Satu Viljainen

REGULATION DESIGN IN THE ELECTRICITY DISTRIBUTION SECTOR – THEORY AND PRACTICE

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in the Auditorium 1382 at Lappeenranta University of Technology, Lappeenranta, Finland, on the 11th of November, 2005, at noon.
Abstract

Satu Viljainen

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This dissertation addresses the problematic issue of regulation design in an infrastructure industry with long asset lifetimes. The regulation of electricity distribution sector is taken as an example. In addition to the long asset lifetimes of 30–50 years, the sector is also characterized by having a universal service obligation, that is, the services of the distribution companies have to be both accessible and affordable to all citizens. In such an industry, it is important that the owners are given incentives to maintain the facilities in appropriate technical condition. Further, electricity distribution networks constitute so called natural monopolies, that is, distribution companies have franchised monopoly positions in their operating areas and, therefore, regulation is often considered necessary to protect customers from monopoly exploitation. Regulation may focus on the prices of monopoly services or the profits of monopoly companies. In addition, regulators may implement broad incentive schemes, which aim to direct the development of the regulated industry according to pre-specified strategic goals. A typical strategic goal in the electricity distribution sector is to improve the efficiency of the sector.

Regulation design tends to be a continuous process, because the regulator’s ability to implement versatile incentive schemes improves along with the increased knowledge on the cost attributes and other characteristics of the regulated industry. This often results in highly complicated regulation models, in which the original incentives may become blurred. Therefore, it is important that both the regulator and the regulated companies are able to see the general view and understand the consequences that the applied regulation methods have on the development of the business environment in the sector. The directing signals of regulation need to remain consistent in order to ensure that distribution companies are able to evaluate the long-term economical consequences of their investment decisions. Otherwise, the credibility problems of regulatory commitment may discourage investments in the highly capital-intensive electricity distribution sector. The objective of this dissertation is to create new knowledge on the directing signals of regulation over the development of business environment. First, the basic theories of regulation are introduced, followed by practical examples of the implementation of these theories. The emphasis is on discussing the role of regulation in setting the goals for the development of the regulated industry, and on analyzing the real-life effects of regulation in the electricity distribution sector. Practical solutions that mitigate the impacts of the observed problems are presented. Finally, methods to assess the future challenges in the electricity distribution sector are discussed.

Key words: regulation, electricity distribution, incentive scheme, efficiency benchmarking

UDC 338.465 : 621.31 : 338.246.025.2 : 338.27 : 346.5
Preface

This dissertation is based on the results that have been obtained in the following research projects carried out in the Laboratory of Electricity Markets and Power Systems at Lappeenranta University of Technology: Investments in distribution pricing, Developments of the DEA model, The role of power quality in the regulation of electricity distribution business, Investments in regulation – especially in efficiency benchmarking, and Developments of electricity distribution business. Several of the projects have been carried out in association with the research team of the Institute of Power Engineering at Tampere University of Technology.


The results of the research projects have been published in several scientific conferences and research reports. The publications have covered a variety of issues in the electricity distribution sector, ranging from the technical solutions of electricity distribution systems to the regulation and business models of the electricity distribution companies.
Acknowledgements

I wish to express my deepest gratitude to my supervisor, Professor Jarmo Partanen. I could not have done this work without his support and encouragement.

I am very grateful to my colleagues in the Laboratory of Electricity Markets and Power Systems: M.Sc. Jukka Lassila, M.Sc. Samuli Honkapuro, and M.Sc. Kaisa Tahvanainen. It has been fun to work with them, and the innovative and enthusiastic environment in our Lab has helped me get through many difficult moments. I also wish to thank my other colleague and friend, D.Sc. Pia Salminen. It has been extremely encouraging to share the experiences of writing the dissertation with someone who has gone through the same process herself.

Special thanks to PhD Hanna Niemelä for her professional help in editing the language of this thesis.

I express my warmest thanks to my parents. Their unquestionable support has given me a great deal of strength through my life.

Above all, I wish to thank my daughter Eveliina for always bringing such a joy to my life, and especially at times when I was struggling through this process. I did manage to keep my promise to you that I would finish this work before you start your school career – I beat the deadline by four days.

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Lappeenranta, 12 August 2005

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Nomenclature

**Roman letters**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>$C$</td>
<td>Cost</td>
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<td>$D$</td>
<td>Loan capital</td>
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<td>$E$</td>
<td>Equity</td>
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<tr>
<td>$f$</td>
<td>Weighting factor</td>
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<td>$p$</td>
<td>Unit price of regulated service</td>
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<tr>
<td>$P$</td>
<td>Price</td>
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<tr>
<td>$q$</td>
<td>Quantity of regulated service</td>
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<td>$r$</td>
<td>Rate-of-return</td>
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<tr>
<td>$R$</td>
<td>Revenue</td>
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<td>$T$</td>
<td>Useful lifetime of an investment</td>
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<tr>
<td>$X$</td>
<td>Efficiency factor</td>
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<td>$Z$</td>
<td>Measure of exogenous changes</td>
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**Greek letters**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tr>
<td>$\alpha$</td>
<td>Sharing factor of costs</td>
</tr>
<tr>
<td>$\Delta Cust$</td>
<td>Change in the number of customers</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Sharing parameter</td>
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<tr>
<td>$\sigma$</td>
<td>Sharing factor of profits</td>
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**Acronyms**

<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMM</td>
<td>Automated Meter Management</td>
</tr>
<tr>
<td>AMR</td>
<td>Automated Meter Reading</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<td>---------</td>
<td>--------------------------------------------</td>
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<tr>
<td>CGA</td>
<td>Customer Growth Adjustment</td>
</tr>
<tr>
<td>CMR</td>
<td>Customer Relations Management</td>
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<tr>
<td>COLS</td>
<td>Corrected Ordinary Least Square</td>
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<tr>
<td>CPI</td>
<td>Customer Price Index</td>
</tr>
<tr>
<td>CPI-(X)</td>
<td>Customer Price Index less the Efficiency factor</td>
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<tr>
<td>DE</td>
<td>Depreciation Expense</td>
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<tr>
<td>DEA</td>
<td>Data Envelopment Analysis</td>
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<tr>
<td>DSM</td>
<td>Demand Side Management</td>
</tr>
<tr>
<td>EMA</td>
<td>Energy Market Authority</td>
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<tr>
<td>ES</td>
<td>Efficiency Score</td>
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<tr>
<td>GDSS</td>
<td>Group Decision Support System</td>
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<tr>
<td>NPAM</td>
<td>Network Performance Assessment Model</td>
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<tr>
<td>OE</td>
<td>Operating Expense</td>
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<td>OPEX</td>
<td>Operational Cost</td>
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<tr>
<td>PBR</td>
<td>Performance Based Regulation</td>
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<tr>
<td>RAB</td>
<td>Regulatory Asset Base</td>
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<tr>
<td>RB</td>
<td>Rate Base</td>
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<tr>
<td>RC</td>
<td>Reasonable Cost</td>
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<tr>
<td>ROR</td>
<td>Rate-of-Return</td>
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<tr>
<td>RPI</td>
<td>Retail Price Index</td>
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<tr>
<td>RPI-(X)</td>
<td>Retail Price Index less the Efficiency factor</td>
</tr>
<tr>
<td>RR</td>
<td>Required Revenue</td>
</tr>
<tr>
<td>SFA</td>
<td>Stochastic Frontier Analysis</td>
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<tr>
<td>TE</td>
<td>Tax Expense</td>
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<tr>
<td>WACC</td>
<td>Weighted Average Cost of Capital</td>
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1. Introduction

The rapid restructuring of the electricity supply industry in Europe started in the late 1980s and the early 1990s, and since then, the industry has undergone significant changes. In those countries that are subject to European Union legislation, either directly or through European Economic Area Agreement, the deregulation process has been governed by a common legislative framework. Even though the requirements of the EU legislation have been the basis of national legislations, they have also left room for different kinds of interpretations. Hence, the process of opening the electricity markets has not followed exactly the same path in any two countries. A common element has been the separation of electricity generation, selling, transmission and distribution from each other, either legally or in terms of accounts or ownership.

The first directive on internal electricity markets given in 1996 set the common guidelines for the market opening (96/92/EC). The objective was to introduce competition in electricity generation and selling, whereas the transmission and distribution sectors were to remain natural monopolies. By the end of the 1990s, it was concluded that the implementation of the internal market in electricity should be accelerated. The Green Paper issued by the European Commission (2000) set new goals for the legislative work. These were, for example, to strengthen the separation of generation and selling from transmission and distribution, to ensure non-discriminatory access to networks, and to ensure that the national regulator of each Member State has the same minimum set of competences. In order to comply with these goals, a new directive was issued in 2003 (2003/54/EC).

1.1. Deregulation and re-regulation

One of the most important goals of deregulation was to promote the efficiency of the electricity supply industry. For decades, the whole supply chain of an electric utility – including generation, selling, transmission and distribution – had been organized as a vertically integrated monopoly, which was generally thought to have resulted in a significant potential for cost savings within the industry. Competition was thought to give incentives for efficiency in the delivery of services over the networks, whereas regulation aimed to mimic competition in the monopoly sectors where actual competition was absent. Consequently, the market restructuring
in the 1980s and 1990s often resulted in an obligation to break the former vertical integration of the electricity supply industry. At present, there are open markets in electricity generation and selling, whereas the transmission and distribution sectors are still regulated natural monopolies. Occasionally, however, the question is raised whether the transmission and distribution networks actually constitute sustainable natural monopolies, but so far these monopoly positions have not been seriously challenged.

In general, the basic elements of market restructuring can be categorized as follows: (1) unbundling of the potentially competitive services from the core of natural monopolies, (2) introducing competition in the services provided over the networks, and (3) introducing the regulation of natural monopolies in order to ensure reasonable tariffs and non-discriminatory network access (Newbery 1997b). A simplified illustration of the electricity supply industry structure in most EU countries at present is shown in Fig 1.1.

![Figure 1.1. A simplified illustration of the electricity supply industry structure in most EU countries.](image)

In the monopoly sectors, the term re-regulation would often be a more appropriate description of the recent developments than the term deregulation, because the reforms in these sectors have typically involved implementing new sets of regulatory rules. Indeed, the term deregulation has often been a source of confusion, because it is used in a very loose manner, and the prefix *de-* itself is open to considerable interpretation (Crew and Kleindorfer 2002). The term is sometimes mistakenly interpreted as the complete abolishment of regulation, but in practice, even the competitive sectors of electricity are usually subject to some form of monitoring by the national regulators. In fact, the regulatory reforms have been the most influential single factor in the industry’s development over the past decade or so. In this dissertation, the term deregulation refers to the opening of electricity generation and selling to competition, whereas the term regulation refers to the monitoring and supervising of network operations.
Regulation has mainly been introduced in order to prevent the monopoly companies from overcharging their customers, and to promote the efficiencies of the monopoly sectors. The transmission monopoly is often granted to a single national company, whereas at the distribution level, there are usually several local companies operating in franchised monopoly positions in specifically defined areas.

1.1.1. Electricity networks – regulated natural monopolies

Natural monopoly occurs when it is more efficient for one firm to serve the entire market instead of two or more firms due to the economics of scale available in the market. In electricity transmission and distribution, the main cost factors are the electricity networks, and usually, one firm can deliver electricity at lower average cost per customers than two firms with parallel networks. As a result, transmission and distribution companies have often been granted legal rights to be the sole operators in specific areas. These industries are characterized by good demand prospect, but the multiple supply prospects do not favour competing ownership, which indicates that the companies will be sustainable natural monopolies (Beesley 1992, p. 35). In electricity transmission, there is often only one regulated company that operates in national level, whereas at the distribution level, there are several local companies, which operate as franchised monopolies.

In literature, the natural monopoly characteristics of electricity transmission and distribution networks are often taken for granted, see for example Ramos-Real (2005); Gorini de Oliveira and Tolmasquim (2004); Jamasb and Pollit (2003); Jamasb and Pollit (2001); Grønli (2001), Førsund and Kittelsen (1998); and Moen and Hamrin (1996). Filippini (1998), on the other hand, suggests that regulators might want to put more emphasis on promoting competition for franchised monopolies. Some authors go even further by questioning the natural monopoly status of electricity distribution networks altogether. Künneke (1999), for example, argues that the natural monopoly of electricity network might be endangered by decentralized electric power generation, the evolution of parallel lines, and controlled electricity transmission and distribution. Gunn and Sharp (1999) discuss the sustainability of natural monopolies of electricity distribution under New Zealand’s regulatory regime that allows some competition in distribution services. The outcome of their discussion is that electricity distribution networks indeed seem to be sustainable natural monopolies.
To conclude, there seems to be no evidence suggesting that the natural monopoly status of electricity transmission and distribution is likely to be removed. There are, however, some exceptional cases, in which the natural monopoly status is not unambiguous. For instance, in Norway low voltage distribution networks are not defined as natural monopolies by law (OED 1990). In principle, a housing co-operative can build its own distribution system, and have one delivery point from the local distribution system operator. In Finland, on the other hand, competition has been introduced in building the low voltage customers’ connecting lines to the local distribution network, and electricity generating units can be connected to other electricity distribution networks besides the local distribution network (Electricity Market Act). Industrial electricity networks are another example of an absent natural monopoly – in Finland, these networks are usually owned and operated by other instances besides the local distribution companies. Finally, not necessarily all operations that the electricity network companies typically do in-house at present constitute natural monopolies. Instead, there might be a case for competition, for instance, in network construction and maintenance. However, this issue has not been seriously addressed in literature so far.

1.1.2. Sustainability of the natural monopolies in electricity distribution business

According to the technological definition, a natural monopoly occurs if a single firm can produce any level of outputs with lower average costs per customers than two or more firms. In the electricity distribution business, such economies of scale exist in some operations, but the process as a whole does not necessarily constitute a natural monopoly. In fact, only the network ownership unambiguously seems to possess the characteristics of a natural monopoly, because building and maintaining parallel networks would lead to excessive capital and operational costs, and the sunk costs of the networks would form a significant fraction of the total cost base of the distribution companies. Occasionally, there might be some confusion regarding the economies of scale in network ownership, because the average costs per customers may sometimes actually rise as new customers are connected to the networks. However, even in such cases, it is still usually less costly to connect the new customers to the existing networks than to build parallel networks, which indicates that the network assets do constitute a sustainable natural monopoly.
As far as some other operations of the basic process – such as the network construction and maintenance, and the metering operations of the electricity networks – are concerned, the outcome of natural monopoly considerations may not be quite as obvious, and the sustainability of natural monopolies in these operations cannot be taken for granted. Regardless of the fact that it is sometimes more economical to produce two or more operations within the same firm than in two or more firms, giving the natural monopoly status to the whole process of electricity distribution cannot be justified by the economics of scale. For instance, the network construction and maintenance are often produced more efficiently by a single firm than by two separate firms, but the situation still cannot be defined as natural monopoly. In fact, the service markets have already started to develop voluntarily in these operations, a fact that indicates that there actually is a case for competition. If these operations can be better and/or more efficiently produced by specialized service providers that operate in competitive markets, then perhaps they could be excluded from the natural monopolies altogether. In practice, this would mean that the costs of these operations were not included in regulatory calculations as such, but obtaining competitive reference prices for these operations were required instead.

Drawing the line between the operations that possess the characteristics of natural monopolies and those that do not is not an easy task. Nevertheless, some recent regulatory developments regarding for instance the metering operations and the procurement of electricity losses indicate that the regulators are, at least to some extent, willing to make such distinctions. After all, just because some operations have been interpreted as natural monopolies in the past does not mean that these definitions would hold in the future as well. For instance, technological innovations or the changes in the cost attributes may sometimes fundamentally change the characteristics of the formerly regulated industries. In addition, the inter-industrial organizational development trends, for instance the increased focus on the core business and the outsourcing of the non-core operations to specialized service providers, almost inevitably result in the restructuring of the regulated industry even without any formal regulatory interventions. Obviously, the sector-specific regulation should not prevent these kinds of organizational developments.
1.2. Sector-specific regulation in electricity distribution business

Natural monopolies have little chance of being driven out of a market by more efficient new entrants, which puts customers at risk. Consequently, some form of regulation is necessary to protect the customers’ rights in monopoly industries such as electricity transmission and distribution. In addition, electricity networks are crucial elements in creating an efficient market place for electricity selling, and regulatory intervention is necessary to guarantee that the terms defined for using transmission and distribution facilities do not prevent competition (Beesley 1992, p. 77). In other words, regulation is essential to maintain the freedom of entry (Vickers and Yarrow 1988, p. 119).

Another reason for regulation is that electricity networks are so called essential facilities, which means that they should be accessible and affordable to all citizens. In Finland, these issues are addressed in the national electricity market legislation by setting the obligation to serve for the distribution companies, and by stating that distribution tariffs shall be reasonable. In addition, the same tariffs are applied to similar customers within a specific network area regardless of the customers’ locations in the network, that is, a so called point tariff principle is applied. The universal service obligation and the point tariffs guarantee that all citizens can have access to electricity networks, and are able obtain reasonably priced monopoly services. Without these principles, the customers in rural areas would be at risk, because in some cases serving these areas might be found unprofitable altogether, or at least the monopoly prices would be unreasonably high.

Economic regulation makes sure that the affordability constraint of the monopoly services is met. However, this is usually not enough, but also technical regulation is needed to ensure the acceptable quality of the monopoly services, not only on average, but also from the point of view of each individual customer. Technical regulations may address issues such as the numbers and durations of planned and unplanned interruptions, and the voltage characteristics.

The best way to ensure reasonable prices and a sufficient quality of the monopoly services is to have an independent regulator who is able to respond to versatile expectations of the stakeholders of the regulated industry. In general, the objectives of regulation are usually set in
legislation, and the task of independent regulators is to define methods by which these objectives are met. This is also how the regulation design typically proceeds in Finland as well.

Regulators’ tasks usually include, for instance, setting the incentive schemes for the distribution companies and monitoring the overall development of the industry. Getting the necessary data from the regulated companies is typically easier if the regulators’ authorities are clearly defined in legislation. In addition, the publishing of this data might prove a less controversial issue if it is based on legislative requirements. Electricity distribution business is typically characterized by having independent sector-specific regulators; however, some of the regulatory tasks could also be left for the competition authorities.

Regulation plays an important role in determining the operational framework for the regulated business, and it also has significant impacts on the overall development of the industry, because firms tend to adapt to their operating environment. In other words, firms aim at optimizing their performance under a given regulatory regime. This sets high requirements to regulation, especially in the industry with long asset lifetimes, because of the far-reaching impacts of today’s decisions. Distribution companies need to believe that they are able to obtain adequate returns of and on their investments if the industry is to be maintained an attractive investment object. Another important issue is to make sure that the so called viability constraint of regulation is met, because regardless of the stakeholders’ price and quality expectations, the regulated companies will only supply the monopoly services if it is profitable for them to do so.

Regulation should ensure that distribution tariffs provide the regulated companies with revenues that cover operation and maintenance costs, and yield a reasonable return on investments, because this is the only way to guarantee that distribution networks can be maintained in appropriate technical shape. In other words, regulation balances the interests of different stakeholders of the electricity distribution business: customers, society, distribution companies and owners (see Fig 1.2).
Finally, the costs of performing regulation should be in relation to the presumable cost savings potential of the monopoly sector. The direct costs of regulation are typically relatively small, but the indirect costs of poorly designed regulation mechanisms can be significant for the economy as a whole, especially if regulation distorts the investment and operational behaviour of the regulated companies. Such a situation could rise, for instance, if distribution companies started to plan the developments of their networks on the basis of maintaining the regulatory asset values instead of the actual investment needs.

1.3. Electricity distribution from a business point of view

The goal of the electricity distribution business is to satisfy the customers’ need for electricity, to ensure the quality of electricity supply, and to yield profits to the owners. The industry is characterized as being highly capital-intensive with long asset lifetimes, typically 30–50 years. Nowadays, practically all citizens in developed countries are connected to electricity distribution networks, and the total price of electricity is significantly influenced by the distribution tariffs. In Finland, for instance, distribution tariffs constitute approximately one half of the total price of electricity paid by the residential customers. In comparison, electricity transmission in regional and national transmission networks constitutes approximately 5 % of the total price.

At the early stages of market opening, several new players entered the electricity distribution business, mainly through acquisitions. At first, the ownership of distribution networks was commonly seen as a useful tool to capture markets in electricity selling. However, electricity distribution is also an important business sector as such, because today’s information societies
are highly dependent on reliable electric power systems. Electricity distribution business, in turn, largely determines the availability of electricity within a society; the reliability of the whole electricity supply depends critically on the functioning of the distribution networks, because over 90% of the interruptions experienced by the customers are caused by faults in medium and low voltage distribution networks. In addition, the voltage quality at customer supply terminals is completely determined by characteristics of the distribution networks.

1.3.1. Typical expenditures of distribution companies

Typical expenditures of the electricity distribution companies consist of the operating and maintenance costs, investments, administrative support, network losses, customer support and corporate overhead. In Finland, the operating and maintenance costs – including items such as personnel costs, stand-by services, metering, corrective/ad hoc maintenance and preventive maintenance – constitute over one fourth of the total cost base. New investments and reinvestments in regional and distribution networks typically constitute 30–40% of the total expenditures, and the administrative support takes up ca. 10%. The remaining one fifth of the expenditures is divided approximately equally among network losses, customer support and corporate overhead.

The cost elements of distribution business that can be influenced through partnership solutions and other organizational developments include operating and maintenance costs, investments and administrative support. The potential cost savings are often considerable, typically 5–30% of the total expenditures, depending on the efficiency and performance improvement measures that have previously been taken. Cost savings in the operating and maintenance operations are usually due to better utilization of resources, the benefits of the economics of scale, and the improved logistics and procurement processes. Efficiency improvements related to investments generally result from the improved logistics and lower capital costs, and from the possibilities to utilize large-scale procurements and alternative engineering/design methodologies. Administrative cost savings are mainly due to the reduced need for the management of operating and maintenance.
1.3.2. Organizational developments

Distribution business in Finland has enjoyed the natural monopoly status for decades without having to face efficiency requirements, which has resulted in a notable short-term cost savings potential within the industry. Possible means to improve the efficiency of the sector include thinking through the processes of distribution business, and reorganizing operations when necessary. For instance, some operations of the basic process of electricity distribution might be better and/or more efficiently produced by specialized service producers than by the distribution companies themselves (see Fig. 1.3).

![Figure 1.3. A simplified illustration of the basic process of electricity distribution.](image)

Due to the nature of the electricity distribution business, partnership solutions are likely to result in more satisfying outcomes than the mere outsourcing of operations, because today’s decisions have such long-lasting impacts. The goal of the partnership approach is to achieve maximum efficiency by using an optimal mix of in-house and external activities. Partnership approach requires that both the client and the service provider are committed to mutual business planning, whereas the simple outsourcing does not necessarily account for such a long-term strategic approach.

At best, the partnership solutions enable the distribution companies to increasingly focus on their core business – managing the network assets – while the service providers take care of improving the productivity of labour and the quality of the network related services. Service providers may also operate in other infrastructure industries, such as in the telecom network business, gas distribution and district heating. Wide expertise in networks industries may enable
the service providers to utilize the best practices and synergies on an extended customer base. For similar reasons, the service providers also tend to operate on cross-border basis and seek for growth opportunities internationally.

Specialized service providers usually operate in open markets; however, their performances may have significant impacts on the regulated electricity industries. Realizing the potential efficiency gains would require that there are enough players in the service markets, and the markets are well-functioning. Harmonizing the regulation principles in different countries would contribute to the development of service markets, because the service providers could then more easily transfer their best practices from one market to another. Similar conclusion obviously also holds for all the other stakeholders of distribution business that operate in various market areas. In addition, the national regulators would probably also benefit from the cross-border co-operation, because they could learn from each other’s experiences and utilize a larger data base for various benchmarking studies.

1.4. Outline of the thesis

This dissertation focuses on the regulation of the electricity distribution business. It aims to explain the reasoning and the driving forces behind the phenomena that have taken place in the electricity distribution business in Finland over the past ten years. The approach is qualitative, and the research is characterized as a case study. The main interest is in describing the process of regulation design and analyzing the real-life effects of regulation on the electricity distribution business. The research is forward-looking in the sense that it attempts to create knowledge about the future challenges and the required new capabilities in the electricity distribution business. In order to do this, an in-dept understanding about the past developments of the industry is required. The main research questions of this dissertation are: (1) how to address regulation design in the capital-intensive electricity distribution that is characterized by long asset lifetimes; and (2) what are the real-life effects of regulation on the development of business environment in the sector.
The research work has partly been carried out in joint research projects. These include: *Investments in distribution pricing*, *Developments of the DEA model*, *The role of power quality in the regulation of electricity distribution business*, *Investments in regulation – especially in efficiency benchmarking*, and *Developments of electricity distribution business*. Close cooperation with the electricity industry and the Finnish Energy Market Authority has been characteristic of the projects, and the projects have covered a variety of subjects in the field of electricity distribution business, including issues such as the development of economic regulation methods, the efficiency benchmarking of the electricity distribution companies, and the regulation of power quality. Several researchers representing the Departments of Electrical Engineering, Industrial Engineering and Management, and Business Administration at Lappeenranta University of Technology, and the Institute of Power Engineering at Tampere University of Technology have participated the projects.

The research results that are presented in this dissertation demonstrate the author’s own contribution in the above mentioned joint research projects. Some of the key findings have also been dealt with in the author’s earlier work (see e.g. Viljainen & al. 2002; Lassila & al. 2003; Viljainen & al. 2004a; Viljainen & al. 2004b; Bergman & al. 2004a; Bergman & al. 2004b; Tahvanainen & al. 2004; Viljainen & al. 2005; Bergman & al. 2005). The results have been exposed to the criticism of scientific community by publishing them in international conferences and journals.

The leading principle throughout the research has been to develop methods that improve the predictability of regulation, and provide electricity distribution companies with incentives for more efficient operation. In general, in the regulated infrastructure industry that is characterized by long asset lifetimes, the direction of the development of the industry is often more important than the rate at which the strategic objectives of regulation are met. Essential for the successful implementation of regulation is to focus on issues that ensure the viability of the distribution companies, and to give incentives for efficient operation. The absolute accuracy of the incentives is obviously desirable, but even more important is the direction towards which the industry develops.
This dissertation is organized as follows. Chapter 1 defines the scope of the thesis and introduces the reader with the subject of the electricity distribution business regulation. Chapter 2 presents the basic theories of regulation. Chapter 3 discusses the challenges of the practical regulation design. These include, for instance, the following issues: (1) defining the strategic goals of regulation and deciding what methodologies will be applied; (2) developing efficiency evaluation procedures and setting appropriate incentives for the regulated companies; and (3) putting the necessary power quality regulations in place. A comparison of the regulatory models used in some European countries is also presented. Chapter 4 analyzes in detail the process of implementing regulation in the electricity distribution sector in Finland during the period of 1995–2004 and introduces solutions to some of the observed problems. These solutions concern issues such as how to develop a uniform system of accounts in the regulated electricity distribution sector, and what methodologies should be used in determining the regulatory asset bases. Of particular interest is also the question how investments should be handled in economic regulation. The real-life effects of the past and present Finnish regulation regimes are analyzed and the economical consequences of different investment strategies on the profitability of distribution business are evaluated. Chapter 5 discusses methods to assess the future challenges in the radically changing electricity distribution business. In addition, it evaluates the need for new capabilities in the sector from the different stakeholders’ perspectives, and introduces a construct (procedure) that has been successfully applied in real-life cases in order to develop such capabilities. Finally, Chapter 6 concludes the dissertation.
2. Theory of regulation

The original objectives of regulation are to avoid monopoly inefficiency and protect customers from monopoly exploitation. In market economy, competition takes care of price regulation and provides companies with incentives for efficient operation. Broadly defined, economical efficiency requires that tariffs are designed to: (1) achieve efficient use of energy; (2) minimize production costs; (3) provide clear investments incentives; and (4) result in efficient organization of electric services industry (Olson and Richards 2003). According to Vickers and Yarrow (1988, p. 79), competition provides an incentive system that impels privately owned firms to behave in ways that are broadly consistent with efficient resource allocation. However, in some industries, these forces of competition are weak or non-existent, and these industries are often considered to possess the characteristics of natural monopolies. Electricity distribution business tends to fall into the category of non-existent forces of competition and, consequently, electricity distribution companies typically have franchised monopoly positions in specifically defined areas. In such a business environment, customers are at risk and, hence, some form of regulation is necessary. In general, regulation is expected to give the distribution companies incentives to act in the public interest. In other words, the value of the regulatory commitment depends on the power of the regulatory incentive schemes (Newbery 1997b).

Olson and Richards (2003) argue that regulation should attempt to emulate the process of competition in those markets where competition is not present. While protecting the customers’ rights, regulation itself is not to make any other interest groups worse off. Thus, according to Beesley (1992, p. 56), the main duties of regulators may be interpreted as consistent with a formal aim of maximizing the net benefits of the interest groups and ensuring a fair distribution of these benefits. Regulation of electricity network industries also plays a role in enabling and promoting competition in electricity generation and selling; the network activities are the key component for competition as they must guarantee access to network services without any discrimination (Ramos-Real 2005). If competition is the ultimate goal, then regulation can sometimes be viewed as a necessary intermediate phase before competition arrives (Beesley 1992, p. 77).

Regulation focuses either on the profits of monopoly companies or on the prices of monopoly services, and the regulators may issue decisions ex post or ex ante. Ex post regulation is often
used at the early stages of regulation, when there exists a severe asymmetry of information between the regulator and the regulated companies, that is, the regulator has inadequate knowledge about the costs of the industry. Ex ante regulation, on the other hand, usually focuses on the prices of monopoly services, for instance the regulator may accept tariffs or the methods by which they are determined prior their coming into force.

Profit regulation is often characterized as being either rate-of-return or cost-plus regulation. Price regulation, on the other hand, typically takes the form of either price cap or revenue cap regulation in the electricity distribution business. Rate-of-return and cost-plus regulation rely on a principle that the profits of the regulated companies shall not exceed the allowed returns, whereas in price regulation, the specific tariffs of monopoly services or the revenues of the regulated companies are limited. Profit regulation is the traditional way of regulating the network industries. However, already the study of Averch and Johnson (1962) revealed that under profit regulation, firms have incentives to expand their regulatory asset bases through over-investments (Vickers and Yarrow 1988, p. 82). In addition, the traditional profit regulation fails to give incentives for efficient utilization of the network assets. This conflicts with the initial goals of the electricity market restructuring of the 1990s, that is, improving the efficiency of the electricity sector. Therefore, deregulation has often been accompanied by regulatory reforms, which have been characterized by the implementation of incentive regulatory schemes, especially in many European countries. Because of the pre-existing regulation, the shift from profit regulation to incentive regulation has been harder in the U.S. than in Europe (Vogelsang 2002). Some practical examples illustrating how incentive regulation has been applied in the electricity distribution business are given for instance by Viljainen & al. (2004b).

2.1. Profit regulation

The two common forms of profit regulation are rate-of-return regulation and cost-plus regulation. In literature, the distinction between these two may be somewhat ambiguous. In this dissertation, the term rate-of-return regulation refers to a situation in which the regulator issues the reasonable rate and then determines whether the actual return has been reasonable. In cost-plus regulation, on the other hand, the regulated company is obliged to show, based on a specific test period, what are its actual costs, and the regulator then audits the calculations and
issues the allowed rate. These definitions, however, represent only the author’s interpretations of the issue.

Profit regulation in general includes determining the allowed returns for the regulated companies as well as auditing the adjusted profit and loss accounts of the companies in order to make sure that the observed profits do not exceed the reasonable returns. The traditional profit regulation is well established in the U.S. (Beesley 1992, p. 56). The required revenue can be calculated based on projected or historic costs. The former method represents the U.S. type profit regulation, often referred to as cost-plus regulation in literature. Equation 2.1. shows the calculation of required revenue for company \( i \) in year \( t \) from projected costs (Jamask and Pollit 2000):

\[
RR_{i,t} = OE_{i,t} + DE_{i,t} + TE_{i,t} + (RB_i \times ROR)_i, \tag{2.1.}
\]

where
- \( RR_i \) = required revenue
- \( OE_i \) = operating expense
- \( DE_i \) = depreciation expense
- \( TE_i \) = tax expense
- \( RB_i \) = rate base
- \( ROR_i \) = rate-of-return

In the light-handed rate-of-return regulation, the reasonableness of pricing may be evaluated ex post by substituting historic costs in Eq. 2.1. This approach has been applied by some European regulators at the early stages of regulation, and it differs to some extent from the U.S. type of profit regulation.

### 2.1.1. Rate-of-return regulation

In principle, the rate-of-return regulation does not necessarily directly focus on tariffs, even though the ultimate goal is often to ensure the reasonableness of the pricing of the monopoly services. Instead of setting limits to prices, the return on capital is required to remain within reasonable limits, which is thought to limit the level of tariffs. The basic idea is that the regulated firms are allowed to collect revenues that cover their operational and capital costs,
and still earn fair returns on the capital employed. This has been thought to offer a solution to the problem of asymmetry of information between the regulator and the regulated firms, because the allowed prices are such that “fair” return on capital is earned (Vickers and Yarrow 1988, p. 82).

In the capital-intensive electricity distribution business, a fair principle would be that the investors were allowed to earn reasonable returns both of and on their investments. In practice this would mean that the existing electricity networks should form the regulatory asset bases on which the returns are earned, and that the asset bases are also adjusted for new investments. Failing to do this would soon result in the investors’ loss of interest in the distribution business altogether. In fact, the methods by which investments are handled in regulation are a crucial part of any regulation model. Indeed, the essential questions when designing rate-of-return regulation are: what is a fair rate, how should the asset base be valued, and what are the directing effects of regulation (Vickers and Yarrow 1988, p. 82).

The directing effects of rate-of-return regulation are imperfect in the sense that they give incentives for over-capitalization but not for efficiency improvements. Indeed, rate-of-return regulation has rather commonly been criticized because it lacks incentives for efficiency improvements and encourages firms to engage in strategic behaviour (Jamal & al. 2003). Irastorza (2003), on the other hand, sees traditional regulation being problematic because it does not encourage cost reductions and efficiency improvements, and may reward over-investments. The incentives for cost reductions are largely absent, because the authorized prices are consistently linked to realized costs (Bernstein and Sappington 1999).

Regulators often announce in advance what methodologies will be used in audits. However, this is not always possible in ex post regulation, for instance if the regulatory rates depend on annual interest levels. The regulated firms are then expected to plan their operations without knowing the exact reasonable rates in advance, which constitutes a significant regulatory risk for the regulated companies. However, the regulatory risk is not necessarily realized for all the companies because audits may focus only on those companies that are suspected of making excess profits. The rest of the companies experience merely a so called threat of regulatory intervention.
2.1.2. Cost-plus regulation

The basic idea of cost-plus regulation is similar to that of rate-of-return regulation; to allow the regulated companies to collect revenues that cover their operational and capital costs, and yield fair returns. However, the cost-plus regulation applied by the U.S. regulators often takes a more heavy-handed form than the rate-of-return regulation applied by the European regulators. In the U.S. type regulation, a company files a tariff when it wishes to revise its prices, and calculates the operating costs, the capital employed and the cost of capital for an agreed test period, typically the latest 12-month period for which complete data are available (Beesley 1992, p. 56). The regulator then audits these calculations and determines a fair rate of return. Total revenue requirement is determined by using the audited cost data and assumptions about the demand. In literature, the process of revising the tariffs is often called a rate case.

According to Parmesano and Makholm (2004), rate cases at their simplest involve the collection of costs and the appointment of those costs over a project sales volume. In other words, the essential elements of regulated rates are the costs and quantities, and the rate cases allow the regulated companies to revise their tariffs if they need extra money for instance for the network reinforcements and maintenance, or the necessary power quality improvements. This enables the distribution companies to take the appropriate measures to develop their networks when necessary. On the other hand, as Roach (2003) argues, cost-plus regulation puts distribution business into stagnant course as it focuses on constraining profits rather than on constraining costs and encouraging innovation.

2.2. Price regulation

Price regulation sets external limits to price increases and removes the linkage between costs and prices that forms the basis of rate-of-return and cost-plus regulation. The regulated companies can reap the profits from cost reductions, that is, price regulation has built-in incentives for cost efficiency. In addition, it encourages technological innovations that improve the productivity of processes. However, price regulation also tends to give incentives for quality reductions as well, and does not necessarily account even for the necessary capacity expansion.
2.2.1. Price cap regulation

The basic idea of price cap regulation is to set limits to the prices of monopoly services. Price caps can be applied to customers as a whole, or to individual classes of customers (Woolf and Michals 1995). The former method, that is, the single price cap, means that a basket of services rather than individual tariffs are regulated, allowing the companies for maximum flexibility in negotiating the contracts. Price caps that are applied to every customer class mean that limitations are, in fact, set to individual tariffs. Even though this approach has some beneficial virtues, for instance preventing cost shifting between customer classes, a common approach is to regulate a basket of goods or services. In the literature, the term price cap regulation usually refers to this latter approach.

According to Makholm & al. (2000) the three core elements of price cap design are: (1) deciding about the measure of inflation; (2) setting the X-factor; and (3) deciding what costs are allowed to pass-through to prices. Price cap regulation is often characterized by specified plan periods, and during these periods, the prices are allowed to vary from one year to another according to pre-set rules. The regulatory period of a few years is necessary, because otherwise the price cap plans would not have enough time to provide the efficiency incentives and the other useful incentives. Equations 2.2. and 2.3. show how the price cap for company \( i \) in year \( t \) is set (Jamash and Pollit 2000):

\[
P_{i,t} = P_{i,t-1} \cdot (1 + \text{RPI} - X_i) \pm Z_i ,
\]

(2.2.)

\[
P_i = \sum p_j q_j ,
\]

(2.3.)

where

- \( P_{i,t} \) = price cap
- \( \text{RPI} \) = retail price index
- \( X_i \) = efficiency factor
- \( Z_i \) = the measure of exogenous changes
- \( p_j \) = the unit price (tariff) of the regulated service
- \( q_j \) = the quantity of the regulated service
The inflation index should estimate the changes in economy-wide output prices or industry-wide input prices; gross domestic product-price index, retail price index (RPI), or some other price index may be used. The regulated companies have no influence on the inflation percentage, once the index is chosen. Setting the X-factor is the most challenging task in price cap regulation because it is the mechanism by which the customers benefit from the efficiency gains. The X-factor usually takes into account the forecast productivity growth as well as the efficiency improvement potential. Price cap formulas may also contain additive quality related factors that reward or penalize the regulated companies (Woo & al. 2003).

In price cap regulation, for a pre-specified period, the average price of goods and services is not allowed to increase faster than for instance RPI - X. The prices of goods or services within the basket may change during the regulatory period, which allows companies some freedom of price restructuring. On the other hand, if companies are able to reduce costs by more than is implied by the efficiency factor X, then they can keep the additional profits. This creates incentives for cost reductions. Indeed, Beesley (1992, p. 57) points out that the strength of price cap regulation is that it gives incentives for cost-efficiency and allows companies some flexibility to adjust the structure of prices within the basket. In addition, under price cap regulation, companies have stronger incentives to innovate and invest in new technological solutions because they may be able to retain the benefits resulting from their risk-taking (Olson and Richards 2003). The regulator’s duty is to see that companies comply with general pricing formula, whereas specific pricing decisions are left to the companies themselves (Vickers and Yarrow 1988, p. 109). A disadvantage of price cap regulation is that cost reductions may lead to reduced quality of services. To avoid this, price cap plans may include explicit quality measures. A special case of price cap regulation is rate moratoria, in which the X-factor is set equal to the rate of inflation and the Z-factor is set equal to zero, that is, there are no allowed pass-through costs (Vogelsang 2002). The prices are kept constant over the regulatory period, which forces the regulated company alone to face the risks of external price shocks.
2.2.2. Revenue cap regulation

Revenue cap regulation is often considered a special case of price cap regulation, because the two approaches share many common features. It is, however, possible to distinguish between the two. In contrast to regulating the average price of specified basket of goods and services, revenue cap regulation focuses on the total revenue of a company. According to Woolf and Michals (1995), the fundamental difference is that allowed level of revenues may change to reflect changes in sales levels. In other words, it is possible to return the difference between actual and forecast revenues to customers, or recover it from them.

Beesley (1992, p. 68) explains the difference between price cap and revenue cap regulation in the following way: in price cap regulation, the average price of services in the basket, as weighted by observed usage in the previous year, is not allowed to increase by more than RPI – $X$, whereas in revenue cap regulation, the forecasted average revenue per unit of output is not allowed to increase by more than RPI – $X$. The forecast of output in the revenue cap formula may be based on historic data, and load growth is usually taken into account by a specified correction factor. Equation 2.4. shows the main components of revenue cap calculation (Jamasb and Pollit 2000):

\[
\bar{R}_{i,t} = (\bar{R}_{i,t-1} + CGA_i \times \Delta Cust_i) \times (1 + RPI - X_{i,t}) \pm Z_{i,t},
\]  

(2.4.)

where

- $R_{i,t}$ = allowed revenue in year $t$
- $CGA_i$ = customer growth adjustment factor (€/customers)
- $\Delta Cust_i$ = change in the number of customers
- $RPI$ = retail price index
- $X_{i,t}$ = efficiency factor
- $Z_{i,t}$ = the measure of exogenous changes

The allowed revenue determines the level of tariffs, but their structures are left to the regulated companies to decide. Additional regulations may sometimes be necessary to ensure that tariffs are fair, and to avoid unreasonable discrimination.
The benefits of revenue cap regulation are similar to those of price cap regulation; it gives incentives for efficiency improvements and technological innovations, and reduces the incentives for over-capitalization. In addition, revenue cap regulation does not require that the goods and services that are included in the price basket are defined ex ante. Nor is it necessary to decide the weights of the prices within the basket. An additional strength of revenue cap regulation is that the implementation of incentive schemes, for instance quality adjustments, is a rather straightforward process, because adjustments can be targeted directly on the regulated revenues. However, if such adjustments are absent, revenue cap regulation may give disincentives to quality development (Agrell & al. 2000). The straightforward impacts of the various adjustment factors might make it easier for the stakeholders of the regulated industry to understand the interdependencies of regulation and the development of business environment.

2.3. **New regulation – setting incentives by using hybrid schemes**

The new incentive regulation is usually designed for a specified period and often consists of inflationary, efficiency and quality adjustments. The goal is to reduce the implications of asymmetric information, which, according to Vickers and Yarrow (1988 p. 92), give rise to imperfect incentives, thus resulting in inefficiency. The asymmetry of information is a fundamental problem in regulation, because the regulated companies are inevitably better informed for instance on the cost savings potential than the regulator, and this makes it difficult for the regulator to implement efficient yet reasonable incentive schemes. As Jamasb & al. (2003) put it, the basic idea of incentive regulation is to provide the regulated companies with incentives to utilize their exclusive information on effort and costs to improve the operating efficiencies and investment decisions, and to ensure that also customers benefit from the efficiency gains. Olson and Richards (2003) also emphasize that efficiency gains and customer benefits are essential when evaluating the success of regulatory policies.

According to Vogelsang (2002), the fundamental principle of incentive regulation is to offer practical rather than optimal regulation methods, that is, the principle suggests that specific pricing formulas – such as marginal cost pricing or Ramsey pricing – are not necessarily suitable for direct implementation. The interest in incentive regulation often reflects the need for practical approaches to regulation, which may not always be in line with theories of regulatory economics. In real life regulation design, the most important goal is often to find
feasible solutions to practical problems. Crew and Kleindorfer (2002) point out that it is the practical problems that drive the theory in regulatory economics, since it is an area of economics that is enhanced by practice, and most of the important theoretical developments are likely to arise out of practice.

In literature, incentive regulation is sometimes referred to as performance-based regulation or ratemaking. The main principle is, nevertheless, the same: good performance should lead to higher profits, and poor performance should lead to lower profits (Woolf and Michals 1995). The main objectives of performance-based regulation are: (1) to create strong incentives for cost minimization, (2) to promote efficient capital investment expenditures, (3) to ensure fair cost recovery for firms and a fair return on investment, and (4) to enhance information revelation in order to mitigate the traditional asymmetry of information between the regulator and the regulated companies (Yatchew 2001).

Incentive schemes can be included in both profit and price regulation, and they typically address cost efficiency, profit sharing mechanisms and/or service quality. The goal of such schemes might be, for example, to improve the feasibility and acceptability of regulation (Rudnick and Donoso 2000). As a matter of fact, profit and price regulation methods nowadays rarely exist in pure form in practice. Instead, practical regulation models are often combinations of several different regulation approaches that form various kinds of hybrid schemes. For instance, price and revenue caps can be supplemented by targeted incentive schemes concerning for instance power quality, and also combined with various profit or loss sharing schemes. In addition, rate-of-return and cost-plus regulation nowadays tend to be combined with efficiency incentives and profit sharing schemes.

2.3.1. Efficiency incentives

Efficiency incentives are usually defined based on some form of efficiency benchmarking. The purpose of efficiency benchmarking is to exploit the efficiency improvement potentials of the regulated companies by comparing their performances. To find out such potentials, regulators may apply for instance yardstick methods or partial cost adjustments. In principle, these methods are based on the idea of introducing pseudo-competition between the regulated
companies. Vickers and Yarrow (1988 p. 115) show that by promoting competition via regulation, the informational disadvantage of the regulator can be overcome in an economical fashion. Similar conclusion is presented by Makholm & al. (2000) who argue that well-structured incentive regulation is accompanied by market-like forces in an industry where real competition is absent.

2.3.1.1. Yardstick regulation

Efficiency studies are often performed by applying different yardstick methods. In general, yardstick regulation is a method to promote competition between regulated companies via the regulatory mechanism (Yatchew 2001; Vickers and Yarrow 1988, p. 115). In other words, the allowed prices or revenues of regulated companies are made dependent on the performances of other companies.

Yardstick regulation may be problematic in the sense that it does not necessarily take into account the differences in the operating environments of the regulated companies. Cost differences between the companies are often at least partly explained by geographic and demographic factors. Equation 2.5. shows the key elements of a cost-based yardstick regulation (Jamasb and Pollit 2000):

$$P_{i,t} = \alpha_i C_{i,t} + (1-\alpha_i) \sum_{j=1}^{n} (f_j C_{j,t}),$$

(2.5.)

where

- $P_{i,t}$ = overall price cap for the company $i$
- $\alpha_i$ = the share of company’s own cost information
- $C_{i,t}$ = the unit cost of the company
- $f_j$ = revenue or quantity weights for the peer group companies $j$
- $C_{j,t}$ = unit costs (or prices) for the peer group companies $j$
- $n$ = the number of companies in the peer group

The strength of yardstick regulation is that it may provide the regulator with an efficient tool for instance for setting the X-factors. By comparing similar firms, the regulator can use the costs of other companies to infer a given company’s attainable cost level, and by allowing the regulated
companies to recover estimated rather than actual costs, the regulator can encourage cost reductions and weaken the informational advantage of the companies (Bogetoft 1997). Yardstick regulation has been successfully used in cases, where cost data has not been available, and in connection with other methods of regulation (Vogelsang 2002).

Regulated companies can also be benchmarked against a hypothetical efficient company. This approach is problematic in the sense that the efficient long-run costs determined on grounds of engineering models may be inadequate to cover the actual fixed and common costs of the regulated companies (Vogelsang 2002). The reason for using benchmarking based on a hypothetical efficient company might be that there are not enough companies to perform yardstick benchmarking (Grifell-Tatjé and Knox Lowell 2003).

2.3.1.2. Partial cost adjustments

In partial cost adjustment regulation, prices are linked to the regulated company’s actual costs. Incentives for cost efficiency are provided by making price adjustments less than proportional to the actual changes in costs, as shown in Equation 2.6. (Jamasb and Pollit 2000):

\[ P_{i,t} = C^*_i + \lambda (C^*_{i,t} - C^*_i), \]  

(2.6.)

where

- \( P_{i,t} \) = adjusted price
- \( C^*_i \) = reference cost per unit output
- \( C^*_{i,t} \) = actual cost per unit
- \( \lambda \) = sharing parameter

Partial cost adjustments can be applied, for instance, when evaluating the reasonableness of the capital expenditures of the regulated companies.
2.3.2. Profit sharing mechanisms

The goal of profit sharing mechanisms is to share some of the risks between customers and shareholders, and these mechanisms are often used in connection with other regulation methods. The sharing parameter, which triggers the refunds or price reductions can be defined as an exact number or a broader band. In literature, the former case is referred to as profit sharing regulation and the latter case as banded rate-of-return regulation or sliding scale regulation. Woolf and Michels (1995) argue that broad bands provide greater incentives for companies to reduce their costs.

Profit sharing regulation allows customers to participate directly in excess profits or profit shortfalls earned by the regulated companies (Vogelsang 2002). Customers and shareholders share the risks and benefits of extremely high or low profits by accepting ex post refunds or price reductions for future purchases (Olson and Richards 2003). Profit sharing may be used in connection with other regulation methods. For instance, an obligation to return the excess profits to customers may be included in rate-of-return regulation. Similarly, a profit shortfall in one regulatory period may entitle the company to earn an equal amount of extra profit during the next period.

Banded rate-of-return regulation allows the regulated companies to keep the excess profits, and to suffer profit shortfalls within a pre-specified band (Vogelsang 2002). An equation of simple banded rate-of-return regulation is shown in Equation 2.7. (Jamasb and Pollit 2000):

\[ r_t = r_{t-1} - \lambda (r_{t-1} - r^*) \]  

(2.7.)

where

- \( r_t \) = allowed rate-of-return for the period under consideration
- \( r_{t-1} \) = actual return in the previous period
- \( r^* \) = benchmark rate-of-return
- \( \lambda \) = sharing parameter

The achieved rates that are below or above a pre-specified band trigger rate cases to bring the companies’ profits back inside the band, or cause other economical consequences such as ex post refunds or price reductions for future purchases.
2.3.3. Quality regulation

Incentive regulation often tends to encourage both cost and quality reductions unless the quality issue is specifically addressed. In order to guarantee sufficient power quality levels, regulators often implement targeted incentive schemes that focus on the quality issues in particular. In addition, the targeted incentive schemes may also focus on other specific aspects of operation, such as the environmental factors or the use of DSM measures (Jamasb and Pollit 2000). The aim of the targeted schemes is to achieve outcomes that would not necessarily otherwise result from broad incentive schemes (Langset & al. 2001; Didden and D’haeseleer 2003; Grenard and Strbac 2003).

2.3.4. Menu of contracts

A special case of hybrid schemes is the menu of contracts regulation, which allows the regulated companies to choose among different incentive regulation plans, for instance between various combinations of price caps and profit sharing (Vogelsang 2002). For instance, company’s share of profits $\sigma$ can be defined as a function of deviation of the X-factor, as shown in Equation 2.8. (Jamasb and Pollit 2000):

$$\sigma = f(X).$$  \hspace{1cm} (2.8.)

For example, the maximum allowed return can be set at a reasonably high level but, in exchange, there is no guaranteed return, and the efficiency requirement is relatively challenging. On the other hand, the same menu of contracts can allow the owners of distribution companies to choose guaranteed low returns and less demanding efficiency targets. Different contracts can also include company-specific quality incentives.

2.4. Competition and regulation

Presumable price reductions in the electricity supply sector were the grounds for the deregulation and the regulatory reforms of the 1990s, which introduced competition in electricity generation and selling, and left the electricity networks as natural monopolies. According to Vickers and Yarrow (1988, p. 110), the dilemma of policy regarding natural
monopolies is how to enjoy the cost benefits of a single-firm production without suffering from monopolistic behaviour. Regulators are usually expected to find means to promote the efficiency of the regulated sector, and a possible solution is to increase the role competition in the regulated sector. The idea that competition generally results in lower prices is not new, as shown by the following quotation (Smith 1776):

“The price of monopoly is upon every occasion the highest which can be got. The natural price, or the price of free competition, on the contrary, is the lowest which can be taken, not upon every occasion, indeed, but for any considerable time together. The one is upon every occasion the highest which can be squeezed out of the buyers, or which, it is supposed, they will consent to give: the other is the lowest which the sellers can commonly afford to take, and at the same time continue their business.”

There are several ways to increase competition in the electricity distribution business without giving up the basic idea that distribution networks are franchised natural monopolies. Firstly, the regulator may define the operations of electricity distribution included in the monopoly calculations and expect the rest to be purchased in open markets. Second, competition may be introduced via regulation by comparing the regulated companies with each other and making the regulated incomes dependent on the performances of other companies. And thirdly, competition for monopoly may be introduced. The regulators nowadays utilize the first two methods to some extent but the third one has not gained popularity so far.

2.4.1. Reducing the size of natural monopolies

Electricity distribution networks are generally regarded as natural monopolies (see section 1.1.1.). However, not necessarily all the operations of the electricity distribution process possess the characteristics of natural monopolies. Some of the operations might certainly be produced more efficiently in open service markets where competition exists than in the monopoly environment. After all, in many other industries, the specialized organizations are considered to be able to perform better and/or more efficiently than those organizations that do everything in-house. An interesting question is whether the natural monopoly status could be limited to the ownership of the electricity distribution networks, whereas other operations would be defined as potentially competitive. This unbundling would significantly reduce the sizes of the regulated natural monopolies. The resulting industry structure might be as shown in Fig. 2.1.
Increasing the role of competition in certain operations would probably provide means to improve the efficiency of the whole electricity distribution sector. In fact, competition already exists, for instance, in the electricity network construction in Finland, and this has resulted in significant efficiency improvements. In addition, the Finnish regulator has stated that from the start of 2005 the costs of purchasing electricity losses cannot be included in the monopoly calculations as such. Instead, a reference price for electricity losses shall be obtained in open markets. In Finland, the losses typically constitute approximately 3–7% of the total amount of the distributed electricity in medium and low voltage networks.

An approach in which the regulator expects certain operations to be procured in competitive markets is not without problems. First, to issue such decisions would require that there exist well-functioning service markets. Second, if the service markets become too consolidated, competition may not bring the presumed benefits, but it may still be difficult for the regulator to reverse its prior decisions without losing credibility. And finally, an essential question is whether regulation should at all interfere with the organizational issues of the distribution companies, or whether these questions should be left for the owners to decide.

2.4.2. Competition via regulation

Competition-like forces can be introduced by regulatory mechanism, if the forces of competition are otherwise weak or even non-existent. This approach is also referred to as yardstick regulation, and it is based on comparing the regulated companies either to each other or to a benchmark performance. Yardstick regulation is already well-established in the
electricity distribution business as the efficiency benchmarking of the distribution companies often utilizes yardstick techniques. This approach might become even more feasible in the future as regulation matures – once the obvious cost reductions have been achieved, the regulators are expected to find new means to create the appropriate efficiency and quality incentives.

2.4.3. Competition for monopoly

Competition for monopoly, or franchising, means that companies are made to compete to be the one that operates in the market (Vickers and Yarrow 1988, p. 110). In the electricity distribution business, the difficulties of this approach lie in the potentially uncompetitive bidding and complicated contract specification, and especially in the problematic issue of asset handover. A solution to the last problem might be to compete just for an operating franchise, in which case no asset handover takes place. For instance, if electricity distribution networks were owned by municipalities, then the local owners would continue to be responsible for the investment decisions, but the network operations would be contracted out. However, uncompetitive bidding and contract specification might still cause problems.

2.5. Evolution patterns of regulation

The original reason for implementing regulation is usually the same: to avoid monopoly inefficiency and to protect customers from monopoly exploitation. However, the practical approaches often appear to be very different depending on the stage of the regulation development process. For instance, the implementation of the targeted incentive schemes is almost impossible at the early stages of regulation, but becomes a topical issue after a few years of practical regulation.

Some European countries have a long history of regulating the electricity supply sector, whereas others have just recently started sector-specific regulation. However, regardless of the prior history, the past couple of decades have witnessed major regulatory reforms in the electricity supply sector, and started a whole new era of incentive regulation. As a matter of fact, those countries that have the longest history of regulation, have generally experienced
more rapid changes during the past 20 years than they did during the previous 80 years (Crew and Kleindorfer 2002). The evolution pattern of regulation itself has been similar in those counties that have just recently implemented regulation for the first time; however, the development phase has obviously been much faster.

At the early days of electrification, the first form of regulation was often municipal ownership. Profits of the locally owned monopoly companies were ideally used to benefit the inhabitants of municipalities, and the profit expectations were decided by politicians who were responsible to the voting people. Newbery (1997b) argues that the appeal of municipal ownership was that it kept prices reasonable, while the profits financed other local public goods and reduced local taxes. However, the municipal ownership had limited means to resolve the possible problem of inefficiency because for instance labour force issues were subject to regional politics. Increased private ownership in some countries and nationalization in others called for more precise regulation as the decision-making power moved further from municipal level. National regulatory authorities evolved to ensure that investments could be financed, and that the rents were distributed to various claimants (Newbery 1997b). Light-handed rate-of-return regulation has certain resemblances to the regulation method that relies on municipal ownership – the main difference being that in rate-of-return regulation the officially appointed regulators decide the reasonable rate instead of the elected politicians.

In the 1980s and 1990s, major restructuring of the whole electricity sector took place in many countries all over the world. Even though electricity distribution networks remained natural monopolies, they were not immune to the increased efficiency requirements. Regulatory developments introduced incentive mechanisms that were designed to reduce monopoly inefficiencies. Because cost reductions were believed to threaten power quality, incentive mechanisms were considered necessary to ensure sufficient quality of electricity supply for customers. Indeed, quality issues have been high on the agenda for the past few years, and incentive quality schemes have either been implemented, or the regulators are planning to implement such schemes in the near future. Fig. 2.2 illustrates the evolution pattern of regulation in principle level.
The general trend nowadays seems to be towards more precise regulatory requirements and restrictions. However, if the owners’ expectations continue to become more diverse in the future, it may prove necessary to introduce also company-specific regulatory approaches. An example of such an approach could be the introduction of customer participation in regulation, for instance in the form of stipulated settlements (Littlechild 2003). Another example could be the menu of contracts regulation. It could be realized in practice by allowing a wide band of return for the commercially oriented owners who are willing to take risks in their business. For example, the maximum allowed return could be higher than the average, but in exchange there would be no guaranteed return and the efficiency requirements would be relatively challenging. For those owners, who feel that they are in public service business, the maximum allowed returns would be lower but there would be guaranteed returns, and the efficiency targets would be less demanding.

Regulators have so far used benchmarking mainly in trying to find out the potential for cost reductions in the electricity distribution business. The role of benchmarking might change in the future, though. Ideally, the longer the incentive regulatory plans are in effect, the less there is potential for cost reductions. Hence, instead of being used in setting the company-specific incentives, benchmarking might increasingly be used as a method to create a competition-like
business environment for the distribution companies. This changes the nature of the benchmarking procedure; regulators may not necessarily apply individual efficiency scores in regulation as such but rather follow the rank orders of the regulated companies. The economical consequences of efficiency benchmarking may still be significant, but perhaps less so than in the present regulation plans. In fact, it is not just the role of benchmarking that is likely to change in the future, but also the role of regulators may be very different from that of today. The ongoing rapid development of incentive regulation methods requires significant resources from the national regulators at the moment, but inevitably the development process will slow down. The focus will then increasingly shift from the regulation design towards analyzing the real-life effects of regulation, and this may require new competencies from the sector-specific regulators, but not necessarily more resources.
3. Implementing regulation in the electricity distribution sector

In practice, regulation methods rarely exist in their pure theoretical form. Rather, the goal of regulation design is to find feasible solutions to problems that arise out of practice. This calls for sound regulatory judgement. For instance, regulators need to address issues such as how to implement incentives that induce the regulated companies to act on public interest. Incentive regulation usually first deals with efficiency improvements and later with power quality issues, that is, the incentive schemes tend to be implemented gradually. This piecemeal development process may sometimes confuse the directing signals and, therefore, complete revisions of the regulation models are required every once in a while. However, whenever new incentive schemes are implemented, it is important that their directing signals are consistent with the former directing signals of regulation. Otherwise credibility problems arise, as the regulated companies are unaware of the long-term economical consequences of their investment decisions. The lack of credibility on the regulator’s commitment on the long-term term development of the industry as well as the undefined strategic goals of regulation may discourage investments in the highly capital-intensive electricity distribution business.

One of the key characteristics of the electricity distribution business is the universal service obligation, that is, distribution services have to be both accessible and affordable to all citizens. In addition, electricity distribution networks also constitute an important part of a society’s infrastructure and have a high impact on many of its basic functions. In addition, the customers’ expectations concerning the quality of the distribution services are becoming more and more demanding. In general, regulation should give incentives to investments that (1) minimize the total costs of network operation and (2) are necessary to ensure the quality of electricity supply. In addition, it is also important that regulation encourages innovations, both organizational and technological, in order to maintain investors’ interest in the electricity distribution business.

Regulation aims to address the new expectations by assessing both the efficiency and quality of the distribution services. The potential for short-term efficiency improvements in electricity distribution sector is thought to have resulted from the former monopoly position of the vertically integrated electric utilities, and from the lack of incentive regulation for most part of the 20th century. However, the eagerness to promote short-term efficiency improvements in the electricity distribution sector should not distort the long-term development planning of the
distribution networks. Distribution companies need to be given incentives to invest in their networks and maintain them in appropriate technical shape – otherwise it will soon become impossible to meet the customers’ expectations on power quality regarding both reliability and voltage quality. Due to the long asset lifetimes in the electricity distribution business, today’s investment decisions will continue to have an impact on the business for the next 30–50 years.

3.1. Balancing the expectations of stakeholders

Different stakeholders of the electricity distribution business have different needs and expectations, which are often conflicting to some extent; regulation is about making compromises that satisfy these needs and ensure that none of the stakeholders is made worse off. In particular, regulation is to ensure that the interests of customers are met as they have practically no other means to influence the monopoly companies. From the regulator’s point of view, essential goals of regulation are to develop models that provide the regulated companies with incentives for efficient operation, and to ensure that also customers benefit from efficiency gains. In the end, good regulation balances the different stakeholders’ interests in the short-term, for instance returns and tariffs, and recognizes that in the long-term, these interests converge (Rosenzweig & al. 2004).

An attempt to meet the stakeholders’ versatile requirements may sometimes lead to complicated regulation models. As a result, the models may become less comprehensible both for the average electricity users and even for those who work in the industry. An essential requirement for the successful implementation of regulation is that the applied model is generally accepted by the stakeholders. However, the complex models often fail to meet this requirement. Another important requirement for regulation is that the costs of performing the regulatory activities are in relation to the presumable cost savings – this may not be the case if the applied model is highly complex and require detailed micro-regulation.

From the customers’ point of view, the regulatory model should protect them from the excessive prices of monopoly services. In other words, customers dependent on the monopoly services should not be overcharged, and also the quality of monopoly services should be sufficient. To accomplish this, reasonable prices, the role of power quality in regulation and the
appropriate quality levels have to be determined. So far regulation has mainly focused on realizing the potential cost savings within the industry, whereas less effort has been put on ensuring power quality. However, this has not yet resulted in severe power quality problems. In fact, if the networks are in good shape to begin with, which has actually been the case in many European countries, power quality problems seldom arise over a short period of time even if the maintenance of the networks is neglected to some extent. However, if the focus of regulation remains merely on prices and cost reductions, then power quality will inevitably become a problem at some point of time. The situation is obviously quite different if the regulation immediately has to tackle issues such as the aging network assets, which require extensive investment programs. In these cases the regulators are forced to address power quality issues from the very beginning.

From the distribution companies’ point of view, the regulatory model should give incentives for optimal capacity expansion and capacity utilization, and it should treat all distribution companies equally. To minimize the costs of regulation itself, the information gathered by the regulator should be relatively easy for the regulated companies to produce. Proper incentives are important in keeping the distribution networks in appropriate condition as well as in minimizing the regulatory interference with minor company-specific details. The directing signals of regulation should be consistent with the general planning and operating principles of distribution networks. However, distribution companies themselves also need to acknowledge the emerging changes in their operating environments. For instance, over the past few years, the customers’ interest in power quality has increased significantly, which in turn forces also the distribution companies to look at the quality issues from new perspectives. What used to be sufficient quality in the past may not be that in the future, and this has to be taken into account when planning the network developments and operations. However, improving the quality levels is often costly and might require price increases. The real challenge is then to convince both the regulators and the customers to accept higher prices if they require better quality.

From the owners’ point of view, the regulatory model should protect their rights by ensuring reasonable returns of and on their network investments. In general, it is important that regulation does not weaken the competitiveness and attraction of distribution sector as an investment object. In order to achieve this goal, emphasis has to be put on the methods used in
defining regulatory asset bases, reasonable returns on equity and loaned capital, and the risks of distribution business.

3.2. Principles of regulation design

Regulation plays an extremely important role in creating the operating conditions for distribution business. Essential for success is that all the stakeholders understand the directing signals and the real-life effects of regulation. According to Parker (1997), it is important that both the regulators and the regulated companies have in-depth understanding about the different variables that are essential in regulation, such as the cost of capital, the asset values, the depreciation rates and the appropriate rates of return, as well as about the consequences of different regulatory interventions.

The direct object of regulation is usually the pricing policy, which is easy to measure and amend, but the effects of regulation on social welfare depend critically on the investment behaviour that it induces (Vickers and Yarrow 1988, p. 81). However, while developing the incentive mechanisms, the regulator is often unable to fully observe the behaviour of the regulated companies, which means that directing signals and feedback mechanisms of regulation have to be well designed in order to minimize the opportunities for strategic behaviour. In practice, regulatory reforms are often characterized by piecemeal and selective developments (Crew and Kleindorfer 2002). This not a problem in itself – and certainly the piecemeal development is something that would be difficult to avoid – however, problems arise when the incentives of regulation model as a whole become contradictory as a result of the piecemeal implementation of versatile incentive schemes. Understanding the whole and thinking through the consequences of regulatory reforms has often proven to be difficult both for the regulators and the industry.

3.2.1. Focus of regulation

The first task in regulation design is to decide whether the regulation should focus on the profits of monopoly companies or the prices of monopoly services. Even though there are essential principle differences between the two approaches, there are common questions that have to be
answered in both cases. For example, the regulator needs to decide whether a uniform system of accounts is necessary, how the network assets are valued, and how investments should be handled in regulation. Especially developing the uniform system of accounts is an important initial step when implementing regulation for the first time, as it enables the regulator to obtain comparable data concerning the costs of the regulated companies. This information is essential at later stages of regulation, when the implementation of various incentive schemes for instance to promote the efficiency of the sector becomes topical.

The basic idea behind the uniform system of accounts is that it ensures that the regulated companies report their operational and capital costs according to the same accounting rules (Joskow 2005). These may specify for instance how to make the distinction between the different cost items of the regulated business, and what kind of depreciation schedules shall be used. Once in place, the obvious benefit of the uniform system of accounts is that it enables the regulator to perform versatile performance studies on the regulated companies, which make it easier for the regulator to create and implement different kinds of incentive schemes. At present, for instance, the trend seems to be to include both efficiency and quality adjustments in the regulated revenues of the distribution companies, as shown in Fig. 3.1.

![Fig. 3.1. An example of determining regulated revenues.](image)

Efficiency requirements are thought to result in declining revenues, that is, lower prices for the customers, whereas the quality adjustments may either increase or decrease the regulated revenues. In the absence of efficiency and quality adjustments, the incentive regulation in Fig.
3.1 is reduced to simple rate-of-return or cost-plus regulation, because the operational costs and the depreciations are accepted as observed, and a fair return on capital is added to them.

### 3.2.2. Incentives

The success of regulation depends on the incentives that it gives to regulated companies. These incentives may focus on the individual cost components, that is, operational costs, depreciations and return, or on the total revenues or prices of the regulated business. In fact, setting limitations separately to the individual cost components results in regulated revenues, while the process itself may become rather complicated as it requires performance evaluations based on the individual cost components. A more straightforward method is to focus the incentives directly to the regulated revenues.

The benefit of focusing the incentives directly to the regulated revenues is that it does not favour any particular operations model over another. For instance, the in-house operations and the use of specialized service providers are equally feasible operations models from the regulatory point of view, and the strategic choice between the two can be made based on the total costs of these operations. This is not necessarily the case if separate efficiency evaluations are carried out for instance on the operational costs but not on the capital costs – the procurement of services typically shifts costs from capital to operational costs, which in this case would virtually weaken the efficiency even though the total costs were reduced. However, if the efficiency of the regulated sector is to be improved, all sources of efficiency should be pursued; internal efficiency by reorganization of operations and applying new technologies, and external efficiency by corporate reorganizations, mergers and joint ventures. As Olson and Richards (2003) argue, the regulators should be indifferent to the methods of achieving the improved efficiency as long as the regulated companies provide efficient, safe, adequate and reliable service to customers.
3.2.3. Regulatory judgement

Unforeseen investment needs sometimes arise in distribution business, especially if power quality is at stake. However, under incentive regulatory regime, additional costs are not automatically allowed to be reflected in tariffs. This may turn out to be a problem if regulation requires performance improvements but does not provide the regulated companies with means to achieve them. Indeed, it is important that if the revenues or profits of the distribution companies are made dependent on their performances, then the companies should be allowed to collect sufficient revenues that cover the costs of operation as well as the upgrading of the assets to meet the new performance requirements. Otherwise, distribution companies are in jeopardy of becoming more and more wretched.

In those countries where distribution networks are in relatively good shape and there is some overcapacity when incentive regulation schemes are first implemented, it takes some time before power quality problems arise even if network investments are neglected. Eventually, however, the regulators also in these countries have to decide how to react to sudden investment needs. The unusual situations and the decisions associated with them are at heart of regulation and, in fact, justify the existence of the sector-specific regulators altogether. Such situations, however, require competent regulators who are able to apply sound regulatory thinking and judgement, and legislation that allows the regulators to exercise such judgements (Rosenzweig & al. 2004).

Sometimes a special case that calls for sophisticated regulatory judgement may arise due to a company’s strategic choice to change its network structure in order to improve power quality. One example is the extensive stepwise renewal of the primary substations of the distribution network in the rural area of Suur-Savon Sähkö Ltd, which is a medium-size distribution company in Finland (Lohjala 2005). The chosen approach significantly improves the reliability of the network over a short period of time – the alternative approach would have been to proceed the traditional way of network design, that is, by developing the network in small steps over a much longer period of time. In the long run, the final results of both approaches would be the same, but in the latter case it would have taken a much longer time to achieve them. The prime mover in the Suur-Savon Sähkö case was the owners’ willingness to make a rather large lump sum investment, and to proceed the path of rapid development. During the transition
period, adjusted tariffs are necessary, but ultimately the outcome will be lower operating costs and improved power quality for the customers. In special cases such as the one of Suur-Savon Sähkö, regulation should not automatically prevent the temporary price increases that are necessary to make the system improvements to improve efficiency and power quality in the long run. If regulation is to succeed in promoting innovations, it needs to have means to handle special cases of this kind open-mindedly.

3.2.4. Feedback mechanisms

Regulation plays a significant role in defining the long term strategic goals of distribution business, and the management of the regulated companies then run the business in accordance with these goals. The need for regulatory micro-management should be avoided. Therefore, built-in feedback mechanisms are essential in any regulation design in order to ensure that the direction of the industry’s development stays as desired. It is often difficult to measure the exact outcomes of certain incentive schemes, but even in these cases the well-functioning feedback mechanisms reduce the undesired implications of regulatory gaming. The existing literature on regulation design, however, does not seem to emphasize the importance of feedback mechanisms from this point of view.

Viljainen & al. (2002) present a practical example of feedback mechanism design, in which the basic idea is to allow the distribution companies to choose the useful lifetimes for their network components within a pre-specified range. These lifetimes are then used in all regulatory calculations (see also section 4.2.2. for a detailed description of the procedure). In this context, the term useful lifetime denotes the time for which the network components are actually in operation before they are replaced.

Ideally, the companies that operate in areas of rapid load growth will choose shorter lifetimes than those companies that operate in areas of low or negative load growth. These useful lifetimes are then used as the depreciation times when determining the reasonable depreciations that are used in regulatory calculations. The reasonable depreciations for each company are obtained by dividing the replacement values of the networks by their useful lifetimes, and the obtained depreciations levels indicate the average investment needs of the distribution
networks. The regulatory asset base is updated annually in accordance to the difference between reasonable depreciations and actual investments. If a company chooses short useful lifetimes for its assets in order to obtain higher rates but fails to invest accordingly, the value of its regulatory asset base begins to decrease and the company is forced to reduce its revenue. Obviously, the incentives for over-investments have to be limited under this kind of regulatory regime (Viljainen & al. 2004a).

Another example of feedback mechanism design is the updating of the regulatory asset base. If a regulatory period of more than one year is used, then the regulator has to decide whether the asset base is updated annually to reflect the actual investments made during each year of the regulatory period. The owners often argue that they should be entitled to earn returns on their investments immediately and not have to wait until after the regulatory review. This is a reasonable request, given that they could well choose some other investment objects beside the distribution networks, which would yield them immediate returns on their investments. The regulator could agree with the owners’ requirement on updating the asset bases annually, but he or she could then also expect that the investments benefit the customers as well, for instance in the form of lower operational costs and/or improved power quality. In other words, the regulator would agree on the annual updating of the asset bases because the investments were assumed to help the distribution companies to meet their efficiency and quality targets. Then, in the next review, the regulator could justifiably use the target cost and quality levels of the previous regulatory period, not the actual ones, as the basis of the revised regulated revenues. The impacts of accepting actual costs and target costs in revenue calculations are shown in Fig. 3.2 a) and b) respectively.

![Fig. 3.2. The evolution of regulated revenues when a) actual costs, and b) target costs are used in revenue calculations at regulatory reviews.](image-url)
In practice, a common approach has been to consider the actual rather than the target costs at reviews, which reduces the power of the incentive schemes. However, the significance of the efficiency targets seems to be increasing, and in the future, the regulated companies will probably be expected to put more effort on actually achieving the pre-defined efficiency targets.

A third example of feedback mechanism design in regulatory performance studies is the use of standard costs for a specific operation on one side and the performance related to that operation on the other side. For instance, the regulator could issue specifically defined maximum costs for customer care, including billing and metering, and then make the regulated revenues dependent on customer service. Regulated companies would then have incentives to seek for more efficient ways to handle customer service without reducing the quality of service. This might promote for instance the use of automated meter reading (AMR), which in turn would enable the use of more diverse pricing principles and could increase the price elasticity of electricity among customers.

3.3. Implementing incentive schemes in practice

In open markets, competition keeps players awake, but in the natural monopoly environment, there are no competitors. Therefore, regulation is often considered to be responsible for introducing market-like forces and to stir the status quo of the monopoly companies every once in while – otherwise the business environment is in jeopardy of becoming rather stagnant with no room for innovations. Regulation is never ready in the sense that it should always be prepared to react to the changes in the state of economy, and minimize the opportunities for strategic behaviour. The longer the regulatory model is in use, the better the companies learn to take advantage of the strategic opportunities. On the other hand, the regulatory period has to be long enough for the incentive mechanisms to take effect.

An essential element of regulation design is the ability to define the long-term goals of regulation through strategic planning, and to implement incentive mechanisms that direct the regulated industry towards the desired future. Getting the incentives right is, however, a challenging task because there are no universal solutions to regulatory problems that would
always apply. Rather, regulation can be seen as a continuous process of evaluating and reassessing the applied regulatory principles, methods, and incentives.

Having a large number of heterogeneous companies adds to the difficulty of creating appropriate incentives. For instance, the owners of the regulated companies may act either on commercial or public service basis, and it is difficult to create incentives that would have the desired effects on the companies’ performances in both cases. Especially the companies that are owned primarily by the municipalities, that is, by the end-customers themselves, often feel that they are in public service, and are not necessarily profit-driven.

Revenue cap regulation and the menu of contracts regulation are examples of methods that try to account for the differences in the owners’ expectations. The first one defines the desired directions of development, for instance the declining revenues, but leaves it to the companies to decide how they want to run their businesses. The latter one goes even further by allowing the owners some say in defining the nature and risks of the business that they are involved in. Regardless of the regulatory method, however, the industry-wide trends indicate that the efficiency requirements are becoming more and more demanding, and the importance of power quality is increasing.

3.3.1. Efficiency adjustments

The goal of regulation is often to improve the efficiency of the regulated sector and reduce the prices of monopoly services. Setting the efficiency targets is a critical feature of incentive regulation, since it determines the division of surplus between the regulated companies and their customers (Bernstein and Sappington 1999). Consequently, inefficiency estimates may have significant financial implications for the regulated companies and, therefore, their reliability is of crucial importance (Farsi and Filippini 2004). In recent years it has become popular to draw the efficiency estimates based on some form of efficiency benchmarking, which, in a broad sense, can be defined as a measure of actual performance against a reference or benchmark performance.
The practical implementation of efficiency benchmarking in economic regulation consists of three stages: (1) making the decision to include benchmarking in the regulatory regime; (2) choosing the benchmarking method, model, and variables; and (3) determining the methods by which the results of benchmarking are applied in regulation. Even the benchmarking process itself has certain directing effects. As efficiency benchmarking highlights certain variables, it tends to lead to improved performance in operations that are measured by these variables (Jamasb and Pollit 2003). For instance, if the interruption costs are included in the efficiency benchmarking as one variable, then regulation gives incentives for the efficient forestry work of the line paths and the preventative condition monitoring of the network components.

Often it does not suffice to pay attention to some variables, but stronger directing signals are needed, and this can be achieved by applying the benchmarking results in economic regulation. It is then important to make sure that the directing signals are consistent with the strategic goals of regulation. It is also important to be aware of a phenomenon sometimes referred to as a “virtual” efficiency improvement – failing to do this, undesirable welfare transfers from customers, or even from other companies, to the gaming company might occur (Jamasb & al. 2003). Incentives for gaming may arise, for instance, if operational costs are included in efficiency benchmarking whereas capital costs are not, in which case virtual efficiency improvements can be achieved by shifting operational costs into capital costs.

In the electricity distribution business, the efficiency benchmarking for regulatory purposes has been done mainly on national basis, and the national regulators have used a variety of different methods. In addition, the methods by which the results have been applied vary from one country to another. For instance, the regulators in the Nordic countries all use different benchmarking methods, and they also apply the results in a different way in regulation (Sand and Nordgård 2004). International electricity companies sometimes find these differences rather problematic.

Occasionally, the question whether benchmarking should be performed on international basis is raised. This approach might improve the validity of the results because the companies would more likely be benchmarked against similar companies (Jamasb and Pollit 2003). Obviously, international benchmarking would raise some additional problems, such as how to make sure
that the initial data produced in different countries is comparable. The quality of the data, as well as the acceptance of the model, is of crucial importance, if distribution companies are regulated based on their individual performance as portrayed by the model results (Edvardsen and Førsund 2003).

Ideally, the efficiency targets should reflect individual companies’ abilities to improve their efficiencies. Bernstein and Sappington (1999) argue that the ideal X-factor for a regulated company varies with its ability to reduce operating costs and increase productivity. Regulators often take this into account by setting both general and individual efficiency targets. The first one usually reflects the productivity growth of the economy as a whole, or the energy sector in particular, whereas the latter one considers the ability of an individual company to improve its performance. Company-specific efficiency requirements are often derived on grounds of efficiency benchmarking. Efficiency benchmarking may also provide the regulators with useful information for the valuation of the overall performance of the regulated sector. Consequently, the regulators sometimes use the results simply to monitor the productivity development of the electricity distribution sector without setting any specific efficiency requirements.

Company-specific efficiency requirements can be viewed as complements to the general efficiency requirements (Norton & al. 2002). However, the use of such requirements has also induced critical counter-arguments. Shuttleworth (2003) and Irastorza (2003), for instance, question the feasibility of company-specific efficiency requirements altogether. Indeed, implementing benchmarking and applying the results in regulation has proven to be challenging, but several European regulators nevertheless set both general and company-specific efficiency requirements for the distribution companies (Viljainen & al. 2004b; Tahvanainen 2004). Problems have often been associated especially with the reliability and consistency of the benchmarking results, and the difficulties in converting the results into X-factors.

3.3.1.1. General efficiency requirements

A general efficiency requirement is designed to address the presumable cost savings potential of the regulated sector, and it reflects the expectations for the future productivity growth of the regulated industry. In practice, the general efficiency requirements can be derived either based
on the historical or the forecast productivity growth. In electricity distribution sector, these requirements are typically 1.5–3 % p.a. (Viljainen & al. 2004b).

Total Factor Productivity (TFP) analysis is a widely applied method in determining general efficiency requirements. It involves a historical analysis of the productivity differential of the industry and the economy at large (Norton & al. 2002). If the expected rate of productivity growth of the industry is the same as that of the whole economy, then the general efficiency requirement is zero. Regulators also apply frontier methods, such as Data Envelopment Analysis (DEA), Corrected Ordinary Least Square (COLS), and Stochastic Frontier Analysis (SFA), to measure the past productivity growth. When using such methods, the results often include both the frontier shift effects and the movements towards frontier, and these are sometimes difficult to separate.

Historic productivity rates often serve as a good approximate for future productivity growth, assuming that there have not been any major structural changes in the industry (Bernstein and Sappington 1999). The development that has taken place in the telecommunication sector over the past decade provides a good example of a structural change that reduces the applicability of the historic data, as the diffusion of mobile technologies has completely changed the cost drivers and business logics of the whole sector. Electricity distribution sector has not recently witnessed such radical structural changes, as the technological developments have been mainly incremental. However, sometimes the new regulation principles and methods can cause fundamental changes in the cost drivers of the regulated industry. For instance, the ongoing discussion between the electricity distribution companies and the regulator in Sweden concerning whether the existing overhead lines should be replaced by underground cables to a large extent in order to improve reliability may eventually result in regulatory driven structural changes that reduce the applicability of the historic data.

3.3.1.2. Company-specific efficiency requirements

Regulators may derive company-specific efficiency requirements on the basis of efficiency benchmarking, which is considered to reveal economical inefficiencies. Company-specific efficiency requirements provide the regulated companies with incentives to close the inefficiency gaps, and yield an additional assurance that also the customers benefit from the
efficiency gains. Company-specific efficiency requirements can also be interpreted as a substitute of market forces that are absent in the monopoly industry.

European regulators appear to use more sophisticated benchmarking techniques than the corresponding authorities in the U.S. (Irastorza 2003). However, regardless of the sophistication of the applied methodologies, there are several issues that require careful consideration when setting individual X-factors. The problems are mainly associated with the subjective nature of the procedure and the limitations resulting from the features of efficiency benchmarking. In other words, the results of benchmarking are often sensitive to both model specification and the selection of parameters. In addition, the quality of the initial data that is used in benchmarking affects the results.

Regulators sometimes attempt to reduce the subjectivity of the benchmarking procedure by converting the results into X-factors in a rather mechanical way. For instance, the Norwegian regulator has used a specific formula to derive individual X-factors from the results of DEA benchmarking. Some regulators apply less transparent procedures in converting the results of benchmarking into individual X-factors. Regardless of the technique, however, sound regulatory judgement is required when setting the X-factors, because the financial consequences for the regulated companies are often significant. When setting the efficiency targets, the regulators have to, among other things, decide the reasonable rate of cost reductions, that is, the rate at which each presumably inefficient company is expected to close its inefficiency gap.

3.3.2. Quality adjustments

It is widely acknowledged that the customers’ expectations on power quality have increased significantly over the past few years. However, at the same time, there is a threat that the incentive regulation that focuses on cost efficiency may lead to the declining quality of the monopoly services, if the quality issue is not specifically addressed. Providing quality is often costly, and thus there is a conflict between efficiency and quality, unless the regulator is able to enforce quality directly (Dalen 1997). In addition, various market participants and business models have different objectives, and it is often difficult to combine cost minimization with the need for costly investment in the redundant infrastructure (Moss 2004).
In order to provide appropriate incentives, regulators may define minimum requirements for power quality. So far, the quality regulation has usually been concerned only with reliability, that is, the numbers and durations of outages. However, even this is often a challenging task because of the customers’ diverse expectations on reliability. Interruptions have different impacts on customers, depending on what kind of customer is in question, as well as on the day, time and duration of the interruption (Willis and Garrod 1997). In addition, including the customer service factor in power quality regulation is nowadays becoming a topical issue, which adds to the complexity of the corresponding incentive schemes. As for voltage quality, the Standard EN 50160 usually still applies as such. However, also the restrictions on voltage quality may become more demanding in the future than they are at present (Sand & al. 2004).

In distribution business regulation, there are three common ways to take power quality into account: (1) to include power quality adjustments in price or revenue cap formulas; (2) to include power quality in efficiency benchmarking; and (3) to evaluate power quality outside of price regulation for instance from a technical point view (Partanen & al. 2005). The economical consequences of the first two should be such that they provide distribution companies with sufficient incentives to take care of power quality under normal operating conditions and in most fault situations. Force majeure situations require separate evaluation. Force instance, distribution companies may be required to make provision plans describing how they intend to handle major disturbances, and these are notified to the regulator. If such disturbances occur, the regulator is then able to evaluate the performances of companies against their provision plans.

Economical consequences of power quality regulation together with the provision plans ensure that, on average, power quality remains at acceptable level. However, individual customers may still suffer from poor power quality. Therefore, defining additional restrictions, or norms, concerning the acceptable reliability and voltage quality levels may be necessary. Distribution companies may be required to pay compensations directly to the customers if they fail to meet the reliability targets, or the regulator may issue sanctions if distribution companies do not fix for instance the observed voltage problems in given time. Bernstein and Sappington (1999) argue that the direct rebates to customers have the virtue of ensuring that the effective price
decrease is delivered to the customers who experience the decline in quality, whereas the quality adjustments on revenue cap formulas do not necessarily share this virtue.

3.4. Examples on implementing regulation in some European countries

The basic legislative framework for the electricity supply regulation has been similar in those countries that are subjected to the European Union legislation. One common goal has been to align incentives so that the distribution companies deliver what customers value the most: efficient prices and good quality services. Indeed, incentive regulation is becoming a more and more common form of regulation in Europe, even though setting the appropriate incentives has proven to be rather challenging. The Nordic regulators, for instance, have struggled especially with developing fair and transparent efficiency benchmarking methods and applying the benchmarking results in economic regulation. Regardless of the common legislative framework, however, the practical implementation of regulation often differs significantly from one country to another. Table 3.1. illustrates the differences in the applied regulatory principles in some European countries (Viljainen & al. 2004b).
Table 3.1. Overview of regulation principles in some European countries in 2004 (Viljainen & al. 2004b).

<table>
<thead>
<tr>
<th>Country</th>
<th>Regulation principles</th>
<th>Benchmarking/target</th>
<th>Supply quality adjustment</th>
<th>Regulatory asset base (rate-of-return)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>Ex-post rate-of-return regulation</td>
<td>DEA / Opex</td>
<td>Average interruption time as an output-factor in DEA</td>
<td>Network replacement value (4,175 % 50/50 debt/equity ratio)</td>
</tr>
<tr>
<td>Norway</td>
<td>Ex-ante revenue cap regulation</td>
<td>DEA / revenue</td>
<td>Companies are given targets for interruption costs; if they fail to meet these targets, revenues are reduced and vice versa</td>
<td>Adjusted network book value (7,7 %)</td>
</tr>
<tr>
<td>Sweden</td>
<td>Ex-post/ex-ante revenue cap regulation</td>
<td>Reference network / revenue</td>
<td>Interruption times and frequencies affect allowed revenues</td>
<td>Network replacement value based on fictitious network</td>
</tr>
<tr>
<td>Denmark</td>
<td>Ex-ante revenue cap regulation</td>
<td>Network volume model / total costs</td>
<td></td>
<td>Network book value</td>
</tr>
<tr>
<td>Spain</td>
<td>Ex-ante revenue cap regulation</td>
<td>Reference network / revenue</td>
<td>Service quality is taken into account when composing reference networks</td>
<td>Reference network, that is corrected according to real network if the data from real network is available.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Ex-ante tariff regulation</td>
<td>DEA / revenue</td>
<td>Starting 2004 companies are given targets for interruption times and frequencies; if companies fail these target, revenues are reduced and vice versa</td>
<td>Standardized book value (5 % 60/40 debt/equity ratio)</td>
</tr>
<tr>
<td>UK</td>
<td>Ex-ante revenue cap regulation</td>
<td>COLS / Opex</td>
<td>Revenues are adjusted according to companies performances based on differences between target levels for interruption times and frequencies (max ± 1,75 % of the revenue) and customer services (max ± 0,125 %)</td>
<td>Network book value (6,5 %)</td>
</tr>
</tbody>
</table>

Table 3.1. introduces the regulatory principles as they were in 2004. Since then, there may have been changes for instance due to the regulatory revisions. In Finland, for instance, a new regulation model came into force at the start of 2005. At present, there is no efficiency benchmarking connected to regulation, but the regulator still monitors the efficiency scores during the first regulatory period and may apply them in later regulatory periods. Also, a regulatory revision has taken place in the UK in 2005.
3.4.1. Finland

Formal regulation was unknown to the Finnish electricity supply sector prior the market restructuring of 1995. In the absence of formal regulation, the supervision of monopoly companies had been dealt mainly by public ownership. For instance, there was one large state-owned company, which owned a significant portion of the total generation capacity in Finland, and also most of the transmission networks. In addition, there were a few other large generators owned mainly by the Finnish pulp and paper industry. And finally, also the local electric utilities owned some generating facilities. The local utilities were typically owned by municipalities, and they held franchised monopoly positions in specifically defined areas. The market restructuring caused significant changes in the ownership structures of the local utilities as new commercially oriented players entered the market mainly through corporate acquisitions. Customers were no longer protected from excess profits of monopoly business by public ownership, and thus, formal regulation became necessary.

3.4.1.1. Public ownership

Public ownership is one way of protecting customers from monopoly exploitation, because the politicians who are responsible for the corporate governance also bear the political responsibility to the voters. Under this kind of regulatory regime, the goal of the municipally owned electric utilities is often to provide the inhabitants with a good quality electricity at as low a price as possible, and even if the company makes excess profits, this money is ideally spent on providing other services to the inhabitants.

In a way, public ownership resembles rate-of-return regulation; both of them are based on defining explicitly the reasonable return that the companies can earn. In the former case, the local politicians define what is reasonable and, in the latter case, the national regulator is responsible for this task. However, there is a threat that public ownership leads to a situation in which electricity tariffs become tax-like payments, a characteristic that seems to make it rather intolerable in today’s societies. Another problem is that implementing efficiency incentives is often difficult in publicly owned companies because, for instance, the employment issues easily become a part of local politics.
In spite of the absent efficiency incentives, regulation based on public ownership was well-established in Finland, and was successfully applied for several decades. However, the market restructuring of 1995 created new business opportunities in the electricity supply sector, which attracted private investors. The new owners were often interested mainly on the competitive electricity selling, and owning the distribution networks was largely seen as an efficient tool to capture these markets. However, it soon became obvious that also the electricity distribution sector provided interesting business opportunities, and the monopoly positions of the distribution companies provided the owners – both private and public – with possibilities to exploit monopoly powers. The society felt that this threat of abuse had to be taken seriously, and finally, formal regulation was introduced to protect the customers’ rights in the new situation.

Apparently, the abuse of monopoly powers has not taken place on a large scale, since the distribution prices have behaved rather steadily over the past few years, as indicated by Fig. 3.3. On the other hand, the figure also shows that regulation has not been particularly powerful in promoting price reductions, either.

Fig. 3.3. The development of the distribution price levels (excluding taxes) for the middle-sized industrial customers and household customers in 1997–2005. The prices are adjusted to the changes in the consumer price index. (Source: The Finnish Energy Market Authority, available online at http://www.emvi.fi)
The price increases in 1999 were probably due to the issuing of the regulator’s first decision on distribution pricing. Until then, the distribution companies had not known the exact regulation principles but once they became aware of the evaluation criteria, they could also adjust the distribution prices accordingly.

3.4.1.2. Regulatory reforms

Associated with the electricity market restructuring in 1995, the basic guidelines for formal regulation were laid down, yet no exact regulation methodologies were defined. The Finnish Electricity Market Act (386/1995) simply stated that distribution pricing shall be reasonable and distribution companies shall operate efficiently. Detailed regulation model was formed during the first case-specific investigation on the reasonableness of distribution pricing. The regulator chose to evaluate the reasonableness of distribution pricing ex post on the basis of the observed rate-of-return. Evaluations were carried out on annual basis. The first decision was issued in 1999, and it became legally binding in 2000. Occasionally, the regulation methods were revised as new decisions on distribution pricing were issued.

In the early days of regulation, most distribution companies experienced merely a threat of regulation, because investigations were carried out only on those companies that were suspected of overcharging their customers. There was no constrained profit sharing connected to the regulation methodology, that is, distribution companies were not expected to return the excess profits even if the regulator’s decisions on their pricing policies were condemnatory. If the customers wanted to get their money back, they had to file complaints individually. The regulator had no formal legislative power, and its decisions were always case-specific. However, the decisions were precedent in nature, because it would have been difficult for the regulator to justify the use of different methods in similar cases.

In principle, the evaluations consisted of five steps: (1) calculating the amount of capital invested in the networks and drawing up an adjusted balance sheet; (2) dividing the invested capital into equity and loaned capital; (3) calculating the reasonable returns separately for both equity and loaned capital; (4) drawing up an adjusted profit and loss account; and (5) comparing the result of the adjusted profit and loss account to the reasonable return. Adjusting the balance
sheet in step 1 included substituting the present value of the network for the book value of the network. Present value depended on the replacement value of the networks, that is, what it would cost to build the network with the contemporary cost levels, and the remaining lifetimes of the network components.

Cost-efficiencies of the distribution companies were measured by efficiency benchmarking carried out by means of Data Envelopment Analysis (DEA). The model specifications were first introduced in 2000 (Korhonen & al. 2000). The efficiency scores were originally meant to be used in determining the reasonable cost levels for each distribution company (Viljainen & al. 2002). However, there were several problems in applying the results in economic regulation. For instance, the large annual variations in the DEA scores resulted in highly inconsistent directing signals for the development of distribution business. In addition, the model treated the distribution companies unequally. And finally, the power quality factor, which was included in the DEA model, was proven to be an extremely problematic issue – some companies had incentives to pay attention to power quality, whereas others could neglect the issue (Lassila & al. 2003). Eventually, the regulator used the DEA scores only in cases where the investigated companies were found efficient and, therefore, entitled to additional efficiency bonuses.

New regulation methodologies entered into force at the start of 2005. The first regulatory period was set to cover the years 2005–2007. The new approach continues to apply the rate-of-return regulation principles but has also certain efficiency incentives connected to it. The regulator calculates the annual profits during the regulatory period, but no decisions are made based on the one-year values. Instead, the reasonableness of distribution pricing during the regulatory period is evaluated as a whole. All the distribution companies are subjected to regulation, that is, regulation no longer focuses randomly on just some specific companies. There will also be elements of profit sharing mechanisms connected to the new regulation model – if a distribution company is found to have overcharged its customers it is obliged to return the excess profits, for instance by future price reductions. Similarly, windfall losses are transferred into the next regulatory period.

In the new regulation model, the regulator sets limits ex ante to the different cost items of distribution business; operational costs, depreciations and return. In practice this means that also
the revenues of the distribution companies are limited to some extent. During the first regulatory period there will be a general 1.3 % efficiency requirement, which is targeted to the operational costs of the distribution companies. It is widely acknowledged, however, that the general efficiency requirement is not sufficient in the long run but more specific incentives are also needed. Consequently, setting the individual efficiency requirements will become a topical issue during the next regulatory review.

3.4.2. Norway

In Norway, the formal regulation of the electricity distribution business was introduced in 1991 along with the electricity market deregulation. Until 1996 the regulator applied rate-of-return regulation. There were no specific incentives but the regulator rather attempted to gain as much knowledge about the regulated sector as possible. While lacking efficiency incentives, the regulation model generally encouraged investments. Fig. 3.4 shows the annual investment levels in the distribution networks in Norway in 1994–2001.

![Fig. 3.4. Distribution network investments in Norway in 1994–2001.](Source: The Norwegian Water Resources and Energy Directorate, available online at [http://www.nve.no](http://www.nve.no))

Since 1997, the Norwegian regulator has applied revenue cap regulation, in which the allowed revenues are determined on the basis of historic costs, and the book values of the network assets are used as the regulatory asset bases. In 1998, the regulator introduced the efficiency adjusted revenue caps. The goal was to strengthen the incentives for cost reductions. The efficiency
requirements consist of a general and an individual part. The general efficiency requirement is determined based on the forecast productivity growth and the individual efficiency requirements are derived from the results of the efficiency benchmarking that is carried out by means of Data Envelopment Analysis (DEA).

The power quality issue has been specifically addressed in economic regulation since 2001, when the quality adjusted revenue caps were first introduced. If a distribution company fails to meet its individual power quality target, that is, the observed interruption costs exceed the expected interruption costs, the allowed revenue is reduced by an amount equal to the difference between these interruption costs, as shown in Fig. 3.5. Power quality (modelled as interruption costs) is also taken into account in efficiency benchmarking.

The Norwegian regulatory system also has elements of banded rate-of-return regulation, because the regulator defines limits for both the minimum and the maximum return on capital. At present, the minimum return is 2 % and the maximum return is 20 % (Gammeltvedt 2003). Windfall profits that exceed the maximum return on capital have to be returned to customers by means of future price reductions. Similarly, windfall losses justify excess profits in the future.

The future challenges include issues such as how to align incentives to promote investments and not only cost reductions, and how to make sure that power quality remains at acceptable level. The first issue can be addressed by setting the maximum allowed rate-of-return at a level which

Fig. 3.5. An example of a quality adjusted revenue cap.
is also interesting for the commercially oriented owners of the distribution companies. The latter issue probably requires that in the future power quality will be regulated by means of economic regulation as well as by specifically defined norms.

3.4.3. Sweden

The deregulation of the electricity markets in Sweden took place in 1996. The new electricity law stated that the distribution tariffs and the costs of distribution business shall be reasonable. In order to supervise this ex post rate-of-return regulation was enforced. The development of the average consumer price of electricity is illustrated in Fig. 3.6. The market restructuring does not seem to have caused any major changes in the average distribution tariffs, whereas the total price of electricity has significantly increased.

At first, regulation did not contain any specific efficiency incentives. However, the regulator acknowledged the need for such incentives and started to measure the efficiencies of the distribution companies by means of Data Envelopment Analysis (DEA), but the results were never officially used in economic regulation. The first decision on the reasonableness of distribution pricing was issued in 2003, after a trial of several years. In theory, the decision laid
down the principles applied in regulation. However, the legislation had been changed while the case had been in trial, and thus in practice the decision did not have a precedent nature after all.

The regulatory decisions are now to be based on both the reasonableness of pricing and the performances of the distribution companies. The goal is to provide the distribution companies with incentives for more customer-oriented operation. In order to measure the performances of the distribution companies, the regulator has initiated the development of a so called Network Performance Assessment Model (NPAM). The model uses an engineering economic analysis to form a fictive network for each distribution area, and the allowed revenues are based on the efficient operation of these fictive networks. Power quality is also included in the NPAM calculations; the expected interruption costs are determined for each distribution company, and the allowed revenues are reduced if the observed interruption costs exceed the expected ones. The present regulation model used in Sweden has elements of ex ante revenue cap regulation, but the final decisions are made ex post.

3.4.4. The United Kingdom

The deregulation and privatization of the electricity markets in the UK started in 1990. In the electricity distribution business, the regulator has applied price cap regulation from the very beginning. The principle objective has been to protect the interests of both present and future customers by promoting the efficiency of the sector. While doing this, a framework for stable business environment is to be created through consistent and credible regulation. Since privatization, the operating costs of the distribution companies have gone down significantly. Customers have benefited from the efficiency gains in the form of lower distribution prices as shown in Figure 3.7.
Figure 3.7. Average distribution charge to a typical domestic customer (3300 kWh/year) in the UK (Crouch 2005).

While the distribution companies have reduced the operating costs, they have also improved the reliability levels of the distribution networks, as shown in Figure 3.8. In other words, the incentive regulation regime in the UK seems to have been truly efficiency enhancing.

Figure 3.8. The development of the average customer minutes lost in the UK since privatization (Crouch 2005).
The incentive regulation regime has also succeeded in providing the distribution companies with incentives to invest in their networks, as shown in Figure 3.9.

Some of the future developments include promoting distributed generation and encouraging innovations in the electricity distribution sector. More focus will also be put on the quality issues and ensuring the security of supply. The regulatory framework continues to evolve as new incentive schemes are implemented.

3.5. Conclusions on implementing regulation in practice

Regulation is expected to protect customers from monopoly exploitation, to give incentives for efficient operation, and to ensure the quality of the monopoly services. Implementing the appropriate incentives is a challenging task, and often requires that the regulator has extensive knowledge about the regulated industry. This is usually not the case at the early days of regulation. Therefore, in the beginning the focus of regulation tends to be on ensuring that customers are not made worse off than they were previously.

A common approach is first to evaluate that the returns of monopoly companies remain within reasonable limits. As the regulator’s knowledge increases, he or she will be able to implement
more precise incentive schemes that direct the industry towards the desired goals. The evolution pattern is similar also in power quality regulation; regulators usually first collect sufficient data during several years before they set any detailed quality targets. The Finnish energy regulator also followed the above described patterns. The regulator first applied ex post rate-of-return regulation for several years, but has now set detailed targets concerning the cost items of distribution business for the regulatory period of 2005–2007. At present, however, power quality is not included in the incentive regulation schemes.

The first incentive schemes usually deal with efficiency, and they are often targeted either to the regulated revenues or the operational costs. For instance, many European regulators have already implemented various efficiency incentives in the electricity distribution sector (see Table 3.1.). Quality incentives are equally important as the efficiency incentives, but usually even more difficult to implement. The customers’ expectations differ significantly depending on whether they are for instance household or industrial customers, and the regulators have to take these differences into account when designing the incentive schemes. In practice, the new incentives schemes have customarily been implemented on top of the old regulatory models, and this piecemeal development has often resulted in highly complicated new models. The piecemeal development of regulation is, to some extent, unavoidable because of the continuous nature of the regulation process. Nevertheless, the next couple of steps of the process should always be known in advance at least at some level – otherwise the business environment becomes highly unstable. The regulators should be able to define the goals and the desired direction of regulation well in advance, long before the actual regulation methods are known. In addition, the regulators also need to be aware of the effects that the various incentive schemes have on the investment decisions of the regulated companies. For instance, the mere use of efficiency benchmarking as a regulatory tool may distort the long-term investment planning of distribution companies, which obviously is not a desired outcome of regulation.

Legislation usually determines the principles of regulation, and the regulators then implement methods that are in line with these principles. There always exists an asymmetry of information between the regulator and the regulated companies, and thus the regulator can never authentically monitor the impacts of regulation on the performances of the regulated companies. Therefore, the appropriate feedback mechanisms and directing signals are essential elements of good regulation design. Well-designed feedback mechanisms reduce the need for regulatory
micro-management; the managerial issues can be left to the management of the distribution companies to handle while the desired direction of development is still maintained. In an industry with long asset lifetimes, such as those of 30–50 years in the electricity distribution sector, the direction of development is often more important than the rate at which the objectives of regulation are met.

Feedback mechanisms should be built-in features in any regulatory model. This requires that they are considered already in the beginning of regulation design, and again whenever regulatory reforms take place. In literature, the importance of feedback mechanisms seems to be undervalued to some degree, perhaps because their impacts are often difficult to measure exactly. In addition, the piecemeal development has often made the regulatory models so complicated that the feedbacks have become blurred. The appropriate directing signals are of particular importance if the number regulated companies is large and, therefore, the regulator is forced to rely on the self-regulation of the companies to some extent. In addition, it is important that the directing signals remain consistent, because regulation has such a significant impact on the long-term development of the electricity distribution business, and the sudden changes tend to distort the planning processes of the distribution companies.
4. Developments of regulation – case Finland

Electricity markets in Finland were deregulated in 1995 and a national regulator, Energy Market Authority, was founded to supervise the functioning of the markets. Finland had joined EU in 1995, and the electricity market deregulation at that time was necessary in order to comply with the amending EU legislation (96/92/EC). Competition was introduced in electricity generation and selling in order to promote efficiency in these sectors. Since 1 September 1998, all customers have been allowed to choose their electricity suppliers. Electricity transmission and distribution were defined as natural monopolies, and the Electricity Market Act (386/1995) issued that regulation is to be focused on these natural monopolies. The market restructuring was carried out without privatization – an approach that has been typical for the Nordic countries with a large number of publicly owned distribution companies. However, several new players entered the market through corporate acquisitions. In 1995, there were over one hundred electricity distribution companies, which were owned mainly by municipalities. At present, there are approximately 90 privately and publicly owned electricity distribution companies, which are regulated by the Finnish Energy Market Authority.

In Finland, the new EU Directive (2003/54/EC) has recently forced changes in the regulation principles of the electricity distribution business. In order to comply with the new directive, the regulator is now expected to ensure that transmission and distribution tariffs are non-discriminatory and cost-reflective. In addition, distribution system operator shall maintain a secure, reliable and efficient electricity distribution system in its area with due regard for the environment. And finally, distribution tariffs should be sufficient to allow the necessary investments in the networks to be carried out in a manner allowing these investments to ensure the viability of the networks. The decisions on complaints are to be given in four months. For instance, the Finnish regulator had previously applied ex post regulation, and under this kind of regulatory regime, it would have been practically impossible to issue decisions within the required time. Consequently, the Finnish regulator has now adopted more ex ante methods in regulation and the present regulatory regime can be characterized as being a combination of ex post and ex ante approaches.

The regulator also collects and publishes various data concerning the regulated electricity distribution business. It can use this data for instance in performance studies, in which the
regulated companies are compared to each other. To improve the reliability of such studies, the regulatory key data should be produced according to same principles. Therefore, harmonizing the regulatory key data such as the bookkeeping practices and the principles for compiling the power quality statistics is often an essential initial step when developing regulation frameworks.

4.1. Regulation model in Finland in 1995–2004

The Finnish electricity legislation left it to the regulator to decide what kind of methods are to be used in regulation as long as it focused on evaluating the reasonableness of distribution pricing and the cost-effectiveness of distribution companies. The regulator could not rely on any earlier experiences as there was no prior history of regulation in Finland. It would have been difficult to adopt any other method than the light-handed rate-of-return regulation to start with. As the regulator’s knowledge on the regulated industry increased, more precise restrictions to the different cost items of distribution business were defined. The exact methods of regulation were developed along with the first case-specific investigations that were carried out to assess the reasonableness of distribution pricing.

According to the regulation model that was applied in 1995–2004, the regulatory investigations were started by determining the value of network assets (regulatory asset base) and defining the reasonable rate-of-return on these assets. The financial outcome of the distribution business was then compared with the reasonable return in order to find out whether over-charging had taken place. Efficiency benchmarking was carried out by means of Data Envelopment Analysis (DEA). The idea of benchmarking was to define the levels of reasonable controllable operational costs; however, in practice benchmarking was only used in rewarding the companies that were found efficient by the DEA calculations. For each of these companies, the maximum efficiency bonus was 10% of its controllable operational costs. For all the other companies, the observed costs were accepted as reasonable costs in regulatory calculations. An illustration of the early regulation principles in Finland is shown in Figure 4.1.
Determining the regulatory asset base (RAB), the allowed rate-of-return (ROR) and reasonable deprecations tend to be at the heart of the dispute between the regulator and the regulated companies (Newbery 1997a). This has also been the case in Finland during the past few years. The regulator’s first decision on distribution pricing in 1999 laid down principles according to which the regulatory assets were to be valued.

4.1.1. Regulatory asset base and reasonable rates

The basic principle of the rate-of-return regulation is to prevent the companies from making excess profits at the expense of their customers. This requires defining both how to determine the amount of capital invested in the networks and the reasonable interest rates. The Finnish regulator chose to determine the regulatory asset bases by adjusting the balance sheets by replacing the network book values by their present values in the regulatory calculations. For historical reasons, the use of book values as such was not considered a feasible approach, since they often did not indicate the actual values of the networks. Depreciation methodologies might have been chosen as to minimize the amount of tax liabilities and, therefore, distribution companies had made as large depreciations as possible with due regard to the bookkeeping and
tax legislations. Consequently, the networks appeared to be worth less than they actually were. In addition, some companies had found it easier to book expenditures as operational costs than to get money for investments from the owners. The network book values in these cases were less than they would have been if the bookkeeping practices had favoured activating the expenditures.

The assessment of the reasonableness of distribution pricing was started by determining the replacement values of the distribution networks, that is, the total costs of building the networks with the contemporary cost levels. The replacement values were calculated by multiplying the total numbers of network components by their regulatory unit prices, which were given by the regulator. The present values of the distribution networks were then obtained by taking into account the remaining lifetimes of the networks, as shown in Equation 4.1. (Viljainen & al. 2002):

\[
\text{Present Value} = \left(1 - \frac{\text{Age}}{\text{Lifetime}}\right) \times \text{Replacement Value}
\]  

(4.1.)

The obtained present values of the networks were substituted for the book values of the corresponding networks in the distribution companies’ balance sheets. The total amount of capital invested in the distribution network operations was divided into equity and loaned capital, and the relative return on the invested capital was calculated by using the WACC model (Weighted Average Cost of Capital) as shown in Equation 4.2. (EMA 2002a):

\[
\text{WACC} = C_D \times (1 - t) \times \frac{D}{D + E} + C_E \times \frac{E}{D + E}
\]

(4.2.)

where

\[
C_D = \text{the average cost of loan capital}
\]

\[
C_E = \text{reasonable return on equity}
\]

\[
t = \text{current tax rate in decimals}
\]

\[
D = \text{the amount of loan capital}
\]

\[
E = \text{the amount of equity}
\]

The annual average rate of interest on business loans was used as the cost of loan capital, and the reasonable return on equity was the annual average return on 5-year state serial bonds increased by 1.5 % risk supplement. The average rate of interest on business loans and the average return on serial bonds were taken from the Financial Markets Statistics published
annually by the Bank of Finland. The reasonable returns on equity and the costs of loaned capital in 1997–2004 are illustrated in Table 4.1.

Table 4.1. The reasonable return on equity and the cost of capital in 1997–2004.

<table>
<thead>
<tr>
<th>Year</th>
<th>Return on equity [%] (including the 1.5 % risk supplement)</th>
<th>Cost of loaned capital [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>6.36</td>
<td>5.21</td>
</tr>
<tr>
<td>1998</td>
<td>5.80</td>
<td>4.86</td>
</tr>
<tr>
<td>1999</td>
<td>5.57</td>
<td>4.51</td>
</tr>
<tr>
<td>2000</td>
<td>6.77</td>
<td>5.97</td>
</tr>
<tr>
<td>2001</td>
<td>6.04</td>
<td>4.70</td>
</tr>
<tr>
<td>2002</td>
<td>5.91</td>
<td>4.32</td>
</tr>
<tr>
<td>2003</td>
<td>4.78</td>
<td>3.57</td>
</tr>
<tr>
<td>2004</td>
<td>4.75</td>
<td>3.43</td>
</tr>
</tbody>
</table>

The maximum reasonable return was obtained by multiplying the total amount of capital invested in the distribution network operations by the WACC percentage. Accumulated connection fees and interest-free liabilities were not taken into account in regulatory calculations.

4.1.2. Calculatory profit

According to the Finnish electricity market legislation, the distribution pricing has to be reasonable. The regulator chose to evaluate the reasonableness of pricing by analyzing, whether the expenditures of the distribution companies had been reasonable, that is, regulation did not focus directly on tariffs. The reasonableness of expenses was assessed by first adjusting the profit and loss accounts, and then comparing the results with the allowed returns. The decision-making basis was that the calculatory profit of distribution business was not to exceed the maximum reasonable return on capital. In practice, the calculatory profits for the distribution companies were determined as follows (EMA 2002a):

1) The result (profit/loss) of the accounting period was restored to the state before income adjustment items, direct taxes and financing costs.

2) The result obtained in step 1 was corrected by the difference between planned depreciation on the network property and the amount of average annual investments of the past 3 years.

3) Calculatory profit was obtained by subtracting tax liabilities (29 % in 2001) from the result obtained in step 2.
If the calculatory profit of the distribution business exceeded the reasonable return on capital, distribution pricing had been unreasonable and the regulator obligated the investigated company to equalize its distribution prices. However, if either party appealed to an administrative court, the decision became legally binding only after the final court order, and there was no constrained profit sharing even if the company was found to have over-charged its customers. Practically all the distribution companies that faced condemnatory decisions on their pricing policies appealed to the administrative court. It usually took approximately a year and a half to get the final court order, and the companies were able to continue with their prevailing pricing policies all that time without having to worry about possible sanctions. Customers obviously found this a rather unfair system.

4.1.3. Efficiency benchmarking

The Finnish electricity market legislation also expected the distribution companies to operate cost-efficiently. In the late 1990s, the regulator initiated a research project that aimed to develop means for measuring the efficiencies of the distribution companies. As a result, a method to evaluate the efficiencies by means of the Data Envelopment Analysis (DEA) was introduced in 2000 (Korhonen & al. 2000). The model specification was variable returns to scale (VRS) and the parameters used in benchmarking were operational costs, interruption time, distributed energy, network length and the number of customers. The mathematical expression of the model is show in Equation 4.3. (Lassila & al. 2003):

$$\text{Max } h_0 = \frac{u_1 \cdot \text{Energy} + u_2 \cdot \text{Network} + u_3 \cdot \text{Customers} - v_2 \cdot \text{Interruption time} + c}{v_1 \cdot \text{Operational costs}}$$  \hspace{1cm} (4.3.)

where

- $u_1$ = weight assigned to distributed energy
- $u_2$ = weight assigned to network length
- $u_3$ = weight assigned to the number of customers
- $v_1$ = weight assigned to operational costs
- $v_2$ = weight assigned to interruption time
- $c$ = free variable
In Eq. 4.3., the weights are optimized for each company given the restrictions that the result (i.e. the efficiency score of the company) shall not exceed 1, and when substituting the same weights to the DEA equation of any other company, the result shall not exceed 1, either.

The applied DEA model yielded a relative efficiency score for each company. The range of the efficiency scores was from 0 to 1. The efficiency scores lower than 0.9 were to be improved by decreasing operational costs (error marginal of the DEA calculation was considered to be 0.1). Efficiency scores were meant to be used in determining reasonable operational costs of the distribution companies, as shown in Equation 4.4.,

\[ RC = (ES + 0.1) \times OPEX \quad (4.4.) \]

where

- \( RC \) = reasonable cost level,
- \( ES \) = company-specific efficiency score calculated by using the DEA
- \( OPEX \) = the amount of controllable operational costs

The first intention was to apply the results of efficiency benchmarking in regulation in the following way (EMA 2002b):

1) If the company’s return on capital is reasonable and its operational costs are reasonable, the decision on distribution pricing is acquittal. The level of the reasonable return on capital is increased by an incentive bonus.

2) If the company’s return on capital is reasonable but the costs are unreasonable, the excess costs will be compensated by the return deficit. The decision on distribution pricing is condemnatory if the amount of excess costs is bigger than the return deficit.

3) If the company’s return on capital is unreasonable and the costs are reasonable, the excess return will be compensated by the incentive bonus. The decision on distribution pricing is condemnatory if the amount of excess return is bigger than the incentive bonus.

4) If the company’s return on capital is unreasonable and the costs are unreasonable, the decision on distribution pricing is condemnatory.

The inclusion of efficiency benchmarking in ex post regulation proved to be rather difficult; the efficiency scores were calculated ex post, which meant that distribution companies were inevitably unaware of the reasonable cost levels when making the pricing decisions. Hence, it would have been a rather unfair assumption that distribution companies could have taken the
cost levels into account in pricing. This eventually prevented the efficiency scores from being used in defining the efficient cost levels (EMA 2003). In addition, there were problems associated with the directing signals of efficiency benchmarking, which made the feasibility of the results highly questionable. For instance, the DEA model treated the distribution companies significantly unequally, and there were large annual variations in the DEA scores (Lassila & al. 2003). The real-life effect of such directing signals was an unfair and unstable business environment. And finally, the regulator had intended to apply the results of efficiency benchmarking in such a manner that it would have been impossible for many companies to close the efficiency gaps as expected. The DEA scores of the Finnish distribution companies in 2000 are shown in Fig. 4.2 (Lassila & al. 2003). The average DEA score was 0.830, and 19 companies out of 94 were found efficient.

![Fig. 4.2. The DEA scores of the Finnish distribution companies in 2000 (Lassila & al. 2003).](image)

Due to the publishing of the DEA scores, some of the companies that had been found inefficient in the DEA calculations were suddenly faced with unrealistic expectations to reduce their operational costs. These costs could amount to even over 40 % of their total operational costs. However, based on legal considerations, the regulator eventually gave up the idea of using the DEA scores in setting requirements for cost reductions. Nevertheless, the DEA scores were used as a basis for rewarding those companies that had been found efficient (DEA score of 0.9 or above). The maximum efficiency bonus that a company could earn was 10 % of its operational costs.
Investments were not taken into account in the efficiency benchmarking as such; however, in many cases they may have had an impact on the parameters that actually were included in the DEA model, especially on the operational costs and the interruption times. This kind of efficiency benchmarking that concentrated on measuring the efficiencies only in terms of the operational costs gave incentives for the trade-offs between operational costs and investments.

4.1.4. Evaluating the profitability of investments

The following example illustrates how regulation affected the profitability of investments under the first Finnish regulatory regime. Let us assume that in the beginning of a four-year inspection period, an investment of 2 M€ was made to build a new primary substation. The investment was financed by loaned capital with a 5% interest rate. As a result, the present value of the network increased by 2 M€ and a return on capital amounting to 100 k€ was earned during the first year. The increase in the allowed return covered the financing costs. The investment was depreciated in the adjusted profit and loss account in three years. In other words, the distribution prices were increased so that a cumulative extra revenue of 2 M€ was obtained over the next three years, and this money was used to pay off the loan.

The economical lifetime of the investment was 30 years, that is, the present value of the network was depreciated annually by 67 k€. After the first three years, the present value of the network was still 1.8 M€ higher than it was before the investment was made, which meant that an additional 90 k€ return on capital was still earned during the fourth year. Primary substation investment also improves the reliability of the network. In this example, this was assumed to cause a 0.2% unit increase in the company’s efficiency score. Original operational costs were 15 M€, and thus the efficiency improvement meant that an additional efficiency bonus of 30 k€ was earned annually. During the fourth year, the additional net profit of the investment was then 90 k€ + 30 k€ = 120 k€. This additional profit did not depend on the question whether the investment was carried out efficiently, or whether it was necessary at all. The economical consequences of the investment are summarized in Table 4.2.
Table 4.2. An example calculation of the economical consequences of a 2 M€ investment.

<table>
<thead>
<tr>
<th>Year</th>
<th>Present value</th>
<th>Loan payment</th>
<th>Additional revenue</th>
<th>Allowed return</th>
<th>Financing expenses</th>
<th>Efficiency bonus</th>
<th>Additional profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+2 000 k€</td>
<td>-667 k€</td>
<td>+667 k€</td>
<td>+100 k€</td>
<td>-100 k€</td>
<td>+30 k€</td>
<td>+30 k€</td>
</tr>
<tr>
<td>2</td>
<td>+1 933 k€</td>
<td>-667 k€</td>
<td>+667 k€</td>
<td>+97 k€</td>
<td>-67 k€</td>
<td>+30 k€</td>
<td>+60 k€</td>
</tr>
<tr>
<td>3</td>
<td>+1 867 k€</td>
<td>-667 k€</td>
<td>+667 k€</td>
<td>+93 k€</td>
<td>-33 k€</td>
<td>+30 k€</td>
<td>90 k€</td>
</tr>
<tr>
<td>4</td>
<td>+1 800 k€</td>
<td>0</td>
<td>0</td>
<td>+90 k€</td>
<td>0</td>
<td>+30 k€</td>
<td>120 k€</td>
</tr>
</tbody>
</table>

As shown by the above example, the first Finnish regulatory regime had strong incentives for investments – even to the extent of over-investments – because it rewarded the distribution companies rather generously for practically all the network investments. Companies could easily have maximized their profits by carrying out extensive investment programs to increase the asset bases and to improve the reliability of the networks. On the other hand, depreciations could not be made of those investments that had been made more than three years ago. Given time to mature, this kind of regulatory regime practically would have forced the distribution companies to collect the money spent on investments over a period of three years. This would have led to continuously changing distribution tariffs for the customers, because in the distribution business, the annual investment needs vary significantly from one year to another, and a three year period is not long enough to even out the differences.

In the electricity distribution business where the planning horizon is at least 30–50 years, the large annual price fluctuations resulting from the applied regulation model would have been a rather contradictory outcome. This kind of regulatory regime would obviously have failed to protect both the present and the future customers. Given that the distribution company had made significant over-investments in order to maximize its profits, the present customers suffer from both the price increases due to the larger depreciations in the adjusted profit and loss account, and the increased allowed return due to the larger asset base. The future customers will continue to share the burden of the unnecessarily large asset base. The development of operational costs and investments of the Finnish distribution companies in 1997–2003 are shown in Figure 4.3.
The first decision on the reasonableness of distribution pricing in 1999 laid down the principles applied to the regulation, which meant that the distribution companies were now able to accommodate their pricing principles to match the regulatory requirements. However, despite the possibilities to make extensive profits, the owners did not seem to exploit the strategic opportunities of the regulation model on a large scale.

There probably are several explanations for the moderate behaviour of the owners of distribution companies. Firstly, the effects of regulation have generally been poorly understood. For instance, the distribution companies have not always been able to calculate how regulation actually affects the profitability of investments. Secondly, regulation has not yet been able to create a stable business environment in the electricity distribution business, which is often required to attract investments. Instability has been, to some extent, unavoidable because the first years of regulation typically constitute a learning period for all the stakeholders. In the particular case of the electricity distribution business, the withholding of investments may actually have benefited the customers, but in general it is extremely dangerous if regulation alone distorts the investment behaviour in a capital-intensive industry. Thirdly, most distribution companies in Finland are still owned by municipalities, and this kind of ownership structure may have protected the customers from monopolistic behaviour to some extent.
4.1.5. Problematic issues and the development needs

The analysis of the real-life effects of the first regulation model that was used in Finland raised several research questions concerning the applied principles and methodologies. The analysis drew attention to issues that are, in fact, at the heart of any regulation design. That is, regardless of the chosen approach, regulation always needs to address basic questions such as:

- Is it necessary to develop a uniform system of accounts that lays down the principles that are used in distinguishing between the different cost items of distribution business, and in defining the reasonable depreciation schedules;
- What methodologies should be used in the valuation of the regulatory asset bases; and
- How should investments be handled in regulation.

In addition, regulation may also include incentives that are designed to promote the efficiency of the regulated sector, and to ensure the appropriate quality of the monopoly services.

The first regulation model that was applied in Finland gave incentives for excessive investments because they always increased the regulatory asset base and could be depreciated in regulatory calculations in only three years (Viljainen & al. 2002). In addition, the applied asset valuation methodology contained many uncertainties and provided opportunities for strategic behaviour. In theory, the method whereby the present values of the regulatory asset bases were determined based on the remaining lifetimes of the network components was correct. In practice, however, determining such remaining lifetimes was nearly impossible for both the regulator and even for the distribution companies themselves (Viljainen & al. 2002). And finally, the rate-of-return regulation as such did not contain incentives for cost efficiency. The DEA model, which was introduced to change this matter, eventually ended up causing problems rather than solving them because the directing signals of efficiency benchmarking were often controversial (Lassila & al. 2003). Due to the one year regulatory period, all the calculations were made on annual basis, which made the business environment rather unstable.

Efficiency benchmarking also gave incentives for trade-offs between operational costs and investments, as only operational costs were taken into account in the DEA model. Whenever possible, it was beneficial to book operations as investments rather than as operational costs, because the resulting virtual efficiency gains improved the DEA scores. This directing signal
was further strengthened as all the investments also increased the asset bases. Consequently, distribution companies were able to earn guaranteed returns on all their investments, and some investments even yielded additional profits due to the improved efficiency scores. Power quality was technically taken into account by including a quality index (i.e., the interruption time) in the DEA model. However, because the DEA model was essentially designed to measure cost-efficiency, not power quality, the model could actually define the power quality index as an insignificant factor in terms of efficiency. As a matter of fact, power quality did not affect the DEA scores of over 20% of the distribution companies (Lassila & al. 2003).

Regardless of the problems, however, the chosen light-handed ex post rate-of-return regulation was a feasible approach to begin with. Other options also became possible as the regulator’s knowledge about the industry increased; however, the regulator continued to apply rate-of-return regulation. In many other countries, the regulators in similar situations had moved towards applying more ex ante methods and incentive regulation, which had often meant shifting the focus of regulation from the profits of distribution business to the prices of monopoly services. In Finland, the basic question whether it should be the profits or prices that are regulated was never thoroughly addressed. One of the reasons might have been that the public discussion concerning the strategic goals of regulation was practically non-existent.

4.2. Research questions concerning the regulatory developments

The problematic issues in the regulation model that was applied in Finland in 1995–2004 raised several research questions (see e.g. Viljainen & al. 2002; Lassila & al. 2003; Viljainen & al. 2004a; Lassila & al. 2004). The objective of the research has been to induce directing signals that promote the development of stable business environment in the electricity distribution sector, and give incentives for the minimization of the total costs of distribution business. Throughout the research, close co-operation has been done with both the national regulator and the distribution companies.

The first research question was concerned with the development of a uniform system of accounts, that is, harmonizing the principles according to which the regulatory key data is reported. The issues that were addressed in the research included defining the guidelines for
making the distinctions between the network related operational costs and investments, and defining the depreciation schedules for the network components (Viljainen & al. 2002). The research on the depreciation schedules concerned both the useful lifetimes of the network components and the applied depreciation methodology.

The second research question dealt with the valuation of the regulatory asset base. According to the regulator’s previous decisions, the present value of the network formed the regulatory asset base; however, the methodology by which the present value was determined was contradictory. The basic idea of the proposed modifications was that the distribution companies should, within pre-specified limitations, first define their reasonable investment levels, that is, what it would take to maintain the distribution networks in appropriate technical shape. Then the distribution companies should adjust their investment behaviour accordingly in order to maintain the values of their regulatory asset bases (Viljainen & al. 2002).

The third research question addressed the issue of how handle investments in regulation. This research phase included issues such as how to define whether the level of investments and the associated costs are reasonable, and whether investments should be taken into account in efficiency benchmarking (Viljainen & al. 2004a; Lassila & al. 2004). The inclusion of investments in efficiency benchmarking would limit over-investments, which otherwise is characteristic of rate-of-return regulation. An obvious threat of such an approach is that it may easily reward the under-investing companies. However, it is possible to mitigate this threat by implementing appropriate feedback mechanisms (Viljainen & al. 2004a).

4.2.1. Developing a uniform system of accounts

The success of regulation depends critically on the incentives that it gives to the regulated companies. Setting the incentives and evaluating their effects requires that the regulator has comparable data on the regulated companies. This is usually not the case at the early stages of regulation. Moreover, the regulator does not automatically obtain such data unless the regulated companies use harmonized principles in reporting the regulatory data. Therefore, one of the first regulatory tasks is often to develop a uniform system of accounts, which defines the main principles that are used in regulatory reporting. In Finland, this was done as a part of a larger
research project that was carried out at Lappeenranta University of Technology in 2001–2002 (Partanen & al. 2002; Viljainen & al. 2002). As a result of the project, a proposal was given concerning for instance how to distinguish between operational and capital costs of distribution business in accounting, and what kind of depreciation schedules – concerning both the depreciation methodology and the useful lifetimes of the depreciable assets – should be used in regulatory calculations.

4.2.1.1. The distinction between operational costs and investments

Distinguishing between operational costs and investments is an extremely important issue in the Finnish regulatory system because this distinction affects the results of regulatory calculations in so many ways: the results of adjusting the profit and loss accounts, the development of the value of the regulatory asset base, and the results of the efficiency benchmarking. In the electricity distribution business in general, the operational costs and investments are not indifferent from each other – network investments usually have significant impacts on the operational costs, and vice versa. In addition, both expenditures also affect the reliability (i.e., the interruption costs) of the distribution networks. There are also several operations that can be interpreted either as maintenance or investment, depending on the applied accounting principles. Regardless of the applied principles, however, the general long-term planning principle has traditionally been to minimize the total costs of distribution business, that is, the sum of operating costs, interruption costs and capital costs, as shown in Equation 4.5.

\[
\text{Min } F(t) = \int_0^T (C_{\text{operation}}(t) + C_{\text{interruption}}(t) + C_{\text{capital}}(t)) dt
\]  

(4.5.)

where

\[
\begin{align*}
C_{\text{operation}} & = \text{operational costs} \\
C_{\text{interruption}} & = \text{interruption costs} \\
C_{\text{capital}} & = \text{capital costs} \\
T & = \text{useful lifetime of an investment}
\end{align*}
\]

The same long-term planning principle still applies; however, the introduction of formal regulation in the electricity distribution sector has drawn attention to the possible trade-offs between operational and capital costs mainly for two reasons. Firstly, the rate-of-return regulation itself encouraged expenditures to be booked as investments, because they increase
the regulatory asset base. And secondly, operational costs were included in efficiency benchmarking, whereas investments were not.

The existing accounting legislation does not solve the dilemma of how to make the distinction between the operational and capital costs, because it leaves so much freedom for different interpretations. The accounting principles of the distribution companies have evolved differently for various historical reasons, such as the attempt to minimize taxes. In addition, sometimes it may have been easier to book expenditures as costs than to convince especially the municipal owners to give money for investments. At one extreme, a distribution actually booked the construction of low voltage network as operational costs. At the other extreme, some companies activated all expenditures that they possible could. Following these observations, it became obvious that a specifically defined uniform system of accounts was necessary in order to obtain comparable data about the regulated companies. Viljainen & al. (2002) suggest the following accounting principles to be applied to the electricity distribution business:

1) All the expenditures that increase the value of the network and/or increase the capacity of the network and/or continue the lifetime of a network component are investments.

2) Labour costs are allocated to the corresponding investment project. These costs include network planning, field planning, purchasing and installation work.

3) The purchasing expenses of computers, software and automation devices are investments.

4) All the expenditures that do not belong to any of the above three categories are to be booked as operational costs.

The regulator also agreed with the proposal, and now the proposed accounting principles are widely applied by the Finnish distribution companies.

4.2.1.2. Useful lifetimes of network components

Historically, the distribution companies have used different lifetimes for different purposes; economical lifetimes for accounting and technical lifetimes for maintenance planning, and these two did not necessarily have anything to do with each other. Technical lifetimes of the network components were typically much longer than the corresponding economic lifetimes that were used in accounting. Technical lifetimes were component-specific, and the indicative values might have been given by the manufacturers. For the economic lifetimes, the industry-wide
instructions suggested that economic lifetimes of 5–50 years be used for all network components. Obviously, these were not accurate enough for regulatory purposes. Research on the issue revealed a need more precise definitions concerning the actual useful lifetimes of the network components. In this context, the term useful lifetime denotes the time that the network component is actually kept in the network before it is replaced.

Without formally agreed lifetimes, the decisions on distribution pricing were often dragged on, because the regulator and the investigated company could not reach an agreement on what lifetimes should be used for the network components, and what were their remaining lifetimes. Consequently, there was an obvious need to define the lifetimes more precisely. These lifetimes had significant impacts on the calculations of regulatory asset bases, which set high requirements for their correctness. Further, the lifetimes had to take into account the prevailing operating conditions of distribution companies, and acknowledge that these conditions were divergent in different parts of the country. A proposed solution was to define a range for the useful lifetimes of network components, which would be based on the previous experiences concerning their usage (Viljainen & al. 2002). The proposal was drawn based on surveys and interviews of the representatives of distribution companies. There were 13 distribution companies altogether participating in the research, and they represented 45 % of the customers and 36 % of the distribution networks in Finland. Some companies operated in areas with zero or negative load growth, whereas others operated in rapidly growing city areas. The goal was to find out how long different network components are actually kept in the networks before they are removed for one reason or another, and the results were interpreted as useful lifetimes of network components.

The results of the surveys and interviews indicated that especially in the operating areas with rapid load growth, network components are often removed before the end of their technical lifetimes for instance due to town planning reasons. In some areas, on the other hand, components such as transformers may operate at low loads, which makes them last longer. Consequently, the opinions about the useful lifetimes of the network components diverged depending on the operating environment. In order to take the differences in operating environments into account, a range was defined for each component group, as shown in Table 4.3. Distribution companies could then choose the lifetimes that best suit their operating environments within the given range.
Table 4.3. Useful lifetimes of network components (Viljainen & al. 2002).

<table>
<thead>
<tr>
<th>Network component</th>
<th>Useful lifetime [a]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>110 kV lines</strong></td>
<td></td>
</tr>
<tr>
<td>- 110 kV overhead lines (wood poles)</td>
<td>35…45</td>
</tr>
<tr>
<td>- 110 kV overhead lines (steel poles)</td>
<td>35…60</td>
</tr>
<tr>
<td>- 110 kV cables</td>
<td>30…40</td>
</tr>
<tr>
<td><strong>Substations</strong></td>
<td></td>
</tr>
<tr>
<td>- 110 kV switchgear and control gear (GIS)</td>
<td>30…40 (45)</td>
</tr>
<tr>
<td>- 20 kV switchgear and control gear (GIS)</td>
<td>30…40 (45)</td>
</tr>
<tr>
<td>- Main transformer</td>
<td>30…45</td>
</tr>
<tr>
<td><strong>Medium voltage lines</strong></td>
<td></td>
</tr>
<tr>
<td>- Overhead lines</td>
<td>30…40</td>
</tr>
<tr>
<td>- Insulated lines</td>
<td></td>
</tr>
<tr>
<td>- Cables</td>
<td></td>
</tr>
<tr>
<td><strong>Low voltage lines</strong></td>
<td></td>
</tr>
<tr>
<td>- Aerial bunched cables</td>
<td>25…35</td>
</tr>
<tr>
<td>- Cables</td>
<td>30…40</td>
</tr>
<tr>
<td><strong>Distribution transformer stations and distribution transformers</strong></td>
<td></td>
</tr>
<tr>
<td>- Pole-mounted transformer stations</td>
<td>25…35</td>
</tr>
<tr>
<td>- Pad-mounted transformer stations</td>
<td>30…40</td>
</tr>
<tr>
<td>- Building-mounted transformer stations</td>
<td>30…40</td>
</tr>
<tr>
<td>- Distribution transformers</td>
<td>30…40</td>
</tr>
<tr>
<td><strong>Disconnectors and disconnector stations</strong></td>
<td></td>
</tr>
<tr>
<td>- Disconnectors</td>
<td>25…30</td>
</tr>
<tr>
<td>- Remote controlled disconnectors</td>
<td></td>
</tr>
<tr>
<td><strong>Distribution automation in disconnector stations and substations</strong></td>
<td></td>
</tr>
<tr>
<td>- kWh-meters</td>
<td>15…20</td>
</tr>
<tr>
<td><strong>Telecommunication systems</strong></td>
<td></td>
</tr>
<tr>
<td>- Software</td>
<td>5…10</td>
</tr>
<tr>
<td><strong>Tools</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Transportation and machinery</strong></td>
<td></td>
</tr>
<tr>
<td>- Real properties</td>
<td>30…50</td>
</tr>
</tbody>
</table>

Determining the useful lifetimes of the network components on the survey basis obviously contains a risk that the distribution companies exploit their informational advantage. However, it was the only practical short-term solution to answer the need for harmonizing the source data of the regulatory calculations – later a long-term follow-up study can be carried out to verify the accuracy of the surveyed data. Regardless of the deficiencies of the research methodology, however, the surveyed data concerning the useful lifetimes of the network components is nowadays used for regulatory purposes. It certainly would have been a highly sceptical assumption that all the distribution companies that participated in the survey were engaged in strategic behaviour, especially since the results were in line with the previous experiences on
the issue. For the regulatory period of 2005–2007, the useful lifetimes of the network components shown in Table 4.2 were taken into use almost as such: the lower limits remained unchanged, and upper limits were only slightly modified (EMA 2004). The upper limits of the useful lifetimes of medium voltage lines, low voltage aerial bunched cables, low voltage cables, pole-mounted transformer stations, and kWh-meters were increased by five years each.

4.2.1.3. Depreciation schedules

In profit regulation, the valuation of the network assets is one of the key elements because the allowed return is calculated on grounds of the capital invested in the network assets. The research revealed a need for a more straight-forward asset valuation method than the one that the regulator applied during the years 1999–2004, as it was widely acknowledged that there should be a direct linkage between the investment behaviour of the regulated companies and the development of the regulatory asset bases. The development of the valuation method immediately raised the question whether specifically defined depreciation schedules should be used in depreciating the network assets, that is, whether the distribution companies should use the same depreciation methodology as well as the same useful lifetimes for the network components. This question was addressed in the research in detail, and the result was that the harmonized depreciation schedules would add to the value of the uniform system of accounts (Viljainen & al. 2002; Partanen & al. 2002).

Traditionally, the Finnish distribution companies had used the straight-line depreciation methodology. It is a simple and straight-forward method, which yet manages to capture some fundamental characteristics of the distribution business: the ability of a network component to participate in the revenue production is (largely) indifferent of its age, and the risk of the premature removal of the component is rather small. Hence, the straight-line depreciation methodology provided a good starting point for the harmonization of the depreciation schedules. The next research question was concerned with the appropriate depreciation times of the network assets. The use of the previously determined useful lifetimes of the network components provided an obvious solution to this question, since the primary objectives of determining such lifetimes had been to apply them throughout the regulatory process, and to get rid of the contrived separation of the technical lifetimes and the economic lifetimes of the network components. In addition, the useful lifetimes denote the average times that the network components are actually kept in the networks and, hence, take into account that some
components are removed before the end of their technical lifetimes, whereas others may last longer than the technical lifetimes indicate. Consequently, the straight-line depreciations were to be calculated by dividing the replacement values of the networks by their useful lifetimes.

Finally, and perhaps most importantly, the research addressed the issue of how to apply the straight-line depreciations in regulation. The solution was to adopt an approach, in which the impacts of the straight-line depreciations were twofold. Firstly, in the adjusted profit and loss accounts, the depreciations according to the plan were to be substituted by the straight-line depreciations. Notifying short useful lifetimes would mean large depreciations, which, in turn, would enable distribution companies to collect higher revenues. Similarly, notifying long useful lifetimes would mean lower revenues. Secondly, the straight-line depreciations were also to be used in the evaluation of the regulatory asset bases: the network present values were to be adjusted annually according to the difference between the actual investments and the straight-line depreciations. This latter approach is based on the idea that since the straight-line depreciations indicate the annual expenditures that are required to renew the networks by the end of their useful lifetimes, the straight-line depreciations also reflect the annual investment needs of the networks. Hence, given that a distribution company had chosen short useful lifetimes, it would then also have to invest accordingly, or else the value of its regulatory asset base would decrease, and vice versa. The distribution companies thus face an extremely challenging task of choosing the appropriate useful lifetime, because these will continue to affect their approved (and expected) reasonable investment levels in the future and, consequently, the asset valuation process.

4.2.2. Asset valuation

According to the regulator’s previous decisions on distribution pricing, the present values of the electricity distribution networks formed the regulatory asset bases, which were determined based on the lifetimes and ages of the network components. Theoretically, this method was a correct one but in practice, the process of was often very difficult. The first problem was that there were no exact instructions concerning the useful lifetimes of the network components, which made the process of determining the lifetimes a potential source of strategic behaviour. This issue was addressed in the proposal to develop the Finnish regulation principles by defining the useful lifetimes for the network components (see section 4.2.1.2.). The second
problem was that the process of determining the ages of the networks was filled with uncertainties. For instance, in medium and low voltage networks, it was not unusual that the poles were the original ones whereas almost all the other components of the line (stay wires, conductors, cross-arms, etc.) had been changed over the years, but there was no detailed information concerning what components exactly had been changed and when. In cases like this, the age of the whole line was interpreted as being the same as the average age of the poles, which was obviously a rather incorrect assumption. Determining the ages of transformers was often a more straight-forward process as the years of manufacturing simply revealed the actual ages; however, even these cases were complicated if fundamental improvements had been carried out.

Removing, or even mitigating, the uncertainties associated with process of determining the ages of the network components was practically impossible. Therefore, a proposal was made that the distribution networks should be assumed to be in the midst of their lifetimes, that is, the present values of the networks would initially be 50% of the corresponding replacement values (Viljainen & al. 2002). If a company could prove that its network was worth more than the assumed 50% of the replacement value, then a higher percentage value could be approved. After the starting point, the present values would change in accordance to the annual investments less the depreciations, as shown in Equation (4.6),

\[ \text{PresentValue}_t = \text{PresentValue}_{t-1} + \text{Investments}_{t-1} - \text{Depreciations}_{t-1}. \]  

(4.6.)

The depreciations in Eq. 4.6. represent the reasonable annual investment level, and they are determined by using the straight-line depreciation methodology (see section 4.2.1.2.), that is, by dividing the replacement values of the networks by their useful lifetimes. According to the proposal, the same depreciations would be used also when adjusting the profit and loss accounts of the distribution companies. This would somewhat limit the incentive to over-invest, but would not completely remove it as all the investments would still increase the asset base. The following example shows how investments and depreciations would affect the present value of the network if the proposed asset valuation and the straight-line depreciation methods were used.

At the start, the replacement value of the network is 100 M€ and the average lifetime of the network is 40 years. The present value is assumed to be 50% of the replacement value, that is,
50 M€. The annual straight-line depreciations are $100 \text{ M€} / 40 = 2.5 \text{ M€/a}$, which also indicates the reasonable investment level assuming that the network is to be kept in its present shape. After each year the replacement value is calculated on the basis of total amount of network components and their unit prices. If the replacement value has increased for other reasons than the increase in unit prices, the company is interpreted to have made extension investments. The amount of extension investments is calculated by subtracting the old replacement value from the new one and by taking the possible changes in the unit prices into account. The rest of the investments are replacement investments. Both extension and replacement investments are taken into account when calculating the changes in the present value.

### 4.2.3. Investments in regulation

The first regulation model allowed a fair return to be collected on invested capital and all investments to be depreciated in three years. Investments increased the present values of the networks (i.e., the capital invested in the network) and, consequently, the allowed return. Depreciating investments in three years meant that they could be financed with nearly direct cash-flow financing. In this sense, the regulation model strongly encouraged investments, even to the extent of over-investments. On the other hand, investments that had been made more than three years ago were not taken into account in regulatory calculations even though the useful lifetimes of the network components were typically tens of years.

The regulator also expected that investments were divided into extension investments and replacement investments in order to supervise that distribution networks were kept in good technical shape, that is, enough money was spent on maintaining the existing networks. However, the regulator had no way to ensure that the distinction was made correctly, but he or she simply had to rely on the information given by the distribution companies. Thus, requiring such distinction to be made only caused additional work to the distribution companies while it had very little significance in practice. This contradicted with the original idea that regulation itself should not cause unnecessary additional burden to the regulated companies.
In addition to increasing the regulatory asset base, investments often improved power quality and caused a decrease in the operating costs of the distribution networks. This usually improved the efficiency scores, which enabled the distribution companies to earn additional efficiency bonuses. The traditional way of planning network investments no longer applied as such, because in the regulated business environment, the planning principle of minimizing the sum of operating costs, interruption costs, and investments did not fully cover all the economical consequences of investments. Instead, certain investments yielded additional profits equal to the increased allowed return plus the efficiency bonus, as shown in Equation 4.7. The efficiency bonus was always either positive or zero.

\[
\text{Additional profit of an investment} = \text{Increase in the allowed return} + \text{Efficiency bonus} \quad (4.7)
\]

The reason for the additional profits was the treatment of investments in regulation; the regulation model strongly encouraged investments but did not evaluate the efficiencies of them because investments were not taken into account in the DEA model. Investments nevertheless affected the source information of the DEA calculations, and it was possible to earn additional profits even on investments that were not economically justified according to the traditional planning principles.

The research question concerning the treatment of investments in regulation was approached from three different angles. First, the straight-line depreciations would determine the reasonable level of annual investments. This approach was based on the idea that the regulator first defines the framework for the depreciation schedules (i.e., the straight-line depreciations calculated by using the useful lifetimes of the network components), and the distribution companies are then allowed to choose the appropriate depreciation times within the given framework. Second, the original costs of investments would be approved as such, that is, no standard cost approach would be applied. This was considered to be a simple and straight-forward approach, which allowed the owners to earn returns of and on their actual investments. And third, starting from a base year, the regulatory asset bases would be valued at the original costs of building the networks and updated annually according to the actual investments less the straight-line depreciations. The research also addressed the issue of including investments in the efficiency benchmarking of the distribution companies (see e.g. Partanen & al. 2004; Lassila & al. 2004). However, discussing the exact mechanisms by which this can be done in practice is not within the scope of this dissertation.
4.2.4. Evaluating the profitability of different investment strategies

A key element in regulation design is to analyze the investment behaviour of the regulated companies under a given regulatory regime. Therefore, an important part of the research was to evaluate the impacts of different investment strategies on the overall level of tariffs (i.e., the revenues), and on the profitability of the distribution business. The results of the analyses indicated that the most profitable investment strategy for the distribution companies is to invest annually in accordance with the straight-line depreciations, as shown in Fig. 4.4 (Viljainen & al. 2004a). This stresses the importance of the distribution companies choosing the useful lifetimes of the network components as accurately as possible, that is, in a manner that corresponds to the actual investment needs of the networks. However, it was also observed that, in the short run, an under-investing could retain its net revenue almost at its initial level, and even the reduction in the actual profit turned out to be moderate.

Figure 4.4. The impacts of different investment policies on the net revenues and actual profits of a distribution company. The gap between the reasonable investments and under-investments, as well as the gap between the reasonable investments and over-investments, was approximately 45 % (Viljainen & al. 2004a).

The above example shows clearly that the threat of under-investments was one that was to be taken seriously. In principle, the under-investing companies were punished, because under-investing decreased the values of their regulatory asset bases. The problem was, however, that the immediate economical consequences were mild, because this feedback mechanism affected rather slowly. Therefore, an additional regulatory mechanism was needed to mitigate the threat of under-investments (Viljainen & al. 2004a). One possible approach was to use the straight-
line depreciations in the adjusted profit and loss accounts automatically only for one regulatory period. If a company was suspected of being engaged in strategic behaviour, that is, under-investing in this case, the reasonable depreciation level in the profit and loss account was to be reduced to correspond the actual lower investment levels. This would force the company to reduce its revenues for the next regulatory period. In all cases, the upper limit for reasonable depreciations was defined by the straight-line depreciations as to limit over-investments. The economical implications of such actions on the net revenue and actual profit are shown in Fig. 4.5 (Viljainen & al. 2004a).

Figure 4.5. Net revenues and actual profits under different investments strategies (Viljainen & al. 2004a).

If the under-investing company later changes its investment strategy to respond the prespecified investment needs, its revenues can be brought back up by accepting again the straight-line depreciations in the adjusted profit and loss account.

Failing to implement a regulatory mechanism that imposes sanctions against companies that exploit their monopoly positions may further encourage strategic behavior. Profit-driven companies may find it tempting to increase the actual rate of return by under-investing, if the only sanction is the slightly decreasing present value of the network. The under-investing issue is of particular importance if power quality is not directly enforced – neglecting investments may not cause immediate inconvenience to the customers but the long term consequences might still be significant. Fig. 4.6 shows the impacts of different investment strategies on the actual rate of return when a) there are no additional sanctions for under-investing, and b) the level of reasonable depreciations in the profit and loss account is reduced due to under-investing (Partanen & al. 2004).
Fig. 4.6 shows that the regulator needs to have means to revise the reasonable level of depreciations unless the under-investing company has an authentic explanation for behaving in such a manner. For instance, provisioning for an extensive investment program in years to come, and being able to show the exact investment plans, could qualify as the authentic explanation.

4.3. Regulation model in Finland in 2005–2007

Historically, the Finnish regulator had applied light-handed ex post rate-of-return regulation, but this was changed as a new regulation model came into force at the start of 2005. The new regulation model is introduced in detail in the guidelines for assessing the distribution pricing (EMA 2004). The main regulation principles are still the same as previously, that is, the final regulatory decisions on the reasonableness of distribution pricing are made ex post on the basis of financial statements of the distribution companies. However, regulation now contains also ex ante methods, which define precise limitations to the various cost items of the distribution companies. The regulation model allows distribution companies to appeal against the regulatory decisions – both the ex ante and ex post decisions – but the appeals entail no stay of execution (EMA 2004).
The main reason for introducing ex ante methods was to bring the Finnish regulation principles in line with modified EU Directive (2003/54/EC) on the internal markets in electricity. The ex ante methodologies concern issues such as (EMA 2004):

- principles for the valuation of the capital invested in network operations,
- reasonable rate of return in distribution business,
- principles for adjusting the profit and loss accounts, and the balance sheets of the distribution companies, and
- general efficiency requirements.

Another major difference compared with the previous regulation model is that the reasonableness of pricing of all the distribution companies is now automatically assessed. And finally, the length of the regulatory period is now three years instead of just one year, and the reasonableness of pricing is assessed during the 3-year period as a whole. If a company has accrued windfall profits during this period, it is obliged to return them to the customers through price reductions during the next regulatory period. Similarly, windfall losses enable the company enforce price increases during the period. A simplified illustration of the regulation model that is applied in years 2005–2007 is shown in Fig. 4.7.

Figure 4.7. An illustration of the regulation model that is applied in Finland in years 2005–2007.
4.3.1. Depreciation schedules

Under the present regulatory regime, the adjusted profit and loss accounts allow for straight-line depreciations calculated based on the replacement values of the network assets and their useful lifetimes. The straight-line depreciations are also used in calculating the annual changes in the present values of the of the networks assets. The lifetime deviations for the network components are mainly based on a research project carried out at Lappeenranta University of Technology (EMA 2004). The method by which the useful lifetimes of the network components were determined and intended to be used in regulation were covered in sections 4.2.1.2. and 4.2.1.3., respectively.

4.3.2. Asset valuation

The existing electricity networks form the basis for assessing the reasonableness of distribution pricing, that is, distribution companies are entitled to earnings that enable them to maintain and develop the networks. The networks possessed by the network operators are treated in the same way in regulatory calculations regardless of whether they are owned or leased by the operators (EMA 2004). The valuation of the network assets starts with the calculation of the replacement value (repurchasing price) of the network, which indicates the actual cost of constructing a corresponding network at current cost levels. The replacement value of the network is updated annually; if any changes should occur, also the straight-line depreciations will be adjusted accordingly. The present value of the network is then calculated by using the replacement value of the network and taking its average age and useful lifetime into account (see also Eq. 4.1., page 68). So, in this regard, the regulation principles of the new model have remained the same as they were in the first model. However, if a company is unable to specify the ages of the network components in detail, then 50 % of the replacement value is used as the present value. As discussed earlier in Sec. 4.1.5., determining the actual ages of the network components was one of most contradictory procedures in the first regulation model, and using the 50 % values enables regulatory decisions to be made within a reasonable time.

Once the present values of the networks are known, the balance sheets of the distribution companies are adjusted by substituting the present values for the corresponding book values of
the networks. Starting from the base year of 2005, the present values of the networks will change in accordance with annual investments less the straight-line depreciations. The costs of investments are notified as pre-specifically defined standard costs. The regulator also monitors the development of the present values calculated on the basis of the replacement values of the networks, and their average ages and useful lifetimes. Comparing the results of the two methods used in calculating the present values provides valuable information for the future regulatory developments.

The in determining the reasonable rate of return in distribution business, the interest on a five-year Finnish government bond completed in May of the preceding year (3.53 % in 2004) is used as the risk-free interest rate. The risk premium, that is, the difference between risk-free interest rate and the return on equity investment, is 5 %, and the asset beta is 0.3. The cost of capital equals the risk-free interest rate plus a premium of 0.6 %. In the regulatory calculations, the same fixed capital structure of 30/70 is used for all distribution companies. Table 4.4 shows the parameters that are used in calculating the reasonable rate of return on the distribution network operations (EMA 2004).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Applicable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-free interest rate</td>
<td>5-year government bond interest (average in May of the preceding year)</td>
</tr>
<tr>
<td>Risk premium</td>
<td>5 %</td>
</tr>
<tr>
<td>Asset beta</td>
<td>0.3</td>
</tr>
<tr>
<td>Capital structure</td>
<td>30/70</td>
</tr>
<tr>
<td>Cost of interest-bearing</td>
<td>Risk-free interest rate + 0.6%</td>
</tr>
<tr>
<td>loaned capital</td>
<td></td>
</tr>
</tbody>
</table>

Calculating the weighted average cost of capital by using the parameters in Table 4.4 (see Eq. 4.2 in page 68), yields a reasonable rate of return of 4.77 % in the year 2005. The rate of corporation tax in the year 2005 is 26 %.
4.3.3. Efficiency

In the present regulation model, the costs of network operations are adjusted in accordance with a general efficiency requirement, that is, in regulatory calculations, the actual cost base of each distribution company is replaced by an adjusted cost base. Company-specific efficiency requirements are not applied during the regulatory period of 2005−2007. The general efficiency requirement amounts to 1.3 per cent annually, and it is allocated to the average controllable operational costs over the period 2000−2003. These costs include the following items of the profit and loss accounts (EMA 2004):

\[
\text{Controllable operational costs} = \text{Materials, accessories and energy purchases} \\
+ \text{Increase or decrease in stocks} \\
+ \text{Staff costs} \\
+ \text{Rents} \\
+ \text{Other external services} \\
+ \text{Other costs} \\
+ \text{Production for in-house use}
\]

Purchasing electricity to cover the network losses is not included in the controllable operational costs because, according to the Directive (2003/54/EC), distribution companies are expected to employ open, non-discriminatory and market-based procedures to procure electricity. Hence, the price of losses is tied to the market price of electricity and not within the control of distribution companies. Standard compensations, which are paid to the customers who have experienced interruptions lasting for 12 hours or more, are also not included in the controllable operational costs (EMA 2004). Consequently, the general efficiency requirement is not allocated to standard compensations.

4.3.4. Power quality

Power quality is not included in the economic regulation during the regulatory period of 2005−2007. The regulator nevertheless monitors the development of various power quality related key figures and intervenes if necessary. Standard compensations, in a way, attempt to address the power quality issue. However, in regulatory calculations, the standard compensations are accepted as observed, which means that they are reduced to mere welfare
transfers from the whole customer base to those customers who have experienced interruptions lasting for 12 hours or longer.

4.3.5. Analysis of the regulation model 2005–2007

One of the most important evaluation criteria of regulation is how well it answers the needs of the various stakeholders of the regulated industry. In distribution business, for instance, customers need to be protected from the exploitation of monopoly powers, and provided with good quality services. Distribution companies, on the other, need to be given incentives to pursue all sources of efficiency. They also need to be treated equally in terms of regulation. The owners expect profits of and on their investments – failing to ensure this, regulation will jeopardize the development of the distribution sector altogether. And finally, the society expects efficient prices and equal treatment of all citizens. Balancing the various needs and expectations was a key guideline when designing the new regulation principles and methodology. Indeed, the new regulation model removes some of the contradictory directing signals that were characteristic to the previous regulation regime.

Distribution networks have evolved into their present forms for various different historical reasons, and the present management can only be expected to manage the networks as efficiently as possible. Adjusting the balance sheets by substituting the present values of the networks for their book values also takes into account that historically, distribution companies have applied different bookkeeping practices. Taking the existing networks as the basis of regulation acknowledges that distribution companies are likely to be stuck with their existing network assets for quite some time still – a fair assumption in an industry with asset lifetimes of 30–50 years – and the backward-looking straight-line depreciations are an attempt to avoid stranded costs. In addition, the asset bases are updated annually so the owners can earn returns of and on their investments.

4.3.5.1. Improvements in the directing signals

Regulation now focuses on all companies at all times, which makes it easier for the regulator to monitor the development trends of distribution business, and ensures that companies are investigated on equal grounds. The 3-year regulatory period creates a more stable business
environment for the distribution companies compared to the previous one year regulatory period. The updating of the asset bases is nowadays done by using a more straight-forward procedure than previously, which makes the real-life effects of regulation more understandable. In addition, the use of straight-line depreciations to represent reasonable investment levels improves the predictability of regulation; distribution companies are allowed to prepare for investments that are required to renew the networks by the end of their useful lifetimes. Finally, the new regulation model also includes constrained profit sharing mechanisms. Distribution companies are now obliged to return windfall profits to the customers through future price reductions, which improves the customers’ position in the monopoly sector. However, the companies also have a permission to accrue windfall losses during the next regulatory period.

4.3.5.2. Incentives and the development needs

Despite of the improved directing signals, the analyses of the regulation model of 2005–2007 also revealed further development needs of the model. For instance, the use of straight-line depreciations to represent the reasonable investment levels is not unproblematic because it enables under-investments without significant economical consequences in the short-term. Quite the contrary actually; profit driven companies might find it rather tempting to improve the actual rates of return by under-investing. This threat is to be taken seriously especially since the role of power quality is practically non-existent in the present regulatory regime.

Given that the goal is to make the distribution sector more efficient, setting the general efficiency requirement to all distribution companies gives correct directing signals. However, the problem is that putting all the distribution companies on the same line does not take the possible previous efficiency improvement measures into account. Those companies that have previously ignored the directing signals of regulation may now be able reach the efficiency target simply by making virtual efficiency improvements. Those companies that have already been active in developing their organizations are facing a more difficult task in reaching the efficiency targets. Finally, as long as the efficiency requirements focus on the operational costs instead of the total costs of network operation, the incentive to pursue all sources of efficiency, for instance by seeking efficiency improvements through an optimal mix of in-house operations and partnership solutions, is largely absent. This conflicts with the goal of making the distribution sector more efficient, and also with the idea that regulation should be indifferent to
the methods of achieving efficiency improvements as long as the quality of services remains at an acceptable level.

In general, under the present regulation regime, the incentives for efficient and well-organized processes of the distribution business are weak. In addition, distribution companies are able to earn maximum allowed returns at nearly zero risk because they can optimize their pricing over the three year regulatory period as a whole. For instance, excess profits or under profits can be compensated by making necessary adjustments to tariffs during the other two years. This stabilizes the business environment to the extent that it would be difficult for a company not to earn the maximum allowed return, given that profit maximizing is the strategic goal of the owners.

There are, however, some incentives for efficiency associated with the use of standard cost approach in evaluating the reasonableness of investment costs, and with the use of fixed average interest rates for the cost of capital. The first one may give incentives to carry out investment projects efficiently, whereas the latter one enables the companies to earn additional profits if they are able to finance investments with loans that have the interest rates below the average. However, exploiting these benefits is a potential source of a regulatory risk in the future if the regulator later decides to use the observed company-specific (lower) investment costs and the (lower) costs of capital instead of the corresponding average values in the regulatory calculations. In addition, many other regulatory risks today also result from the fact that the regulation principles of 2008 and onwards are still unknown to a large extent.

In particular, the unresolved issues associated with the future regulation principles include the model specification and the parameters of the efficiency benchmarking, and the treatment of power quality in regulation. For instance, if a company outperforms its efficiency target, the initial level of its reasonable operational costs for the next regulatory period will probably be lower than it would otherwise be. Again, the company may have achieved the efficiency target by neglecting the maintenance of the network, which is beneficial under the present regulatory regime but may eventually lead to reliability problems. This, in turn, may prove a regulatory risk if the reliability indices are later taken into account in regulation. However, even then the possible impacts of neglecting the maintenance operations might be quite the opposite
depending of the applied power quality regulation scheme. If the reliability indices were included in the efficiency benchmarking, the company would suffer from its previous poor performance regarding these indices. On the other hand, if the historical reliability indices were used to define the company-specific targets for future performance, the company might actually benefit from not making any improvements so far. Finally, the present regulation regime allows for extensive investments, but these may prove a risk if investments are later included in the efficiency benchmarking. Added to this, the present rather low allowed return on equity may not be sufficient for some owners, especially the private investors, and this affects the new investment decisions in the sector. Given all the uncertainties resulting from the undefined future regulation principles, it is not surprising if the distribution companies choose to put investment decisions on hold to as large extent as possible.

As mentioned above, the standard cost approach to evaluate the reasonableness of investment costs enables the distribution companies to earn additional profits, but it is also a source of a regulatory risk in itself. In addition, it is also an example of micro-regulation that is difficult to carry out in practice, and the benefits of which are often questionable. Under the previous regulatory regime, the distribution companies were expected to distinguish between extension and replacement investments in regulatory reporting; even this task was found difficult and burdensome. However, compared to the standard cost approach, the mere distinction was easy to make and report. Now the companies are expected to report their annual investments on a much more detailed level, while the regulatory standard costs for investments still inevitably fail to fully cover all the investment types that are made in distribution business. While giving incentives to carry out investment projects efficiently, the standard cost approach still fails to distinguish between the efficiency of different solutions to handle a given problem, and to give incentives to automatically choose the solution that minimizes the total costs of network operation. At the end, making sure that regulation gives incentives to investments that minimize the total costs of network operation is much more important than trying to supervise the costs of individual investment projects. The latter issue can be left to management of the distribution companies. Finally, the standard cost approach fails to acknowledge that sometimes the operating conditions are such (e.g. for the environmental reasons) that the standard costs cannot reasonably be assumed to be within the reach of the companies operating in these conditions.
Another problem associated with the standard cost approach deals with the recycling of usable materials that are released during demolition works. In principle, it is beneficial to use these materials in other construction projects if possible, because the standard costs for investments are determined based on the prices of new components, and the companies are allowed to keep the difference between the two. However, the recycling of materials also constitutes a significant regulatory risk because the regulator may later determine the reasonable investment costs on the basis of the observed lower costs due to recycling. Distribution companies, on the other hand, are aware that such materials are not always available, which may prevent them from recycling altogether. This would obviously be an extremely undesirable, yet a possible result of the standard cost approach.

4.4. Future regulatory developments

In Finland, the regulator has recently moved from applying simple ex post rate-of-return regulation towards using more ex ante methods. Limitations are now set separately to different cost items of distribution business, that is, operational costs, depreciations, and return, before the start of a regulatory period. This, in fact, restricts the revenues of the distribution companies even though the revenue caps are not formally determined. The next regulatory development could be to define the so called open revenue caps, in which the company-specific incentives would play an important role. The goal would be to enable different operations models and encourage innovations in the electricity distribution sector. At best, this kind of approach would give incentives for efficient operation as well as contribute to the development of competitive service markets within the sector. Certain initial values – preferably historical – for operational costs, depreciations, returns, and efficiency and quality adjustments would be used in determining the base revenues, but after the starting point, the regulator would be indifferent to the distribution of costs between various activities. The open revenue cap approach would contain powerful incentives for the distribution companies to pursue all sources of efficiency, for instance by searching for the optimal mix of in-house operations and partnership solutions.

The use of the open revenue cap approach would obviously require that (1) the regulator is able to determine the initial revenue caps based on fair and reasonable costs of network operations; (2) the efficiency requirements are derived based on a reliable efficiency benchmarking method – regarding both data quality and model specifications; and (3) power quality is appropriately
addressed in regulation. After the base year, the distribution companies would be expected to reduce their revenues according to general and company-specific efficiency requirements. The volume adjustment factor would take the correlation between volume growth and the corresponding increase in revenue into account. The regulated revenues would also be quality adjusted – failing to meet the quality targets would reduce the allowed revenues, and beating the targets would increase the allowed revenues. Exact fault limitations would also be set for the reliability and voltage quality key figures, and direct compensations to customers would be mandatory if the fault limits were exceeded. Partanen & al. (2005) discuss the principles according to which power quality regulation could be carried out in practice.

Occasionally, the idea of having a common pan-Nordic regulation framework induces an active debate in Finland and elsewhere in the Nordic countries, and the harmonization of the regulation principles at some level also seems to be a common European goal. The electricity distribution sectors in Finland, Norway and Sweden are characterized by having a large number of distribution companies that operate in significantly different environments and are of various sizes. The large number of distribution companies makes it possible to apply sophisticated benchmarking methods, although the heterogeneity of the operating environments adds to the difficulty of benchmarking.

Given all the present similarities and the long history of co-operation in the field of electricity supply industry in the Nordic region, these countries have chosen surprisingly different regulatory approaches. For instance, there is an obvious case for co-operation in the field of benchmarking, but the national regulators have more or less struggled alone through developing the benchmarking methods. Harmonized regulatory framework would probably benefit the companies that operate in the whole Nordic region, and might even promote efficiency in performing the regulatory tasks. Developing such a framework would also provide interesting research questions. However, the possibilities and obstacles of applying harmonized regulation principles in the Nordic countries are not within the scope of this study.
4.5. Conclusions on the regulatory developments in Finland

Formal regulation of the electricity distribution business was first introduced in Finland in 1995 associated with the electricity market restructuring. The tasks assigned to the regulator were, among other things, to supervise the reasonableness of distribution pricing, and to promote the efficiency of the distribution sector. The exact methodology of supervision was not addressed in legislation, and the methods remained undefined until the regulator completed the first investigation in 1999. The first decision laid down the principles that were to be used in regulation in years to come. Investigation was nevertheless always case-specific and it was carried out only if over-charging was suspected.

The regulator chose to evaluate the reasonableness of pricing based on the profits that distribution companies had made. The financial statements of the distribution companies were not taken as such but they were adjusted to take the present values of the electricity distribution networks into account instead of their book values. Reasonable depreciations were determined on the basis of the average investments made annually during the previous three years. The so-called calculatory profits were obtained by adjusting the profit and loss accounts according to certain principles, and the reasonable returns were obtained similarly by adjusting the balance sheets. The regulator then evaluated ex post whether the calculatory profit of the investigated company had been reasonable by comparing it to the allowed reasonable return.

Analysis of the real-life effects of the first regulation model revealed several development needs. For instance, the model contained strong incentives for investments, even to the extent of over-investments, because investments always increased the regulatory asset base and could be depreciated in three years regardless of the actual useful lifetime. In addition, the applied rate-of-return regulation as such did not contain incentives for efficient operation even though the need for such incentives was widely acknowledged among the stakeholders of the distribution business. The first real revision of the regulation principles took place at the start of 2005. However, due to the regulator’s increased knowledge about the distribution sector and its cost attributes, new regulatory mechanisms had been added on top of the old ones even before this. Table 4.5 shows some of the milestones of the regulatory developments in Finland.
### Table 4.5. Some of the milestones of the regulatory developments in Finland.

<table>
<thead>
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<tr>
<td>Politicians set the profit expectations for the local electric utilities. The goal was to achieve an optimal distribution of social welfare. The electricity sector was characterized by universal service obligation: services had to be both available and affordable to all citizens.</td>
<td>The introduction of formal regulation in 1995 as electricity market restructuring took place. The Electricity Market Act required reasonable prices and efficient operation. At first, distribution companies experienced mostly a threat of regulatory intervention. The exact regulation methodologies remained undefined until the first decision on distribution pricing was issued in 1999.</td>
<td>Ex post rate-of-return regulation - light-handed approach - case-specific decisions - one year regulatory period - no constrained profit sharing Investigations took place if overcharging was suspected. Some of the evaluation parameters (e.g. the reasonable interest rates) were known only after the regulation period had ended.</td>
<td>Rate-of-return regulation with both ex ante and ex post characteristics - focuses on all distribution companies - 3-year regulatory period - profit sharing mechanisms included Ex ante decisions e.g. concerning the principles of determining the asset bases and reasonable rates of return, and making the necessary adjustments to the financial statements. Final decisions are made ex post based on the results of the whole regulatory period.</td>
</tr>
<tr>
<td>Regulatory asset base</td>
<td>Present value of the electricity network</td>
<td>Present value of the electricity network</td>
<td></td>
</tr>
<tr>
<td>Depreciation methodology</td>
<td>Not defined</td>
<td>Straight-line depreciations</td>
<td></td>
</tr>
<tr>
<td>Treatment of investments</td>
<td>Investments increased the asset base. Investment costs accepted as observed and depreciated in 3 years in regulatory calculations.</td>
<td>Investments increase the asset base. Investment costs accepted as standard costs and depreciated during useful lifetimes.</td>
<td></td>
</tr>
<tr>
<td>Reasonable operational costs</td>
<td>All costs of network operation accepted as observed.</td>
<td>Reasonable operational costs at the start are defined as the average costs of 2000–2003; then 1.3 % reduction annually</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>DEA scores used in rewarding efficient companies since 2001; maximum bonus was 10 % of the operational costs</td>
<td>General 1.3 % efficiency requirement. Benchmarking method undefined</td>
<td></td>
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</tbody>
</table>
With the exception of including efficiency benchmarking (DEA model) in regulation in 2001, the modifications generally improved the predictability of regulation. The problems associated with the DEA model were twofold: firstly, the regulator was unable to apply the results in ex post decision-making as planned; and secondly, the analysis of the results revealed several development needs in the DEA model itself. Consequently, the contradictory directing signal of efficiency benchmarking continued to be a source of confusion among the distribution companies for quite some time.

The results of efficiency benchmarking were eventually used only in rewarding companies that were found efficient in DEA calculations. However, even the introduction of the benchmarking procedure itself started to direct the planning processes of the network operations. For instance, distribution companies started to pay greater attention to the key figures that were included in the efficiency benchmarking, and one outcome of such behaviour were the trade-offs between operational and capital costs. The reason for this was that operational costs were included in the DEA model but capital costs were not. Shifting costs from one category to another obviously resulted only in virtual efficiency improvements, but was nevertheless a reasonable reaction to the prevailing regulatory regime. However, the fact that only operational costs were included in the DEA model instead of the total costs of network operations also had more severe consequences than shifting costs between different categories. Indeed, while focusing only on operational costs, the model failed to give incentives to pursue all sources of efficiency. For instance, partnership solutions between distribution companies and specialized service providers have proven to be a powerful way of improving the efficiency of the distribution process, but from the regulatory point of view the incentives for service procurements have been negative.

The total interruption time was also included in the DEA model as to represent power quality. This meant that the efficiency scores could be improved either by decreasing operational costs, or improving the reliability of the networks, or both. Investments that had consequences of this kind were highly favourable, because the profits of such investments were twofold; higher returns through the increased asset bases and the additional efficiency bonuses. Efficiency benchmarking thus sometimes added to the already strong incentives to invest that were characteristic to regulation model in years 1999–2004. In years 2005–2007 the efficiency benchmarking procedure as such does not have formal role in regulation. However, the
regulator will continue to monitor the DEA scores. In addition, the data for the future performance studies is produced during the ongoing regulation period so the regulated companies are not able to ignore the benchmarking issue completely.

The efficiency benchmarking procedure itself has been a source of significant regulatory risk in the distribution business all through its existence. The mere introduction of efficiency benchmarking came as a shock to the industry that had until then experienced only very light-handed regulation. Some of the companies that had been found inefficient in the DEA calculations were suddenly faced with unrealistic expectations to close the inefficiency gaps. The requirements for cost reductions were later cancelled mainly on legal grounds, but the industry interpreted this as an agreement that the DEA model was a failure. The efficient companies, on the other hand, could first retain their additional efficiency bonuses in years 2000–2004, but then these bonuses were suddenly removed associated with the regulatory revision of 2005. The new regulation model, among other things, brought all distribution companies in line in terms of efficiency requirements. For the efficient companies, this meant that the former efficiency bonuses, which could amount to 10 % of their operational costs, were now replaced by general efficiency requirements, which force them to reduce operational costs by 1.3 % annually. In general, regulation has so far encouraged rather stagnant behaviour in the electricity distribution business in Finland; following the regulatory revisions, the innovative approaches of the distribution companies towards the development of their business processes have, almost without an exception, resulted in a less beneficial initial position under the revised regulatory regime.

The author’s contribution to the regulatory developments in Finland lies mainly in the proposed new methodologies that improve the directing signals of regulation (see section 4.2.). In many cases, the research results have either affected the formal regulation design, or the proposed ideas have been voluntarily taken into use by the distribution companies. For instance, at the time when the proposal concerning the accounting principles was made, the Finnish regulator did not have the authority to set norms for the distribution companies. This meant that the regulator could not force the distribution companies for instance to apply pre-specified accounting principles. However, the industry itself decided to follow the proposed principles concerning how to make the distinction between operational costs and investments in accounting, and to draw a formal guideline that was based on the proposal.
The useful lifetimes of the network components are another example, in which the industry willingly accepted the proposed ideas even before they were formally taken into use. Later, the proposed useful lifetimes were included in the regulation model of 2005–2007 almost as such; the lower limits were all accepted as proposed, as well as most of the upper limits (16 out of 21). The upper limits of five component groups (medium voltage lines, low voltage aerial bunched cables, low voltage cables, pole-mounted transformer stations, and kWh-meters) were increased by five years each. The lifetime deviations for the network components are mainly based on the author’s previous research on the issue.

A third example of the author’s contribution to the regulatory development in Finland concerns the depreciation and the asset valuation methodologies. The use of straight-line depreciations in regulation was accepted as proposed, and also the main principles of the proposed asset valuation methodology were taken into use. As far as the treatment of investments in regulation is concerned, the regulator adopted a slightly different approach than the one that was proposed by the author; instead of accepting the actual costs of investments in regulatory calculations, the regulator chose to define standard costs for different kinds of investments.

The use of straight-line depreciations generally improves the predictability of regulation. However, adjusting the profit and loss accounts by using the straight-line depreciations is not without problems because the depreciations then react to different investment strategies rather slowly, which may sometimes provide the distribution companies with opportunities for strategic behaviour. It is possible to mitigate the threat of such strategic behaviour by implementing appropriate feedback mechanisms in the regulation model. Obviously, one also needs to acknowledge that sometimes the owners’ intention may simply be to exploit the monopoly opportunities and then flee the distribution business altogether, in which case almost any feedback mechanisms are powerless. Therefore, it is essential to specifically address also the quality of the monopoly services by using appropriate indices, which signal if the direction of development appears to be disturbing.
5. Assesing future challenges in the changing business environment in electricity distribution sector

The business environment in the electricity distribution sector has experienced radical changes over the past decade or so, and the restructuring of the industry is still in progress. The emerging changes create many uncertainties in the sector, yet the discontinuity points also create new business opportunities. Exploiting these opportunities and turning them into competitive advantages requires new capabilities of the stakeholders of distribution business. In order to develop such capabilities, stakeholders need to recognize the changes in the business environment and to understand the forces behind them. Creating new knowledge presumes that individuals recognize useful information and are able to convert it into knowledge that brings future value for the organization (Senge 1990). In addition, organizations should have the capacity to change before the need for change becomes too obvious (Hamel and Välikangas 2003). Essential for success in the changing business environment is that the stakeholders of the industry have means to assess the future challenges, and to develop capabilities, which help them to answer the new requirements.

In the electricity distribution sector, an important goal of the restructuring processes has been to promote more efficient operation of the natural monopolies. Consequently, the national regulators have set versatile incentives for the distribution companies to improve their performance. The incentive schemes have been designed to reward companies for the efficiency improvements while ensuring that also customers benefit from the efficiency gains. However, understanding the long-term consequences of these incentive schemes has proven to be difficult for both the regulators and the industry. In addition to the regulatory requirements, there are also other important driving forces in the electricity distribution sector. For instance, the owners are now increasingly considering electricity distribution as a commercial business. This applies also to the municipal owners. The owners are no longer willing to handle the efficiency requirements by giving up their profits. Thus, distribution companies are now facing the challenge of finding more efficient ways to perform their tasks. There is also an industry-wide concern about the possible lack of skilled employees in the future. This might force especially small distribution companies to seek different forms of co-operation and eventually result in significant organizational changes in the sector. Finally, also the technological development may restructure the industry in the future.
The regulatory, organizational and technological changes in the electricity distribution sector have revealed a need for methods to assess the future challenges. The ongoing changes create possibilities for organizations that are able to identify opening opportunity gaps in the industry before others do. Still, this is not enough; organizations also have to be able to fill these gaps with new innovations and business activities. Because the development of new organizational capabilities is a path-dependent activity, that is, new knowledge-based assets and systems cannot be created overnight, it is crucial for success that early identifiers are also early movers. It is important for the organizational renewal and for the creation of appropriate capabilities and new innovations that decision makers in organizations interpret and respond correctly to the messages they receive (O’Connor & Veryzer 2001). Firms have to invest in capability building before they know exactly what capabilities will be the most profitable ones in the new competitive environment. In order to fill the existing capability gaps, a new construct (procedure) has been developed and tested in real-life cases with several stakeholders of the electricity distribution business (Bergman & al. 2004a). The construct is based on using two teamwork techniques: the scenario method, which provides a structured way of creating new knowledge about the changing business environment; and the innovation process, which gives ideas how the obtained new knowledge could be utilized in practice.

The basic idea of combining the scenario method and innovation sessions is that the utilization of knowledge embedded in scenarios can be promoted by the innovation sessions. For instance, in the case study of developing the electricity distribution business, the results of the heuristic scenario process, that is, the created tacit and explicit knowledge, were converged further on the idea level in innovation sessions (Bergman 2005). The scenario process was carried out in a collaborative and open inter-organizational context, and the created knowledge did not often reach concrete enough level. The innovation sessions provided means to analyze and evaluate the created knowledge, and to generate new innovation ideas based on the new and prior knowledge. The new construct was developed as a part of a larger research project “Development of electricity distribution business”. The three year project was carried out in 2003–2005 at Lappeenranta University of Technology and Tampere University of Technology. The project was financed by the National Technology Agency of Finland and several industrial partners, including a global electrical engineering company, an international energy company, an international telecom company, and several electricity distribution companies, service
providers, software companies and component manufactures. The expertise of the industrial partners was utilized by interviewing various stakeholders prior the scenario process, and in the idea generation of innovation sessions. From the working group, which consisted of researchers, the development of the construct required wide expertise in the fields of knowledge management, electricity distribution business, and economic regulation. Bergman (2005) describes in detail the development process of the new construct from the knowledge management point of view. The author’s main interest in the project was analyzing the effects of economic regulation on the development of business environment in the electricity distribution sector.

5.1. The scenario method

The scenario method is often used to improve understanding about the future development of the business environment. In general, scenarios describe alternative development paths for the future. Scenarios provide a method for discovering and comparing firm-specific capabilities with future requirements, and make it possible to face the situations of complex rapid change (Schoemaker 1992). According to Bergman (2005), the scenario process enables divergent thinking, and makes it possible to convert the created new knowledge into explicit presentations, that is, scenarios. The scenario process can be conceptualized as having four stages: delimitation of the focus, interactive knowledge sharing, scenario creation and implementation of scenarios (Phelps & al. 2001). The scenario method was considered an appropriate approach for creating new knowledge about the future business environment in the electricity distribution sector. The working group for the scenario process consisted of researchers that had wide expertise in the fields of knowledge management, electricity distribution business, and economic regulation. The working group held an intensive two-day scenario session to create the alternative scenarios of the future business environment in the electricity distribution sector. The description of the process is shown in Fig. 5.1 (Bergman & al. 2005).
The scenario process required in-depth understanding about the past, present and future development of the business environment in the electricity distribution sector. In the electricity distribution sector, for instance, the regulators continuously learn more about the cost attributes of the industry. Hence, they are able to introduce more precise requirements as the regulation matures, and this reshapes the business environment in the sector. Secondly, the municipal owners that used to consider electricity distribution as a public service are adopting more commercial attitudes towards ownership. Thirdly, customers’ expectations on power quality are increasing. Finally, distribution companies are starting to reorganize their operations as a response to the international and inter-industrial trend that encourages companies increasingly to concentrate on their core businesses. This creates new business opportunities especially for the service providers to enter the market. The regulatory challenge in an environment of this kind lies in the ability to develop regulatory principles and practices, which encourage innovations, and which do not conflict with the general development trends of the economy as a whole.

### 5.1.1 Scenarios of distribution business in 2010

The target of the scenarios of the electricity distribution business was set to be the year 2010. The first phase of the scenario process was information gathering, which played an important role in defining the focus of the scenarios. The process was continued by determining the main
driving forces, which affect the development of the business environment, and the key environmental uncertainties in the electricity distribution sector. The driving forces were then categorized, and their significance were evaluated. The main categories of the driving forces were: business aspects, customer-related issues, regulation and technology. Based on the experiences of the past few years, regulation was considered an extremely strong driving force in the electricity distribution sector at the moment. The customer-related issues were combined with regulation, because in the monopoly business, the customers cannot usually directly influence the industry, but the regulator uses the customers’ voice instead. Business aspects were also considered to have significant influence on the development of the distribution sector in short term, whereas the industry is not likely to witness any major technological breakthroughs that would cause fundamental changes in the basic processes of electricity distribution. Through detailed analyses and evaluations, the working group concluded that, at present, regulation and business aspects are the most significant factors that direct the development of the business environment in the electricity distribution sector. Therefore, these two categories defined the framework conditions for the continuation of the scenario process, against which the representations of the possible future outcomes, that is, the scenarios, were assessed. The extremes of the scenario co-ordinate were strict regulation – no regulation in the horizontal axis, and in-house operations – service markets in the vertical axis, as shown in Fig. 5.2.

Fig. 5.2. The scenarios of distribution business in 2010. (Source: author’s presentation at Distribution Europe 2005 Conference)
During the scenario process, four alternative initial scenarios that reflected the interpretations of the working group were generated: enlightened regulation, wild west, EUN-poly and basic service. Each scenario captures alternative developments in the driving forces: the horizontal axis depicts alternative developments in regulation varying from tightly regulated markets to open (unregulated) markets, and the vertical axis depicts developments in industry structures varying from monopoly to diverged and specialized business. The basic elements of the alternative scenarios are listed below:

- **Enlightened regulation** scenario is characterized by a common regulatory framework within the EU. Distribution networks are still considered natural monopolies, but the companies have quite extensive operational freedom to organize their business. However, the number of operations that can be included in monopoly revenue calculations is reduced. In other words, the regulators expect an increasing number of operations to be produced in service markets. The prices of monopoly services are declining. Regulators have also put quite sophisticated power quality regulation schemes into practice. These are often based on customer-specific measurements.

- **Wild west** scenario is based on an assumption that electricity distribution is no longer regulated. There are well-functioning service markets in many operations, and the investors find the whole sector very interesting. The price and quality of distribution services are determined on a customer-specific base. This sometimes causes problems in remote areas.

- **EUN-poly** scenario describes a situation in which there is no regulation, and the markets are highly consolidated. Few large companies control the whole energy sector in Europe, and it is almost impossible for new players to enter the market. Energy markets are generally characterized as being oligopolistic, or even monopolistic in some market areas. In some areas, on the other hand, small local distribution companies have been established as a protest to the pricing policies of large international companies. Prices and quality are customer-specific.

- **Basic service** scenario is characterized by strict regulatory rules, which leave only little freedom for distribution companies. Regulators have a strong hold of the distribution sector. Investors are not particularly interested in the sector, because the rate of return is low, and regulation does not reward innovations. Customers are satisfied with the stable prices of monopoly services.
The scenario creation drew attention to the importance of regulation in the development of the electricity distribution sector, because the business environment will be notably different depending on the applied regulation methods, and business opportunities for different stakeholders vary significantly from one scenario to another. The final phase of the scenario process, that is, the implementation of scenarios, further strengthened this notion; regardless of the discussion forum, regulatory issues always began to dominate the discussion at some point.

5.1.2. Testing the validity of the scenarios

In order to evaluate the validity of the results of the scenario process, the created alternative scenarios were tested by a group of experts representing different stakeholders of the industry: the regulator (6), distribution companies (15), national associations (2), researchers (6), and component manufacturers and service providers (6). The participants of the inquiry were asked, for instance, to evaluate the credibility and probability of each scenario, and then choose the most desirable scenario. The results of the inquiry showed that all the scenarios were considered credible. The most probable scenario was enlightened regulation, and it was also found the most desirable one among the participants of the inquiry. The main reasons were that it was seen to balance the expectations of different stakeholders, to give incentives for the efficient functioning of the distribution sector, and to ensure good quality of the monopoly services. In addition, it was thought that harmonized regulation principles within the EU would make it easier for the international players to transfer their best practices from one market to another. Enlightened regulation would also provide a very challenging future, because in many cases it would mean significant structural changes in the processes of electricity distribution. However, if efficiency is the ultimate goal, then rethinking the processes might well be one of the very basic prerequisites of achieving this goal. An illustration of a possible value network description associated with the enlightened regulation scenario is shown in Fig. 5.3.
In Fig. 5.3, the core competence of a distribution company consists of operations such as asset management, customer relationship management (CRM), business planning, and making the long-term network development strategies. Network design is a borderline case, which in some cases can be contracted out to service providers. Operations that can be categorized as network construction, network operation, or customer service are procured in service markets. This situation may actually become reality in the near future. At present, the service markets already function in the network construction and maintenance operations. An interesting development is also in progress in the metering business where the increased use of automated meter reading and management (AMR/AMM) creates new business opportunities.
5.2. Innovation sessions

The scenarios were utilized by using them as a background material in several innovation sessions that were arranged to help organizations to evaluate their own capabilities against future requirements, and to develop new capabilities. The enlightened regulation scenario was used as the framework condition against which the future challenges and opportunities were assessed. The value network description (see Fig. 5.3) revealed the connections and transactions between the different players within the scenario, and also indicated the existing business potentials for each of the players. The participants of the innovation sessions represented distribution companies, software and component manufacturers, industrial associations and the regulator. The innovation sessions made use of versatile teamwork techniques such as the electronic group decision support system (GDSS) and the role play approach.

5.2.1. Electronic innovations

The electronic GDSS innovation sessions began with an introduction and orientation phase, which activated the participants into the process. The process was then by continued by five sequential phases. The main part of the process was the idea brainstorming phase, during which the participants individually generated ideas around the topic of the session. The ideas were then clarified and specified either by those who had generated them, or by the chairman of the session. The commented ideas were clustered under main categories, and, if necessary, additional information was given on them. The ideas within the categories were then prioritized by anonymous voting according to the future needs of the participating organizations. The results were documented for further use in the participating organizations. Finally, the participants were able to give feedback of the innovation session itself. The principles of the idea generation process of the GDSS innovation sessions are illustrated in Fig. 5.4.
The first innovation session was carried out with an international distribution company, which sought for new business opportunities especially in the service provision. The second innovation session was held with a globally operating measurement system manufacturer. The aim was to identify development trends, which might reshape the company’s business environment in the future. These included for instance the customer-specific power quality measurements and the real-time pricing of electricity. The third innovation session was arranged to find new ways of organizing the processes of electricity distribution. It was carried out as a collaborative session, and the participants represented distribution companies, service providers and manufacturers. Finally, the fourth innovation session was carried out with the representatives of an industrial association. It was designed to improve the participants’ strategic understanding about the driving forces and development trends of the electricity distribution business.

During each innovation session, approximately 40–60 ideas were generated concerning the new business opportunities and development needs in electricity distribution business. The ideas were typically clustered in the following categories: regulatory issues, human resource management, ownership questions, power quality issues, technological developments, and the
outsourcing of services. For instance, the results of the third innovation session (i.e. organizing the processes of electricity distribution) were as shown in Table 5.1. The voting scale ranged from 1 to 10, a high score indicating high priority. The results of the example show that most competitive advantages in this case can be obtained by a better understanding of the regulatory issues and by improved human resource management. On the other hand, in this example, all the ideas have received quite high scores, which indicates that all the categories contain ideas that cannot be neglected.

Table 5.1. An example of results of an innovation session.

<table>
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<tr>
<th></th>
<th>No. of ideas</th>
<th>Importance of ideas (range 1…10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regulatory issues</td>
<td>7</td>
<td>6.0 … 9.5</td>
</tr>
<tr>
<td>2. Human resource management</td>
<td>7</td>
<td>7.6 … 9.2</td>
</tr>
<tr>
<td>3. Ownership questions</td>
<td>3</td>
<td>6.9 … 8.8</td>
</tr>
<tr>
<td>4. Power quality issues</td>
<td>8</td>
<td>6.3 … 8.8</td>
</tr>
<tr>
<td>5. Technological developments</td>
<td>8</td>
<td>7.3 … 8.4</td>
</tr>
<tr>
<td>6. Services, partnerships and outsourcing</td>
<td>11</td>
<td>6.8 … 8.4</td>
</tr>
</tbody>
</table>

All the innovation sessions came to the conclusion that regulation plays an extremely important role in the development of electricity distribution business, and they revealed several development needs that should be taken into account in the future regulation design. Another important finding was that effort should also be put into studying the readiness of the companies that are involved in electricity distribution business to adopt new technological innovations and business models. The participants of the innovation sessions generally felt that they were able to obtain valuable knowledge about the future challenges and opportunities of the electricity distribution business.

5.2.2. The role play approach

Some of the innovation sessions were carried out as a role play, which made use of the participants’ expertise in the field of electricity distribution business. Participants were first divided into four groups representing the main stakeholders of distribution business: customers/society, operator/network companies, owners and the regulator. They were then given fictional descriptions defining the basic characteristics of the presumable operating environment. The descriptions were loosely based on the results of the scenario work, and they revealed problems that could occur under poorly designed regulation regime. The participants were assigned to discuss the problems and the possible solutions for them within the groups. Finally, each group brought its own ideas, including the minimum requirements for successful
regulation regime, to the closing discussion. During the closing discussion, the participants were expected to reach consensus on the regulation principles that satisfied the primary needs of each group. The role play innovations were carried out with leading experts of the electricity distribution from four Nordic countries – Finland, Sweden, Norway and Denmark – as well as with representatives of the Finnish regulatory authority.

The shared vision of harmonizing the regulatory principles of the electricity distribution sector in the Nordic countries had brought together several representatives of electricity distribution business from Finland, Norway, Sweden, and Denmark. An innovation session was arranged to address the challenges of successful regulation design. The goal of these lead users, that is, people who are capable of bringing “hidden” information about the needs and solutions of the industry into the innovation process, was to bring up ideas, goals, challenges, implementation principles and practical guidelines for the development of regulation. The main conclusion of the innovation session was that fair incentive mechanisms are an essential part of any regulation model. However, the development of such schemes is also one of the most challenging tasks of regulation design. In the Nordic countries, there are still development needs for instance in the fields of efficiency benchmarking and power quality regulation. Nordic co-operation in these fields might be possible, and furthermore, it could bring added value for both the regulators and the industry.

The Finnish regulator has recently issued new regulation principles that will be applied in years 2005–2007. These principles were designed to comply with the EU Directive (2003/54/EC); however, the problem is that the applied rate-of-return regulation creates a rather stagnant business environment for electricity distribution (Viljainen & al. 2004b). Therefore, a major revision of regulatory principles might be necessary in the near future. An innovation session was arranged to clarify the regulator’s strategic goals of the revision, and it drew attention to the following research questions: 1) how to utilize the findings of international best practice studies and benchmarking in national regulation design; 2) how to handle investments in regulation; and 3) should the regulator take a stand in defining the responsibilities of the distribution companies more specifically if partnership solutions bring new non-regulated players to the sector. The above questions are essential in the strategic planning of the future regulatory revisions.
5.3. Conclusions on assessing future challenges

The changing business environment in the electricity distribution sector brings new challenges and opportunities for all the stakeholders of the industry, and the ability to innovate and identify new business opportunities before the others creates competitive advantages. A new construct was applied to assess the challenges of the changing business environment. The construct was based on combining two teamwork approaches: the scenario method and the innovation process. First, the scenarios of distribution business in 2010 were used as framework conditions against which the future challenges were evaluated, and the innovation sessions then provided means to integrate the existing knowledge with the new understanding about the driving forces and development trends of the industry. During the innovation sessions, a number of ideas were generated concerning the new business opportunities and development needs in the electricity distribution business. All the innovation sessions came to the conclusion that regulation does play an extremely important role in the development of the electricity distribution business, and it was agreed that the present regulation methodologies still require further development.

In addition to understanding the role of regulation in the electricity distribution business, it is also essential to consider the readiness of the different stakeholders to adopt new business models and technological innovations in the electricity distribution sector. For instance, in the future, the organizational developments in the electricity distribution sector may lead to situations in which the distribution companies increasingly focus on their core businesses and outsource the non-core operations to specialized service providers. This will probably improve the efficiency of the sector, but the development of successful partnership solutions also requires new competencies that the stakeholders do not necessarily possess at the moment. For the distribution companies, for instance, the contract management becomes one of the core competences in itself if partnership approach is applied. Service providers, on the other hand, need to have in-depth understanding about the real-life effects of regulation even though they are not directly subject to regulation. Finally, the regulators need to acknowledge that regulation should give incentives to pursue all sources of efficiency, and to be indifferent of the applied operations models.
6. Concluding remarks

Improving the efficiency of the electricity distribution sector is one of the fundamental goals of regulation. In addition, the customers’ expectations on power quality are increasing as the societies are becoming more and more dependent on reliable electricity supply. Regulators are starting to take these aspects into account in regulation by designing and implementing versatile incentive schemes. Finally, the regulators may also issue other codes of conduct that have significant impacts on the development of the electricity distribution sector. For instance, the regulators may require that energy meters are read on a monthly basis, in which case the automated meter reading inevitably becomes the most common form of meter reading. If the regulators also expect that power quality is measured on customer-specific basis, then the installed new energy meters will include also power quality measuring properties. Good regulation design, organizational developments and technological innovations are necessary in order to meet the various new expectations. However, accomplishing these goals often requires knowledge and capabilities that the stakeholders of the sector do not necessarily possess at the moment.

The main contribution of this dissertation is that it creates new knowledge concerning the role of regulation in setting the goals for the development of the electricity distribution sector as well as the real-life effects of regulation on the development of business environment in the sector. The results are based on detailed analysis of the past, present and future developments of regulation, which has been the main driving force in the electricity distribution sector in Finland for the past decade or so. The main guideline throughout the research has been to find feasible solutions that provide the Finnish distribution companies with fair and stable business environment, and that ensure reasonably priced and good quality monopoly services for the customers of the distribution companies. In the capital-intensive electricity distribution business that is characterized by long asset lifetimes, the directing signals of regulation are often more important than the actual rate at which the strategic objectives of regulation are met. This is a key element of successful regulation design. So far, regulation has encouraged rather stagnant behaviour in the electricity distribution business in Finland; following the regulatory revisions, the innovative approaches of the distribution companies towards the development of their business processes have, almost without an exception, resulted in a less beneficial initial position under the revised regulatory regime.
In this dissertation, the basic principles of regulation were first discussed in detail, and several examples of their implementation in real-life circumstances were given. The experiences of regulation design and the observed problematic issues were then analyzed, and practical solutions to address issues such as how to develop a uniform system of accounts, how to value the regulatory asset base, and how to handle investments in regulation were presented. Finally, a construct (procedure) to help the stakeholders of the distribution business to create new knowledge about the future challenges of the industry was introduced.

6.1. Regulation design

Regulation design is a continuous process, but despite of this characteristic, the goal should be to create a stable business environment for the regulated companies. This is of particular importance in the electricity distribution sector because today’s investment decisions will continue to have an impact for quite some time due to the long asset lifetimes in the sector. Regulation should not distort the long-term planning processes of the distribution companies, but rather, the investors should be able to earn returns of and on their investments. In addition, regulation is expected to protect the customers’ rights, that is, the customers should be provided with reasonably priced and good quality monopoly services.

Essential in regulation design is to find practical solutions to problems such as: (1) how to value the regulatory asset base; (2) how to implement efficiency adjustments; and (3) what kind of role should power quality play in the regulation. The author’s research revealed several development needs in the methodology that was applied to address the above issues when regulation was first introduced in Finland. The author’s contribution to the regulatory developments in Finland lies in developing methodology that increase the stability of business environment and improve the directing signals of regulation. These include, for instance, harmonizing the regulatory accounting principles and developing the applied asset valuation methodologies.
6.2. Assessing future challenges

The changing operating environment in the electricity distribution business requires new capabilities from regulators as well as the other stakeholders of the industry. Regulators play an important role in creating operating conditions for electricity distribution. Therefore, they need to have in-depth understanding of the long-term impacts of different regulation principles on the operating environment of distribution business. An essential part of obtaining such understanding is to gather knowledge about the readiness and willingness of distribution companies to adopt new technology and business models. This, in turn, requires that regulators are aware of the industry’s development trends and the driving forces behind them. However, it is equally important for the industry representatives to have in-depth understanding about the driving forces that shape their operating environment, if they want to influence its future development.

In order to help the stakeholders to create new knowledge and capabilities, a construct based on combining the scenario method and innovation sessions was developed. The alternative scenarios of electricity distribution business reflected the interpretations of the working group but they were also tested by other experts of the industry for instance for credibility, probability and desirability. The scenarios provided a suitable starting point for innovation sessions, which assessed the future challenges and opportunities of the different stakeholders of the electricity distribution sector. The developed construct was tested in several real-life cases, in which the author had an active role. In this final stage, the author’s previous knowledge on regulation and other driving forces of the electricity distribution business was effectively utilized.

6.3. Future work

An interesting research question in the future is to find out whether it is possible to separate asset ownership, asset management, and the network-related services from each other in the electricity distribution business. And if so, what is the willingness and readiness of the distribution companies and the other stakeholders of the industry to promote such development? In practice, this would mean introducing various new partnership solutions in the electricity distribution sector, which would presumably improve the efficiency of the sector. The potential cost savings and the other strategic values of the partnership solutions are not automatically
achieved, and the future research will therefore address issues such as 1) what is the distribution companies’ readiness to develop their own organizations, 2) what network related services could be produced by independent service providers, and 3) what would it take to create well-functioning service markets in these specific services.
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