



UPPSALA
UNIVERSITET

UPTEC STS 15044

Examensarbete 30 hp
Februari 2016

Premium Quality Contracts

An investigation of the applicability of
premium quality contracts in Sweden

Hanna Persson



UPPSALA
UNIVERSITET

Teknisk- naturvetenskaplig fakultet
UTH-enheten

Besöksadress:
Ångströmlaboratoriet
Lägerhyddsvägen 1
Hus 4, Plan 0

Postadress:
Box 536
751 21 Uppsala

Telefon:
018 – 471 30 03

Telefax:
018 – 471 30 00

Hemsida:
<http://www.teknat.uu.se/student>

Abstract

Premium Quality Contracts

Hanna Persson

The dependency of electricity is constantly increasing in today's society. It is therefore important that the supply of electricity is reliable. The reliability of the electricity can be defined as the quality of electricity supply. In order to ensure that the quality of electricity supply is good, it is regulated with for example guaranteed standards that are defined by regulatory authorities. Electricity customers that are sensitive to disturbances in the supply of electricity might, however, be interested in a customized quality of electricity supply. A regulatory tool used to meet individual customers quality of electricity supply needs, is a premium quality contract. A premium quality contract is an agreement between a network operator and a customer that requests customized quality of electricity supply. The customer pays the network operator for the contract, and the network operator compensates the customer in case the quality of electricity supply that is specified in the contract is not supplied. This master thesis aims to investigate the applicability of premium quality contracts in Sweden. Studying the use of premium quality contracts internationally, and Swedish energy market actors' views of quality of electricity supply and implementing premium quality contracts in Sweden will investigate this purpose. The participating actors in Sweden are DSOs, industries and the regulatory authority.

The conclusions of the study are that premium quality contracts are applicable in Sweden. This, since higher quality of electricity supply, than the guaranteed standards, is requested by the participating industries. The DSOs are also, in principal, willing to enter a contract and discuss the quality of electricity supply problems with its customers. However, the DSOs are not sure if the standards that are requested by the customers can be guaranteed. It is also concluded that regulations would facilitate the implementing of premium quality contracts, and that it is possible to introduce such regulations in the Swedish regulatory system. Other alternatives of changes in the quality regulation that possibly could satisfy the customers and the DSOs are also discussed. The alternatives discussed are, defining good quality for different kind of customers, include power quality specifications in the connection agreement or keep the regulations as they are today without any further operations. If premium quality contracts or any of the other alternatives is most suitable in Sweden, has to be studied further.

Handledare: Lars Ström
Ämnesgranskare: Cajsa Bartusch
Examinator: Elisabet Andrésdóttir
ISSN: 1650-8319, UPTEC STS 15044

Sammanfattning

Beroendet av el ökar i dagens samhälle. Det är därför viktigt att överföringen av el är tillförlitlig för att inte orsaka några problem för samhället. Tillförlitligheten av el kan definieras som leveranskvalitet. God leveranskvalitet innebär att elen som levereras av nätägare uppfyller krav som en tillsynsmyndighet specificerat i lagar och direktiv. Elkunder som är känsliga för störningar som kan förekomma i den el som levereras, kan dock vara intresserade av bättre leveranskvalitet än den leveranskvalitet som är specificerad av myndigheten. Ett alternativ som används för att möta individuella kunders leveranskvalitet är leveranskvalitetskontrakt. Ett leveranskvalitetskontrakt är ett avtal mellan en nätägare och dess kund som begär kundanpassad leveranskvalitet. Kunden betalar nätägaren för kontraktet, och nätägaren kompenserar kunden om den kvalitet som specificerats i kontraktet inte uppfylls.

Syftet med denna studie är att undersöka om leveranskvalitetskontrakt kan appliceras i Sverige, om ett behov av bättre leveranskvalitet efterfrågas. Detta undersöktes genom att studera användningen av leveranskvalitetskontrakt internationellt, men även den svenska energimarknadens aktörers perspektiv på leveranskvaliteten och att implementera leveranskvalitetskontrakt i Sverige studerades. Det material som användes för att besvara syftet, samlades in genom litteraturstudier, epostenkäter och intervjuer. Enkäterna skickades till utländska regleringsmyndigheter, och intervjuer gjordes med aktörer på den svenska energimarknaden. De aktörer som deltog i studien var industrier, elnätsägare och den svenska regleringsmyndigheten, Energimarknadsinspektionen (Ei). Industrier och elnätsägare valdes som deltagare för att industrier har visat ett behov av bättre leveranskvalitet och för att de leveranskvalitetskontrakt som har introducerats i andra länder är mellan elnätsägare och industrikunder.

De slutsatser som studien kommer fram till är att leveranskvalitetskontrakt kan appliceras i Sverige. Detta då studien av leveranskvalitetskontrakt internationellt visar att leveranskvalitetskontrakt kan användas i länder med en kvalitetsreglering som liknar den svenska. Det är även möjligt att implementera leveranskvalitetskontrakt för att det finns kunder som efterfrågar bättre leveranskvalitet. Det finns dock faktorer som skulle försvåra implementeringen av leveranskvalitetskontrakt. Elnätsägarna ser bland annat leveranskvalitetskontrakten som en finansiell risk och tror det kan bli svårt för dem att garantera de krav som kunderna har. De nämner även att det kommer krävas mer resurser för att hantera kontrakten. Studien visar även att utveckling av nya direktiv från Ei skulle kunna underlätta införandet av leveranskvalitetskontrakt. Nya direktiv skulle kunna ge kunderna möjlighet att använda leveranskvalitetskontrakt om intresse finns och elnätsägarna riktlinjer om

hur leveranskvalitetskontrakt kan användas. I studien diskuteras även andra alternativa ändringar i regleringen som skulle kunna göras för att tillgodose kundernas behov. De alternativ som diskuteras är att definiera god kvalitet för olika typer av kunder, inkludera leveranskvalitet i anslutningsavtalet eller behålla den nuvarande regleringen som den är. Fortsatta studier krävs dock för att kunna avgöra vilket alternativ som är mest lämpligt i Sverige.

Table of contents

1.	Introduction	5
1.1	Problem Discussion	6
1.2	Purpose	7
1.3	Disposition	7
1.4	Limitations	8
2.	Background	9
2.1	Quality of Electricity Supply	9
2.1.1	Continuity of Supply	9
2.1.2	Voltage Quality	10
2.2	Consequences of Poor Power Quality	12
2.3	Quality Regulation	13
2.4	Premium quality contracts	15
2.5	Advantages and Disadvantages with Premium Quality Contracts	16
3.	Methodology	19
3.1	Structure of the Investigation	19
3.2	Literature Review	20
3.3	Email Questionnaires	21
3.4	Interviews	22
3.5	Critical Evaluation	24
4.	Premium Quality Contracts Internationally	26
4.1	France	26
4.1.1	Quality regulation	26
4.1.2	Premium quality contracts in France	27
4.2	Italy	28
4.2.1	Quality regulation	28
4.2.2	Premium Quality Contracts in Italy	29
4.3	South Africa	30
4.3.1	Quality Regulation	30
4.3.2	Premium quality contracts in South Africa	30
4.4	Detroit Edison Company, USA	32
4.4.1	Quality regulation	32
4.4.2	Premium Quality Contracts in Detroit Edison Company	33
4.5	Norway	33
4.5.1	Quality regulation	33
4.5.2	Power Quality Contracts in Norway	34
4.6	Summary	35
5.	The Swedish Energy Market	36
5.1	The Swedish power system	36
5.2	Power Quality Regulation in Sweden	37
5.2.1	Selective quality regulation	37
5.2.2	Collective quality regulation	38
6.	View of Premium quality contracts in Sweden	39
6.1	Industrial Customers	39
6.1.1	Power quality issues	39
6.1.2	Willingness to pay for increased power quality	40
6.1.3	Views of implementing premium quality contracts	41
6.1.4	Summary	42

6.2	Distribution System Operators (DSOs).....	42
6.2.1	The DSOs current ways of working with power quality	42
6.2.2	Possible advantages and disadvantages, for the DSOs, with premium quality contracts	44
6.2.3	Views of implementing regulations about customized power quality	46
6.2.4	Summary	46
6.3	Ei's view of premium quality contracts.....	48
7.	Analysis.....	50
7.1	Are premium quality contracts used in Sweden?	50
7.2	Is there a need of premium quality contracts in Sweden?	51
7.3	Why should/should not, premium quality contracts be introduced in Sweden?	51
7.4	How can current regulations be modified to facilitate the use of premium quality contracts in Sweden?	53
7.5	Alternatives to Premium Quality Contracts	54
8.	Conclusion	56
9.	Discussion	58
9.1.1	Further studies.....	58
	References.....	60
	Interviews	62
	Appendix A	64
	Appendix B	72
	Appendix C.....	73

1. Introduction

The dependence of electricity is constantly increasing in today's society (IEA, 2014). This, since functions like lightening, computers, heating systems, industrial motors, and healthcare systems, need electricity to work. As a result of the increasing dependency, the end-users of electricity request a reliable supply of electricity, which is defined and measured as the quality of electricity supply (Fumgalli et al. 2007).

In order to ensure that the quality of electricity supply benefits the society to reasonable costs, the quality of electricity supply has to be regulated. Quality regulation includes three basic elements, and these are measurements, performance standards and financial incentives. Measurements are needed to measure the actual performance of a network operator. Performance standards specify the quality that a customer can expect from a network operator, and the financial incentives are generally used to penalize the network operator if the performance is below the performance standards. The network operator is, sometimes, rewarded if the performance is above the standards (Fumgalli et al., 2007).

Internationally, standards that concern the quality of electricity supply have been developed. For example, the International Electrotechnical Committee (IEC) and the European Union (EU) have developed quality of electricity supply standards. However, these standards are seen as insufficient regarding some quality aspects. According to an report by European Regulators' Group for Electricity and Gas (ERGEG, 2006), the issues, with the European standard, are, for instance, that all countries cannot be generalized according the standard, various voltage aspects should be better defined, and clearer limits are needed. In order to solve the issues with this standard, regulatory authorities in countries, normally develop their own standards (Perez-Arnaga, 2013). However, these standards might not be sufficient to customers that are sensitive to disturbances in the supply of electricity either. In such a case a regulatory tool called premium quality contract, can be implemented (Hulshorst et al., 2007b).

A Premium quality contract is a contract where individual performance standards are specified and agreed between a network operator and a customer that requests customized quality of electricity supply. The customer pays the network operator for the contract and the network operator ensures that the contracted quality of electricity supply is delivered to the customer. If the standards that are specified in the contract are not met, the customer is compensated by the network operator (Fumgalli et al., 2007).

Several different countries have implemented premium quality contracts as a regulatory tool. In cases where premium quality contracts are used, it is an

agreement between the distribution system operator (DSO) and its customers, even if the contracts in theory can be agreed between the transmission system operator (TSO) and its customers. The customers that has shown the greatest interest in premium quality contracts are customers within the industrial sector. The reason is that industries are using equipment that is sensitive to disturbances in the supply of electricity. Disturbances, in the supply of electricity, can therefore imply great costs for these customers due to production loss and damaged equipment. In countries where premium quality contracts have been introduced it has been a successful regulatory tool. This, since premium quality contracts have increased the quality for the customers that the contract concern (Hulshorst et al., 2007b).

1.1 Problem Discussion

As stated in the introduction, different customers have different preferences with respect to the quality of electricity supply. Determining a level of quality of electricity supply that satisfies all customers independent of sector is therefore a complex task (Fumgalli et al. 2007). Increasing the guaranteed performance standards, in order to satisfy customers such as industries, implies that the network operator has to invest more in the network. This can then result in a higher electricity tariff for all customers, even if higher quality of electricity supply is not requested. Premium quality contracts can be used to solve this problem, since the customer pays for its own higher quality of electricity supply through the premium quality contract (Fumgalli et al. 2007). The use of premium quality contracts is not widely spread, even if it has had positive outcomes, like improved quality, where it has been implemented (Hulshorst et al., 2007b). According to, ERGEG(2006), the reason is that the customers have to be willing to pay for the premium contracts, and setting minimum voltage quality standards is a preliminary step for the diffusion. Another aspect to increase the use of premium quality contracts is to develop the concept of premium quality contracts and clarifications of when premium quality contracts are applicable (ERGEG, 2006).

According to a report by Åkerlund et al. (2006), the costs in Sweden, due to poor quality of electricity supply, were estimated to be about 5 billion SEK per year. The total costs within the process industry were estimated to be 1500 MSEK. Since costs due to poor quality are experienced in Sweden, it is reasonable to argue that an interest of higher quality of electricity supply in Sweden might be requested by industrial customers in order to reduce the costs. The regulatory authority in Sweden, the Swedish Energy Markets Inspectorate (Ei), noticed during the development of the quality of electricity supply directives (EIFS 2013:1), that industries requested higher quality of electricity supply than the guaranteed standards. To meet these customers' requests, without increasing the costs for all customers, premium quality contracts might be a regulatory option.

Based on the discussion above, premium quality contracts seem to be an interesting alternative to introduce in the Swedish energy market. This, since premium quality contracts can meet individual customers' needs and industrial customers experience costs due to disturbances in the supply of electricity. It would also be interesting to investigate how premium quality contract would affect the quality of electricity supply regulations, and if changes in the regulations are required in order to implement premium quality contracts in Sweden. The thesis is written for the Swedish regulatory authority, Ei.

1.2 Purpose

The purpose of this thesis is to investigate the applicability of premium quality contracts in Sweden. In order to investigate if premium quality contracts are applicable in Sweden, other countries where premium quality contracts are used, the Swedish quality of electricity supply regulations, and actors in the Swedish energy market, are studied. The following research questions are addressed in order to answer this purpose:

- Is there a need for introducing premium quality contracts in Sweden?
- Why should/ should not, premium quality contracts be implemented in Sweden?
- How can current regulations be modified to facilitate the use of premium quality contracts in Sweden?

1.3 Disposition

This section describes the disposition of this thesis in order to give the reader an understanding about the overall structure of the report. Chapter 2, provides background information about the studied subject. This, to gain an understanding about important concepts that will be used throughout the report. The chapter includes sections about what power quality is and how it can be regulated, what the consequences of poor quality are and a description of the premium quality contract design, and its advantages and disadvantages. This will be followed by chapter 3, which is the methodology chapter where the research method is presented. The purpose of this thesis was answered by reviewing literature, studying the use of premium quality contracts internationally, and interviews with actors in the Swedish energy market. Chapter 4 presents the result from the investigation of premium quality contracts internationally. Included in the study are premium quality contracts used in France, Italy, Norway, Detroit Edison Company in USA, and South Africa. Chapter 5 and 6 presents the Swedish energy market and the results from the interviews with actors in the Swedish energy market. The results from the previous chapters will then be analyzed in chapter 7,

and chapter 8 will conclude the analysis and answer of the purpose of the thesis. After the conclusion the results, the problems that exist and how they possibly can be solved are discussed further in chapter 9.

1.4 Limitations

In this study, only customers within the industrial sector will be included in order to investigate the customer view of premium quality contracts. The reason is that industries experience the greatest costs due to disturbances in the quality of electricity supply (Hulshorst et al. 2007a). Therefore industries might be most interested in premium quality contracts. The TSO's view of premium quality contracts will not be included in the study either. This, since most premium quality contracts that have been used internationally are agreed between DSOs and its customers (Hulshorst et al., 2007a).

2. Background

This chapter provides an understanding about important concepts that are used in this report. Section 2.1 defines quality of electricity supply and what it includes. Section 2.2 presents the consequences of poor quality of electricity supply. This is followed by section 2.3 about quality of electricity supply regulation. After these sections, premium quality contracts as a regulatory instrument, and its advantages and disadvantages are described in sections 2.4 and 2.5. The theories about quality regulation, premium quality contracts and its advantages and disadvantages will be used in the analysis of the research questions.

2.1 Quality of Electricity Supply

According to Fumgalli et al. (2007) the quality of electricity supply can be divided into three different areas. These are commercial quality, continuity of supply and voltage quality. The continuity of supply and voltage quality can be regulated with premium quality contracts, and therefore only these aspects are presented in the following sections. The continuity of supply and the voltage quality are generally referred to as power quality. The quality of electricity supply with respect to both the continuity of supply and voltage quality is therefore referred to as power quality continuously throughout this thesis.

2.1.1 Continuity of Supply

The continuity of supply to a customer is described by the number of interruptions when the voltage drops to zero at the connection to a customer (Fumgalli et al., 2007). The interruptions are defined as either planned or unplanned and long or short. Planned interruptions occur when, for example, planned and scheduled maintenance work in the power system causes an interruption in the supply of electricity. Unplanned interruptions, on the other hand, occur due to unpredicted accidents in the power system, such as environmental events. The planned and unplanned interruptions can either be long or short. Long interruptions are defined as longer than three minutes, and short as less than three minutes. The cause and duration of an interruption depend on the time that is necessary to locate and fix the fault, and the reliability of the entire power system including generation, transmission and distribution networks. This, since a fault in any of these processes can cause an interruption. The number of interruptions and the duration can be shown in measured data. The following indicators are in most cases used to express the continuity of supply, and are used in quality regulations to measure the performance of the DSOs (Fumgalli et al., 2007):

- Average number of interruptions per customer per year
- Average interruption duration per customer per year
- Energy not supplied

The average number of interruptions per customer per year is internationally defined as SAIFI (System Average Interruption Frequency Index). This index, indicates how often the average customer experience a long interruption during a year. Regarding the number of short interruptions per year, an index called MAIFI (Momentary Average Interruption Frequency Index) is used. The average interruption duration per customer per year is expressed with the indicator SAIDI (System Average Interruption Index). An index, regarding the duration of short interruptions, is not relevant to the customers, and therefore no such index exists. The last indicator Energy-Not-Supplied (ENS), indicates the capacity, in kWh, disconnected during an interruption per year (Fumgalli et al., 2007).

2.1.2 Voltage Quality

The voltage quality is described by deviations in the supplied voltage from the ideal waveform. The voltage variations are caused by several different phenomena. The variations in the supply voltage can be divided into two categories, voltage variations and voltage events. Voltage variations are small deviations from the nominal or desired voltage level, and are characterized by having different values at any moment in time. The causes of voltage variations are mainly load pattern, changes of the load or nonlinear loads. Phenomena that are associated with voltage variations are supply voltage variations, flickers, voltage unbalances and voltage harmonics. Voltage events are sudden and significant deviations from the nominal or desired voltage. The nominal value of the voltage, is the value that the voltage ideally should be equal to in an electrical system. Rapid voltage changes, voltage dips, swells and transient over-voltages are all voltage events that affect the quality of electricity supply. The voltage events are occasional and rare, and therefore of large concern for the end-users. For example, the voltage events can cause a complete stop in an industrial process (Fumgalli et al., 2007). The different voltage variations and voltage events that are used in voltage quality regulations are described below:

Supply Voltage Variation

A supply voltage variation is an increase or decrease of the voltage magnitude with respect to the nominal value of the voltage. This characteristic is, for example, caused by the power system design and load changes. The supply voltage variations are usually corrected at various points of the system, for example, by using automatic tap changers at transformer substations. The indicator for the supply voltage variations is the root mean square (RMS) values in a given time interval (Fumgalli et al., 2007).

Rapid Voltage Change

Rapid voltage change is defined as a single rapid variation of the RMS value of the voltage. The duration of a rapid voltage change is definite but unspecified.

The characteristics of rapid voltage changes include maximum voltage change and steady state voltage change, both are expressed in the percentage of the nominal voltage. A rapid voltage change can be either instantaneous, gradual or exponential. The phenomenon is caused by for example load switching or transformer tap-changers (Fumgalli et al., 2007).

Voltage dips and swells

Voltage dips and swells are reductions in the supply voltage magnitude, followed by a voltage recovery after a short period of time. A voltage dip is a decrease in the voltage magnitude followed by a recovery, while a voltage swell is an increase of the voltage magnitude followed by a recovery. The duration of the voltage dip or swell is usually between ten milliseconds to hundreds of milliseconds. (Fumgalli et al., 2007). A sudden reduction of the voltage is recorded as a voltage dip only when the supply voltage is reduced to less than a given threshold (Hulshorst et al., 2007). The most common faults causing voltage dips are short circuits and the starting of large loads. Voltage swells on the other hand are caused by lightning strokes, switching operations and sudden load reductions (Hulshorst et al., 2007a, Fumgalli et al., 2007).

Flicker

The phenomena flicker is defined as a series of voltage changes or a cyclic variation of the voltage. Flicker is caused by voltage fluctuations, which can cause, for example, changes in the luminance of lamps. Sources of flicker are mainly heavy industrial loads such as resistance welding machinery and large motors with varying load, but also small household equipment can cause flicker (Hulshorst et al., 2007a, p.96).

Voltage Unbalance

Voltage unbalance is when the RMS value of the phase voltages, or the phase angles between consecutive phases are not all equal in a three phase electrical system. Voltage unbalance is mainly caused by asymmetries in the line impedance and load unbalance, which means that the load is uneven distributed over the phases (Fumgalli et al., 2007). This can appear because of asymmetrical inductance in the transmission lines due to incomplete twinned lines. Long transmission lines that are not fully twinned have active effect transformed between the phases (Åkerlund et al., 2006).

Harmonic Distortion

Harmonic distortion means that the voltage never is a single frequency sine wave. A periodic waveform can be described as a sum of sine waves with frequencies that are multiples of the fundamental frequency. The non-fundamental

components are called harmonic distortions. The harmonics are mainly caused by customer nonlinear loads connected to the power system, but also harmonic currents flowing through the system impedance give rise to harmonic distortions (Fumgalli et al., 2007). The harmonics are also created when the current is rectified and get another waveform than the voltage sinusoidal waveform. In total is about 70% of all electricity passing rectifying circuits. Therefore the phenomenon occurs in most of the electricity supplied to the customers (Åkerlund et al., 2006).

Transient over voltage

Another dimension of voltage quality is transient over voltage, which is a voltage deviation with short duration, high magnitude and fast rise time. The cause of transient over voltages are lightening strokes and switching of heavy or reactive loads (Fumgalli et al., 2007).

Signaling Voltage

The last aspect, covered in the standards, is main signaling voltage. This phenomenon can occur when the distribution network is used for transmission of signals. The disturbance in the supply voltage is caused when the mains signaling voltage is superimposed on the supply voltage, for the purpose of transmission of information through the distribution system (Fumgalli et al., 2007, p.102).

2.2 Consequences of Poor Power Quality

As stated in the problem discussion, disturbances in the supply of electricity are costly for industries. The power quality aspects that have shown to be most costly are long interruptions, short interruptions, transients, voltage variations, harmonics, voltage unbalance and flicker (Hulshorst et al., 2007a, Åkerlund et al., 2006). Consequences that have been experienced by customers are, for example, damaged equipment, energy losses in machines and production loss. Damaged equipment results in a shorter life-length of the equipment, which implies increased equipment costs for the customers. In order to protect the equipment, customers that have sensitive equipment may invest in protective devices. Several different protective solutions exist. The protective devices can be complex installations and can be costly to install. For example, protection against long interruptions requires a back-up generation or a redundant electricity supply system. Other alternatives that are more economically beneficial, like filters that protect against harmonics exist, but these alternatives still require an investment for the customer. The energy losses in machines that might occur due to the power quality aspects, cost the industries since it implies that the machine consume more energy. The last possible consequence of insufficient power quality is a stop in an industry's production. The cost of a stop depends on the duration and the time of the interruption. Restarting the production is, however, almost always a costly

process that affects the industry. The longer the stop is the more costly it is due to the production loss. Industrial customers are, for example, more likely to be affected during weekdays, when they probably are running more operations than during weekends. The consequences, mostly, impact the customers financially, but also non-financial costs can affect the customers. The phenomenon flicker, for example, can disrupt the lightning in facilities, which can cause annoyance to the customer (Fumgalli et al., 2007, Hulshorst et al., 2007a, Åkerlund et al., 2006).

2.3 Quality Regulation

The distribution of electricity is a natural monopoly in the energy market. This, since the customers only is connected to one DSO, and cannot choose DSO. Monopoly markets must be regulated to ensure the optimal outcome for the society, else the company that has a monopoly can charge customers a price that is much higher than the production cost. In the perfect monopoly market, the profit motive induces innovation, investment in new projects, reduced costs, and competition puts downward pressure on prices. The most important for the regulator, to ensure that the customers pay a reasonable price, is therefore the regulation of the revenue from the electricity distribution. The revenues must be sufficient to enable the utility to cover its operating costs and to make necessary investments, while earning return on the capital invested. Generally the objectives of the regulation is to determine allowable revenues, attempting to provide the service or product at the lowest possible cost. The aim is to define a regulatory design that achieves an optimal trade-off between efficiency and quality of service and find the optimum quality that is good enough at the lowest cost (Pérez-Arriaga, 2013).

The power quality regulation process is complex. Generally it takes several years to develop a regulatory system. This, since the regulatory tools require measurements of the power quality aspects in order to regulate the supply of electricity (Fumgalli et al., 2007). According to ERGEG (2006), voltage quality regulation is important in the regulatory system for several different reasons. For example, it is important to obtain a quality of electricity supply that is beneficial for the society as a whole, customers experience costs due to poor quality, and to provide a good basis for managing disputes between network operators and customers.

According to Fumgalli et al. (2007), four different instruments can be used to secure a desirable quality of electricity supply. The first instrument is data publication of company performance. Measured data of the power quality aspects demonstrates the actual quality supplied to the customers, and thus demonstrates the performance of the network operator. The second instrument is guaranteed standards. The guaranteed standards specify the minimum performance standards that the network operators are obliged to supply. Non-compliance with the

minimum levels might include penalties. The third instrument also specifies performance standards and is called reward and penalty schemes. The reward and penalty scheme modify the network operating company's revenue according to its actual performance. The higher quality of electricity supply the network operator delivers, the higher is the revenue. The regulator aims to develop a scheme with the optimal level at which the benefits of additional quality is equal the costs of supplying the specified quality. Reward and penalty schemes are preferably used to regulate the continuity of supply. The fourth instrument is premium quality contracts, which is an agreed contract between the network operator and its customer. The premium quality contract can include continuity of supply and/or voltage quality specifications. A deeper presentation of premium quality contracts is found in 2.4.

The different regulatory instruments can either be employed alone or in combination with one another. The regulatory tools that are appropriate to use vary between different countries. This, since different countries have different power systems with different prerequisites. The quality of electricity supply is regulated on an individual level or/and system level. Guaranteed standards and premium quality contracts include performance standards and financial incentives that are measured individually and aim to control the quality on a customer level. These regulatory tools can therefore be called selective quality regulation. The reward and penalty schemes on the other hand aim to control the average quality of electricity supply on system level. Since the reward and penalty schemes control the average quality and affect the customers collectively, reward and penalty schemes can be called collective quality regulation. Table 1 shows the regulatory tools that regulate the energy market on the collective level and the selective level, and what quality aspects that can be included in the regulatory tools respectively. The framed area represents the focus in this thesis. The table is based on a table 2.1 in *Service quality regulation in electricity distribution and retail* (Fumgalli et al., 2007).

Table 1. Quality of electricity supply regulation.

Collective quality regulation	Selective quality regulation	
Reward and Penalty Scheme	Guaranteed Standards	Premium Quality Contracts
Commercial Quality	Commercial Quality	Continuity of Supply
Continuity of Supply	Continuity of Supply	Voltage quality
	Voltage quality	

2.4 Premium quality contracts

As stated previously, a premium quality contract is an agreement between a network operator and a customer that requests higher power quality than the guaranteed standards. The customer pays the network operator for the contract, and in return the network operator ensures that the quality specified in the contract is delivered to the customer. If the agreed power quality is not met, the network operator has to compensate the customer for the costs that are caused by disturbances in the supply of electricity (Fumgalli et al., 2007). The customer pays for the customized power quality individually. The costs of providing a reliable supply of electricity is thus not averaged across all customers, and not included as revenue in the electricity tariff (Fumgalli et al., 2004).

The International Electrotechnical Commission (IEC) has, in the power quality standard IEC 61000-4-30, recommended a list of factors that should be included in a premium quality contract. For example, achievable and acceptable individual performance standards, the price to be paid by the customer, the compensation to be paid by the network operator, and events that are excluded from the contract, are specified in the standard. Standards regarding interruptions and voltage dips have, in most cases, shown to be included in the contracts (Hulshorst et al., 2007a).

The price of the contract, to be paid by the customer, and the level of coverage depend on the customer's value of reliable electricity and the costs of the service that is requested in the contract. The most efficient pricing of a premium quality contract is when the premium paid is equal the expected value of the reimbursements. In this case, the customer is protected from any decrease in quality of electricity supply and the utility has additional incentives to improve the quality. The revenue from the premium quality contract is not aimed to meet the revenue requirements for current fixed and operational costs. These are received from the delivery tariff. The revenues will only cover the compensation or future investments to improve the reliability that are specified in the contract (Fumgalli et al., 2004).

In order to protect the DSO, it is important that the pricing is sufficient to cover the investment costs or the compensation that the DSO have to pay its customer in case the specified standards are not met, else the DSO risks to be bankrupt. It is also important to ensure that the price of the contract is not too high for the customer. Therefore should events that can cause great costs for the DSO or cannot be controlled by the DSO, be excluded from the contract, to protect the DSO and decrease the price of the contract. For example, the DSO should not be responsible for interruptions caused by generation or transmission of electricity or be responsible for interruptions caused by large deviations in the customers load profile. Regarding disturbances in the supply of electricity caused by weather

conditions, which might result in large reimbursements can either be exempted from reimbursements or included in the pricing. This since, the DSO can prevent damage from such events by moving lines underground or remove trees around the lines. Another important aspect to consider to ensure that the investment costs are covered by the contract, is the duration of the contract. If the duration is not specified the customer can chose a contract with high coverage in the beginning and a lower coverage when the DSO has invested and improved the quality. Contracts with long duration and with the ability to upgrade coverage but not downgrade the coverage will protect the DSO from these problems (Fumgalli et al., 2004, Hulshorst et al., 2007a). Another alternative, presented by Fumgalli et al. (2004) in order to protect the DSO from bankruptcy, is make the premium quality contracts compulsory in the initial stage of implementing premium quality contracts. The regulator can in this stage determine a minimum level of coverage for various classes of consumers during the first few years that the premium quality contracts are implemented. This, since the DSO will not be able to immediately differentiate the reliability to the individual load level. This will also make the customer learn about the contracts and do not refuse to purchase due to lack of understanding. However, it is important to allow customers with low preferences of reliability to be relieved for paying for higher quality than they need in this stage. In order to ensure that the network operator offers a contract at a fair price, the regulator can, for example, set a price baseline for different types of customers based on the average reliability of a service area.

Necessarily, premium quality contracts do not have to concern higher power quality. Price sensitive customers that prioritize the cost of electricity before the quality might be interested in lower voltage quality, to reduce the electricity costs. This system enables the network company to interrupt these customers when the system is under stress, to avoid interruptions at other customers (Hulshorst et al., 2007a).

2.5 Advantages and Disadvantages with Premium Quality Contracts

Premium quality contracts have both advantages and disadvantages for the customers and the DSOs. The customers benefit from the premium quality contracts since the contracts provide a power quality according to the customer's individual preferences and value of power quality. Another advantage for the customers is that the use of premium quality contracts implies that the financial risk is eliminated for the customers. This, since the customer is compensated, if the DSO fails in supplying the contracted power quality (Fumgalli et al., 2004, Hulshorst et al., 2007). Additionally, premium quality contracts benefit the customers because the cost for the power quality that is offered in the contract, is not averaged to all customers. This entails that collective improvements at a

single, higher charge for all customers is not required, and customers with low reliability preferences avoid paying for unneeded reliability. At last premium quality contracts can be a price efficient alternative for the customer. This since the price of the premium quality contract can be lower than the cost of installing protective devices. The customer might for example install back-up generators to ensure a reliable supply of electricity, which could cost less if the DSO installed it. This, since the DSO has the ability to, for example, provide backup generation for customers that are located near each other and split the cost between these customers. The drawback for the customers of using premium quality contracts is that customers might use each other's contracts. The customer can, for example, take the risk and purchase for a lower level than their actual value of power quality. The customer will, in such a case, not receive sufficient compensation for the losses (Fumgalli et al., 2004).

The advantages, from the DSO's perspective, of using premium quality contracts are a more efficient network management and aggregating customers at separated nodes. The management can, for example, be more efficient since the DSO does not has to deliver uniform reliability to all customers, and can focus on improvements in the network where it is needed according to the customer preferences. Aggregating customers at separated nodes enables the DSO to, for example, differentiate between industrial areas and residential areas according to their different values of power quality. A risk with customer aggregation is, however, that it creates the opportunity for the customers to benefit from other customers' contracts. This, since investments in a feeder that is connected to the customer with a premium quality contract may affect other customer at that feeder. A customer that is aware of that other customers at the same feeder have premium quality contracts with a certain level of coverage can therefore choose a lower level and benefit from the other customers choices. However, this requires that the customers need to know the level of aggregation and the DSO's ability to differentiate the reliability, to benefit from this. The ability to identify contracts of neighbors is limited and the customers are therefore not likely to have information about the level of aggregation. A solution to avoid customers to benefit from aggregation is to offer long term contracts. This since coverage of quality levels are locked for significant time periods (Fumgalli et al., 2004). At last, another disadvantage for the DSO is the financial risk that the contract implies. This, since there is a risk that the reimbursement costs exceeds the value of the contract. This risk can, however, be reduced by exclusions and well-developed specifications in the contract (Fumgalli et al., 2004, Hulshorst et al., 2007). Table 2 summarizes possible advantages and disadvantages that the customers and the DSOs might experience if premium quality contracts are introduced.

Table 2. Advantages and disadvantages for DSOs and customers of using premium quality contracts.

	Advantages	Disadvantages
Customer	<ul style="list-style-type: none"> • Customized power quality • Eliminated financial risks • Avoid paying for unneeded reliability 	<ul style="list-style-type: none"> • A risk that customers benefit from each other's contracts
DSO	<ul style="list-style-type: none"> • Efficient network management • Minimized reimbursement costs 	<ul style="list-style-type: none"> • Possible financial risks for the DSOs

3. Methodology

This chapter presents the research method used to answer the purpose of this thesis. Section 3.1 provides a general overview of the investigation. Sections 3.2-3.4 that include presentations of the different research methodologies; literature review, email questionnaire and interview follow this. The last section 3.5 contains a critical evaluation of the study, where the credibility of the study is discussed.

3.1 Structure of the Investigation

The methodology that has been used to answer the purpose of the study was performed in three steps. The first step was to investigate the use of premium quality contracts internationally. The reason for studying the use of premium quality contracts in other countries, was to provide an understanding about what is required to introduce premium quality contracts in the regulatory system. Another reason to study premium quality contracts internationally is to provide an understanding about why premium quality contracts are used and how it is experienced in the studied countries. The countries included in the investigation were France, South Africa, Italy, USA, and Norway. These were chosen because premium quality contracts are or have been used in these countries (Hulshorst et al., 2007b). The information about premium quality contracts internationally were derived from literature reviews and email questionnaires that were sent to regulatory authorities in France, South Africa, Italy, and Norway.

The second step in the process was to study the Swedish quality regulations. This is necessary in order to see what changes in the power quality regulations that might be needed in order to introduce premium quality contracts. It is also essential in order to being able to compare the Swedish regulatory system with the other countries', where premium quality contracts have been introduced, quality regulations. Additionally interviews with industries and DSOs in Sweden, and the Swedish regulatory authority, Ei, were performed. This provided the view of premium quality contracts from all actors that are affected, if premium quality contracts are introduced in Sweden. The customers' views are important in order to see if a need of customized power quality exists, if the customers are willing to pay for customized power quality, but also how premium quality contracts would affect them. The DSOs' views are essential to gain an understanding about their possibilities to manage customized power quality and how premium quality contracts might affect their businesses. The view from Ei is significant to gain an understanding about the impact of premium quality contracts on the current regulatory system and for discussing alternative solutions to premium quality contracts. The different views from all actors are important to achieve the result that is most beneficial for the society.

The gathered data from these steps was then analyzed in order to answer the purpose of the study. Figure 1 illustrates the different parts of the investigation and the methods that were used to gather the data is stated within the parentheses.

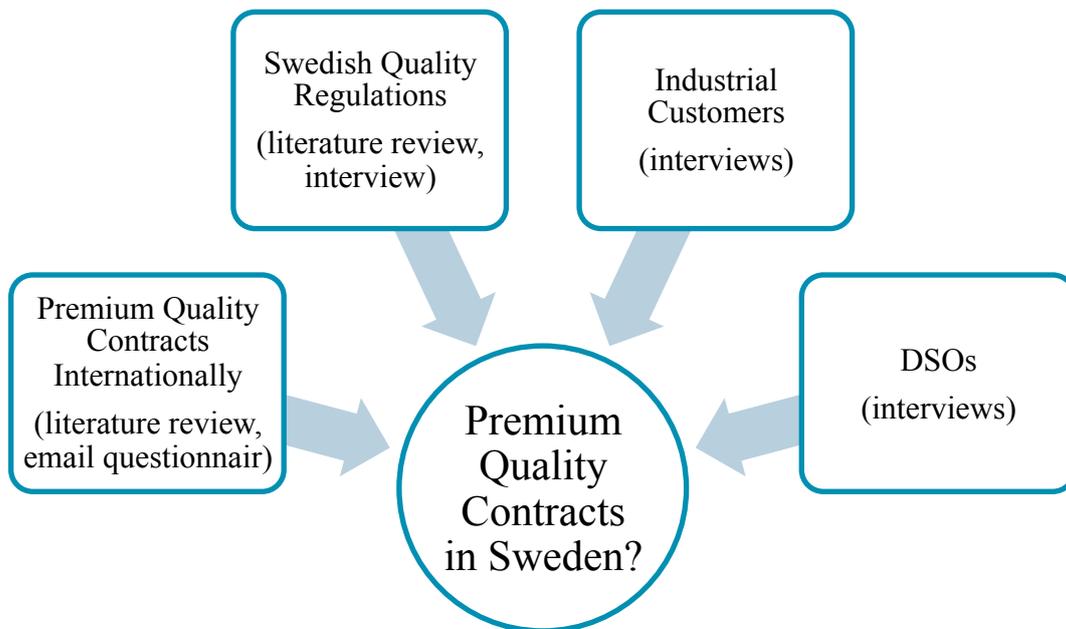


Figure 1, Research methodology

3.2 Literature Review

In order to gain an understanding about the studied subject, literature reviews were performed. Literature has been used to gather the background information, but also to provide information about the use of premium quality contracts internationally, the Swedish energy market, and the Swedish power quality regulations. The literature reviews were mainly performed in the beginning of the project, but it has been performed throughout the project. According to Bell (2006), literature reviews help the author to gain an understanding about what already have been studied and what the most important questions to examine are. Since the purpose of the literature review, in this study, was to gain an understanding about the studied subject and how different countries are using premium quality contracts, it was seen as an appropriate method.

The literature that were used in this study came from various sources, such as, reports, websites, books, governmental publications and directives. The literature that has been chosen is therefore derived from primary and secondary sources. According to Bell (2006) primary sources are the first occurrence of a piece of

work. These include sources such as reports, central and local government publications, but also unpublished manuscript sources like letters, memos and committee minutes. Secondary sources are for example books and journals. The literature that was chosen is seen as reliable because it comes from sources that are reliable and trustworthy. This is important for the credibility of the study (Bell, 2006).

3.3 Email Questionnaires

Information regarding the use of premium quality contracts internationally was, except literature reviews, derived from email questionnaires that were sent to regulatory authorities in the studied countries. The questionnaires are found in Appendix A. The questionnaires were developed based on how premium quality contracts are used in each country respectively and therefore the questionnaires differentiate from each other. The purpose with sending email questionnaires was to gain a deeper understanding about the role of premium quality contracts in the studied countries and to receive updated material about premium quality contracts. Since, the regulators in the chosen countries are positioned far away from Sweden and personal meetings were not possible, this was seen as an appropriate alternative.

The questions sent to the regulators were designed as open, which means that the responses to the questions are not suggested in the questionnaire (Ian, 2008). The questions were chosen to be open since the answers cannot be predetermined and to give the respondent the opportunity to give the full answer to avoid loss of information. According to Ian (2008) open-ended questions are used when the researcher cannot predict the responses.

Representatives at the regulatory authorities in the France, South Africa, Italy and Norway were chosen as respondents. This since they were considered to have great knowledge about each country's quality regulation that concerns premium quality contracts. A questionnaire was not sent to USA and the regulatory authority in Detroit because the contracts that have been used there have expired. France and Norway responded to the questionnaire. Italy did not respond through the questionnaire. The questions were instead sent to the Italian regulator through Ei, when Ei representatives had a meeting with the Italian regulator. South Africa could unfortunately not participate. In table 2 the representatives from France, Italy and Norway are presented.

Table 2. The participating international regulators

Name	Country	Regulatory Authority
Vincent Jérémy	France	Commission de Régulation de l'Énergie (CRE)
Luca Lo Schiavo	Italy	Autorita per l'Energia Electric il Gas (AEEG)
Kjersti Vøllestad	Norway	Norwegian Water Resources and Energy Directorate (NVE)

3.4 Interviews

In order to gain a deep understanding about the studied subject the qualitative method interviews were chosen. According to Bell (2006), interviews are used to gain a deep understanding and developed responses about the studied area. This since, the interviewer can follow up questions, receive feelings, and touch areas that are impossible in, for example, a questionnaire (Bell, 2006). Therefore interviews were an appropriate method. The interviews were performed in a semi-structured manner. This implies that the interviewer working with an interview guide where themes and major questions are defined, but there will also be room for deviation from the guide during the interview (Justesen & Mik-Meyer, 2010). It was hard for the interviewer to predict the answers, and therefore it had to be room for reflection. A guide with the interview questions was used, so the interviewer could ensure that all questions were covered during the interview (Bell, 2006). The interview questions were designed to not be valuing or judging, and not lead the respondent in any direction. According to Bell (2006), this is important to receive reliable responses. The interview questions used in this study were shown for the supervisor of the thesis before the interviews to ensure that the questions could be used to answer the purpose.

The interviewees that were chosen for this study were representatives from DSOs in Sweden, the industrial sector in Sweden, and Ei. Tables 3 to 5 present the interviews that have been performed. The interviews were either face to face, video call or telephone call. The reason of using different methods was that the interviewees were spread out in Sweden. It was therefore not possible to manage personal meetings with all participants. The industries that participated were

Billerud Korsnäs AB, Sandvik AB, Stora Enso AB and one industry that has chosen to be anonymous. This industry will be defined as Industry A in this report. One of the interviews was performed with two industries. The reason was that the respondents were gathered in Stockholm and could manage to meet there together. The DSOs chosen for the survey are Vattenfall AB, EON AB and Ellevio AB. These are the largest DSOs in Sweden and own most of the regional networks where industries are connected. After the interviews with DSOs and industrial customers, interviews were performed with representatives from Ei. Before these interviews the results from the interviews with customers and DSOs were presented for the Ei participants. This to ensure that the respondents were aware of the existing problems, and could discuss possible solutions during the interview. The interviews that were conducted through personal meetings and video call were recorded to avoid loss of information (2005). The telephone interviews were not possible to record, therefore notes were taken instead.

Table 4. Industrial customer representatives

Name	Company	Date	Type of interview
Beng-Arne Wallden	Billerud Korsnäs	2015-10-23	Personal meeting
Lars Skoglund	Sandvik AB	2015-10-23	Personal meeting
Anders Heldemar	Stora Enso	2015-10-29	Telephone
Industry A respondent	Industry A	2015-11-12	Telephone

Table 3. DSO representatives

Name	Company	Date	Type of interview
Per Norberg	Vattenfall AB/Chalmers	2015-10-20	Personal meeting
Eskil Agneholm	Ellevio AB	2015-11-06	Personal meeting
Thomas Eng	Vattenfall AB	2015-11-03	Video call

Fredrik Roos	EON AB	2015-11-05	Telephone
--------------	--------	------------	-----------

Table 5. Ei representatives

Name	Regulatory Authority	Date	Type of interview
Lars Ström	Swedish Energy Markets Inspectorate (Ei)	2015-12-02	Personal meeting
Linda Werther	Swedish Energy Markets Inspectorate (Ei)	2015-12-08	Personal meeting

3.5 Critical Evaluation

In order to investigate the need of premium quality contracts in Sweden, views from all actors that are affected by premium quality contracts were considered. Including all these views in the investigation strengthen the result of the study. However, the participating industries are within the industrial sectors that consume most energy in Sweden. According to The Swedish Energy Agency (2015), the pulp and paper industry, the iron- and steel industry and the chemistry industry are the most energy-intensive sectors in Sweden. In order to increase the credibility of the study, could for example customers from other sectors and less energy-intensive sectors be included in the study as well.

The credibility of the study could also have been affected due to the poor responses of the email questionnaires, and that the regulatory authorities that responded did not have that much information about the premium quality contracts that are used. This means that all information that was requested could not be derived. However, the information that the respondents provided were very useful since it provided updated information about the premium quality contracts. Other information like, how frequently used premium quality contracts are, and how they are used is beside the regulatory authorities businesses, and therefore could no information about this be derived. However this has not affected the result of the investigation.

Another factor that might affect the credibility is that the interviews have been performed in different manners, in group, personal meetings, telephone calls, and video calls. It was not possible to meet all participants in person. This, since a

limited amount of people working with these questions and they are positioned in different cities in Sweden. However, the use of different interview methods does not seem to have affected the result. For example, two interviews were performed with Vattenfall AB, one through a personal meeting and one through video call, and the interviews had the same result.

At last the credibility of the study can be questioned because the respondents are non-anonymous. Mentioning the names of the participants can affect their responses, especially when it comes to responses about economics. However the participants has reviewed the result of the study in order to ensure that no misunderstandings have been made. I do not think this has affected the result of the study, the outcome would probably have been the same. However, letting the participants being anonymous possibly could have derived information about the costs and the willingness to pay for premium quality contracts.

4. Premium Quality Contracts Internationally

This chapter presents five different examples of premium quality contracts that are or have been used internationally. The countries that are studied are France, Italy, South Africa, USA and Norway. Each country is presented separately, and the first section about each country describes the quality regulation in the country. The second section demonstrates how premium contracts were developed and are used as a regulatory tool. Studying other countries experiences of premium quality contracts will support the analysis of this thesis. This, since it provides an understanding about how premium quality contracts are used, when premium quality contracts are requested, and what is required for a successful implementation of premium quality contracts.

4.1 France

4.1.1 Quality regulation

The French energy market is regulated by the commission de regulation de l'Energi (CRE). This regulatory authority ensures that the energy market allows development of competition in order to benefit the customers (CRE, 2015). The energy market in France was deregulated recently, from 1999-2007, and is therefore still dominated by one company. This company is Elecricite de France (EDF). EDF is owned by the French state and the company owns both the TSO, RTE, and the DSO, ERDF that manage about 95% of the distribution network (Deloitte, 2015). The DSOs in France are operating the network at voltage levels from 230/400V to 20kV. Voltage levels above 20kV are operated by the TSO (Jérémy, 2015).

The power quality regulations in France are incentive based. The incentives are important to encourage operators to maintain or improve the quality of electricity supply while increasing productivity. In order to ensure that the quality of electricity supply is sufficient, SAIDI and SAIFI indicators are measured at all voltage levels to measure the performance and establish penalties and rewards (Jérémy, 2015). The continuity indicators are measured and published on a yearly basis, and the regulator sets interruptions standards that have to be met by the network operators. The electricity tariff in France is divided into two different parts, the first part depends on the power capacity of its facility, and the second part is variable and depends on the energy consumed by the customer's facility. The customers are refunded a percentage of the fixed part of the tariff. Regarding the voltage quality, France had no monitoring system installed. However, regulations regarding voltage quality can be specified in customized contracts (CEER, 2008, Jérémy, 2015). Customized contracts for higher power quality is only offered by the TSO, and the contracts are offered to customers that are sensitive against disturbances in the supply of electricity (Fumgalli et al., 2007).

At the DSO level is only something called grid access contracts used and it is only for customers above 250kVA. The compensation for these contracts is defined case by case and the number of interruptions that are defined in these contracts depends on the performance history of the area (Jérémy, 2015).

4.1.2 Premium quality contracts in France

The need of premium quality contracts in France began in the beginning of 1990. The reason for introducing the contracts was that the use of more sensitive electronics increased among the customers, and therefore the customers requested higher power quality. In 1994, the use of the contract, called Emeraude, took place and since then the contracts have been developed (Hulshorst et al., 2007a). In the contracts, a minimum level of power quality is specified, but also maximum levels of emissions to the system that the customers must not exceed. The limits are assured to not be exceeded by monitoring recorders installed at the customers, if the limits are exceeded, the network operator compensates the customer for the damage caused by the disturbance (Hulshorst et al., April 2007, Fumgalli et al. 2007). Dependent on the customer's need, two different premium quality contracts are offered by EDF. The revenue from the premium quality contracts is an additional revenue for the TSO, and separated from the regular tariff (Jérémy, 2015).

The first type of contract with customer-adjusted levels of power quality is only offered to customers connected at the medium voltage (MV) level (Fumgalli et al. 2007) and to customers who have operations that are sensitive to disturbances in the supply of electricity. In this contract is the number of short interruptions and voltage dips are determined on customer request, and the contracts can be established for longer than one year. Number of voltage dips that is included in the contract depends on the performance history of the area where the network is located and it can include commitments from one to four dips per year. The customer is compensated for all expenses that results from the voltage dip. (Jérémy, 2015). The customer pays for the contract. In 2007, the cost of the contract was about 1000 Euros per year, if the contract covered voltage dips, else it would cost the customer about 500 Euros per year (Hulshorst et al., 2007a). Included in this fee is monitoring equipment and production of a yearly report that shows the quality supplied by the network operator (Hulshorst et al., 2007a, Fumgalli et al., 2004). Last year 213 customers subscribed these contracts (Jérémy, 2015).

The second alternative is a plus contract, this contract is specialized for customers with very sensitive processes that demand high levels of power quality. Compared to the other contract, this contract includes that the distribution network operator performs investigations when critical improvements of the power supply system becomes necessary. The purpose of the investigations is to enhance the power

supply and make the customer installation less sensitive against disturbances. The costs of these improvements are then shared between the customer and the distribution network operator in proportion to the customer's needs, the network properties, and the number of disturbances generated by the customer and the operator (Hulshorst et al., 2007a). This alternative is only accessible for customers who already have been taken the first level contract for at least three years. Three customers subscribed this contract last year and it is especially facilities with very sensitive processes, such as paper mills, that are using this contract (Jérémy, 2015).

In addition to the different premium quality contracts presented above, EDF offers a variety of other services to large and medium sized customers in order to ensure good power quality. One of these services is called Fiabelec. This service is offered to customers who want their electrical installations to be less sensitive against disturbances. The service ensures that the power quality matches the customer's needs. EDF charge the customer for this service, and the cost depends on the complexity of the problem to be solved, customer requirements, and the network characteristics. Prevenance is another service offered by EDF. This service is offered for free and includes that EDF consults the customer about appropriate dates and times for performing maintenance and improvements on the power supply network. At last another service that is free of charge, called Echo Reseau, is offered to the customers. This service allows EDF to provide information about the quality of their power supply to customers that are planning factory constructions or expansion projects (Hulshorst et al., 2007a).

4.2 Italy

4.2.1 Quality regulation

Autorita per l'energia electric il gas (AEEG) regulates the energy market in Italy. This authority was established in 1995 with the purpose to protect the interest of users and consumers, and ensure cost effective and profitable services with satisfactory quality levels. The main tasks of AEEG are to maintain a reliable and transparent tariff system, reconciling the economic goals of operators with general social objectives, and promoting environmental protection and the efficient use of energy (AEEG, 2015). The energy market, which is deregulated, had in 2010, 144 different distribution network operators and among these the company Enel Distributions is dominating, since it operates 86.3 % of the distribution networks (Monesi, 2012).

To assure that all the operators deliver sufficient power quality AEEG has established guaranteed quality standards regarding the continuity of supply and the voltage quality. The continuity of supply is measured by the continuity indicators, SAIDI and SAIFI at different voltage levels, and specified levels of

these indicators are set as guaranteed standards that the customer can require the DSO to deliver. The regulator determines the measurement rules and randomly inspects the interruption data. If the recording of data is insufficient, the continuity data and the penalties and incentives is recalculated. All regulated companies are at least inspected once every four years. Italy is also using reward and penalty schemes. The objective of the reward and penalty scheme in Italy is to improve the continuity levels and reduce regional gaps in continuity. The incentive and penalty schemes has had positive effects in Italy, this since it has improved the continuity of electricity supply in the country. The minimum standards regarding the voltage quality follow the European standard, EN50160. The voltage quality is monitored and the distribution companies are compelled to provide voltage quality individual verification when it is requested by the customer (CEER, 2005). In order to receive a higher power quality than the specified standard, customers and DSOs have the opportunity to introduce premium quality contracts (Hulshorst et al., 2007a; CEER, 2005).

4.2.2 Premium Quality Contracts in Italy

In the Italian regulations, it is specified what a premium quality contract should include. The contracts can only concern higher power quality than the standards set by the regulator. The revenue from the contract is not included in the revenue framework. The DSO has to be report the revenues and eventually paid compensation to the regulator. According the Italian regulations (2015), the contract must specify performance standards for one or more quality indicators, both continuity indicators and voltage quality indicators can be included. Also a premium price to be paid by the customer, compensation to be paid by the distribution network operator in cases of non-compliance with the performance standards, and the events that are excluded from the payments should be specified in the contract (Hulshorst et al.,2007a). The customer and the network operator determine the duration of the contract, but it has to be at least one year and no more than four years. Exclusions from these guidelines are however possible, if the involved parties agree. The customer can also request for quality indicators that are not already measured, the parties are then obliged to arrange for a period of measurements. The customer pays for such measurements and is entitled to install its own measuring instruments if needed (Fungalli et al., 2007). At last, another obligation is that the distribution network company is responsible of reporting the number and contents of premium quality contracts to the regulator. It might happen that more than one customer connected to the same distribution network is interested in quality improvements. The costs and benefits of premium quality contracts can then be shared among several customers. The revenue from the contracts is treated as a service excluded from the DSOs' regular tariff (CEER, 2008).

The possibility to implement premium quality contracts, concerning voltage quality and interruptions, exists in Italy since 2004, but in 2008 no such contracts had been established yet, and much experience of using premium quality contracts has still not been noticed by the Italian regulator (CEER, 2008). According to a report by Enel (2007), the reason to why no contracts have been implemented, despite the opportunities, can be that the customers have not been in need of increased power quality. Surveys performed by Enel showed that only a few customers asked for better quality (Enel, 2007). The regulator in Italy was asked how many contracts that are used today. No exact number could be presented but according to their knowledge, just a few contracts are used in Italy today (Schiavo, 2015).

4.3 South Africa

4.3.1 Quality Regulation

The regulatory authority in South Africa is called National Energy Regulator of South Africa (NERSA). NERSA regulates the electricity, piped gas and petroleum pipelines industries in the country (NERSA, 2015). The primary tasks of NERSA is to issue licenses and conditions for the generation, transmission and distribution of electricity, for the import and export of electricity and for the traders of electricity, but also register and monitoring those who want to be or already are licensed. NERSA is also responsible of regulating the pricing and tariffs at the energy market, plan the electricity infrastructure and design the regulatory framework (NERSA, 2015).

To assure that the supply of electricity is of good quality, NERSA has developed specified standards. Included in these standards are minimum power quality standards, but also procedures of measurements, application guidelines for utility companies and recommendations of what agreements that can be included in a contract if a customer wish higher power quality than the minimum standards (NRS 048-4). In South Africa, only one company is operating in the energy market. This company is Eskom, and Eskom is responsible for the generation, transmission and distribution of electricity to industrial, mining, commercial, agricultural and residential customers (Eskom, 2015). Eskom offers premium quality contracts to their customers if better power quality is requested by th customers (Hulshorst et al., 2007a).

4.3.2 Premium quality contracts in South Africa

The need of premium quality contracts started when the supplier of electricity in South Africa, Eskom, experienced problems with the power quality. The problems occurred due to long distances between the customers and the production of electricity. Since the customers experienced the disturbances higher the customers

requested higher power quality. At first a power quality program with minimum standards was developed. The program was introduced in the beginning of 1990, and in 1992 started an implementation of power quality measurements at substations. This, to quantify the levels of power quality experienced by the customers and addresses the increase in customers' plants sensitivity and thus greater awareness of the actual power quality. During the same time as the measurements took place, Eskom performed interview surveys about the power quality among the customers. This, to be aware of the costs associated with disturbances in the supply of electricity (Hulshorst et al., 2007a).

In addition to the customer survey and measurements another project was established to investigate possible solutions against power disturbances at the customers' side. The objectives of this project were to demonstrate solutions at the costumers' side and develop skills and tools to allow the use of new technology in the power systems (Hulshorst et al., 2007a).

As a next step in the development of the regulations, individualized premium quality contracts were introduced. Eskom offers three different contracts, and the contracts include both the utility company commitments and customer commitments. The first contract is called *delivery according to national power quality standard*, which implies that Eskom guarantees a minimum power quality level. In case the requirements are not met, Eskom is obliged to improve the standard, if the standard is higher than the required level from start the customer pays no additional fees and does not need to sign any agreements. The second option is called *network specific option*. The contract included in this option provides the customer with a higher power quality than the minimum standard. Eskom establishing and examine what quality that can be offered from the existing network that is connected to the customer. The customer then pays for a certain part of the investigation performed by Eskom. Based on the investigations is a customer-adjusted agreement signed between the customer and the distribution network operator. The third alternative is a *premium power option*. This contract offers better power quality compared to the other options. The agreement in this kind of contract is that Eskom performs investments in the grid or at the customers to guarantee an improved quality of electricity supply. The cost of this contract is fixed during the contract period and if the guaranteed levels are not reached, the customer is rewarded according to the agreed reward specified in the contract. The procedure of implementing the premium power option follow the steps presented below (Hulshorst et al., 2007a).

- 1) A customer requests a level of electricity quality that exceeds what the system can deliver.
- 2) Eskom performs a technical study of the customers plant and power network to determine the sensitivity of the plant equipment and how often disturbances occur.

- 3) Eskom develops end design solutions
- 4) The customer and Eskom negotiate and agrees about a monthly charge
- 5) Eskom purchases, installs and commissions the necessary power conditioning equipment at the plant.
- 6) Eskom carries out maintenance during the period of the agreement.

Customers and consultants have responded very positive to this method and it has been a profitable solution in South Africa (Hulshorst et al., 2007a).

4.4 Detroit Edison Company, USA

4.4.1 Quality regulation

The energy regulation in the USA is complex, and is regulated by various federal and state agencies, departments and state entities. The distribution of electricity is generally regulated by individual state regulatory agencies or municipal agencies (Gergen et al., 2012). In south east of Michigan where one of the largest electricity utility company in USA, Detroit Edison Company (DTE), operates, is the distribution of electricity regulated by Michigan Public Service Commission (MPSC) (DTE Energy, 2015). MPSC is responsible for the electricity utility regulation including the regulatory responsibility over the privately owned electric utility companies, among them DTE (MPSC, 2015).

MPSC has performed surveys and measurements to set up minimum quality standards that the utility companies in the state have to meet to ensure that the power quality is sufficient for the customers. These standards have been developed since year 2000 (Martinez et al., 2009). The reliability of the electricity supply in Michigan is regulated through approval of capital and operation and maintenance expenditures related to reliability based programs. The commission review quality indicators such as SAIDI and SAIFI to measure the need of reliability investments. Service quality and reliability standards for electric distribution systems are also used to regulate the power quality in the area (Quackenbush et al., 2013). The network operator DTE utilize standards for the RMS voltages magnitude and duration, for customers who have equipment that is sensitive against disturbances. DTE has therefore created a curve with RMS voltage criteria. DTE also offer customers with sensitive processes an engineer that will provide a solution to power quality issues. The engineer gathers information about the power quality issue and work with the customer to resolve the problem (Isiogu et al., 2009). Before the minimum standards were developed some industrial customers, in DTE's distribution area, requested better power quality and therefore quality contracts were established between DTE and some of its industrial customers (Hulshorst et al., 2007a).

4.4.2 Premium Quality Contracts in Detroit Edison Company

The premium quality contracts were introduced for the first time in 1994, at three of the largest customers to DTE. In the area where DTE operates are many large industries located that have equipment sensitive to disturbances in the supply of electricity. These industrial customers requested higher power quality, because they experienced increased production costs due to disturbances in the supply of electricity. The contract is especially offered to those customers that have sensitive equipment and is called Special Manufacturing Contract (SMC). Requested in the contract were specified limits of interruptions and voltage deviations, but also the duration of the contract to be as long as ten years. This means that these contracts has expired today and are not used anymore. The first contracts was developed in 1995, and was just concerning interruptions, this since agreements of voltage dips required new measurements. The agreements about voltage dips were therefore not implemented in the contracts until 1998. The agreed levels in the contracts are based on measurements and the agreed penalty of the contract varies depending on the type of activity that the supply of electricity serves. The customer is compensated by DTE, if the agreed annual levels of disturbances are exceeded. The compensation is based on the manufacturer's costs of production losses due to the disturbances (Hulshorst et al., 2007). In total three different companies 50 different locations had the SMC contract (Sabin et al., 1999).

Introducing the contracts has had positive effects on the power quality. It has decreased the number of interruptions and improved the quality at the customers that are using the contracts, but also the penalty payments decreased after the implementation of the contract (Hulshorst et al., 2007a). According to Dettloff and Sabin (2000), the SMC is beneficial for all parties involved. Since it is a long-term contract, the DSO retains its customer, and the customers experience reduced losses of the production and thus less production costs. The utility company has also been more active with projects to reduce interruptions and voltage dips since the SMC was introduced.

4.5 Norway

4.5.1 Quality regulation

The Norwegian Water Resources and Energy Directorate (NVE), regulates the Energy Market in Norway. NVE's main tasks are to control monopoly operations, safeguard consumer rights, and ensure efficient operation, utilization and development of the electricity grid. NVE determines the overall legal framework and issues necessary instructions to ensure that the actors operating in the energy market operates according to the Energy Act. The Norwegian energy market is

deregulated since 1991. In 2009 were 162 distribution companies operating at the Norwegian energy market and they were mainly publicly owned.

The Norwegian regulator regulates both the continuity of supply and the voltage quality. Continuity indicators, the regulator audit sample of the data and the recording procedures regulate the continuity of supply. During the auditing process might errors be found and then the data must be corrected within a given time, if the distribution network operator fails, the company has to pay a daily fee until the problem is solved. At the system level is the quality regulated by continuity standards and reward and penalty schemes. The objective of the reward and penalty scheme is to achieve a socio- economically acceptable level of continuity rather than improve it. The indicator that is used in the regulation is Energy Not Supplied (ENS). This factor is measured as the difference between the expected interruption costs and the actual interruption cost. This is calculated each year and added to the company's revenue cap if it is positive, and subtracted if it is negative. The reward and penalty scheme has had positive effects on the supply of electricity, this since the ENS factor has been reduced. Regarding the voltage quality, the distribution companies are compelled to provide voltage quality individual verification when requested by the customer. The voltage quality is monitored and the regulator has set minimum standards regarding the different voltage quality phenomena. Since, the European standard has shown to not be sufficient enough, the Norwegian regulator has developed own standards for voltage quality (CEER, 2005).

4.5.2 Power Quality Contracts in Norway

The Norwegian regulator has developed directives with minimum standards, but in these directives is it also specified that the customer and the DSO can sign individual premium quality contracts. The contracts can be implemented if either a higher or lower quality than the guaranteed standards is requested. The distribution network operators are not allowed to enter collective contracts with several customers. However, the levels can be adjusted for a group of customers, if each customer in the group has signed an individual contract (Seljeseth et al., 2005). Only customers with expected yearly consumption of more than 400 000kWh can sign contracts that include a direct payment to the network operator. The design of the contract is such that the network operator pays the interruption costs directly to the end user, when such a contract is signed the energy not supplied is not included in the general incentive based regulation. Mainly large customers are using this contract like for example, alumni industry, factories or very large farms. The income to the DSO from the contracts in Norway is included as a cost that defines the revenue base. All investments also those that are covered by the contract are included in the regulatory asset base. Since the investments that are a result of the premium quality contract are included in the revenue cap (Vøllestad, 2015).

4.6 Summary

The introducing of premium quality contracts varies between the studied countries. In France, South Africa and USA (DTE), premium quality contracts were introduced before any other regulatory tools and before regulatory authorities controlled the energy market. The premium quality contracts in Italy and Norway differ from the others since they were introduced in the regulatory system after other regulatory tools were developed. France and South Africa have similar systems that are based on different options that the customer can choose from and both these countries had well-developed systems that include premium quality contracts. The premium quality contract developed at DTE differs from the others since it had a longer duration. In Italy and Norway that have similar regulatory systems with both guaranteed standards, reward and penalty schemes and premium quality contracts are premium quality contracts used, but it cannot be said how widely spread it is. The difference between these two countries is that Italy has more specification about what a contract should include and their system allow collective contracts. The Norwegian regulations does not include as many specifications but allows contracts for both lower and higher power quality. Table 6 summarizes what regulatory tools that are used in the studied countries.

Table 6. Regulatory tools in the studied countries

	Guaranteed Standards	Reward and Penalty Schemes	Premium Quality Contracts	Regulatory Authority
France	Yes	No	Yes	Yes
Italy	Yes	Yes	Yes	Yes
South Africa	Yes	No	Yes	Yes
USA	Yes	No	Yes	Yes
Norway	Yes	Yes	Yes	Yes

5. The Swedish Energy Market

This chapter will introduce the Swedish energy market and how it is regulated. This provides an understanding about the design of the Swedish power system, and the quality of electricity supply regulations. This will be used to enable an analysis of how premium quality contracts would affect the current regulations and if it is applicable in the Swedish system.

5.1 The Swedish power system

The Swedish energy market consists of several actors, such as electricity producers, electricity suppliers and power system operators (Swedish Energy Market inspectorate, 2014). The Swedish energy market was deregulated in 1996, so today, you as a customer can choose from what company you want to buy the electricity (Swedish Energy Market inspectorate, 2013). The Swedish power system is divided into three different levels. The transmissions network transports 220kV - 400kV in Sweden, and is operated by Svenska Kraftnät. The transmission network is connected to the regional network that transports 130kV to 30kV. This network is connected to the local network, which transports the electricity to most of the customers. The local networks have, in most cases, voltage levels of 20, 10 or 6kV. The lowest voltage level is 0.230-0.4 kV (SOU 2007:99). Figure 2 illustrates the structure of the Swedish power system. Approximately, 170 DSOs, which are operating the regional and the local network, exist in Sweden. All of them have a natural monopoly at the market (Swedish Energy Market inspectorate, 2014). Three major DSOs in Sweden are E.ON Elnät Sverige AB, Vattenfall Eldistribution AB and Ellevio AB. (SOU 2007:99).

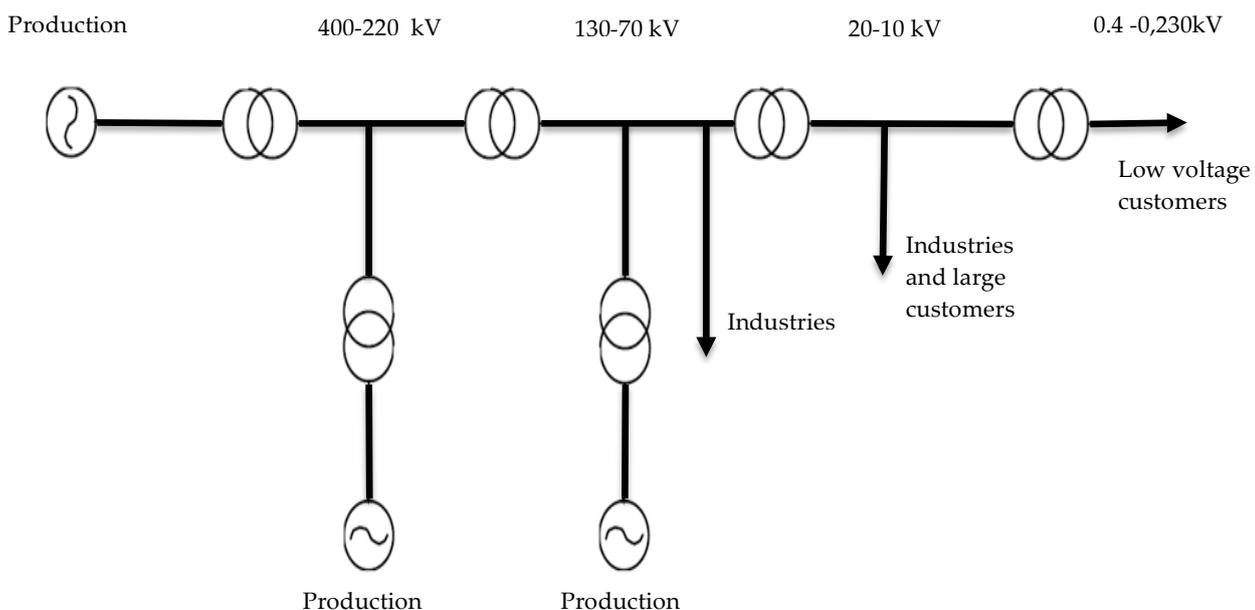


Figure 2, the power system in Sweden.

5.2 Power Quality Regulation in Sweden

The natural monopoly that exists in Sweden implies that, the transmission and distribution of electricity is regulated in order to ensure effective operation of the network and that all network operators offer a reliable supply of electricity to reasonable prices. As stated previously in the introduction, the regulatory authority in Sweden that controls and monitors the Swedish energy market is the Swedish Energy Markets Inspectorate (Ei). The operations performed by Ei can be divided into four different areas. The first is continuity of supply, which relates to the electricity that can be supplied to the customer without interruption. The second area is voltage quality. These two areas include that Ei monitors and requires that the electricity supplied by the network operators to the customer is of good quality and delivered according to standards defined by Ei. The third area is to manage technical-, and functional requirements that should be fulfilled by the network operators to reduce threats and problems in the supply of electricity. The fourth area is that Ei monitors risk analysis and action plans that are performed by the network operators. This area includes the work of demanding the network operators themselves to analyze their networks, but also identifying and remedying prospective problems before the customer is affected (Swedish Energy Markets Inspectorate, 2013).

The regulations of the Swedish energy market are described in the electricity act (Ellagen 1997:857) and in specific regulations developed by Ei, according to the act. In the Electricity act it is stated that the electricity have to be of good quality, and what good quality is, is stated in the regulations, EIES 2013:1. As stated in the background chapter, quality regulation can either be selective, and regulated on the customer level with guaranteed standards and/or premium quality contracts, or it can be collective and regulated on the average system level with reward and penalty schemes. Sweden has both selective and collective quality regulation. Following sections will describe the individual- and system level quality regulation in Sweden.

5.2.1 Selective quality regulation

Both the TSO and the DSO specify through the definition of good quality that is specified in the directives guaranteed standards that have to be achieved. Ei has developed standards regarding both the continuity of supply and the voltage quality. The continuity standards include definitions and limits of long and short, planned- and unplanned interruptions. The long interruptions are defined as longer than three minutes and short interruptions last between 100ms and three minutes. The number of non-announced interruptions should not exceed eleven per year (EIFS 2013:1).

According to the specifications regarding the voltage quality, the voltage level should not increase or decrease more than 10 percent from the RMS value of the reference voltage. The reference voltage is the voltage level that is identified in a system. In the standards of the voltage quality are special limits developed for harmonics, unbalance, voltage fluctuations, voltage variations, voltage dips and swells, rapid voltage changes and interruptions. Voltage quality standards for the other voltage phenomenon, like flicker, follow the European standard EN50160.. The yearly risk analysis including quality measurements and action plans of how to improve the quality, are used to ensure that the network operators achieve the specified standards. If the requirements are not met, it is the network operators' responsibility to inform the customers about their right to be reimbursed, if disturbances in the electricity supply occur, but also to reward the customers (Bollen et al. 2011).

5.2.2 Collective quality regulation

In addition to the selective regulation with guaranteed standards, reward and penalty schemes are used. The collective revenue cap regulation enters a new regulatory period from 2016-2019. This is the second regulatory period in Sweden and the regulations from the first period have been developed further for this new period. Specifications regarding the revenue cap regulation are stated in the electricity act (1997:857). According to the act (1997:857), the revenue cap should cover reasonable operational costs, and the costs of delivering good quality of electricity supply and reasonable return on capital. The collective regulation aims to give incentives for a socioeconomically beneficial certainty of supply for the customer collective. The collective quality regulation strives to give the network operators financial incitement for a certainty of supply that is optimal for the society. The financial incitements are penalties and rewards in the revenue cap. The regulation is called an output-regulation. This implies that network operator is regulated based on how well the network operator maintains a good quality at the end customer. If the continuity of supply is above a certain level the network operator is rewarded, else the financial consequences are negative. The indicators used to measure quality in the reward and penalty scheme are SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) for distribution networks. For regional networks the indicators used are PNS (Power Not Supplied) and ENS (Energy Not Supplied) (Swedish Energy Markets Inspectorate, 2015). In order to provide incentives to decrease the variety in power quality the quality indicator CEMI₄ is introduced. CEMI₄ represents the number of customers with at least four interruptions per year.

6. View of Premium quality contracts in Sweden

In this chapter the result from the interviews with actors in the Swedish energy market is presented. Section 6.1 presents the result from the interviews with the industrial customer and section 6.2 includes the result from the interviews with DSOs in Sweden. Section 6.3 includes the result from the interviews with the Ei representatives. The information presented in this chapter will be used in analysis in order to answer the research questions.

6.1 Industrial Customers

The participating industries in this investigation were Billerud Korsnäs, Sandvik, Stora Enso and Industry A. Billerud Korsnäs and Stora Enso operate within the forest industry, and Sandvik operates within the steel industries. The first part of this section demonstrates the power quality issues that the industries experience. This information is essential in order to analyze if a need of premium quality contracts exists. The second part presents the customers' willingness to pay for increased power quality. This will later be used in order to analyze why premium quality contracts should or should not be introduced, since premium quality contracts require that the customers pay for the power quality. The third part includes the customers' views of implementing regulations about customized power quality. This will be used to analyze if regulations would facilitate the introducing of premium quality contracts from the customer perspective.

6.1.1 Power quality issues

The representatives from, Billerud Korsnäs, Industry A and Sandvik state that their industries experience costs due to poor power quality. According to Walldén (2015) at Billerud Korsnäs, the total cost for the forest industries in Sweden is about 400 MKR per year. The average cost for Billerud Korsnäs, and Industry A is about 0.5 MSEK and 10 MSEK per year respectively (Walldén, 2015; Industry A, 2015). However, Industry A (2015) states that most of this cost comes from disturbances that occur seldom, and not even once a year. These disturbances can cost at least 20 MKR. The financial costs at Sandvik are not available for the public (Skoglund, 2015).

Voltage dips cause the greatest problems for the Billerud Korsnäs, Sandvik and Industry A. This, since they affect the electrical motors in their processes. Industry A (2015), states that the risk of voltage dips has to be taken into account when choosing equipment for their processes. This results in that Industry A does not choose the most energy efficient equipment because it is more sensitive to voltage dips. According to Industry A (2015), interruptions are also always a cost for the company since it results in production loss.

In order to protect against disturbances, Billerud Korsnäs, for example, run their plants through island operation if a critical situation with the network occurs (Walldén, 2015). Industry A do not have a back-up system for their whole process, the company only has one redundant system and a complementary steam turbine for systems that are critical (Industry A, 2015). Although the industries have protective devices, Walldén (2015) states that studies have shown that about 70% of all disturbances can be reduced by operations in their mills, the other 30 % can only be reduced by improvements in the network.

The experience of power quality problems at Stora Enso differs from the others. Heldemar (2015), states that the company does not experience any noticeable issues due to poor power quality. The company is therefore not in need of increased power quality. Heldemar (2015), however, states that it is important that the existing quality maintains. Stora Enso does not want any decrease in power quality. In case the disturbances are too large the company has a direct discussion with the DSO to find the source of the event that has occurred (Heldemar, 2015).

6.1.2 Willingness to pay for increased power quality

The representatives from Billerud Korsnäs, Sandvik and Industry A state that it is hard for them to say how much they are willing to pay for higher power quality, but they are all interested in higher power quality (Skoglund, 2015, Walldén 2015, Industry A, 2015). According to Skoglund (2015) at Sandvik, it is a question about the responsibility of the power quality. Skoglund (2015) also states that it is not reasonable that the industries should invest in protection against disturbances that occur because of other loads that are connected to the network, and affect their power quality. It is important that the cost that could be paid to the DSO through a premium quality contract does not exceed their current cost due to voltage deviations. The cost would else just be moved to the electricity tariff (Skoglund, 2015). According to Skoglund (2015) at Sandvik and Walldén (2015) at Billerud Korsnäs, it should be of political interest to keep a good infrastructure that enables industries to operate in Sweden. The industry representatives, therefore want the power quality to be assured and meet their needs without extra costs. According to Skoglund (2015) at Sandvik, the requested quality should be something the industries should to expect when they choose to locate their plants in Sweden, and therefore better power quality should be of socioeconomic interests. However, he is aware of that it is not that simple. The Industry A representative states that the power quality that are requested by industrial customers should be guaranteed in the regular tariff and that the industries do not have to pay extra for the power quality (Industry A, 2015).

6.1.3 Views of implementing premium quality contracts

The only contract that exists today that is mentioned by the industry representatives is the connection agreement. These contracts do not include any specifications about power quality (Heldemar, 2015, Skoglund, 2015, Industry A, 2015, Walldén, 2015). The power quality that the DSOs guarantee the industries follows the EIFS 2013:1. At Billerud Korsnäs and Sandvik, only the accepted short circuit power is specified as an interval in the contract. This interval is used to dimensioning their process, and the lower limit of the interval is important since that is the power required to start the motors (Skoglund, 2015, Walldén, 2015). According to Heldemar (2015) at Stora Enso, the contract concerns the connection and the accepted limits of reactive power that the industry is allowed to consume. Industry A discusses the quality with the DSO in established groups. However, the network operator and the industry have different views, which makes it complicated to make agreements. According to Industry A, the DSO presents the quality that the customer can expect.

The participating industries state that a contract that specifies the power quality could be good for them (Skoglund, 2015, Walldén, 2015, Industry A, 2015). Skoglund (2015) at Sandvik, states that it also would be important to include the network strength in the contract. This to avoid sectioning of the network so the industries' processes disturbs the power system. It is then a risk that the industry has to pay the DSO for this. The Industry A representative states that the advantages of using premium quality contracts would possibly be that the industry can lose less money over time, if the network operator improves the network and improve the quality. According to Walldén (2015) at Billerud Korsnäs, regulations regarding premium quality contracts would facilitate the introducing of premium quality contracts to customers that request better power quality. This, since it could make the customers aware of the opportunities and provide a quality assurance of the electricity supplied. Walldén (2015) states that almost all other products have some kind of quality assurance but not electricity. The reason, according to Walldén (2015), is that the quality always has been very good, but the quality is decreasing and therefore some kind of specification would be good. According to Walldén (2015), Skoglund (2015) and Industry A (2015), long term contracts would be most beneficial, since it would ensure a reliable supply of electricity in the long run. The Industry A representative think that it would facilitate the introducing of premium quality contracts, if Ei developed standards that are more suitable for industries. Industry A opens for discussions with the DSO about premium quality contracts and the requirements they as an industry have (Industry A, 2015).

6.1.4 Summary

Table 7 summarizes the industrial customers' views of premium quality contracts.

Table 7. Summary of the industrial customers' views of premium quality contracts.

	Experienced power quality issues	Willingness to pay for improved power quality	View of directives from Ei
Billerud Korsnäs AB	Voltage dips	Depends on the cost	Positive
Sandvik AB	Voltage dips	Depends on the cost	Positive
Stora Enso AB	None	No	Not in need of premium quality contracts
Industry A	Voltage dips, interruptions	Depends on the cost	Positive

6.2 Distribution System Operators (DSOs)

The participating DSOs are Ellevio, Eon and Vattenfall. The first part presents how the DSOs currently are working with power quality and solving possible power quality problems that the customers experience. This will be used in order to see if the DSOs are using premium quality contracts. The second section presents possible risks and opportunities that the DSOs see with premium quality contracts. This will be useful when analyzing the reasons for using or not using premium quality contracts. The last section presents if the DSOs believe that directions from Ei would facilitate the introducing of premium quality contracts.

6.2.1 The DSOs current ways of working with power quality

Discussions about power quality are important for Vattenfall (Eng, 2015, Norberg, 2015). The company gives its customers product information, about the supplied electricity, that includes what power quality the customer can expect. Norberg (2015) states that this is important, for Vattenfall, because it makes the customer aware of what quality that can be expected, and thus more satisfied with

their product. Vattenfall delivers something called the basic supply with respect to the voltage quality and certainty of supply to its customers. Voltage dips are valued to a fixed price (SEK/kW) in this basic supply (Norberg, 2015). Vattenfall analyzes the network and what protective devices that are installed, if a customer requests higher power quality than the quality supplied. This enables Vattenfall to evaluate solutions for customers, and if investments in the network are motivated. The ambition for Vattenfall is to solve the customers' problems, and ask if the customer has evaluated possible investments in its own plant, but also inform the customer about the alternative to pay for the investments that are necessary (Norberg, 2015). According to Norberg (2015), it is almost always most economically beneficial for the customers to invest in their own plant. For example, one efficient solution is to invest in a Static Var Compensator (SVC), which is an energy storage device and used to improve the power quality (Norberg, 2015). Vattenfall has experienced a willingness to pay for the power quality. Customers to Vattenfall have financed investments in the network that not were motivated by Vattenfall (Norberg, 2015, Eng, 2015). Regarding the opportunity to subscribe for lower quality, it is not possible according to Norberg (2015), due to the design of the power system. Customers located close to the electricity production, naturally has higher power quality, and it is not reasonable that these customers pay a higher price for the network connection (Norberg, 2015).

In addition to discussing and inform the customer about the power quality, Vattenfall is developing a customized contract. The plan is that this contract will include specifications about what a customer, above a predetermined size, has the right to do without disturbing other customers. The reason for developing this kind of contract is because it is hard today, to point out exactly what a customer has the right to do without disturbing other customers. A contract about the customer rights will provide the opportunity for Vattenfall to differentiate when the customer should pay a higher price for increased rights and when the responsibility is on Vattenfall to increase the strength of the network (Norberg, 2015, Eng 2015). Eng (2015) states that Vattenfall wants more agreements about the withdrawal of power with specifications about how large currents that can be withdrawal with respect to the power quality parameters. According to Eng (2015), additional specifications about the voltage quality are not needed in this contract. This, since the EIFS 2013:1 regulations and CENELEC EN 50160 clearly specifies standards about power quality, and these standards are seen as sufficient (Eng, 2015). The idea with the contract about withdrawal rights has had good responses when Vattenfall has discussed this option with its customers (Eng, 2015).

Ellevio is discussing the power quality with its customers and possible and necessary operations in case a customer is interested in higher power quality. Customers connected to the regional network have personal contracts. In the

discussions about the power quality the investments costs and the responsibility of the problems are discussed (Agneholm, 2015). Agneholm (2015) at Ellevio, means that it in the end is a discussion about whether the collective or the individual customer shall bear the cost. Agneholm (2015) also states that it might be possible for Ellevio to improve the quality, if the customer is interested, the question is how much the customer is willing to pay for the improvements. The cost must be compared to measures in customers' own plants. According to Agneholm (2015), it is not reasonable that the collective should pay in case one customer has higher requirements than the quality standards that exist.

Eon, is discussing power quality issues with customers when new connections are planned and when customers express a wish to expand their business and thereby, there is a need for renegotiations of connection agreements (Roos, 2015). Roos (2015) at Eon, states that these discussions in many cases result in short-circuit power levels according to the customers' requests as long as they are willing to pay for the reinforcements. Values of three-phase short-circuit current in points of connection are specified in connection agreements. Eon's first suggestion to customers that experience a quality of electricity supply that is not considered sufficient is that the customer should evaluate possible investments in their own plants. This, since the most cost-efficient solutions in most cases is performed the customers' plants (Roos, 2015). Concerning evaluation of the immunity levels of middle-sized customer plants to voltage dips, it has been difficult, according to Roos (2015), to start this process, because it requires that the customers install their own measurement equipment. On the other hand, large industries, such as steel and paper mills, have in many cases full control of their immunity levels, and know what power quality levels are manageable (Roos, 2015). According to Roos (2015), these customers have been working internally with power quality issues for a very long time and are therefore not often complaining about the experienced power quality levels. Roos (2015) states that how much a particular customer is willing to pay to improve immunity and reduce emissions depends of course on how costly the interference events are.

6.2.2 Possible advantages and disadvantages, for the DSOs, with premium quality contracts

According to Eng (2015) at Vattenfall, premium quality contracts could be a good option since it provides well-defined routines about how to work with power quality. It could probably clarify when the DSO is responsible for the power quality and when the customer is responsible. Roos (2015) at Eon says that the customer should have the right to negotiate about the power quality and this could be provided by premium quality contracts, but it should be optional to enter the contracts.

All the DSOs have the view that it will be problematic to guarantee specifications that concern voltage dips. This, since the voltage dips occur due to lightening, originates from the transmission network and the design of the Swedish power system with no local generation (Norberg, 2015, Eng, 2015, Agneholm, 2015, Roos, 2015). The DSO representatives state that it often is expensive to reduce voltage dips by investments in the network, and they are not sure if ordinary customers are willing to pay for such investments since it is so few who are concerned about it. The reason, why the operations are expensive, is because it is hard to protect the network against lightening that causes voltage dips. In order to protect against lightening all lines have to be equipped with lightening rods since the lightening can hit anywhere (Norberg, 2015, Eng, 2015, Agneholm, 2015, Roos, 2015). However, the earth resistance in Sweden is high and this makes it hard to protect against lightening even if lightening rods are installed (Norberg, 2015).

Agneholm (2015) at Ellevio states that investments to increase the power quality have been discussed, but the willingness to pay has not always been as high as the request of higher power quality. According to Roos (2015) at Eon, it will not be problems to perform maintenance work to ensure that the voltage dip rates are not increasing, the problem for them is to guarantee a specified number of voltage dips. Roos (2015), also states that it probably will be hard to determine the responsibility of voltage dips from the transmission network. Since the voltage dips originate from the transmission network or surrounding regional networks, the connecting DSO cannot control all dips at customers connected to the regional network. Roos (2015) is therefore not sure if premium quality contracts are best suited for customers connected to the regional network. Both Agneholm (2015) and Roos (2015) also state that it might be problematic with the contracts if voltage dips that cannot be controlled are excluded from the contract. The premium quality contracts will then not solve the customers' problems. Another factor regarding the difficulties of managing voltage dips that is mentioned by Eng (2015) at Vattenfall is that a strong network reduce voltage parameters, such as, flicker and harmonic distortions, while voltage dips are more spread the stronger the network is. However, Eng (2015) states that it always is possible to contract about reasonable limits that are manageable for the DSO. According to Eng (2015), the important question for Vattenfall in these questions is what is happening if the limits are exceeded. These questions are especially important when it comes to the larger customers. This, since they can put a greater pressure on the DSO to perform within the specified limits, and force the DSO to reconstructions of the grid, which could imply great costs for the DSO (Eng, 2015).

In addition to the risk of not being able to manage the voltage dips and guarantee the requirements in the contract, Agneholm (2015) at Ellevio and Eng (2015) at Vattenfall mention the new way of working with power quality that premium

quality contracts implies. According to Eng (2015) individualized agreements would result in extra calculations and that the company has to guarantee a standard that differs from EIFS 2013:1, while requiring the customer to have a business that does not interrupt other customers. Another possible problem, stated by Roos (2015) at Eon, is how the cost should be distributed if network reinforcements benefit more than one customer. As long as the customer pays for the contract and it will cover the costs, Roos (2015), does not see any problems with this. The only risk is that the DSO guarantees something that cannot be met.

6.2.3 Views of implementing regulations about customized power quality

Vattenfall is to some extent positive to directives. Norberg (2015) at Vattenfall states that quality regulation constantly is updated, which implies that the network planning cannot take new directions, because then it is a risk that it becomes regulations because of that. According to Eng (2015) at Vattenfall, directives would partly facilitate their job. Since Vattenfall already is in the developing process of a contract where power quality aspects are included, and are trying to find a routine of doing it, it is good if that job continues within Vattenfall. However, support from Ei could be useful when it comes to the development of appropriate withdrawal levels that could be specified in the contract. This since Vattenfall, is experiencing uncertainties in these questions. The pricing for the service that could be provided in the premium quality contract is also a difficult task for Vattenfall, according to Eng (2015). It would therefore help if Ei had a price baseline that Vattenfall could look at (Eng 2015).

Agneholm (2015) at Ellevio, states that it probably would be hard for Ei to develop general guidelines about premium quality contracts. This since the power quality need is very individual for each customer. The specification that can be included in a contract is very dependent on what type of industry the contract concerns, what kind of equipment that are installed, and the design of the network at the connection.

According to Roos (2015) at Eon, it should be optional to introduce premium quality contracts. Guidelines and recommendations from Ei would indeed facilitate the customer relations concerning such contracts.

6.2.4 Summary

Table 8 summarizes the DSOs views of premium quality contracts and how they currently are working with power quality.

Table 8. Summary of the DSOs views of premium quality contracts.

The DSOs current ways of working with power quality	Possible advantages and disadvantages of implementing premium quality contracts	View of implementing regulations about premium quality contracts	Experience of customers that have invested in the network	
Ellevio AB	Discussions The customer can pay	Difficult to control voltage dips High cost Good for the discussion about power quality problems More resources	Negative	No, unknown
Eon AB	Discussions The customer can pay A part of new connection agreements	Difficult to control voltage dips High cost Good for the discussion about power quality problems Investments that affect more than one customer	Positive	No
Vattenfall AB	Discussions Information to the customers The customer can pay Developing a contract	Difficult to control voltage dips Expensive Good for the discussion about power quality problems More resources	Both positive and negative	Yes

6.3 Ei's view of premium quality contracts

This section presents the result from the interview with the Ei representatives Ström (2015) and Werther (2015). This information will be used in the analysis about what possible changes in the Swedish quality regulations that would facilitate the introducing of premium quality contracts based on the interviews with the industrial customers and the DSOs.

According to Ström (2015), it has been indicated, in power quality discussions with industries, that the industries are interested in higher power quality than the existing standards. The advantage of introducing premium quality contracts is, according to Ström (2015), that the customers have the possibility to receive customized power quality. Therefore premium quality contracts might be an option for the Swedish quality regulation system. Introducing premium quality contracts would affect the quality of electricity supply regulation in Sweden. For example, premium quality contracts have to interact with the revenue framework. This, since premium quality contracts might result in revenues and investments that will be included in the revenue framework. Ström (2015), states that it probably will not be a problem for Ei to manage premium quality contracts if regulations about how the contracts work are developed, but it will require more resources.

Based on the result from the interviews with DSOs and industrial customers, the requirement, in order to introduce premium quality contracts, is that the DSOs have to take the financial risk that premium quality contracts implies, according to Ström (2015). Therefore changes in the regulations that forces DSO to enter premium quality contracts, if it is requested, might be required (Ström, 2015). Another important aspect, according to Ström (2015), to enable an implementation of premium quality contracts is to ensure that the parameters that are included in the contract can be measured. This, to enables the customer to see improvements and what the customer is paying for (Ström, 2015). At last, Ström (2015), states that it is important that the cost of the contract does not exceeds the costs of the power quality issues experienced by the customers. It has to be economically beneficial for both the DSOs and the customers to introduce premium quality contracts (Ström, 2015).

According to Ström (2015), different alternatives to premium quality contracts that possibly could satisfy the customer needs exist. One option is to negotiate about the power quality in the connection agreement. It could then be specified in the electricity act that power quality parameters should be included in the connection agreement. The customer would then be able to negotiate about the power quality in this contract and pay for the contracted quality. The second option is to define good quality for different kind of customers, with higher

requirements of the power quality to large industrial customers. The last alternative is to keep the system as it is today (Ström, 2015).

Energy storage is another alternative that possibly could meet the customers' requirements of the power quality (Werther, 2015). In Falbygden, for example, who has a lot of wind power installed, has energy storage been installed in order to secure a reliable supply of energy (Falbygdens Energi, 2015). Another alternative is a solution similar to specifications in the district-heating act (Werther, 2015). In the district-heating act is stated that the district heating company is obliged to negotiate about the connection if a customer wants to connect to the network. The district-heating company is also obliged to offer a suggested contract and has the rights to set a reasonable price for the contract that should cover the company's costs with respect to the specifications (District-heating act, §37).

7. Analysis

This chapter includes an analysis of the derived material from the interviews and literature reviews. The chapter starts with a clarification about if premium quality contracts exist in Sweden, and if a need of premium quality contracts exists among the studied industrial customers. This is followed by an analysis of possible advantages and disadvantages of introducing premium quality contracts in order to address the question why premium quality contracts are not used and why it should be used. The last part analyzes if regulations from the Swedish energy markets inspectorate (Ei) would facilitate the introducing of premium quality contracts in Sweden, and what the different alternatives that enabling customized power quality are.

7.1 Are premium quality contracts used in Sweden?

According to the theory presented in section 2.4, a premium quality contract is an agreement that includes customized voltage quality parameters or continuity of supply specifications. The customer pays the DSO for the customized power quality, and the DSO ensures that the contracted power quality is supplied to the customer, else the customer is reimbursed by the DSO (Fumgalli et al. 2007). None of the participating industries or the DSOs states that such a contract is used. The DSOs ensure that the guaranteed standards, specified in EIFS 2013:1, are supplied to their customers. However, Eon is discussing and specify the power quality in the connection agreements when new connection agreements are introduced or when the connections agreements are renegotiated and the connection fee is then based on the specifications in the contract. The customer pay for an agreed power quality in this case but it is a onetime fee, and the fee is a part of the regular tariff, and therefore not seen as a premium quality contract. Vattenfall, is developing a customized contract and is working towards the direction of offering individualized services to its customers. The contract, that Vattenfall is developing, does not concern specification about voltage parameters or continuity of supply, therefore is the contract not seen as a premium quality contract either. Although, premium contracts are not used, all the DSOs offer its customers the alternative to pay for the investments that are required to improve the power quality if the customers are interested, but they do not offer any guarantees. The result from the interviews with industries and Ei, does not indicates that any premium quality contracts exists either. The customers say that they receive the quality according to EIFS 2013:1 and Ei is not aware of that any contracts exist. Since, the awareness of premium quality contracts does not exists among any of the participating actors in the Swedish energy market it can be argued that no premium quality contracts exist in Sweden.

7.2 Is there a need of premium quality contracts in Sweden?

A need of premium quality contract exists if a customer experience that the power quality supplied by the DSO is seen as insufficient and the customer is willing to pay for customized power quality (Fumgalli et al., 2007). Among the participating industries, three of them experience power quality issues and financial costs due to disturbances in the supply of electricity. The industries that are experiencing costs due to poor quality state that exclusively voltage dips and interruptions represent the majority of the costs. The costs for the industries vary between 0.5 and 10 MSEK per year. The industries that are interested also state that protective devices already are installed, so most of the problems that are experienced have to be fixed or mitigated by measures in the network. Stora Enso is the only industry that does not experience that poor power quality affects their processes, but it is important for them that the power quality does not decrease.

Regarding, the willingness to pay for a premium quality contracts uncertainties exist. The customers are not sure if they are willing to pay for improved power quality, it depends on the costs of the premium quality contract. The representatives from Billerud Korsnäs, Sandvik, and Industry A state for example that it should be of socioeconomically interest to offer industrial customers higher power quality instead of letting the customers pay. Industry A (2015), states that it would be good if a power quality specified for industries was included in the regular electricity tariff. Although, uncertainties about the willingness to pay exists, the fact that one example shows that a customer has invested in the network and has paid for improved power quality, indicates that a willingness to pay actually exists. It can therefore be argued that a willingness to pay for premium quality contracts exists, as long as the cost of the contract does not exceeds the current costs due to poor power quality.

7.3 Why should/should not, premium quality contracts be introduced in Sweden?

In the background chapter several advantages and disadvantages of introducing premium quality contracts were addressed. The advantages for the customers that are stated in the theory is that the customers are offered customized power quality, the financial risks are eliminated for the customers and customers avoid paying for unneeded reliability (Fumgalli et al. 2007, Fumgalli et al., 2004). With respect to what the customers have responded, customized power quality would benefit the customers. The majority of the industries request higher power quality, than the EIFS 2013:1 standards, to reduce costs. A premium quality contract could therefore be beneficial for the customers and satisfy these customers' needs. The eliminated financial risk that is associated with premium quality contracts depends on the costs. For example, Skoglund (2015) says that it is a risk that premium

quality contracts would shift the costs due to poor quality to the electricity cost. The advantageous factor that customers avoid paying for unneeded reliability would also make premium quality contracts an advantageous alternative for the customers in Sweden. This, since the investigation demonstrated that all industrial customers did not request higher power quality. Stora Enso did not experience that the current quality was insufficient and might therefore not be interested in paying for increased power quality.

A risk for the customers is, according to the literature, that customers can benefit from each other's contracts. This is not mentioned as a risk by the participating industries and does, therefore, not seem to be a problem. However, this is mentioned by Roos (2015) at Eon as an aspect that possibly can be problematic when managing the premium quality contracts. It can, for example, be hard for the DSO to manage the contract, if the contracted investments affect more than one customer.

The advantages for the DSOs of introducing premium quality contracts are, according to the theory, efficient network management and minimized reimbursement costs (Fumgalli et al., 2004). Eng (2015) at Vattenfall states, for example, that the positive effect would be that premium quality contracts results in well-defined routines about how to work with power quality, and possibly clarify questions about the responsibility of power quality problems. Agneholm (2015) at Ellevio, is also positive to the discussions about power quality that premium quality contracts can result in. At last Roos (2015) at Eon states that it is good because it is giving the customer the right to negotiate about the power quality. This shows that, the advantage with premium quality contracts for the DSOs are a more efficient management of the network since it will affect their way of working with power quality positively. The advantages of minimized reimbursement costs are not mentioned by any of the DSOs as possible advantages.

Regarding possible risks, the DSOs, in accordance with the theory, states that the premium quality contract implies a financial risk (Fumgalli et al., 2004). The participating DSOs are not sure if they can meet the customers' requests without expensive investments in the network and they are not sure if it is possible to guarantee a specified number of voltage dips. This since voltage dips occur due to lightening and originate from the transmission network and are difficult for the DSOs to control. According to the theory, this should not be a problem for the DSOs since all risk factors can be excluded from the contract. Although this opportunity exists and would benefit the DSO, it is argued by Agneholm (2015) that there is a risk that the contracts become useless for the customers, if such problems were excluded from the contract. Another aspect that is mentioned as disadvantageous for the DSOs is that it will affect their job and require more

resources. This, since managing the contracts will require new methods of working with power quality.

7.4 How can current regulations be modified to facilitate the use of premium quality contracts in Sweden?

The customers' views of changes in the regulations to introduce premium quality contracts are positive in general, even if the industries have the opinion that it should be of socioeconomically interest to improve the quality. The industries that are interested in improved power quality, say that directives from Ei probably would facilitate the introducing of premium quality contracts. According to Walldén (2015), it is important that the electricity is quality assured. If premium quality contracts are introduced, the customers prefer long-term contracts, in order to ensure a reliable supply of electricity in the long run.

The DSOs are both positive and negative to directives from Ei about premium quality contracts. Since different customers have different needs it is important that the premium quality contracts are optional according to Agneholm (2015) and Roos (2015). Agneholm (2015) also states that it probably will be hard for Ei to develop general guidelines due to meet individual needs. Vattenfall is both positive and negative about including premium quality contracts in the regulations. This, since the company is developing their own contract and wants to continue with this job. However, it would be helpful for Vattenfall with support from Ei in order to clarify uncertainties, about for example the pricing.

The study of premium quality contracts internationally demonstrates that the countries where premium quality contracts have been successfully implemented are in those countries where it was implemented before other quality regulations were introduced. France, South Africa and DTE in USA had the most developed systems. In all those countries were premium quality contracts introduced because customers requested higher power quality and during the introducing of premium quality contracts were no regulatory authorities existing in the countries and therefore these contracts were developed between the DSOs and the customers. In these countries, the premium quality contracts do not have to interact with reward and penalty schemes and therefore these examples are not applicable in Sweden either. However, these contracts can provide valuable inspiration about what a premium quality contract can include and how it can be designed. For example it would be interesting to look at the contract offered by DTE since it is a long-term contract, which is suggested by the participating customers. Italy and Norway have regulatory systems that are similar to the Swedish system. These countries have, like Sweden, both guaranteed standards and reward and penalty schemes. The difference is that the countries also have introduced regulations that concern premium quality contracts. Premium quality contracts are used in both countries but the regulators in the countries could not answer how many contracts that were

used, this since premium quality contracts are an agreement between the DSO and the customer, without involvement of the regulatory authority. The difference between Italy and Norway is that Italy has more developed directives about premium quality contracts than Norway. Since, it cannot be said how many contracts that has been introduced in Norway and in Italy respectively it is hard to conclude if directives about premium quality contracts similar to the Norwegian or the Italian would be most beneficial in Sweden. However, these examples show that regulations about premium quality contracts are used in regulatory systems that are similar to the Swedish system and that premium quality contracts are used even if other regulatory tools are well developed. Therefore it should not be any problem to interact the premium quality contracts with reward and penalty schemes. The investments can be included in the capital base and the revenue in the revenue cap. The problem is the premium, which is a new component in this system. One alternative about how to manage the premium is to regulate it as the interruption reimbursement. According the Electricity act the reimbursement for interruptions should come from the network operator's revenue and this system could be applicable on the reimbursements from premium quality contracts as well.

According to Ström (2015), regulations that forces the DSO to enter premium quality contracts seems to be required based on the result from the interviews with DSOs and industrial customers. This, since the premium quality contracts imply a financial risk for the DSOs, and the DSOs mean that it will be difficult to guarantee the requested power quality. The problem with this is that the DSOs might not be satisfied if they are forced to enter premium quality contracts. In order to satisfy the DSO, an alternative is to develop specifications that will protect the DSO. For example that power quality problems that cannot be controlled by the DSO should be excluded from the contract. The risk with this is, however, that the customer will not be satisfied with the contracted quality, if quality aspects are excluded to protect the DSO.

7.5 Alternatives to Premium Quality Contracts

Different options to meet the customers' needs and DSOs needs were discussed with Ei. The first alternative discussed was to define good quality for different types of customers. This would probably satisfy most of the industrial customers. This since the industries that showed an interested in higher power quality said that it would be of socioeconomically interest to provide higher power quality for industries. However, this could be problematic since not all customers of a certain size are in need of higher power quality and different customers have different requirements. The second alternative discussed was to require power quality specifications in the connection agreement. This is good because it would result in customized power quality that both the customer and the DSO agree, and it will force the DSOs and customers to discuss the power quality. The connection

agreement is a onetime cost, and it is therefore a risk that this cost gets very high for the customer if the customer requires high levels of power quality. However an option could be to split the cost to a determined period of time. Another alternative that was discussed was to keep the system as it is today. The situation would probably remain the same in such a case. There is a question between the customers and the DSOs about the responsibility of the power quality and with respect to their view about the question the situation does not seem to be solved. If it remains the same it requires that the customers pay for the investments in the network.

Another alternative that the DSOs have been discussing as the most economically beneficial alternative is that the customers should invest in their own plants. An alternative for the customers mentioned by Norberg (2015) is investing in a SVC, which is a type of energy storage used to improve power quality (ABB, 2015). Since, alternatives that could be more economically beneficial for the customers, than operations in the network, seems to exist, it would be good if the different alternatives were evaluated by the DSO and the customer before contracts are entered. Forcing the customers and the DSO to a discussion about the different options that exist through regulations might therefore be an alternative solution. The discussions could for example include what it would cost for the DSO to meet the customers' requirements and compare these costs with what other alternatives cost. This should not be a problem since the DSOs, for example, have stated that they are willing to improve the quality if the customer pay and already are discussing what power quality the customers can expect. As stated by Werther (2015), the district-heating act has introduced regulations that force the discussions between the district-heating company and a customer that wants to connect to the system. A similar solution could be feasible in this case. In the district-heating act is stated that the district heating company is obliged to negotiate about the connection if a customer wants to connect to the network. The district-heating company is also obliged to offer a suggested contract and has the rights to set a reasonable price for the contract that should cover the company's costs with respect to the specifications (District-heating act, §37). A solution, similar to this that forces the DSO to negotiate about the power quality if a customer requests higher power quality could for example be introduced in the Electricity Act. What alternative, among all that are stated in this section, that is most suitable in Sweden has to be evaluated further.

8. Conclusion

The overall purpose of this thesis was to investigate the applicability of premium quality contracts in Sweden. The results showed that premium quality contracts are applicable in Sweden. However, regulations that enabling customized power quality seems to be required in order to implement premium quality contracts. The answers of the research questions that have been used, in order to answer the purpose, are presented below.

Is there a need for introducing premium quality contracts in Sweden?

The result of this study has shown that no premium quality contracts exist in Sweden today. A need of higher power quality exists among three of the participating industries. It is, however, hard to draw any conclusions about if a need of premium quality contracts exists since the customers are not sure if they are willing to pay. As long as the quality that is specified in the contract, can be guaranteed by the DSO and the cost of the contract does not exceeds the current costs of poor power quality, a premium quality contract should be of interest for the customers and premium quality contracts are therefore applicable with respect to the need of higher quality of electricity supply.

Why/ Why not, should premium quality contracts be introduced in Sweden?

The reasons for introducing premium quality contracts in Sweden are that premium quality contracts can provide the customers with customized power quality according to their individual needs. Premium quality contracts could also benefit the DSOs, since it could provide an efficient management of quality of electricity supply questions. The reasons why premium quality contracts should not be introduced in Sweden are that the specifications that are requested by the customers are difficult and expensive for the DSOs to control. It is, therefore, a risk that premium quality contracts will not satisfy the customer needs. Another disadvantage of introducing premium quality contracts is that the management of premium quality contracts probably would require more resources for the DSOs.

How can current regulations be modified to facilitate the use of premium quality contracts in Sweden?

It is also concluded that regulations about premium quality contracts would facilitate the introducing of premium quality contracts. For example, premium quality contracts have been introduced in countries with regulatory systems that are similar to the Swedish regulatory system. This indicates that regulations about premium quality contracts facilitate the introducing of premium quality contracts and that it is applicable in the Swedish regulatory system as well. The interviews with and DSOs also indicated that regulations would facilitate the introducing of premium quality contracts. This, since customers are interested in the

opportunities that can be provided by a premium quality contract. The DSOs are interested in guidelines about the contracts, and in order to being able to manage the contracts more efficient. At last, regulations about premium quality contracts seem to be required in order to force the DSO to take the financial risk that a premium quality contract implies for them. Other alternatives that possibly could satisfy the customers and the DSOs are also discussed in the thesis, but which alternatives that are most suitable for Sweden has to be evaluated further.

9. Discussion

During the investigation, the participants had no or just a little knowledge about premium quality contracts. Introducing premium quality contracts in the regulatory system would probably make the actors aware of that the option exists. Maybe this knowledge would result in premium quality contracts if it is requested. In this study it has been shown that it is hard for DSOs to meet the large customer's requirements. Smaller customers might not have as high requirements and might require contracts that can be guaranteed by the DSOs to reasonable costs. It is for example stated by Roos (2015) at Eon that middle size customers would be more suitable for premium quality contracts.

In the discussion about weather premium quality contracts or any other extended power quality regulation should be introduced, the development of power quality problems in the future has to be considered. The power system is changing since more renewable energy is being connected to the network and new technologies are used. For example a study by Farhoodnea et al. (2013) about the impact of renewable energy generators and electrical vehicles on the power system shows that these installations cause frequency and voltage variations. Since the society is going towards the direction of more renewable energy and electrical vehicles it is possible that the power quality problems will be more common in the future and this can be seen as a problem that will maintain in the future as well.

9.1.1 Further studies

If premium quality contracts are investigated further, it would be interesting to study if a need of power quality contracts exists within other sectors and among smaller customers. This, since it would be good to know what customers that might be interested, if directives about premium quality contracts are developed. It has for example been stated by Roos (2015) that premium quality contracts would be more suitable for smaller industries. A quantitative study could, for example, cover customers of different sizes and more information about the customers' willingness to pay, since the participants would be anonymous.

Another aspect to investigate further is the estimated costs of meeting the customers' requirements, this could show an indication of if the costs are too high for the customer or if the customers would save money over time. Then the costs of meeting the customers' requirements could be compared to the cost of other backup alternatives. It is also interesting to study the impact of premium quality contracts on the revenue framework and how it would be affected by introducing premium quality contracts. The different alternatives to premium quality contracts

should also be evaluated further. This could point out the possible risks and opportunities with each alternative respectively, and then it could be evaluated what alternative that is most socioeconomically beneficial for Sweden.

References

- ABB. 2015. *Energilager- Så funkar det*, Available online:
<http://new.abb.com/se/om-abb/teknik/sa-funkar-det/energilager> [2015-12-10]
- AEEG. 2015. *Italian Regulatory Authority for Electricity Gas and Water*,
Available online: <http://www.autorita.energia.it/it/inglese/>
- Bell, J. 2006. *Introduktion till forskningsmetodik*, 4th edition. Studentlitteratur
- CEER. 2008. *4th Benchmarking report on quality of electricity supply 2008*,
Council of European Energy Regulators ASBL: Bruxelles
- CEER. 2005. *3rd benchmarking report on quality of electricity supply*, Council of
European Energy Regulators ASBL: Bruxelles
- CRE, 2015. *CRE's missions*, Available online:
<http://www.cre.fr/en/presentation/missions> [2015-09-02]
- Deloitte, 2015. *European energy market reform, Country profile: France*,
Available online:
<https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-merket-reform-france.pdf> [2015-09-02]
- Dettloff, A. Sabin, D. 2000. *Power quality performance component of the special manufacturing contracts between power provider and customer*, Ninth
International Conference on Harmonics and Quality of Power
- DTE Energy. 2015. *Electric/Gas Utilities*
<https://www2.dteenergy.com/wps/portal/dte/aboutus/aboutDteEnergy/> [2015-09-04]
- DTE Energy. 2015. *About DTE Energy*, Available online:
<https://www2.dteenergy.com/wps/portal/dte/aboutus/aboutDteEnergy/> [2015-09-04]
- EIFS 2013:1 Energimarknadsinspektionens föreskrifter och allmänna råd om krav som ska vara uppfyllda för att överföringen av el ska vara av god kvalitet.
- Enel. 2007. *Enel Distribuzione remarks about ERGEG publication "Towards Voltage Quality Regulation in Europe"*, Divisione Infrastructure e Reti, Ingegneria Rete Elettrica: Roma
- ERGEG. 2006. *Towards Voltage Quality Regulation in Europe, An ERGEG Public Consultation Paper*, Ref: E06-EQS-09-03, 06-DEC-2006.

- Eskom, 2015. *Company Information*, Available online:
<http://www.eskom.co.za/OurCompany/CompanyInformation/Pages/CompanyInformation.aspx> [2015-09-04]
- Farhoodnea, M. Mohammed, A. Shareef, H. Zayandehroodi, H. 2013. *Power Quality Impact of Renewable Energy Based Generators and Electric Vehicles on Distribution Systems*, The 4th International Conference on Electrical Engineering and Informatics (ICEEI 2013), Procedia Technology, Vol 11, pp. 11-17.
- Fumgalli, E. Schiavo, L,L. Delestre, F. 2007. *Service Quality Regulation in Electricity Distribution and Retail*, Springer. Berlin
- Fumgalli, E. Black, J,W. Vogelsang, I. Ilic, M. 2004. *Quality of Service Provision in Electric Power Distribution Systems through Reliability Insurance*, IEEE Transactions on power systems, Vol 19, no 3, pp. 1286-1292.
- Gergen, M,J. Gianvecchio, N. Schwartz, D,L. 2012. *Energy Regulation Markets Review*, Latham & Watkins: Washington DC
- Hulshorst, W,T,J. Smeets, E,L,M. Wolse, J,A. 2007a. *Premium Power Quality contracts and labeling*, Work package 2 of the quality of Supply and Regulation project. Arnhem, KEMA Consulting.
- Hulshorst, W,T,J. Smeets, E,L,M. Wolse, J,A. 2007b. *Benchmarking on PQ desk survey: What PQ levels do different types of customer need?*, Work package 3 from Quality of Supply and Regulation Project. Arnhem, KEMA Consulting.
- IEA. 2014. *Energy Technology Perspectives 2014*. International Energy Agency, OECD/IEA: France.
- Italian regulation, 2015, Testo Integrato Della Regolazione Della Qualita' Dei Servizi Di Distribuzione e Misura Dell'Energia Elettrica, Titolo 9 Contratti per la qualità
- Isiogu, N, O. Martinez, M. Transeth, A, S. 2009. *Report on Status of Power Quality in Michigan*, Michigan Public Service Commision, Department of Licensing & Regulatory Affairs
- Justesen, L. Mik-Meyer, N. 2011. *Kvalitativa metoder, från vetenskapsteori till praktik*. Studentlitteratur AB, Lund
- Monesi. S. 2012. *The Energy Regulation and Markets Review*, Latham & Watkins: Milan
- MPSC. 2015. *Electricity*, Available online:
<http://www.michigan.gov/mpsc/0,4639,7-159-16377---,00.html> [2015-09-03]
- NERSA, 2015, <http://www.nersa.org.za/#>. <http://www.nersa.org.za/#>
- Perez-Arnaga, I,J. 2013. *Regulation of the Power Sector*, Springer: London

- Sabin, D. Dettloff, A. Goodman, F. 1999. *Overview of Detroit Edison's Voltage Dip Performance Agreements, Electrical Power Quality and Utilisation*, Vol. 5, No. 2, pp. 53-58
- Seljeseth, H. Sand, K. Samdal, K. 2005. *Quality of Supply in Norway going beyond EN 50160*, 18th International Conference on electrical distribution, Turin 9-16 juni 2005.
- SFS 1997:857. *Ellag*
- Swedish Energy Agency, 2015, *Industri*, Available online: <http://www.energimyndigheten.se/statistik/slutlig-anvandning/industri/?currentTab=0>, [2015-12-27]
- Swedish Energy Markets Inspectorate. 2015. Kvalitetsreglering för intäktsram för elnätsföretag –Reviderad version för tillsynsperiod 2016-2019, Ei R2015:06, Eskilstuna
- Swedish Energy Markets Inspectorate. 2014. *Electricity markets and trade in electricity*, Available online: <http://ei.se/en/Electricity/The-electricity-market/Electricity-markets-and-trade-in-electricity/>
- Swedish Energy Markets Inspectorate. 2013. *Quality of supply*, Available online: [\[2015-09-15\]](#)
- Quackenbush, J. White, G. Talberg, S. 2013. *Staff Report on Status of Power Quality in Michigan*, Michigan Public Service Commission, Department of Licensing & Regulatory Affairs
- Åkerlund, J. Bollen, M. Grape, U. Johnson, T. 2006. *Elöverföring av god kvalitet, förstudie av projekt elkvalitet II- planering av framtidens överföring av god kvalitet*, Elforsk rapport 06:81

Interviews

- Agneholm, E. 2015. Ellevio AB, personal meeting, Karlstad, 2015-11-06
- Eng, T. 2015. Vattenfall, video call, 2015-11-03
- Heldemar, A. 2015. Stora Enso AB, telephone interview, 2015- 10-29
- Industry A. 2015. telephone interview, 2015-11-12
- Jérémy, V. 2015. CRE, France
- Norberg, P. 2015. Vattenfall AB, personal meeting, Stockholm, 2015-10-20
- Roos, F. 2015. Eon AB, Telephone interview, 2015-11-05
- Schiavo L,L. 2015. AEEG, Italy
- Skoglund, L. 2015. Sandvik AB, personal meeting, Stockholm 2015-10-23

Ström, L. 2015. Swedish Energy Market Inspectorate, personal meeting,
Stockholm, 2015-11-30

Vøllestad, K. 2015. NVE, email questionnaire, Norway

Walldén, B-A. 2015. Billerud Korsnäs AB, personal meeting, Stockholm 2015-
10-23

Werther, L. 2015. Swedish Energy Markets Inspectorate, personal meeting,
Stockholm 2015-12-09

Appendix A

Interview questions, France

Premium Quality Contracts and Quality Regulation

Premium quality contract is a tool used for power quality regulation. In this study is the definition of premium quality contracts from the book *Service Quality Regulation in Electricity Distribution and Retail* used. According to the book is a premium quality contract a contract between a grid operating company and its customer. The contract specifies customer adjusted power quality standards that has been developed individually regarding the customer's preferences of power quality. The customer pay for the contract and is compensated if the DSO (Distribution System Operators) does not deliver the contracted power quality standard. Both the price paid by the customer and the compensation should also be specified in the contract. According to literature that I have read are customer adjusted contracts offered, to customers that request higher power quality than the minimum standards, in France. This customer adjusted contract can thus be seen as a premium quality contract.

Different countries have adopted different quality regulations to assure that customers have an adequate quality level regarding power interruptions and sometimes also voltage quality. Examples of quality tools that the regulator use are:

- Information on quality levels for different DSOs (Distribution System Operators)
- Incentive-based regulation where quality indicators such as SAIDI, SAIFI and ENS are used to adjust the DSO's revenues.
- Guaranteed standards

Following questions will be about the quality regulation in France and the use of premium quality contracts.

- 1. What kind of quality regulation is adopted in France? Are any other regulatory tools than contract for minimum standards and premium quality contracts used in France? A CEER report from 2005 stated for example that France was interested in introducing reward and penalty schemes.**
 - a) If other quality regulatory tools are of interest or are used, how do you think these would or are affecting the use of premium quality contracts?**

2. **Are premium quality contracts a big part of the quality regulation or is it working aside of a strong incentive-based regulation for quality or/and strong regulation on minimum standards that must be fulfilled for all customers?**
3. **How frequently used are the premium quality contracts in France? Are many customers using the contracts?**
4. **What kind of customers are mainly using agreed contracts for better power quality?**
5. **How is the use of premium quality contracts perceived by the customers and the distribution network operators? Do they, for example, experience any obstacles or advantages?**

The impact of Premium Quality Contracts on DSO's and on the tariff

With the following questions we would like to identify the impact on the DSO's business when having premium quality contracts and also the impact on the tariff for the DSO's customers.

6. **To gain an understanding about the revenue framework in France, I would like you to give a short summary of how it is designed.**
7. **How do the premium quality contracts impact the DSO's business?**
 - a) **How this income for the DSO from the contracts handle in the revenue framework? Or is it not included in the revenue framework?**
 - b) **How are the investments, to improve quality for the customer with quality contract treated? Is the investment included in the regulatory asset base for the DSO?**
8. **If a DSO have many customers with premium quality contracts how are the customers with no contracts affected?**

If the investments for approving quality for the customers with premium quality contracts are included in the revenue framework, does this not mean that the tariff for all the DSO's customers is increased?

Interview questions, South Africa

Premium Quality Contracts and Quality Regulation

Premium quality contract is a tool used for power quality regulation. In this study is the definition of premium quality contracts from the book *Service Quality Regulation in Electricity Distribution and Retail* used. According to the book is a premium quality contract a contract between a grid operating company and its customer. The contract specifies customer adjusted power quality standards that has been developed individually regarding the customer's preferences of power quality. The customer pay for the contract and is compensated if the DSO (Distribution System Operators) does not deliver the contracted power quality standard. Both the price paid by the customer and the compensation should also be specified in the contract. According to literature that I have read are customer adjusted contracts offered to customers in South Africa that request higher power quality than the minimum standards. This customer adjusted can thus be seen as a premium quality contract.

Different countries have adopted different quality regulations to assure that customers have an adequate quality level regarding power interruptions and sometimes also voltage quality. Examples of quality tools that the regulator use are:

- Information on quality levels for different DSOs (Distribution System Operators)
- Incentive-based regulation where quality indicators such as SAIDI, SAIFI and ENS are used to adjust the DSO's revenues.
- Minimum standards.

Following questions will be about the quality regulation in France and the use of premium quality contracts.

- 9. What kind of quality regulation is adopted in your country? Are any other regulatory tools than contract for minimum standards and premium quality contracts used in South Africa?**
 - b) If other quality regulation tools are of interest or are used, how do you think these would or are affecting the use of premium quality contracts?**
- 10. Are premium quality contracts a big part of the quality regulation or is it working aside of a strong incentive-based regulation for quality or/and strong regulation with minimum standards that must be fulfilled for all customers?**
- 11. How frequently used are the premium quality contracts in South Africa? Are many customers using the contracts?**

- 12. What kind of customers are mainly using agreed contracts for better power quality?**
- 13. How is the use of premium quality contracts perceived by the customers and the distribution network operators? Do they, for example, experience any obstacles or advantages?**

The impact of Premium Quality Contracts on DSOs and on the tariff

With the following questions we would like to identify the impact on the DSO's business when having premium quality contracts and also the impact on the tariff for the DSO's customers.

- 14. To gain an understanding about the revenue framework in South Africa, I would like you to give a short summary of how it is designed.**
- 15. How do the premium quality contracts impact the DSO's business?**
 - c) How is the income to the DSO from the contracts handled in the revenue framework? Or is it not included in the revenue framework?**
 - d) How are the investments, to improve quality for the customer with quality contract treated? Is the investment included in the regulatory asset base for the DSO?**
- 16. If a DSO have many customers with premium quality contracts how are the customers with no contracts affected?**
 - a) If the investments for approving quality for the customers with premium quality contracts are included in the revenue framework, does this not mean that the tariff for all the DSO's customers is increased?**

Interview questions, Italy

Premium Quality Contracts and Quality Regulation

Premium quality contract is a tool used for power quality regulation. In this study is the definition of premium quality contracts from the book *Service Quality Regulation in Electricity Distribution and Retail* used. According to the book is a premium quality contract a contract between a grid operating company and its customer. The contract specifies customer adjusted power quality standards that has been developed individually regarding the customer's preferences of power quality. The customer pay for the contract and is compensated if the DSO (Distribution System Operators) does not deliver the contracted power quality standard. Both the price paid by the customer and the compensation should also be specified in the contract. According to the 4th Benchmarking report on quality of electricity supply 2008 by CEER, is it stated that Italy has directives regarding contracts that can be agreed between the DSO and their customers that request higher power quality, this can thus be seen as a premium quality contract.

Different countries have adopted different quality regulations to assure that customers have an adequate quality level regarding power interruptions and sometimes also voltage quality. Examples of quality tools that the regulator use are:

- Information on quality levels for different DSOs (Distribution System Operators)
- Incentive-based regulation where quality indicators such as SAIDI, SAIFI and ENS are used to adjust the DSO's revenues.
- Minimum standards.

Following questions will be about the quality regulation in France and the use of premium quality contracts.

17. What kind of quality regulation is adopted in your Italy?

18. Are premium quality contracts a big part of the quality regulation or is it working aside of a strong incentive-based regulation for quality or/and strong regulation with minimum standards that must be fulfilled for all customers?

19. According to the 4th Benchmarking report on quality of electricity supply 2008 by CEER, no contracts were agreed in Italy 2008. Are still no contracts used have contracts been signed between DSOs and its customers?

If, premium quality contracts are used, according to your knowledge...

- 20. How frequently used are premium quality contracts? Are many customer using the contracts?**
- 21. What kind of customers have signed agreed contracts for higher power quality?**
- 22. How is the use of premium quality contracts perceived by the customers and the distribution network operators? Do they, for example, experience any obstacles or advantages?**
- 23. Do you think the directives from the regulatory authority regarding premium quality contracts has facilitated the use of premium quality contracts? Why/why not?**

If no contracts are used, according to your knowledge ...

- 24. Why do you think there has been no use of premium quality contracts?**
- 25. Do you think any changes in the directives regarding power quality regulation would increase the use of premium quality contracts? What kind of changes and why/why not?**

The impact of Premium Quality Contracts on DSO's and on the tariff

With the following questions we would like to identify the impact on the DSO's business when using premium quality contracts and also the impact on the tariff for the DSO's customers.

- 26. To gain an understanding about the revenue framework in Italy, I would like you to give a short summary of how it is designed.**
- 27. What is the impact on the DSO's business when using premium quality contracts?**
 - a) How is the income to the DSO from the contracts handled in the revenue framework? Is it included in the revenue framework or not?**
 - b) How are the investments, to improve quality for the customer with quality contract treated? Is the investment included in the regulatory asset base for the DSO?**
- 28. If a DSO have many customers with premium quality contracts how are the customers with no contracts affected?**

- a) **If the investments for approving quality for the customers with premium quality contracts are included in the revenue framework, does this not mean that the tariff for all the DSO's customers is increased?**

Interview questions Norway

Premium Quality Contracts and Quality Regulation

Premium quality contract is a tool used for power quality regulation. In this study is the definition of premium quality contracts from the book *Service Quality Regulation in Electricity Distribution and Retail* used. According to the book is a premium quality contract a contract between a grid operating company and its customer. The contract specifies customer adjusted power quality standards that has been developed individually according to the customer's preferences of power quality. The customer pay for the contract and is compensated if the DSO (Distribution System Operators) does not deliver the contracted power quality standard. Both the price paid by the customer and the compensation should be specified in the contract. In the Norwegian power quality regulations it is stated that customers and distribution network operators can contract for higher or lower power quality, this can thus be seen as a premium quality contract.

Different countries have adopted different quality regulations to assure that customers have an adequate quality level regarding power interruptions and sometimes also voltage quality. Examples of quality tools that the regulator use are:

- Information on quality levels for different DSOs (Distribution System Operators)
- Incentive-based regulation where quality indicators such as SAIDI, SAIFI and ENS are used to adjust the DSO's revenues.
- Guaranteed standard

Following questions will be about the quality regulation in Norway and the use of premium quality contracts to gain an understanding about the role of premium quality contracts in the Norwegian energy market.

29. What kinds of quality regulation is adopted in Norway?

30. Are premium quality contracts a big part of the quality regulation or is it working aside of a quality regulation mainly based on incentives or/and guaranteed standards that must be fulfilled for all customers?

31. Are premium quality contracts used in Norway?

If, premium quality contracts are used, according to your knowledge...

32. How frequently used are premium quality contracts? Are many customer using the contracts?

- 33. What kind of customers have signed agreed contracts for higher/lower power quality?**
- 34. How is the use of premium quality contracts perceived by the customers and the distribution network operators? Do they, for example, experience any obstacles or advantages?**

If no contracts are used, according to your knowledge ...

- 35. Why do you think there has been no use of premium quality contracts?**
- 36. Do you think any changes in the directives regarding power quality regulation would increase the use of premium quality contracts? What kind of changes and why/why not?**

The impact of Premium Quality Contracts on DSOs and on the tariff

With the following questions we would like to identify the impact of premium quality contracts on the DSO's business and also the impact on the tariff for the DSO's customers.

- 37. To gain an understanding about the revenue framework in Norway, I would like you to give a short summary of how the revenue framework is designed.**
- 38. What is the impact on the DSO's business when using premium quality contracts?**
- c) How is the income to the DSO from the contracts handled in the revenue framework? Or is it not included in the revenue framework?**
 - d) How are the investments, to improve quality for the customer with quality contract treated? Is the investment included in the regulatory asset base for the DSO?**
- 39. If a DSO have many customers with premium quality contracts how are the customers with no contracts affected?**
- b) If the investments for approving quality for the customers with premium quality contracts are included in the revenue framework, does this not mean that the tariff for all the DSO's customers is increased?**

Appendix B

Intervjufrågor, Kund

Namn:

Företag:

- Hur upplever ni leveranskvaliteten som nätägarna levererar till er? Uppfyller den era förväntningar? Är den tillräckligt bra? Om inte varför? Vad skulle behöva förbättras i så fall?
- Upplever ni några kostnader i på grund av att leveranskvaliteten inte är tillräcklig? I så fall vilka kostnader och hur stora är dessa kostnader?
- Vilka störningar i leveranskvaliteten upplever ni som mest kostsamma? Avbrott(långa, korta), spänningsfall, övertoner osv.
- Skulle ni kunna tänka er att skriva kundanpassade leveranskvalitetskontrakt med nätägaren för att få bättre leveranskvalitet? Är ni beredda att betala för dessa kontrakt? Finns det redan kontrakt?
- Ser ni några problem med att skriva den här typen av kontrakt? Skulle det till exempel innebära att er verksamhet kräver extra resurser för att hantera kontrakten.
- Vilken längd skulle ni kunna tänka er att kontrakten ska gälla?
- Har ni någon form av skyddsutrustning för att skydda mot störningar i leveransen av el? Om ni har det tror ni kostnaderna för skyddsutrustningen skulle kunna minska om ni fick högre leveranskvalitet? Anser ni att förbättring av elnätet skulle ha större nytta för er än lokala åtgärder?
- Om ni är intresserade av leveranskvalitetskontrakt, vilka risker ser ni med kontrakten? Skulle det innebära extra arbete? eller fördelar tror ni att ni kan komma att stöta på om dessa skulle introduceras, såsom till exempel extra arbete eller en bättre relation med nätägaren?
- Vilka fördelar ser du med leveranskvalitetskontrakt? T.ex. att ni slipper vara oroliga för att förlora produktion eftersom ni blir kompenserade om ni inte får den förväntade leveranskvaliteten?
- Om ni är intresserade av leveranskvalitetskontrakt, varför har ni inte infört något? Har ni efterfrågat högre leveranskvalitet hos nätägaren?
- Skulle det underlätta införandet av leveranskvalitetskontrakt om EI utvecklade riktlinjer för vad kontrakten ska innehålla, samt beräknade ett bas pris för kontraktet som t.ex. ska gälla för olika sektorer och områden?

Appendix C

Intervjufrågor, DSO

Namn:

Företag:

- Har kunder efterfrågat bättre leveranskvalitet, än de standarder som finns specificerade? Varför? Har ni i så fall förbättrat kvaliteten för dessa kunder eller funderat på lösningar för att tillgodose kundernas behov? Vilka lösningar har ni i så fall funderat på? Krävs mer resurser för att tillgodose kundernas behov?

Om kunder har efterfrågat bättre leveranskvalitet...

- Vilka kunder har efterfrågat detta?
- Varför har de efterfrågat bättre leveranskvalitet? Vilka brister i distributionen av el har upplevts av dessa kunder? Är det tex avbrott (långa och korta), spänningsfall, övertoner osv.
- Har ni i dessa fall förbättrat kvaliteten hos dessa kunder genom till exempel investeringar i elnätet som är kopplat till kunden, även om de garanterade minimumkraven redan är uppfyllda?
- Om ni inte har gjort det, har ni lämnat över ansvaret på kunden som själv får investera i skyddsutrustning?
- Skulle det krävas mer resurser hos nätägarna för att investera i bättre leveranskvalitet? Vilken typ av resurser i så fall? T.ex. finansiella resurser eller finns tekniska begränsningar som inte gör det möjligt att förbättra leveranskvaliteten?
- För att finansiera bättre leveranskvalitet, skulle ni kunna tänka er att skriva kontrakt med kunder som önskar högre kvalitet? Varför? Detta innebär att kunden betalar nätägaren för bättre kvalitet än de specificerade minimum standarden och nätägaren ser till att kvaliteten förbättras, annars blir kunden kompenserad enligt avtalet.
- Vet du om kunderna är beredda att betala för högre leveranskvalitet?
- Skulle ni kunna tänka er att skriva den här typen av kontrakt med alla typer av kunder eller endast med kunder anslutna över/under en viss spänningsnivå? Vilken nivå i så fall och varför?
- Ser ni några risker eller problem med ett sådant här kontrakt? Vilka och varför i så fall? Till exempel att kunder kan utnyttja varandras leveranskvalitetskontrakt. Har ni möjlighet att hantera leveranskvaliteten

till kunderna separat? Är ni som nätägare orolig för att de investeringar som krävs kommer kosta mer än kunden betalar för kontraktet?

- Anser ni att EI borde utveckla riktlinjer samt beräkning av ett bas pris som ska gälla för kontraktet, beroende vilket område och vilken typ av kund kontraktet avser?
- Vilken längd kan ni tänka er att kontrakten ska gälla?
- Vilka fördelar ser ni med kontrakten? Skulle det till exempel kunna säkerställa att kunderna fortsätter bedriva sin verksamhet i ert distributionsområde?
- Vet ni om kunderna är beredda att betala för högre kvalitet?
- Kan ni tänka er att teckna avtal för lägre kvalitet än de standarder som finns? Det skulle till exempel göra att ni skulle kunna störa vissa kunder mer än andra för att utföra underhållsarbete.
- Vet du någon mer nätägare som kan vara aktuell för intervju?