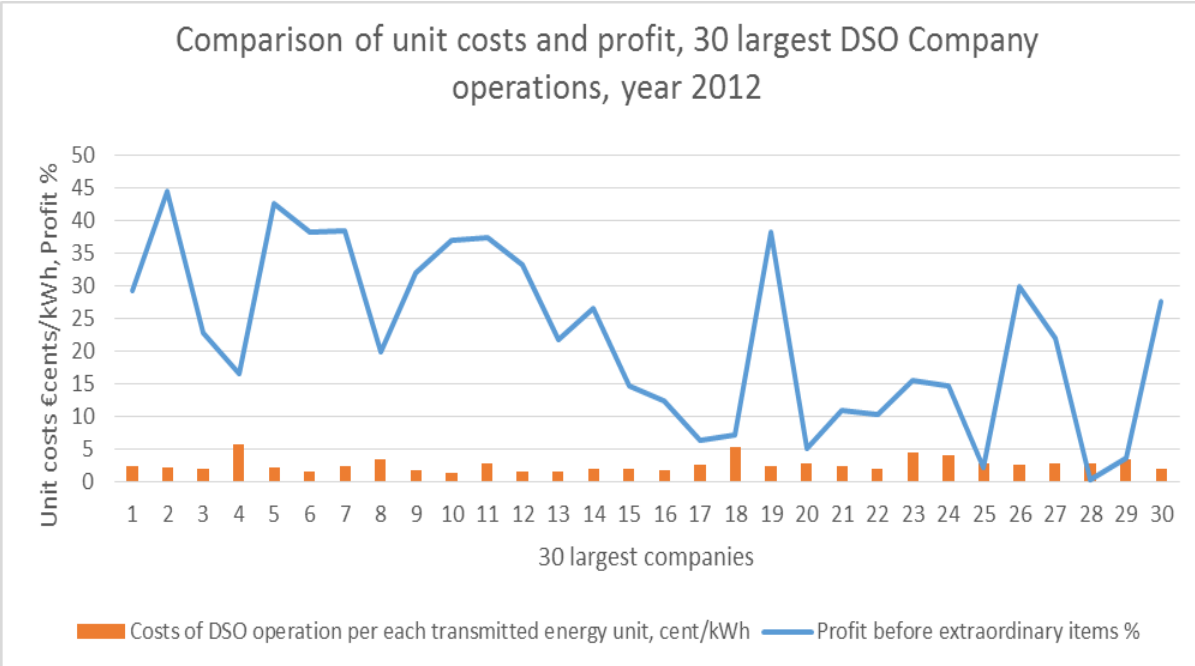

Figure 29. Comparison of profit and unit costs/kWh. The 30 largest DSO companies in year 2012.

In the group of 30 largest DSO companies the profit percentage is better and all positive compared to the 30 smallest company group, however the variation range profit is between 0 and 45% when in the group of small companies profit variation range is between -8 and 28%. In addition, the unit cost level is lower in the group of large companies showing the economics of scale benefit.

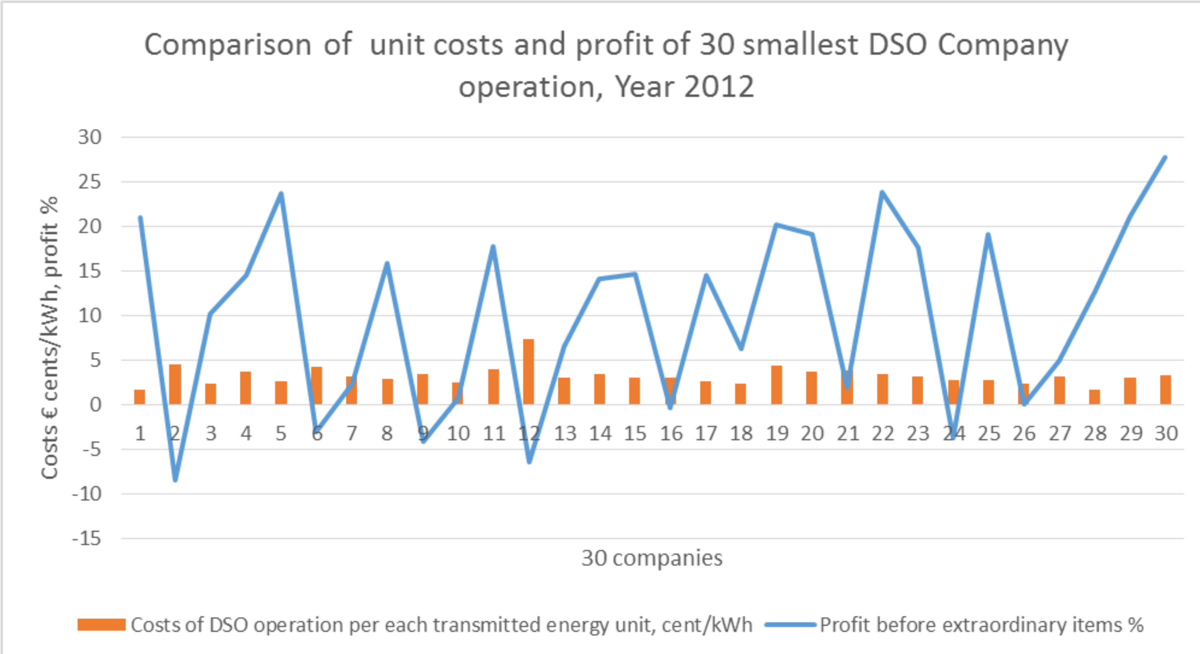

Figure 30. Comparison of the profit and unit costs/kWh. The 30 smallest DSO companies in year 2012.

8.5. Self-organizing Maps (SOM)

Self-organizing Maps analysis was done by using Matlab Neural Clustering application software, version R2015A. Input data were the same DSO company table consisting of all year 2012 companies and data as in DSO company correlation study. The result of SOM analysis is that there is one large cluster of DSO companies and two smaller clusters and some minor individual groups. The result reflects the large group of existing medium size companies, some very large companies and very small companies and single other companies. The SOM analysis illustration is in Figure 31.

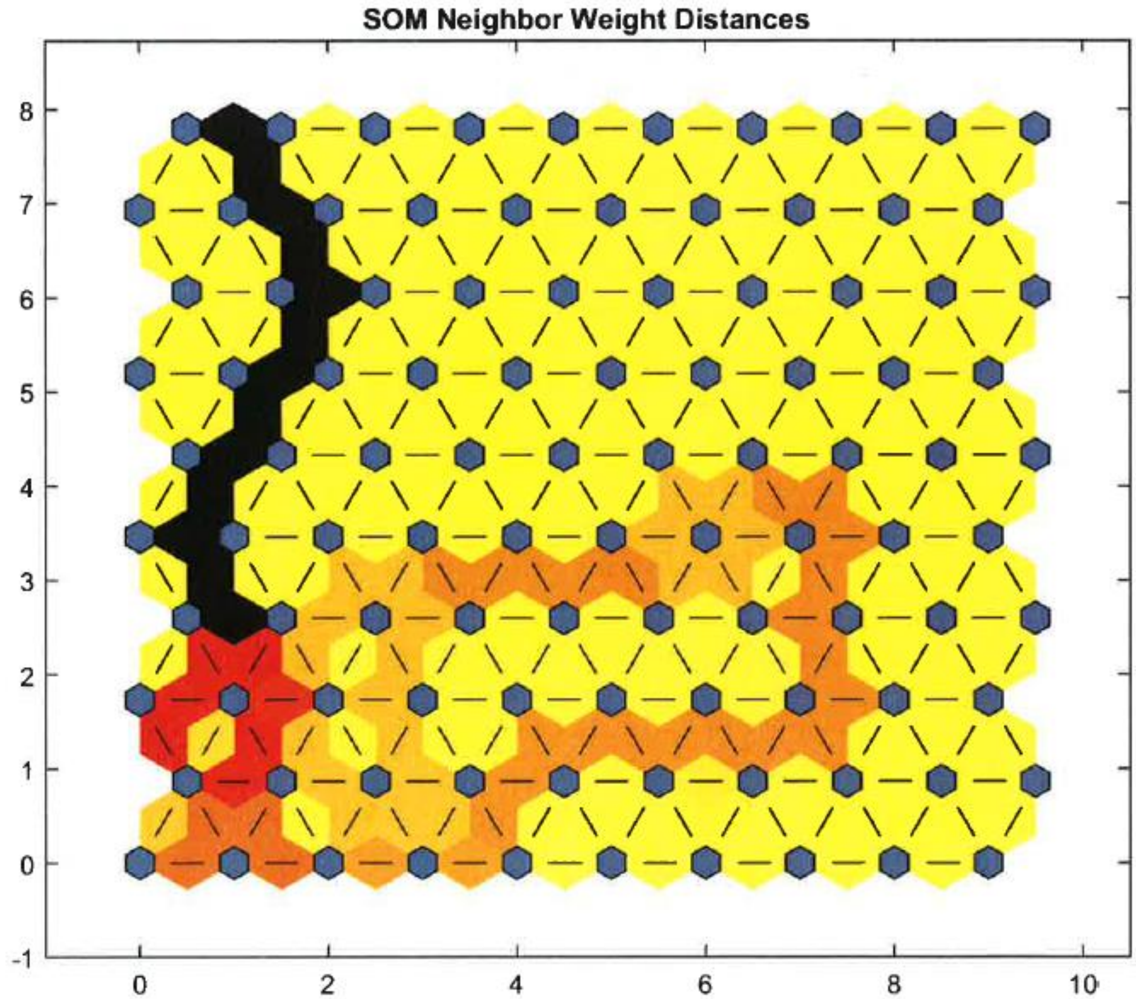

Figure 31. The SOM –method illustration of clusters among all DSO companies, Matlab-analysis.

8.6. Conclusion of the DSO company business performance

The variations between the business performances of companies are significant. One result is the clear correlation between the company size as revenue, the profit and the costs /kWh. The larger the company is, the steadier is the profit and the lower are the specific unit costs/ kWh transmitted energy.

In the hypothesis 1 (H1), claim 1, the number of customers and the length of the transmission grid were claimed to have affect to the profitability of the DSO company and the unit costs of the electricity.

The length and the number of customers: Only in the year 2012 the correlations between profit and grid length and number of customers is strong in the group of all companies and in the group of 30 largest companies. In the years 2013 and 2014, those correlations were changing substantially informing that the most profitable companies have shorter grid length and lower number of customers in the group of 30 largest companies. In the group of all companies the correlations are weak.

The hypothesis H1, claim 1 is false.

In the hypothesis 1 (H1), claim 2, the number of customers and the length of transmission grid were claimed to have an effect to the unit costs: It can be stated that in the group of 30 smallest DSO there is strong correlations between the length and costs in the years 2012 and 2014. This was not the case in other groups. The correlations between the numbers of customers vs. unit costs was negative in the group of 30 largest companies describing that the number of customers/volume gives lower unit costs.

The hypothesis H1, claim 2 is true.

8.7. The financial results and evaluation of selected electricity companies

The second part of this study is an analysis about the profitability factors of six electricity companies in Finland. The companies are Vaasan Sähkö Oy, Oulun Energia Oy, Tampereen Sähkölaitos Oy, Kuopion Energia Oy, Kotkan Energia Oy and Helsingin Energia Oy. The analysis was done by collecting the key figures as profit before extraordinary items, earnings before interest taxation, depreciation and amortization (Ebitda) (Investopedia, 2014) from years 2011, 2012, 2013 and 2014. After this, the analysis regarding the original energy sources for electricity production were collected and analyzed.

All the information was gathered from the annual reports of these specific companies. The main company and concern level financial information was available but specific electricity business related detailed information was available only for some companies.

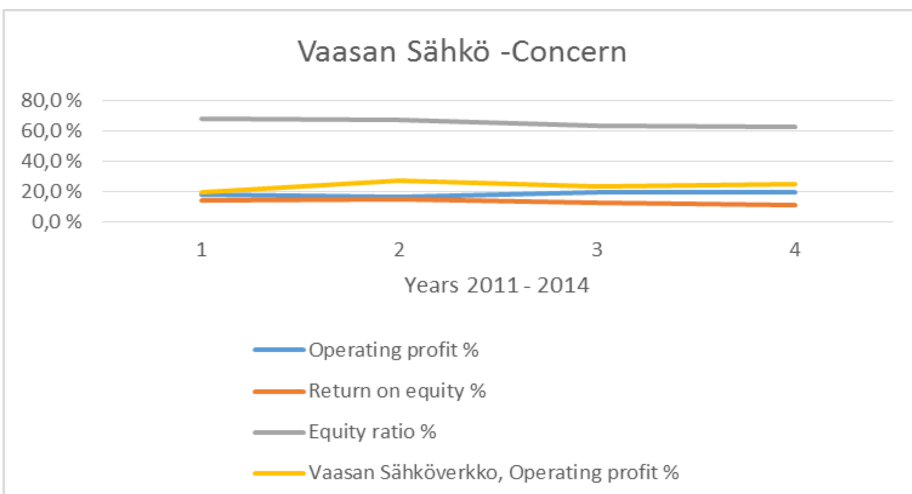

Figure 32. Vaasan Sähkö –Concern financials

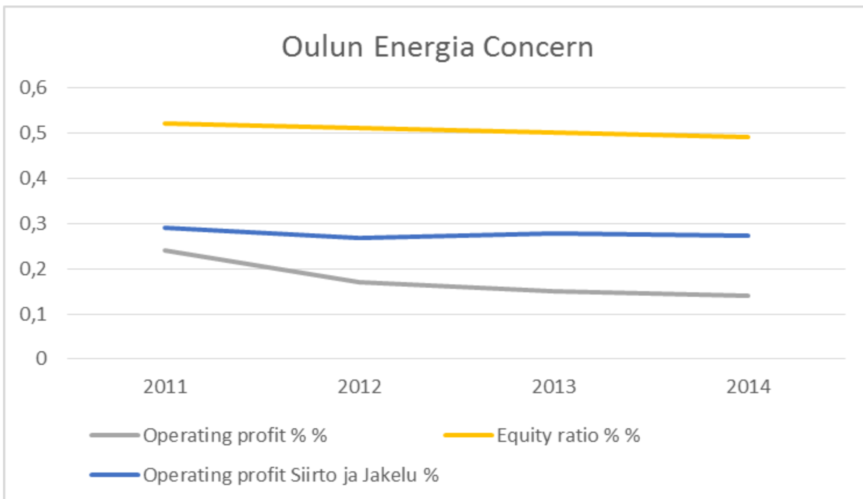

Figure 33. Oulun Energia financials

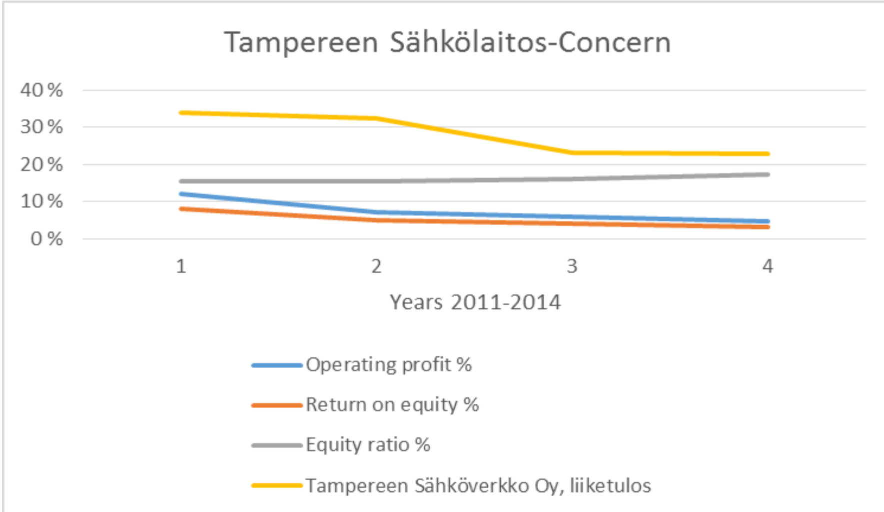

Figure 34. Tampereen Sähkölaitos Oy financials

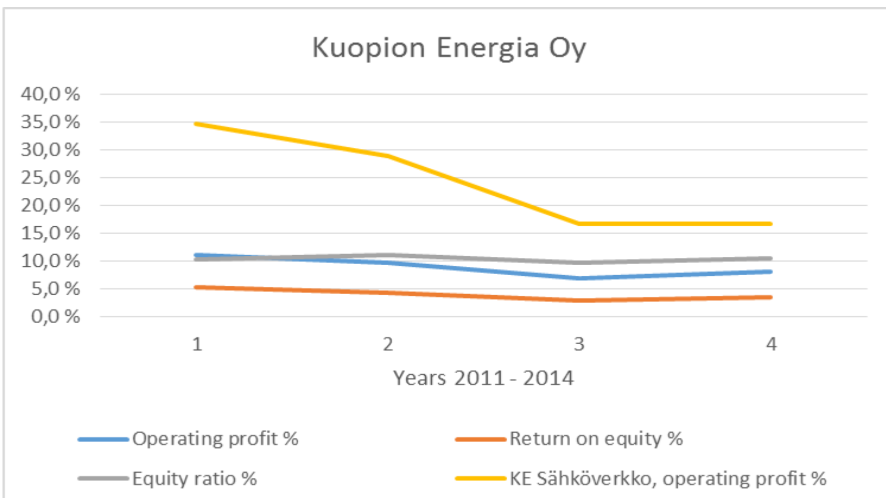

Figure 35. Kuopion Energia Oy- financials

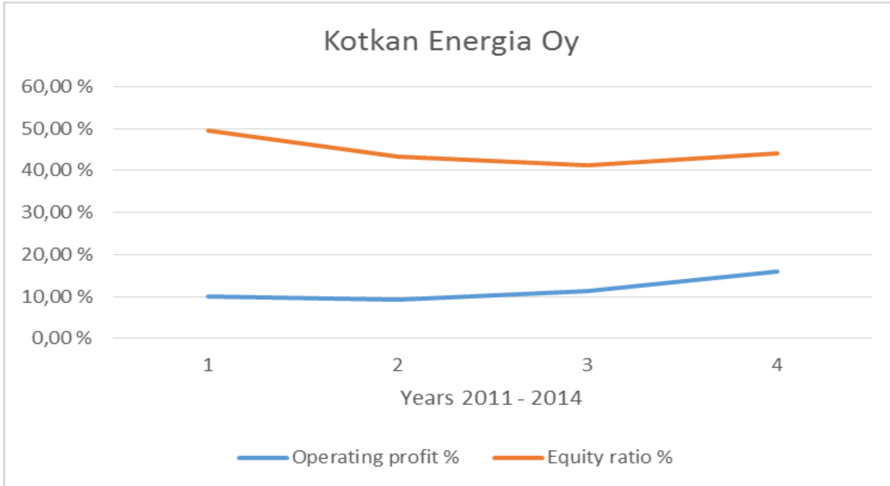

Figure 36. Kotkan Energia Oy - financials

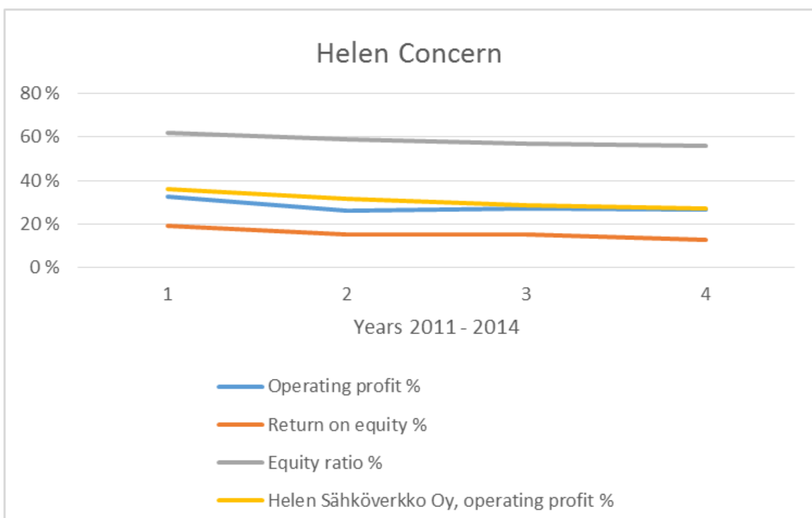

Figure 37. Helen Oy - financials

The conclusion for the financial evaluation of selected electricity companies and their DSO operation business confirms that the operation profit for DSO operations are on the steady good level, however there are variations between the years during the analysis period.

8.8. The analysis of the electricity companies' business performance in relation to the origin of electricity

The target was to study if the electricity origins have an effect on the financial performance of the electricity company. This analysis was done for seven companies described earlier. The grouping for electricity origin was done into seven groups: Hydro, biomass and wind, nuclear, natural gas, other fossil fuels, total share of own production including ownership shares and electricity purchased from markets. This electricity origin grouping reflects the origin portfolio of selected electricity company in this analysis. Five financial topics were taken into analysis; profit before taxes and extraordinary items of electricity and heat sales, operating profit of electricity and heat sales, the concern company profit before taxes and extraordinary items, the operating profit of the concern company and the revenue of the concern company. Elspot average area price annually in Finland calculated from the hourly average prices was included as a one possible affecting factor.

The analysis was done using Pearson correlation methods and analyzing tool Microsoft Excel-program with data analysis program.

The difficulty and challenge in studying the financial performance was in getting proper, comparable data of the electricity sales business performance from the companies. There is strong competition between the companies to sell electricity and therefore the information related to own production, purchased electricity, costs and sales income, are sensitive information and therefore challenging or impossible to find from the public documents like annual reports. Therefore some assumptions have been made in the evaluations between the companies in order to study the differences. Some companies are informing financial performance of electricity and heat sales as a sum of those businesses. The pure electricity sales profit was published only by Vaasan Sähkö Oy and Oulun Energia Oy.

Also there are different practices between the companies to publish the electricity origin data and some assumption was also done to form electricity origin tables. The origin of electricity sold had two forms in information distribution, for the wholesales and for the consumer sales. The wholesale electricity origin describes the original production forms of companies and it was used in electricity origin analysis. However, the missing exact origin knowledge for the comparison leaves some uncertainty for the analysis results. The same uncertainty relates to missing exact information of electricity sales and its financial performance as well.

The energy sources and shares of the selected electricity producing companies are shown in the table 7. In the Table 8 are shown additionally the operating profits for the combined electricity and heat sales and the profits of concern companies.

Table 7. The energy sources of the selected electricity producing companies.

	Year	Share of Hydro %	Share of Biomass and wind %	Share of Nuclear %	Share of Natural gas %	Share of other fossil fuels (coal and peat) %	Share of own production and ownership shares %	Share of Purchased from markets %
Vaasan Sähkö	**2014**	19,1	6,6	30,4	0	34,8	90,9	9,1
Vaasan Sähkö	**2013**	14,0	6,7	29,8	0	37,3	87,8	12,2
Vaasan Sähkö	**2012**	13,3	2,9	28,6	0	24,9	69,7	30,3
Vaasan Sähkö	**2011**	9,5	1,5	28,9	0	32,8	72,7	27,3
Helsingin Energia	**2014**	11	0	21	46	22	100	0
Helsingin Energia	**2013**	10	0	20	49	21	100	0
Helsingin Energia	**2012**	9	0	19	51	21	100	0
Helsingin Energia	**2011**	8	0	20	51	21	100	0
Tampereen Sähkölaitos	**2014**	4,0	18	0	64	14	100	0
Tampereen Sähkölaitos	**2013**	5,0	13	0	74	8	100	0
Tampereen Sähkölaitos	**2012**	7,0	12	0	67	14	100	0
Tampereen Sähkölaitos	**2011**	4,0	10	0	73	13	100	0
Oulun Energia	**2014**	11,3	11,9	11,3	0	13	47,5	52,5
Oulun Energia	**2013**	9,8	12,6	9,8	0	19	51,2	48,8
Oulun Energia	**2012**	9,8	16,5	9,8	0	20	56,1	43,9
Oulun Energia	**2011**	8,0	13,7	9,2	0	29,1	60	40
Kotkan Energia	**2014**	0,0	54	0	0	46	100	0
Kotkan Energia	**2013**	0,0	57	0	0	43	100	0
Kotkan Energia	**2012**	0,0	48	0	0	52	100	0
Kotkan Energia	**2011**	0,0	44	0	0	56	100	0
Kuopion Energia	**2014**	0,0	34,3	0	0	25,8	60,1	39,9
Kuopion Energia	**2013**	0,0	27,7	0	0	35,2	62,9	37,1
Kuopion Energia	**2012**	0,0	20,6	0	0	41,7	62,3	37,7
Kuopion Energia	**2011**	0,0	10,4	0	0	39,2	49,6	50,4
Seinäjoen Energia	**2014**	28,3	23,2	28,3	0	26,7	96,5	3,5
Seinäjoen Energia	**2013**	28,1	19,7	28,1	0	31,9	97,8	2,2
Seinäjoen Energia	**2012**	27,4	17,8	27,4	0	21,3	93,9	6,1
Seinäjoen Energia	**2011**	20,7	7,8	20,7	0	20	69,2	30,8

Table 8. The net sales, operating profits and energy sources of the selected electricity producing companies.

	Year	The Concern company, Net sales M€	The Concern Company, operating profit %	The Concern Company, profit before taxes and extraordinary items %	Electricity and heat sales, operating profit %	Electricity and heat sales, profit before taxes and extraordin. items %	Share of Hydro %	Share of Biomass and wind %	Share of Nuclear %	Share of Natural gas %	Share of other fossil fuels (coal and peat) %	Share of own production and ownership shares %	Share of Purchased from markets %	ELSpot, average area price in Finland €MWh
Vaasan Sähkö Concern	2014	141,64	19,7	19,9	15,8	15,7	19,1	6,6	30,4	0	34,8	90,9	9,1	36,02
Vaasan Sähkö Concern	2013	149,28	19,5	18,9	15,3	14,5	14,0	6,7	29,8	0	37,3	87,8	12,2	41,16
Vaasan Sähkö Concern	2012	149,76	16,4	20,1	14,9	14,6	13,3	2,9	28,6	0	24,9	69,7	30,3	36,64
Vaasan Sähkö Concern	2011	140,23	18,2	18,7	18,3	18,0	9,5	1,5	28,9	0	32,8	72,7	27,3	49,31
Helsingin Energia	2014	819,14	26,8	25,5	23,2	22,0	17	0	50	0	33	100	0	36,02
Helsingin Energia	2013	877,62	27,1	25,9	23,3	21,8	17	0	48	0	35	100	0	41,16
Helsingin Energia	2012	897,09	26,3	24,7	23,3	22,2	27	0	46	0	27	100	0	36,64
Helsingin Energia	2011	876,21	32,7	30,9	30,3	29,0	60	0	22	0	18	100	0	49,31
Tampereen Sähkölaitos	2014	289,37	4,8	1,8	1,6	1,6	4,0	18	0	64	14	100	0	36,02
Tampereen Sähkölaitos	2013	307,48	6,1	1,1	3,1	1,3	5,0	13	0	74	8	100	0	41,16
Tampereen Sähkölaitos	2012	314,26	7,2	1,2	2,5	1,1	7,0	12	0	67	14	100	0	36,64
Tampereen Sähkölaitos	2011	322,95	13,3	4,3	7,2	4,4	4,0	10	0	73	13	100	0	49,31
Oulun Energia	2014	234,91	14,1	4,2	3,9	3,9	11,3	11,9	11,3	0	13	47,5	52,5	36,02
Oulun Energia	2013	238,72	15,7	6,3	3,6	3,5	9,8	12,6	9,8	0	19	51,2	48,8	41,16
Oulun Energia	2012	233,44	16,6	9,0	1,4	1,1	9,8	16,5	9,8	0	20	56,1	43,9	36,64
Oulun Energia	2011	228,92	23,8	14,4	5,6	5,1	8,0	13,7	9,2	0	29,1	60	40	49,31
Kotkan Energia Oy	2014	44,73	16,0	12,0	16,0	12,0	0,0	54	0	0	46	100	0	36,02
Kotkan Energia Oy	2013	43,23	11,4	7,1	11,4	7,1	0,0	57	0	0	43	100	0	41,16
Kotkan Energia Oy	2012	45,88	9,2	5,8	9,2	5,8	0,0	48	0	0	52	100	0	36,64
Kotkan Energia Oy	2011	42,17	9,9	5,8	9,9	5,8	0,0	44	0	0	56	100	0	49,31
Kuopion Energia	2014	66,2	11,0	10,9	8,3	-0,1	0,0	34,3	0	0	25,8	60,1	39,9	36,02
Kuopion Energia	2013	63,27	7,1	7,1	6,9	-2,1	0,0	27,7	0	0	35,2	62,9	37,1	41,16
Kuopion Energia	2012	61,96	10,4	10,4	9,7	1,1	0,0	20,6	0	0	41,7	62,3	37,7	36,64
Kuopion Energia	2011	56,46	14,9	15,1	11,1	2,9	0,0	10,4	0	0	39,2	49,6	50,4	49,31
Seinäjoen Energia	2014	72,93	14,4	8,7	12,7	12,7	28,3	23,2	28,3	0	26,7	96,5	3,5	36,02
Seinäjoen Energia	2013	74,48	17,7	11,6	20,5	20,5	28,1	19,7	28,1	0	31,9	97,8	2,2	41,16
Seinäjoen Energia	2012	68,19	16,6	9,9	20,4	20,3	27,4	17,8	27,4	0	21,3	93,9	6,1	36,64
Seinäjoen Energia	2011	76,6	13,1	7,5	16,0	15,9	20,7	7,8	20,7	0	20	69,2	30,8	49,31

Table 9. The correlation analysis between the profits, fuel shares and El Spot price for the selected electricity producing companies

Correlations between the factors in years 2011 - 2014	Electricity and heat sales, operating profit %	Electricity and heat sales, profit before taxes and extraordin. items %	Share of Hydro %	Share of Biomass and wind %	Share of Nuclear %	Share of Natural gas %	Share of other fossil fuels (coal and peat) %	Share of own production and ownership shares %	Share of Purchased from markets %	ELSpot, average area price in Finland I/MWh
Electricity and heat sales, operating profit %	1									
Electricity and heat sales, profit before taxes and extraordin. items %	0,944	1								
Share of Hydro %	0,374	0,559	1							
Share of Biomass and wind %	-0,304	-0,420	-0,407	1						
Share of Nuclear %	0,642	0,782	0,836	-0,565	1					
Share of Natural gas %	0,019	0,077	-0,168	-0,378	-0,203	1				
Share of other fossil fuels (coal and peat) %	0,131	-0,042	-0,308	0,635	-0,148	-0,615	1			
Share of own production and ownership shares %	0,402	0,442	0,115	0,150	0,097	0,537	0,051	1		
Share of Purchased from markets %	-0,402	-0,442	-0,115	-0,150	-0,097	-0,537	-0,051	-1	1	
ELSpot, average area price in Finland I/MWh	0,130	0,094	-0,135	-0,166	-0,044	0,022	0,109	-0,109	0,109	1

Table 10. The correlation analysis of the selected electricity companies with concern company net sales and profits.

Correlations between the factors in years 2011 - 2014	The Concern company, Net sales MI	The Concern Company, operating profit %	The Concern Company, profit before taxes and extraordinary items %	Electricity and heat sales, operating profit %	Electricity and heat sales, profit before taxes and extraordin. items %	Share of Hydro %	Share of Biomass and wind %	Share of Nuclear %	Share of Natural gas %	Share of other fossil fuels (coal and peat) %	Share of own production and ownership shares %	Share of Purchased from markets %	ELSpot, average area price in Finland I/MWh
The Concern company, Net sales MI	1												
The Concern Company, operating profit %	0,689	1											
The Concern Company, profit before taxes and extraordinary items %	0,622	0,899	1										
Electricity and heat sales, operating profit %	0,488	0,761	0,828	1									
Electricity and heat sales, profit before taxes and extraordin. items %	0,529	0,795	0,778	0,944	1								
Share of Hydro %	0,002	0,313	0,173	0,374	0,559	1							
Share of Biomass and wind %	-0,579	-0,525	-0,503	-0,304	-0,420	-0,407	1						
Share of Nuclear %	0,205	0,605	0,597	0,642	0,782	0,836	-0,565	1					
Share of Natural gas %	0,675	0,061	0,020	0,019	0,077	-0,168	-0,378	-0,203	1				
Share of other fossil fuels (coal and peat) %	-0,469	-0,099	0,068	0,131	-0,042	-0,308	0,635	-0,148	-0,615	1			
Share of own production and ownership shares %	0,333	0,102	0,110	0,402	0,442	0,115	0,150	0,097	0,537	0,051	1		
Share of Purchased from markets %	-0,333	-0,102	-0,110	-0,402	-0,442	-0,115	-0,150	-0,097	-0,537	-0,051	-1	1	
ELSpot, average area price in Finland I/MWh	0,006	0,178	0,103	0,130	0,094	-0,135	-0,166	-0,044	0,022	0,109	-0,109	0,109	1

The correlation analysis related to the number of the electricity sources and profitability gives various interesting results to be evaluated, shown in the tables 9 and 10. The operating profit and profit before taxes and extraordinary items of electricity and heat sales are correlating strongly with the shares of hydro and nuclear electricity. There is also strong negative correlation to the share of purchased electricity from markets. The correlations are close to neutral with natural gas and the use of fossil fuels. The correlations are on the same level also at the concern company levels.

The fuel usage and ownerships in other production companies are varying substantially among the companies. The use of natural gas as a fuel is valid in this study for two companies, Helsingin Energia and even more Tampereen Sähkölaitos. The cost of natural gas due to the increased taxation has had high impact especially on the profitability of Tampereen Sähkölaitos. Also Helsingin Energia has suffered from taxation increase both for natural gas and hard coal. The following Figures 38 and 39 are showing the increases in energy taxation since 2005. Both coal and natural gas taxation have increased multiple times in ten years. These fuel price fluctuations and taxation increases have had affect on financial performance of two companies using those fuels.

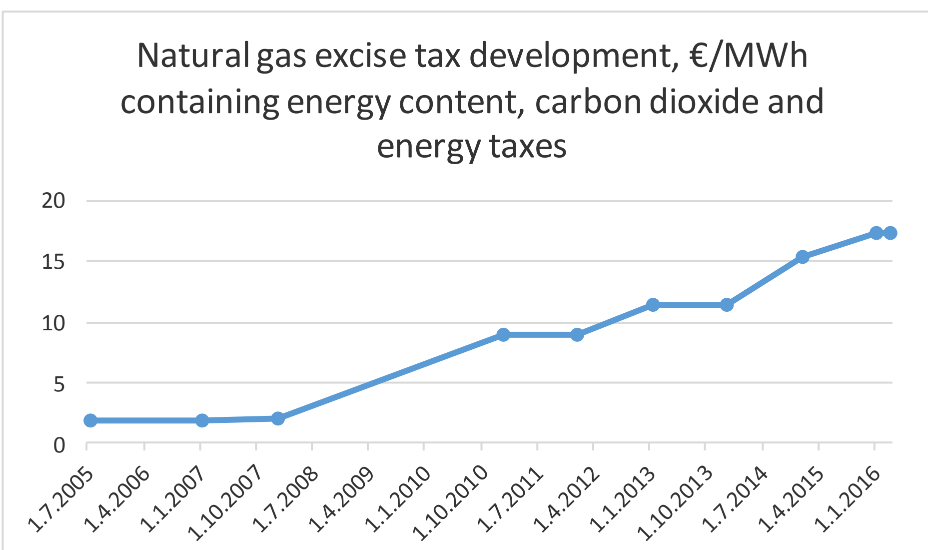

Figure 38. Natural gas taxation development 2005 - 2016. Source: Statistics Finland

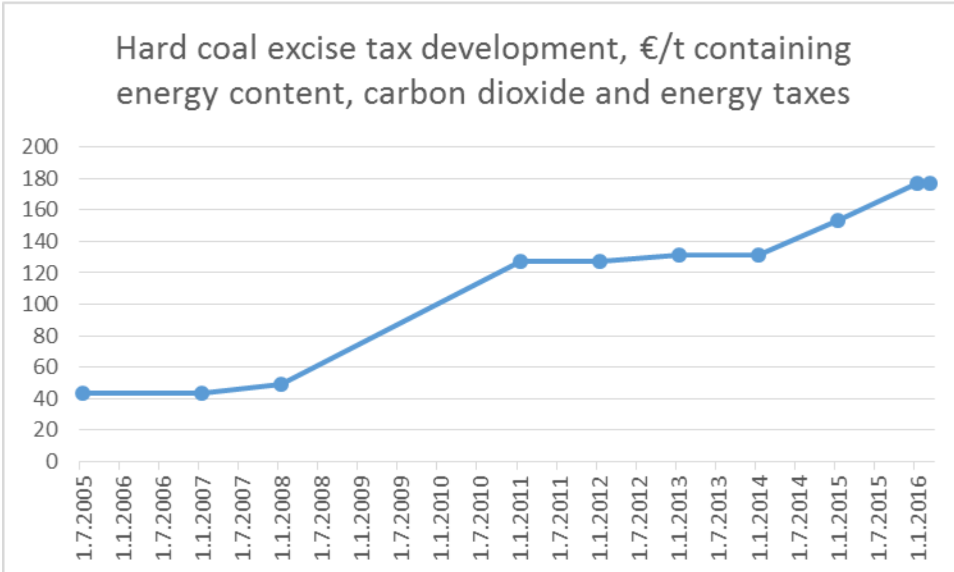

Figure 39. Hard coal taxation development 2005 - 2016. Source: Statistics Finland.

On the other hand the Nord Pool Elspot market prices have reduced the income of the electricity sales but at the same time lowering purchasing prices, Elspot price development is shown in Figure 40. The business conditions are different depending on the company and its' portfolios.

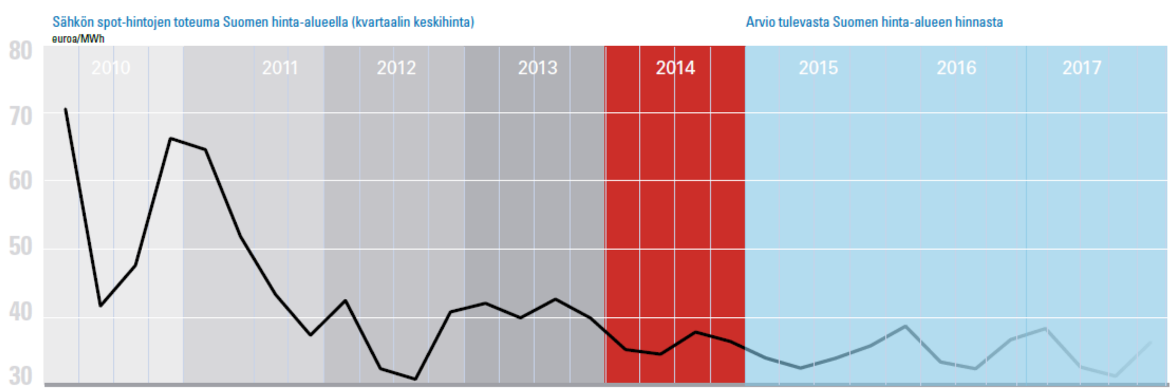

Figure 40. The average electricity Spot price up to end of 2014 and forecast of the future. Source: Tampereen Sähkölaitos Oy (2014).

Preferable is to evaluate each company separately and find possible reasons individually.

Certain companies having large amount of fossil fuels, bituminous coal or natural gas in their fuel portfolio, may have suffered from the high market price fluctuations and various energy taxation increases during the evaluation period. In the Figure 41 there are various fuel prices without taxes and it can be easily seen that the price of natural gas has varied substantially more compared to other fuels.

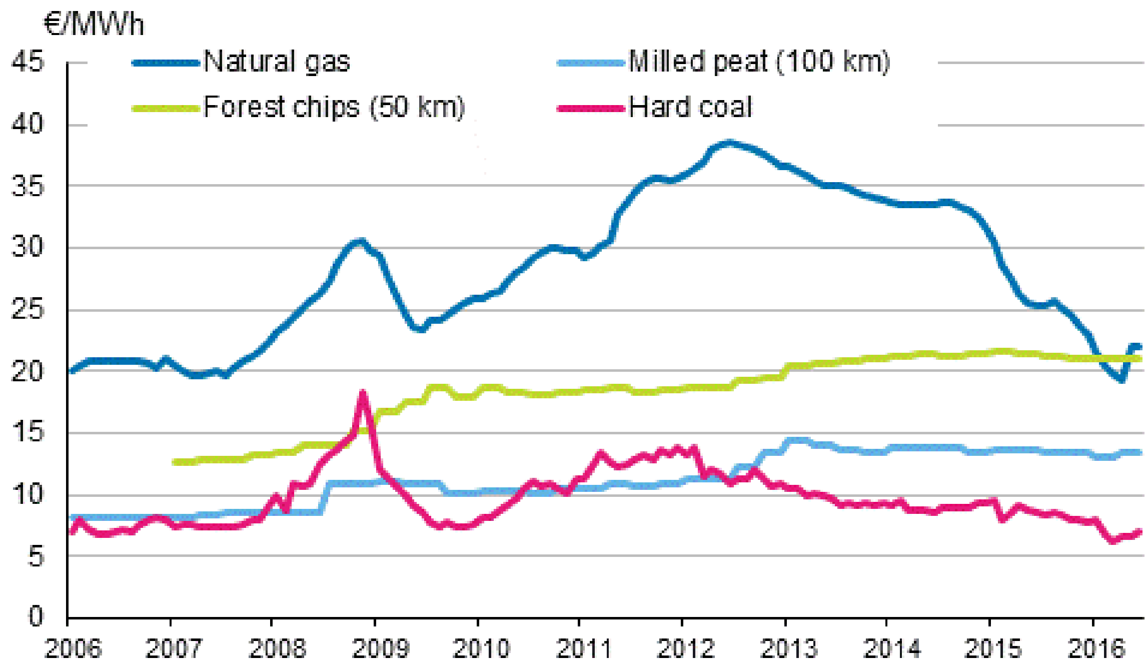

Figure 41. Fuel prices in electricity production, excluding taxes. Source: Statistics Finland.

8.9. Conclusion of the electricity companies' business performance linked to electricity origins

The variations between the businesses performances linked to the origin of the electricity are significant.

In the hypothesis 2 (H2) the claim is, that using only a few energy sources risks the profitability of a company in the constantly changing energy markets.

The following results were found out based on the correlation analysis. The results from this empirical study show that the profitability depends on the specific fuels, fuel origins, ownerships in production companies and the amount purchased from markets. In addition, it can be stated that only with limited amount of different electricity origins operation can be profitable. On the other hand, however, with specific fuels, the costs have substantially increased and if the operation is largely based on that fuel, consequences for the financial performance are obvious. There is no unambiguous answer.

From the risk point of view, one-sided electricity sourcing and fuel portfolio are challenging and may lead to decreasing profitability.

Hypothesis H2 is true.

In the hypothesis 3 (H3) the claim is, that diverse source including renewable energy will secure the profitability of a concern company.

Profitability can be secured by multiple electricity origins compared to one- sided origin portfolio. The amount of renewable electricity itself does not secure the profitability. Diverse electricity sources are beneficial in many ways, gives the freedom to operate, flexibility in production planning and enables the possibility for economical optimization.

Also the electricity market price in the Nord Pool market place has had a decreasing trend during the period of this study, see Figure 42. This has been favorable to the companies purchasing the electricity and unprofitable for the electricity sellers having more expensive production forms.

Hypothesis H3 is true.

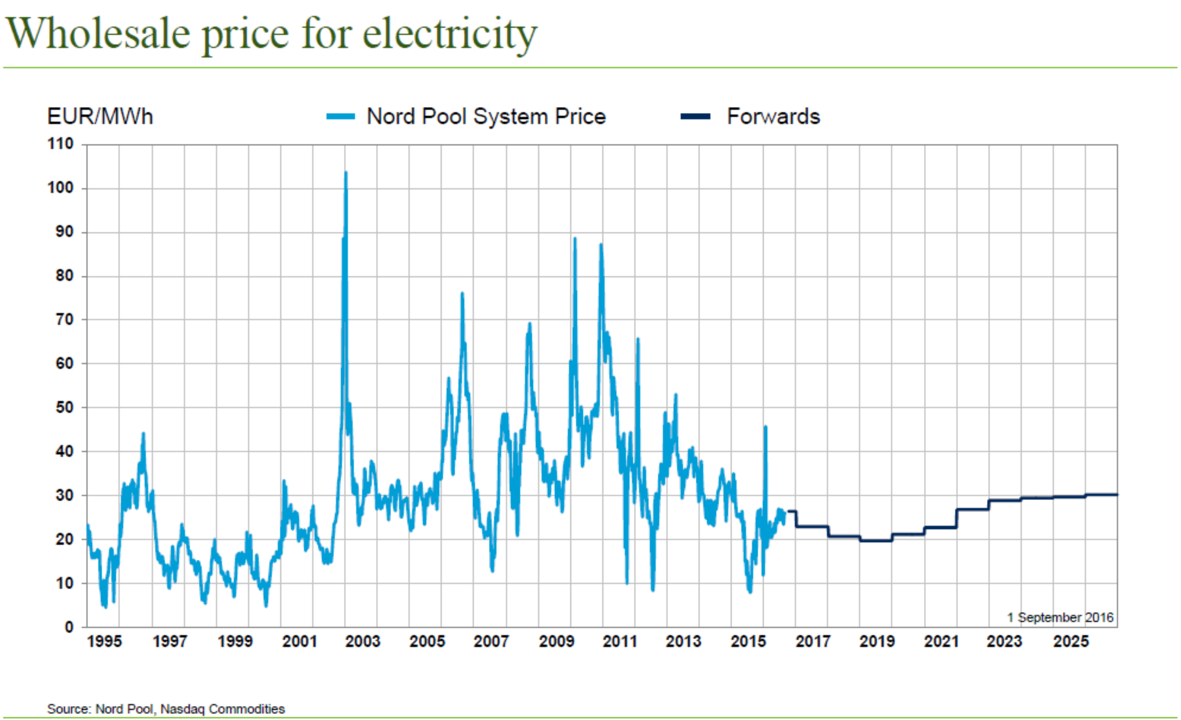

Figure 42. Wholesale price for electricity. Source: Fortum (2016)

9. FUTURE TRENDS AND CHALLENGES FOR THE DSO AND ELECTRICITY PRODUCTION COMPANIES

In the future electricity networks are becoming smarter containing more automation and more connected, as they will transform gradually into smart grids. The role of consumer will change and he can optimize his electricity consumptions based on the momentary price and need.

DSO company operations may be in the future affected by an increased amount of renewable energy and more diversified ways of electricity production. The technologies will be developed to the direction that small scale local production, like photo voltage (PV) solar panels on the house roofs, will be one the solutions together with other small-scale power generation methods. This means, that a house owner can be self-sufficient or even sell surplus electricity to the grid operator. Present consumer can be in the future "prosumer", sometimes electricity producer and sometimes consumer, Vision of the Power Systems 2035.

However, these small-scale productions based on weather related production forms are not always producing enough electricity and grid connections are needed in order to secure the continuous availability of electricity. From the DSO companies this will require more sophisticated technical systems and the amount of transmitted electricity will vary according to the conditions and small-scale production capacities. Due to these changes, business models need to be revised. The vision of future electricity system is illustrated in the Figure 43.

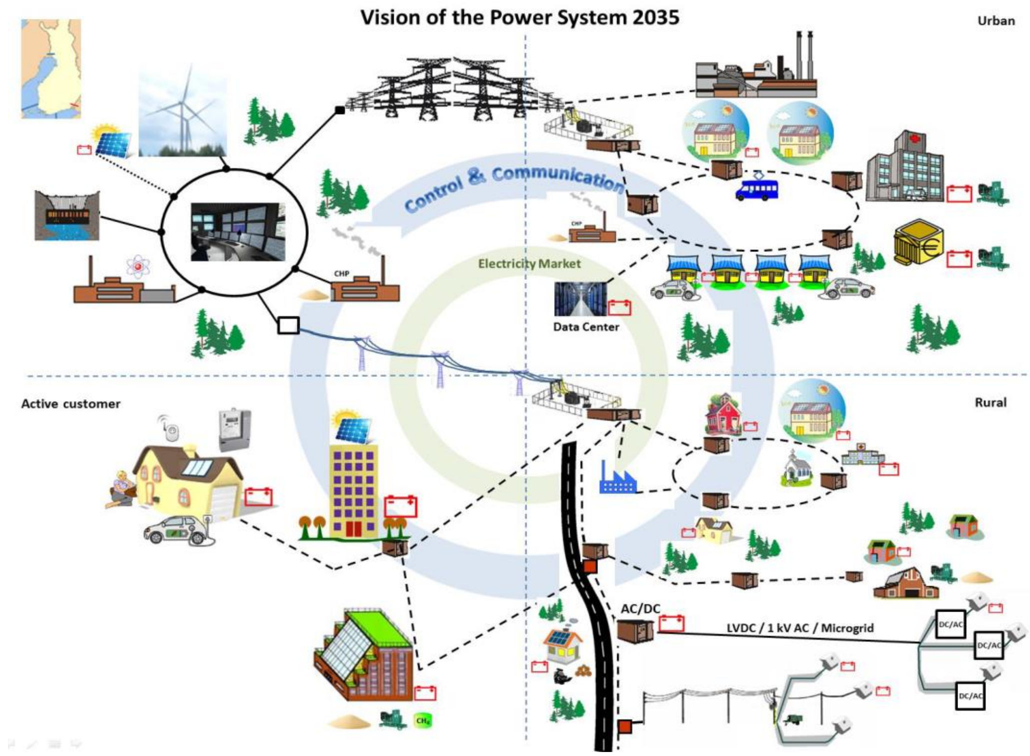

Figure 43. Vision of the Power System 2035, Roadmap 2025, Sähkömarkkina- ja verkkovisio 2035 & Roadmap 2025. Source: LUT, TUT, Univ. of Vaasa and Merinova (2016).

The electricity concern companies will also face new challenges due the new electricity productions methods and their seasonal or weather related variations and local small-scale electricity production as estimated in the Figure 44.

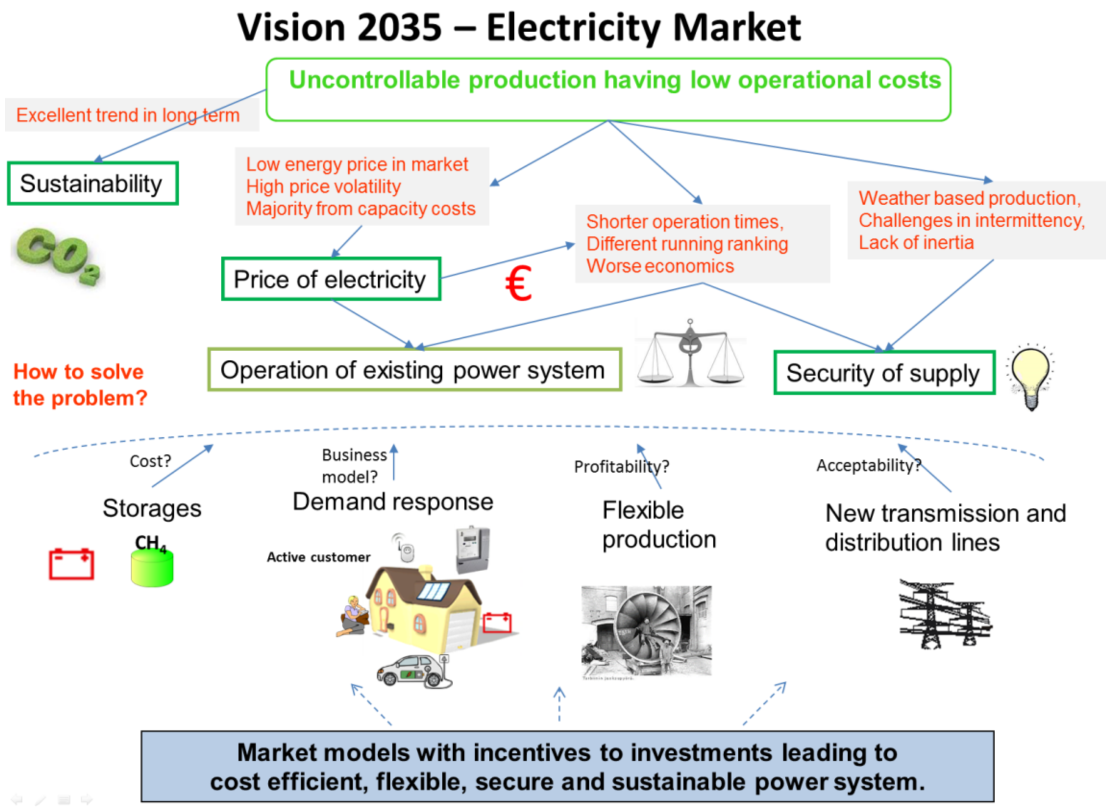

Figure 44. Vision 2035 – Electricity markets

Roadmap 2025, Sähkömarkkina- ja verkkovisio 2035 & Roadmap 2025. Source: LUT, TUT, University of Vaasa, Merinova (2016)

The future business models both for the DSO companies and for the electricity concern companies will be different compared to the present way of operations. The flexibility, utilizing the applications of new technologies, customer service and new business model ideas will secure the future of the businesses.

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APPENDICES

Appendix 1. The year 2012: All DSO Companies

Appendix 2. The 30 largest DSO companies in 2012 based on the revenue

Appendix 3. The 30 smallest DSO companies in 2012 based on the revenue

Appendix 4. Price drivers in Nordic power market. Source: Fortum (2016)

Appendix 5. Nordic power market, several trading places. Source: Fortum (2016)

Year 2012	Company ID	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GWh	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Alajärven Sähkö Oy	134	2056	6,3	6,3	90,71	917,1	22,37	5154	2,54	2,321
Asikkalan Voima Oy	661	2852,187	23,8	23,8	62,499	999,8	17,2	6388	12,361	3,493
E.ON Kainuun Sähköverkko Oy	799	34898,316	37,4	18,5	800,305	13063	172,5	57817	16,931	2,786
Ekenäs Energi	538	3492,362	21,2	21,2	90,9	403,5	21,8	6567	11,834	3,051
Elenia Verkko Oy	734	214967,48	44,5	43,4	5924,6	63230	1413,14	401873	22,338	2,145
Enontekiön Sähkö Oy	7	1078,844	-3,0	-3,0	26,925	711,8	4,4	1773	-2,399	4,314
ESE-Verkko Oy	759	8657,409	32,9	13,2	341,6	1028,7	65,65	23851	17,583	1,912
Esse Elektro-Kraft Ab	98	2243,082	20,3	20,3	53,115	1013,7	15	3755	9,198	4,334
Etelä-Suomen Energia Oy	659	5865,243	27,0	27,0	218,913	1796,2	54,41	12211	14,606	1,966
Forssan Verkkopalvelut Oy	374	6494,052	10,7	10,7	242,639	798,6	47,4	10365	6,309	3,054
Fortum Espoo Distribution Oy	2005	67185	38,2	22,2	2904,9	7562,9	617,07	185272	14,667	1,488
Fortum Sähkönsiirto Oy	733	253901	29,3	29,3	7890	71632,5	2504,6	449630	11,717	2,358
Haminan Energia Oy	471	4533,007	19,9	19,9	165,048	469,9	31,63	7566	7,721	2,358
Haukiputaan Sähköosuuskunta	45	3315	-3,7	-3,7	145,279	932	40,1	9405	14,846	2,699
Helen Sähköverkko Oy	790	120694,1	22,9	22,9	4517,956	6302,9	1004,15	356263	8,467	2,062
Herrfors Nät-Verkko Oy Ab	2007	20389,087	7,2	7,2	360,6	2847	255,5	15775	22,188	5,284
Hiirikosken Energia Oy	92	1514,503	6,5	-4,2	45,6	533,4	12,4	3153	3,313	3,026
Iin Energia Oy	43	2038,52	14,5	14,5	67,643	599,3	20	4828	10,015	2,576
Imatran Seudun Sähkönsiirto Oy	786	14457	15,5	2,7	271,066	2834,4	68,17	24760	160,993	4,541
Jakobstads Energiverk	77	5767	17,4	17,4	283	1229,2	62,5	15548	6,592	2,079
Jeppo Kraft Andelslag	80	704,989	10,3	10,3	29,26	134,8	5,86	742	20,118	2,356
JE-Siirto Oy	783	19865,269	5,1	-0,4	660,935	1305,5	122,44	49497	78,592	2,855
Joroisten Energialaitos	290	2000,227	14,6	14,6	71,09	819,8	14,59	3452	7,448	3,025
Jylhän Sähköosuuskunta	107	2871,657	17,7	17,7	80,4	887,8	19,79	5326	5,834	3,102
Järvi-Suomen Energia Oy	657	82765,509	16,6	3,3	1194,763	27091,8	306,1	100636	47,432	5,801
Karhu Voima Oy	675	1195,958	0,7	-3,1	47,436	36,9	10,61	22	0,114	2,555
Kemin Energia Oy	40	5436,998	5,2	5,2	174,472	824,5	38,5	15004	2,186	2,958
Keminmaan Energia Oy	28	2005	-0,3	-0,3	71,91	766,9	20,01	5227	-0,078	3,069
KENET Oy	798	12046,891	0,3	0,3	415,4	1394,3	85,62	21794	2,51	2,891
Keravan Energia Oy	433	5529,401	16,5	16,5	283,142	477,7	54,85	18480	9,154	1,635
Keuruun Sähkö Oy	140	4511	22,0	22,0	112,126	1585,9	24,02	8925	12,377	3,711
Koillis-Lapin Sähkö Oy	18	5720,017	-5,8	-5,8	160,76	3618	39,03	12611	-0,445	4,075
Koillis-Satakunnan Sähkö Oy	141	6734,195	8,5	8,5	180,155	3884,8	47,37	15986	4,492	4,856
Kokemäen Sähkö Oy	233	2801,965	19,1	19,1	82,163	1000,1	20,29	5806	6,539	3,665
Kronoby Elverk	97	1693,349	14,1	14,1	45,25	695,4	13,3	3151	12,806	3,373
KSS Verkko Oy	776	20058,992	38,3	38,3	660,2	4426,6	142,7	50520	27,856	2,499
Kuopion Energia Liikelaitos	178	14845,969	10,9	10,9	585,077	1543,3	109,5	52212	52,066	2,332
Kuoreveden Sähkö Oy	244	1446,556	17,8	17,8	33,311	642,6	8,6	2249	17,673	3,957
Kymenlaakson Sähköverkko Oy	796	51198,068	38,5	20,9	1346,003	12888	325,22	101830	27,445	2,378
Köyliön-Säkylän Sähkö Oy	317	3909,191	32,7	32,7	120,527	922	26,7	6288	12,121	3,082
Lammaisten Energia Oy	229	3543,049	27,8	27,8	105,19	831,6	26	7387	8,801	3,279
Lankosken Sähkö Oy	206	1452,776	-6,5	-6,5	26,247	1090	7,5	3549	-4,801	7,426
Lappeenrannan Energiaverkot Oy	778	21442,598	6,3	6,3	792,247	6122,5	164,4	55128	6,57	2,559
Lehtimäen Sähkö Oy	135	764,217	14,5	14,5	17,414	455,1	4,88	1785	19,602	3,756
Leppäkosken Sähkö Oy	212	13222,681	14,8	14,8	375,113	4203,5	87,8	28470	7,78	4,007
LE-Sähköverkko Oy	2003	30738,705	33,3	-22,0	1235,574	4531,6	241,2	82496	16,739	1,666
Mäntsälän Sähkö Oy	427	8607,875	12,4	12,4	278,427	2205,3	77,5	13931	8,901	2,697
Naantalin Energia Oy	330	3358,372	19,1	19,1	124,2	447,8	26,19	5854	7,737	2,745
Nurmijärven Sähköverkko Oy	399	10908,427	27,7	15,7	413,821	2270,6	102,7	23204	9,176	2,002
Nykarleby Kraftverk	79	2832	1,9	1,9	77,3	830,5	27,3	4990	15,689	3,836
Oulun Energia Siirto ja Jakelu Oy	2001	26628,1	14,8	14,8	1191,605	3536,2	241,86	93362	7,409	1,936
Oulun Seudun Sähkö Verkkopalvelut Oy	795	12993,253	2,3	2,3	447,975	3390,2	118,3	28458	17,758	2,839
Outokummun Energia Oy	195	3437,12	12,8	12,8	187,697	868,4	28,79	5466	5,372	1,611
Paneliankosken Voima Oy	231	5254,38	32,5	32,5	163,692	1525,2	42,05	9432	9,894	3,134
Parikkalan Valo Oy	307	4836,032	16,6	16,6	139,386	2604,8	32,13	10130	9,814	4,055
Pellon Sähkö Oy	14	472,346	21,1	21,1	21,901	137,1	5,3	1475	3,299	1,73
PKS Sähkönsiirto Oy	794	48095,335	19,9	7,5	1124,125	21351,8	301,16	87945	129,924	3,457
Pori Energia Sähköverkot Oy	789	25647	12,5	12,5	1188,9	3063,6	202,6	49767	6,932	1,873
Porvoon Sähköverkko Oy	785	12106,699	22,0	9,7	440,461	3537	102,3	33291	18,353	2,906
Raahen Energia Oy	58	3431,236	4,9	4,9	107,564	385,2	23,7	7870	3,666	3,227
Rantakairan Sähkö Oy	41	1169	-4,1	-4,1	40,026	975	15	4302	-0,917	3,415
Rauman Energia Oy	314	8732,129	18,1	18,1	290,122	969,1	67,7	20266	8,724	2,541
Rovakaira Oy	36	14667,16	10,4	10,4	645,5	6674,6	137,6	29169	11,398	2,05
Rovaniemen Verkko Oy	2002	7392,699	-4,3	-9,6	327,978	857,6	66,1	24484	1,61	2,383
Sallila Sähkönsiirto Oy	2000	12456,976	29,9	24,3	355,999	4356,7	83,41	22937	11,534	2,572
Savon Voima Verkko Oy	793	68174,142	42,7	15,9	1807,478	25441,4	488,4	112402	26,218	2,231
Seiverkot Oy	2006	10062,071	21,0	21,0	387,595	968,3	75,44	22666	32,51	2,115
Tampereen Sähköverkko Oy	774	46095,328	32,0	0,5	1845,577	3757,7	357	138576	11,016	1,699
Tenergia Oy	101	1104,339	2,3	2,3	39,903	746,3	9,13	2631	4,69	3,125
Tornion Energia Oy	24	4202,068	-1,5	-1,5	174,413	852,3	40	11084	2,709	2,539
Tornionlaakson Sähkö Oy	29	6337,086	3,3	3,3	202,081	3658,1	57,7	14630	1,94	3,108
Tunturiverkko Oy	2008	4716,994	24,3	24,3	147,432	2184,4	38,9	7779	7,902	2,443
Turku Energia Sähköverkot Oy	784	29634,896	21,9	11,1	1526,754	2436,9	415,63	72925	12,739	1,516
Vaasan Sähköverkko Oy	777	27493,838	26,7	17,6	980,555	6135,7	223,91	64302	13,533	2,082
Vakka-Suomen Voima Oy	320	10665	19,6	15,1	351,389	3837,9	86,16	24183	7,254	2,703
Valkeakosken Energia Oy	272	5492,042	42,4	42,4	166,9	928,8	36,81	12419	31,151	2,205
Vantaan Aviaenergia Oy	492	3429,663	0,0	30,4	138,014	91,1	21,4	382	2,646	2,369
Vantaan Energia Sähköverkot Oy	791	37251,846	37,0	23,6	1715	3195,1	328,3	107834	23,535	1,469
Vatajankosken Sähkö Oy	208	9159,474	5,3	5,3	271,565	3867,3	61,01	17922	2,958	3,996
Verkko Korpela Oy	797	12024,841	3,7	3,7	345,159	3470,1	86,32	19972	8,25	3,454
Vetelin Sähkölaitos Oy	102	868,342	23,7	23,7	27,401	387,9	7,31	2158	11,994	2,659
Vimpelin Voima Oy	106	1142,34	16,0	16,0	32,628	375	7,6	2042	6,015	2,911
Yli-Iin Sähkö Oy	42	637,155	-8,5	-8,5	15,686	323,9	4,08	1403	-2,804	4,523
Ääneseudun Energia Oy	152	3879,06	39,2	39,2	120,489	611,4	27,2	9310	11,959	1,991

Appendix 1. The year 2012: All DSO Companies

Year 2012	Company I	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GW	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Fortum Sähkönsiirto Oy	733	253901	29,3	29,3	7890	71632,5	2504,6	449630	11,717	2,358
Elenia Verkko Oy	734	214967,48	44,5	43,4	5924,6	63230	1413,14	401873	22,338	2,145
Helen Sähköverkko Oy	790	120694,1	22,9	22,9	4517,956	6302,9	1004,15	356263	8,467	2,062
Järvi-Suomen Energia Oy	657	82765,509	16,6	3,3	1194,763	27091,8	306,1	100636	47,432	5,801
Savon Voima Verkko Oy	793	68174,142	42,7	15,9	1807,478	25441,4	488,4	112402	26,218	2,231
Fortum Espoo Distribution Oy	2005	67185	38,2	22,2	2904,9	7562,9	617,07	185272	14,667	1,488
Kymenlaakson Sähköverkko Oy	796	51198,068	38,5	20,9	1346,003	12888	325,22	101830	27,445	2,378
PKS Sähkönsiirto Oy	794	48095,335	19,9	7,5	1124,125	21351,8	301,16	87945	129,924	3,457
Tampereen Sähköverkko Oy	774	46095,328	32,0	0,5	1845,577	3757,7	357	138576	11,016	1,699
Vantaan Energia Sähköverkot Oy	791	37251,846	37,0	23,6	1715	3195,1	328,3	107834	23,535	1,469
E.ON Kainuun Sähköverkko Oy	799	34898,316	37,4	18,5	800,305	13063	172,5	57817	16,931	2,786
LE-Sähköverkko Oy	2003	30738,705	33,3	-22,0	1235,574	4531,6	241,2	82496	16,739	1,666
Turku Energia Sähköverkot Oy	784	29634,896	21,9	11,1	1526,754	2436,9	415,63	72925	12,739	1,516
Vaasan Sähköverkko Oy	777	27493,838	26,7	17,6	980,555	6135,7	223,91	64302	13,533	2,082
Oulun Energia Siirto ja Jakelu Oy	2001	26628,1	14,8	14,8	1191,605	3536,2	241,86	93362	7,409	1,936
Pori Energia Sähköverkot Oy	789	25647	12,5	12,5	1188,9	3063,6	202,6	49767	6,932	1,873
Lappeenrannan Energiaverkot Oy	778	21442,598	6,3	6,3	792,247	6122,5	164,4	55128	6,57	2,559
Herrfors Nät-Verkko Oy Ab	2007	20389,087	7,2	7,2	360,6	2847	255,5	15775	22,188	5,284
KSS Verkko Oy	776	20058,992	38,3	38,3	660,2	4426,6	142,7	50520	27,856	2,499
JE-Siirto Oy	783	19865,269	5,1	-0,4	660,935	1305,5	122,44	49497	78,592	2,855
Kuopion Energia Liikelaitos	178	14845,969	10,9	10,9	585,077	1543,3	109,5	52212	52,066	2,332
Rovakaira Oy	36	14667,16	10,4	10,4	645,5	6674,6	137,6	29169	11,398	2,05
Imatran Seudun Sähkönsiirto Oy	786	14457	15,5	2,7	271,066	2834,4	68,17	24760	160,993	4,541
Leppäkosken Sähkö Oy	212	13222,681	14,8	14,8	375,113	4203,5	87,8	28470	7,78	4,007
Oulun Seudun Sähkö Verkkopalvelut Oy	795	12993,253	2,3	2,3	447,975	3390,2	118,3	28458	17,758	2,839
Sallila Sähkönsiirto Oy	2000	12456,976	29,9	24,3	355,999	4356,7	83,41	22937	11,534	2,572
Porvoon Sähköverkko Oy	785	12106,699	22,0	9,7	440,461	3537	102,3	33291	18,353	2,906
KENET Oy	798	12046,891	0,3	0,3	415,4	1394,3	85,62	21794	2,51	2,891
Verkko Korpela Oy	797	12024,841	3,7	3,7	345,159	3470,1	86,32	19972	8,25	3,454
Nurmijärven Sähköverkko Oy	399	10908,427	27,7	15,7	413,821	2270,6	102,7	23204	9,176	2,002

Appendix 2. The 30 largest DSO companies in 2012 based on the revenue

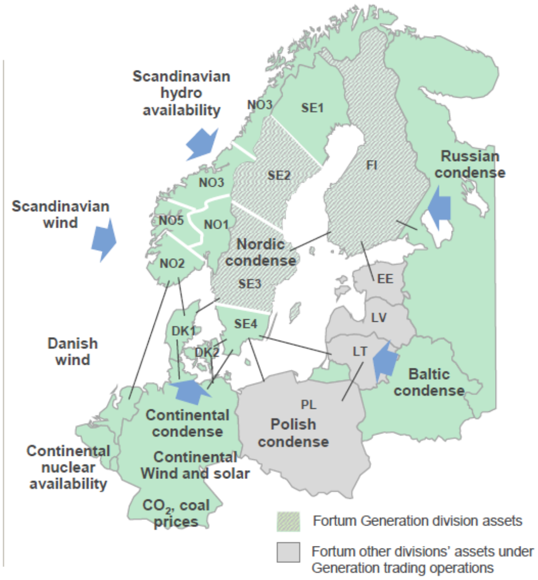
Year 2012	Company ID	Revenue, 1000€	Profit before extraordinary items %	Profit before appropriations and taxes %	The amount of electricity transmitted to end-users, GWh	Total length of grids, km	Largest hourly electricity capacity, MW	Total number of users by voltage levels	Return on equity for network operations	Costs of DSO operation per each transmitted energy unit, cent/kWh
Pellon Sähkö Oy	14	472,346	21,1	21,1	21,901	137,1	5,3	1475	3,299	1,73
Yli-Iin Sähkö Oy	42	637,155	-8,5	-8,5	15,686	323,9	4,08	1403	-2,804	4,523
Jeppo Kraft Andelslag	80	704,989	10,3	10,3	29,26	134,8	5,86	742	20,118	2,356
Lehtimäen Sähkö Oy	135	764,217	14,5	14,5	17,414	455,1	4,88	1785	19,602	3,756
Vetelin Sähkölaitos Oy	102	868,342	23,7	23,7	27,401	387,9	7,31	2158	11,994	2,659
Enontekiön Sähkö Oy	7	1078,844	-3,0	-3,0	26,925	711,8	4,4	1773	-2,399	4,314
Tenergia Oy	101	1104,339	2,3	2,3	39,903	746,3	9,13	2631	4,69	3,125
Vimpelin Voima Oy	106	1142,34	16,0	16,0	32,628	375	7,6	2042	6,015	2,911
Rantakairan Sähkö Oy	41	1169	-4,1	-4,1	40,026	975	15	4302	-0,917	3,415
Karhu Voima Oy	675	1195,958	0,7	-3,1	47,436	36,9	10,61	22	0,114	2,555
Kuoreveden Sähkö Oy	244	1446,556	17,8	17,8	33,311	642,6	8,6	2249	17,673	3,957
Lankosken Sähkö Oy	206	1452,776	-6,5	-6,5	26,247	1090	7,5	3549	-4,801	7,426
Hiirikosken Energia Oy	92	1514,503	6,5	-4,2	45,6	533,4	12,4	3153	3,313	3,026
Kronoby Elverk	97	1693,349	14,1	14,1	45,25	695,4	13,3	3151	12,806	3,373
Joroisten Energialaitos	290	2000,227	14,6	14,6	71,09	819,8	14,59	3452	7,448	3,025
Keminmaan Energia Oy	28	2005	-0,3	-0,3	71,91	766,9	20,01	5227	-0,078	3,069
Iin Energia Oy	43	2038,52	14,5	14,5	67,643	599,3	20	4828	10,015	2,576
Alajärven Sähkö Oy	134	2056	6,3	6,3	90,71	917,1	22,37	5154	2,54	2,321
Esse Elektro-Kraft Ab	98	2243,082	20,3	20,3	53,115	1013,7	15	3755	9,198	4,334
Kokemäen Sähkö Oy	233	2801,965	19,1	19,1	82,163	1000,1	20,29	5806	6,539	3,665
Nykarleby Kraftverk	79	2832	1,9	1,9	77,3	830,5	27,3	4990	15,689	3,836
Asikkalan Voima Oy	661	2852,187	23,8	23,8	62,499	999,8	17,2	6388	12,361	3,493
Jylhän Sähköosuuskunta	107	2871,657	17,7	17,7	80,4	887,8	19,79	5326	5,834	3,102
Haukiputaan Sähköosuuskunta	45	3315	-3,7	-3,7	145,279	932	40,1	9405	14,846	2,699
Naantalin Energia Oy	330	3358,372	19,1	19,1	124,2	447,8	26,19	5854	7,737	2,745
Vantaan Aviaenergia Oy	492	3429,663	0,0	30,4	138,014	91,1	21,4	382	2,646	2,369
Raahen Energia Oy	58	3431,236	4,9	4,9	107,564	385,2	23,7	7870	3,666	3,227
Outokummun Energia Oy	195	3437,12	12,8	12,8	187,697	868,4	28,79	5466	5,372	1,611
Ekenäs Energi	538	3492,362	21,2	21,2	90,9	403,5	21,8	6567	11,834	3,051
Lammaisten Energia Oy	229	3543,049	27,8	27,8	105,19	831,6	26	7387	8,801	3,279

Appendix 3. The 30 smallest DSO companies in 2012 based on the revenue

Price drivers in Nordic power market

Nordic power price setters

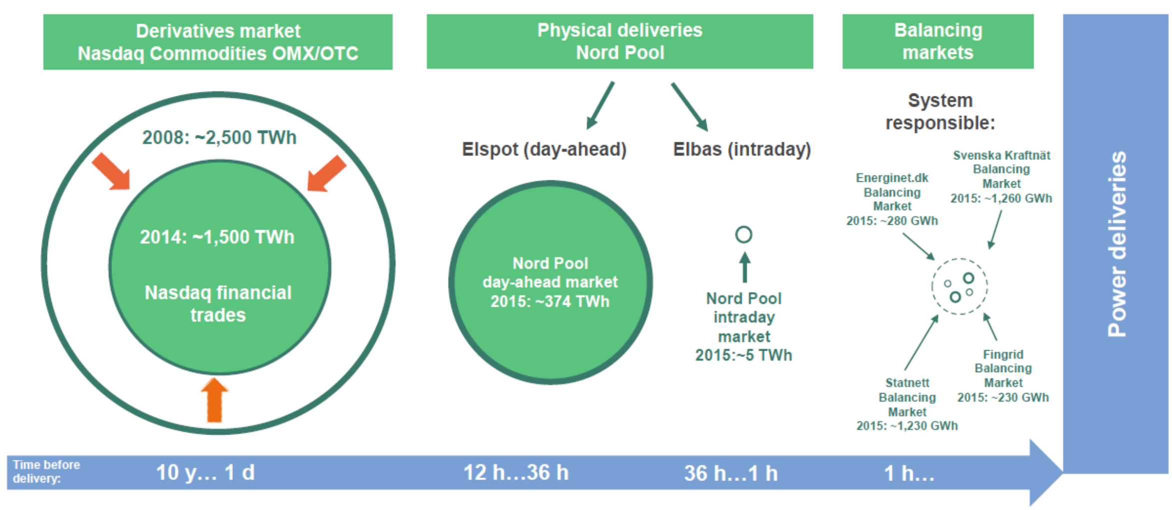
- Nordic power price is determined by the supply and demand balance
- Supply is driven by hydrological variation, available RES, Nordic & Baltic coal condense prices as well as Continental and Russian imports
- Demand is driven by industrial activity, household electrification and export



Appendix 4. Price drivers in Nordic power market. Source: Fortum (2016)

Nordic power market, several trading places

– base load generation hedged long prior to delivery, while reservoir based hydro has optional value closer to delivery



Appendix 5. Nordic power market, several trading places. Source: Fortum (2016)