REGULATORY EFFECTS ON THE INVESTMENT STRATEGIES OF ELECTRICITY DISTRIBUTION COMPANIES

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SUMMARY

In this paper, the dependences between the regulation model and investment strategies are analysed. Regulatory effects are analysed by theoretical analysis and with practical examples. The main aim of the analysis is to show out how companies might adapt to the regulatory environment when deciding their investment strategies.

INTRODUCTION

Electricity distribution is a capital-intensive business and therefore investments are an important part of the business strategy. Minimising the total costs within technical boundaries has been one primary objective of the investment strategies. However, regulation has brought new challenges for the planning of the optimal investment strategies. The significance of the different components of the total costs varies depending on regulation model. For example, the importance of the power quality and thereby incentives for investments that improve power quality are strongly dependent on the regulation model. Investment can also gain economical benefits not only by reduced total costs but also by increased allowed return. Allowed return is in many cases dependent on the current value of the distribution network, which can be increased by investments. Therefore, regulation method affects optimal investment levels.

In this paper, the optimal investment strategies of the distribution companies in the different regulation environments are considered. The theoretical analyses of the effects of the different regulation methods on the investment strategies are presented. The practical examples of the directing effects of the Finnish regulation method are presented. It is also analysed how companies have actually adapted their investment strategy in the Finnish regulation environment.

INVESTMENTS OF DISTRIBUTION COMPANIES

The investments of the electricity distribution companies can be divided to new investments and replacement investments. In replacement investment, an existing network component is replaced with a new identical component. This is usually done for maintenance purposes due to aging or malfunction of the old component. New investment is an investment where a new network component is added to the network.

Since electricity distribution network is an important part of the infrastructure, the development of the society affects rather directly the construction of the distribution network. Therefore, distribution company cannot base its investment strategy only on its own interests but it has to take also the demands of the society on account.

Optimising the investment strategy

The major target of the investment strategy is the minimising of the total costs within technical boundaries during the whole lifetime of the distribution network. Cost components are capital costs, operational costs including losses and interruption costs, as shown in (1).

\[ C_{\text{tot}} = \int_0^T (C_{\text{capex}}(t) + C_{\text{opex}}(t) + C_{\text{interruption}}(t)) dt \]  

(1)

Where

- \( C_{\text{tot}} \) = Total costs
- \( C_{\text{capex}} \) = Capital costs
- \( C_{\text{opex}} \) = Operational costs
- \( C_{\text{interruption}} \) = Costs of interruption
- \( T \) = Life-time of network

However, different costs components in (1) are in many cases strongly dependent on the regulation. Especially the costs of the interruptions affect mainly through the regulation. In addition, some of the technical boundaries, e.g. safety standards, are dependent on the regulation.

EFFECTS OF REGULATION

The regulation of the electricity distribution companies is needed in order to prevent the misuse of the monopoly position, in which these companies operate. Regulation is usually focused either on the price of the electricity or on the profit of the company. Efficiency benchmarking is in many cases included in the regulation in order to provide companies with incentives for efficiency improvements. Depending on the regulation method and the parameters of the benchmarking the investments could have different impact on the incomes of the companies. In the Fig. 1, there is sketched general principles how an investment affect the actual profit of the company. Effects due to regulation are shown as dashed lines.
New investment increases the repurchase value of the network and thereby the present value of the network assets. Replacement investment, on the other hand, does not increase the repurchase value of the network, but it decreases the age of the network and thereby it increases the present value of the network assets. Therefore, it can be said that all of the investments increase the present value of the network assets. If the present value of the network assets is used as a regulatory asset base, the investments increase the allowed income of the company. Investments also affect operational costs and power quality, which could have effect on the allowed income of the company directly or through the efficiency benchmarking. The economical consequences of the investments are rather complex and they are strongly dependent on the regulation model. The discussion how different regulation models provide with incentives for investments will be presented in following chapters.

Rate-of-return regulation

In the rate-of-return regulation allowed profit is defined for each company based on the current value of the network assets. This kind of regulation could encourage even to over investments, since investments always increase the current value of the network assets. Therefore, regulator should determine somehow the reasonable investment level. The reasonable level of the investments could be for example straight-line depreciations based on the repurchase value and the lifetime of the distribution network.

Companies, which operate under the rate-of-return regulation, do not have strong incentives to optimise their investment strategies since return for every investment is guaranteed. In the case investment is financed with loan capital, the return is the amount of the loan interest. If investment is financed by own capital, the return for investment is higher. Thereby companies always get at least the amount of the financing costs as a return of the investment. If the efficiency benchmarking is included in the regulation companies can also benefit from investment as efficiency bonus. The additional profit of the investment can thereby be calculated as shown in (2) \([1]\).

\[
\text{Profit} = \text{Increased allowed return} + \text{Efficiency bonus} \quad (2)
\]

If investment costs are included in the efficiency benchmarking, an efficiency bonus can also be negative.

In the rate-of-return regulation, companies might have tendency to increase investments and decrease operational costs. This could lead e.g. to the situation where the outsourcing of the services is never seen as a cost-effective option.

Price cap and revenue cap regulation

In the price cap regulation regulator sets the limit for the price of the electricity. Price caps are adjusted annually by an inflation factor, X-factor that reflects efficiency improvements and Y-factor that allows for pass-through of the specific cost-items outside the company’s control \([2]\). One approach to achieve the freedom for price rebalancing has been to regulate the basket of the services rather than actual prices. This approach is often referred as revenue cap regulation. \([3]\) Revenue cap regulation could lead to under investments and the decreasing quality of supply if regulator does not set the sufficient level of the power quality.

Companies operating under revenue cap regulation have usually the freedom to choose how to meet the requirements of the regulator. Therefore, the planning of the business is more challenging under revenue cap regulation than in the rate-of-return regulation. Return for every investment is not guaranteed and the best profit can usually be achieved by minimising the total costs. Therefore, companies may found e.g. the outsourcing of some services as a cost-effective option.

Yardstick regulation

In the yardstick regulation the allowed income of the company is dependent on the performance of the other companies. Yardsticks can be used in connection with other methods, such as for price adjustments in the price cap regulation. \([2]\) Yardsticks are usually determined by benchmarking the companies against each other. The special case of the yardstick regulation is benchmarking based on hypothetical efficient company \([2]\) or hypothetical distribution network in the case of the electricity distribution business.

In the yardstick regulation, the incentives for investments are dependent on used benchmarking method and the factors of the benchmarking. One of the most used benchmarking methods is Data Envelopment Analysis (DEA), which is a linear programming application. In DEA the efficiency score is calculated by maximising the ratio of the weighted outputs to weighted inputs. Only constraints for factor weights are that these weights must be positive and the weights of one company should not provide efficiency score larger than 1 to any other company. \([4]\) Since factor weights are chosen to show each company in the best possible light, these weights can vary significantly between factors and between companies. Therefore, also the effects of the changes in the different factors of the benchmarking vary greatly. This could
lead to unpredictable directing effects on the optimal investment strategy. For example, if interruption time is an input factor in the benchmarking, companies put efforts on improving that parameter, which is the desired effect. However, in DEA benchmarking the decrease in interruption time could increase the efficiency score of one company significantly and at the same time be totally insignificant for other company.

If the benchmarking is based on the hypothetical network, the historical circumstances, which have led to the current situation, are not taken on account. Distribution network could be oversized compared to hypothetical network due to e.g. erroneous town planning. However, company should be able to maintain network once built to retain the good level of the reliability of supply. If the costs based on the hypothetical network are too low to cover the fixed and the common costs of the distribution company, the viability of the company and the quality of supply could be threatened. [5]

Role of power quality in the regulation

Regulation should ensure that the price of the electricity is at reasonable level and that the power quality is high enough. However, the increasing of the power quality increases usually also the costs of the supply. Power quality is usually measured as the number of the interruptions and/or interruption time. The costs of the interruptions can be calculated based on these measurements and the cost parameters of the non-delivered energy. Power quality can have direct effect to the allowed income of the company or it can be one factor of the efficiency benchmarking. One way to include the power quality in the regulation is to calculate expected interruption costs based on the historical data for each company and compare these costs to actual interruption costs. The allowed income of the company can then be decreased by the differential of these two interruption costs.

Most of the investments improve the power quality and therefore the role of the power quality has clear effect on the optimal investment strategy. The importance of the power quality and thereby directing signals vary depending on how power quality is included in the regulation. Directing signals also depend on what parameters are included in the regulation of the power quality. For example, if interruption time is measured, companies benefit of the investments, which decrease the highest amount of interruption time, e.g. distribution automation. On the other hand, if the number of the interruptions has greater weight than interruption time, investments are focused on those, which decrease the greatest number of the interruptions. It can be said that the priorisation of the investments depends on the parameters of the regulation. The impacts of the network investments on the power quality [6] and operational costs are shown in table 1.

### TABLE 1 – The impacts of the investments on power quality and operational costs.

<table>
<thead>
<tr>
<th>Customer level impacts</th>
<th>Long interruptions</th>
<th>Short interruptions</th>
<th>OPEX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network topology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- New primary substations</td>
<td>🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td>- New MV lines</td>
<td>🍀 🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td>- Reserve lines</td>
<td>🍀 🍀 🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td><strong>Network components</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Replacing overhead lines with underground or coated cables</td>
<td>🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td>- Surge arresters</td>
<td>🍀 🍀 🍀</td>
<td>🍀</td>
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</tr>
<tr>
<td>- Earth fault current compensation</td>
<td>🍀 🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td><strong>Network automation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Remote-controlled disconnectors</td>
<td>🍀 🍀 🍀</td>
<td>🍀</td>
<td>🍀</td>
</tr>
<tr>
<td>- Fault location system</td>
<td>🍀 🍀 🍀 🍀</td>
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</tbody>
</table>

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**PRACTICAL EXAMPLE - CASE FINLAND**

Finnish regulation method has been changed at the beginning of the year 2005. Old regulation method, which has been in the use until the end of the year 2004, was the rate-of-return and the average of 3 years investments were considered as reasonable depreciation level. That kind of regulatory environment provides with strong incentives even for over investments. Power quality was measured as interruption time, which was one input factor of the DEA efficiency benchmarking. Thereby there was possibility for achieving the efficiency bonus for investments that decrease the interruption time.

In the Fig. 2, the investments of 94 Finnish distribution companies (the average from the years 1999 – 2002) are compared to the straight-line depreciations calculated with the depreciation time of 35 years. In this case these depreciations can be considered as the reasonable investment levels.
Although investments have been strongly encouraged in the Finnish regulation model, the actual investment levels of the companies have been rather low, as can be seen from Fig. 2. Companies could have postponed the investments due to the uncertainty of the constancy of the regulation model. The technical lifetimes of the network components are usually several decades but regulation model can change at the interval of the couple years. In addition, the effect of the power quality has been unclear, since the effect of the interruption time on the efficiency score varied significantly between companies and between years. The effects of the power quality factors in the Finnish efficiency benchmarking are discussed more detailed in [7].

The regulation model remains as the rate-of-return in the new regulation model in Finland. Methodology decisions for 4 years regulatory periods will be given ex-ante and the decisions of the reasonableness of the pricing will be given ex-post. The reasonable depreciation level is the straight-line depreciations based on the repurchase values and the actual lifetimes of the network components. [8] Therefore incentives for investments are not as strong as they were in the past regulation model. At the present, there is not efficiency benchmarking, only general efficiency requirement, which is equal for every company. Individual efficiency requirement is most probably coming in the use at the second regulatory period. In addition, power quality does not have effect on the incomes of the companies at the first regulatory period.

However, the power quality data is collected and the power quality of the first regulatory period could have economical effects at the second regulatory period. In addition, the data for the individual efficiency requirement of the second period is collected at the first regulatory period. Therefore, investments that affect the power quality or other factors of the efficiency benchmarking could have economical consequences at the coming regulatory periods.

**CONCLUSIONS**

Different regulation models provide different incentives for investments. Therefore also optimal investment strategy is strongly dependent on the regulation method. If the current value of the network assets is used as regulatory asset base, companies have tendency to increase the value of the network assets by investments since investments increase the allowed income of the company. If investment increases the quality of supply, it can also provide company an efficiency bonus. However, if investments are an input factor of the efficiency benchmarking, they could also cause negative effect to the incomes of the company. Based on theoretical analysis it can be said that investment levels are dependent on the principles of the regulation and the details of the regulation determine the focus of the investments. The incentives for investments in the different regulation environments are shown in table 2.

<table>
<thead>
<tr>
<th>Regulation model</th>
<th>Efficiency benchmarking</th>
<th>Incentives for investments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rate-of-return</strong></td>
<td>No efficiency benchmarking</td>
<td>At least the financing costs of all investments are covered by increased allowed return. Every investment is profitable, especially if depreciation time is short.</td>
</tr>
<tr>
<td></td>
<td>The input factors of the benchmarking: OPEX and interruption time</td>
<td>Return for every investment is guaranteed. If an investment decreases OPEX or interruption time, also efficiency bonus is provided.</td>
</tr>
<tr>
<td></td>
<td>The input factors of the benchmarking: OPEX, CAPEX and interruption costs</td>
<td>Investments that decrease the total costs as shown in equation (1) are profitable.</td>
</tr>
<tr>
<td><strong>Revenue cap</strong></td>
<td>No efficiency benchmarking</td>
<td>Incentives for investments that decrease OPEX. No incentives for investments that increase power quality.</td>
</tr>
<tr>
<td></td>
<td>Power quality is an input factor of the benchmarking or it affects directly on the allowed income of the company.</td>
<td>Investments that decrease the total costs as shown in equation (1) are profitable.</td>
</tr>
</tbody>
</table>

Revenue cap regulation provides with best incentives for optimizing the total costs. This usually leads to the socio-economical optimum, if the cost parameters of the power quality factors are at the appropriate level. Similar result can also be achieved by the rate-of-return regulation with the efficiency benchmarking where the total costs are an input factor. However, there are not possibilities to the rapid improvement of the power quality level in the revenue cap regulation. Company may choose to improve its power quality level as strategic decision. This kind of improvement demands high investments and the limited revenue do not provide enough capital for these kinds of investments. However, rate-of-return regulation gives possibilities for these kinds of investments since the financing costs of all investments are covered as increased allowed return.

Based on the practical analysis of the Finnish regulation method, companies do not necessarily optimise their investment strategies correspond to the incentives of the regulation model. One reason for this could be that the lifetimes of the network components are several decades while the regulation model could change at the interval of the couple of years. If there is uncertainty about the constancy of the regulation model, the decisions of the investments can be postponed. This could lead to the deterioration of the network and decreasing power quality, which are not desirable effects. On the other hand, also over investments are not preferable, since they could increase the price of the electricity.

Regulation is also rather new issue and therefore companies might decide their investment strategies in a traditional way. However, the ownership of the companies is changing from the municipal owners to the capital investors. Capital
investors are usually seeking for high profits for their investments and therefore 'regulatory gaming' might increase in the future. Due to that, it is essential that regulation model provide with such incentives that direct the investment strategies towards socio-economical optimum.

REFERENCES


