THE NEW SWEDISH REGULATION OF POWER DISTRIBUTION SYSTEM 
TARIFFS – A DESCRIPTION AND AN INITIAL EVALUATION ON ITS RISK 
AND ASSET MANAGEMENT INCENTIVES

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ABSTRACT

From 2012, a new tariff regulation has been introduced in Sweden. A reasonable revenue framework for the distribution system operators (DSOs) is determined before the regulatory period of four years. The aim of this paper is to overall describe the new regulation, especially reliability aspects, including an approach to superficially perform an initial investigation/evaluation on its incentives of risk and asset management. A recently performed M.Sc. thesis by one of the authors shows that the new regulatory method has a great impact on project planning. For example introducing more components is “rewarded”, while demolish old components is “punished”.

The DSOs send a proposition to the Energy Markets Inspectorate (EI), who decides whether the suggested framework is reasonable. The evaluations of the proposed revenue framework is performed by a template method, where EI calculates the reasonable total costs and fair return on capital, with the aim of taking objective prerequisites for the specific DSO into account. After the regulatory period, the DSO’s actual revenue is investigated; if this revenue differs from predetermined levels, the framework will, for the next regulatory period, be reduced or increased.

INTRODUCTION

The Swedish electricity market was deregulated in 1996. However, due to the nature of electric power distribution systems, the infrastructures of the distribution systems are natural monopolies. This creates a need for supervision of the electric power distribution system tariff levels. The task of the regulator is to ensure that the distribution system operators (DSOs) get fully compensated for the cost of distributing electricity and the cost of restricted capital, while also seeing that the costumers pay fair prices. After the de-regulation of the electricity market the DSOs could be fully compensated for their costs regardless of efficiency and quality. To address this problem a new authority was formed in 1998: The Swedish Energy Agency (STEM). The task for STEM was, among other things, to create a better model of regulation [1].

In 2003 the Network Performance Assessment Model (NPAM) was implemented. The idea of the NPAM was that the service of distributing electrical energy creates customer values and that the DSOs should be compensated in level with these values [2]. The NPAM used a fictive power distribution network to calculate the Network Performance Assessment, which is the total expected cost of operating a power distribution system. After the regulatory period, because this was an ex-ante model, the NPA was compared to the actual revenue of the DSOs. If the revenue
was too high the DSO had to pay the customers back [3]. The NPAM met heavy opposition from the DSOs as many of them had to repay their customers each year. The amount of legal claims against the authority was growing every year. Because of this, and the fact that the EU requires an ex-ante regulation by 2012, the model was abandoned in 2009.

During the time since the fall of the NPAM the focus has been on preparing the new regulatory model that has been into force from 2012. The Energy Markets Inspectorate (EI), the part of STEM handling the regulation that is a separate authority from 2008, still controls the tariffs, but they are in some ways self-regulating. If the DSOs charge too much, the rules of regulation might be harder in the next period [4].

**DESCRIPTION OF CURRENT EX-ANTE MODEL**

In the new model, which is being initialized 2012, a reasonable revenue framework for the DSOs will be determined before the regulatory period starts, a so called ex-ante regulation. The DSOs send a proposition to the regulator who decides if the suggested framework is reasonable. The regulatory period is four years and EI might review a DSO’s decision of a revenue framework during or after the period if it turns out that the decision was based on false data [5].

The method of evaluation of the proposed revenue framework is a template method where EI calculates the reasonable total costs and fair return on capital for a DSO, taking objective prerequisites for the specific company into account. The template revenue is then compared to the suggested one. After the regulatory period the company’s actual revenue is checked to make sure that the DSO has kept the revenue within the boundaries of the framework. If the actual revenue exceeds the predetermined levels the framework will, for the next regulatory period, be reduced by the amount exceeding the framework. Similarly, if the revenue has been kept below the expected value, the DSO has the right to an increased revenue framework. If the revenue has exceeded the framework by more than 5%, the framework will be additionally reduced by an overcharging fee [5]. EI has decided to introduce a transition rule with a price cap that gives the companies an 18 year period to adopt the prices to the predetermined revenue frame. The transition rule is contested by companies and has become a court case.
The flowchart in Figure 1 shows the parts that make up the framework for the revenue. The total costs for a DSO includes operational costs and capital costs.

**Operational costs**

Operational costs can be said to be any costs that are not capital costs, and are divided into controllable costs and non-controllable costs (see Figure 1). The non-controllable costs are directly added to the revenue framework, since it is considered that the DSO can do nothing to affect these costs. This can be for example charges to superior grids. The controllable operational costs are for example costs of maintenance, administrative costs or cost of personnel. These costs are calculated from historical data from the company and are associated with an efficiency requirement [6]. The operational costs have to be lowered by 1% every year [5].

**Capital costs**

Capital costs are costs of acquisition of the capital base and the cost of restricted capital. The capital base includes all assets necessary to perform the service of delivering electrical energy. This is for example distribution lines, control equipment and electricity meters. To be able to measure the DSO’s capital costs the value of the capital base must be determined. The DSOs calculate the value of the capital base and state this number in the proposition to the regulator. The value is determined by evaluating the acquisition value of the capital base using norm values.
In other words, the DSOs calculate what it would cost them to obtain their entire capital base today. This way of regarding the grid as brand new has been questioned. EI did however try to ask the Swedish DSOs what the grids were worth today, which turned out to be too hard, if not impossible, to calculate. It was therefore decided to go with the norm value method for the first regulatory period [5]. The norm values are calculated and listed by EI, who has produced several hundreds of norm values [7].

Quality adjustment

The capital costs consist of cost of acquiring the capital base, which is recorded as depreciation, and the demand of return that the shareholders have. It is the shareholders return on invested capital that gets adjusted according to the quality of the electrical energy.

Depending on the quality, which in the coming regulatory period will be measured only by the security of supply, deductions and additions to the return of capital will be made. The reliability in the system will be measured against historical data (2006-2009 in the first regulatory period) and if the DSO has improved the quality an addition to the return of capital can be made. If the reliability has declined, the return will decrease – creating incentives for better quality of the electricity supply.

The reliability of the local distribution system will be measured by the reliability indices SAIFI\(^1\) and SAIDI\(^2\), and calculated separately for announced and unannounced outages, as the announced outages are considered to cause less cost and disturbance for the customer. SAIFI and SAIDI are produced for outages longer than 3 minutes and shorter than 12 hours. Shorter outages are not considered to be interruptions of power supply, but more a quality issue of the same type as for example voltage instability or flicker. The outages longer than 12 hours are already subject to cost for the DSOs through direct outage compensations. In order to not punish the DSOs twice, unannounced outages over 12 hours are not included in the regulation. Reliability results presented in this paper are based on calculations only consider unannounced outages.

In order to scale the quality adjustment of return on capital the average yearly power and energy output in the grid is taken into account by valuing the cost of outage in SEK/kW and SEK/kWh. The costs have been estimated by the Energy markets Inspectorate and can be seen in Table 1, which is collected from table 4 in [8].

<table>
<thead>
<tr>
<th></th>
<th>(P_W) SEK/kW</th>
<th>(P_E) SEK/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Announced outage (AO)</td>
<td>4</td>
<td>38</td>
</tr>
<tr>
<td>Unannounced outage (UAO)</td>
<td>19</td>
<td>54</td>
</tr>
</tbody>
</table>

\(^1\) \(SAIFI = \frac{\sum \lambda_i N_i}{\sum N_i} \left[ \frac{\text{number of interruptions}}{\text{year customer}} \right] \), \(\lambda_i\) is the failure rate and \(N_i\) is equal to number of customers in point \(i\).

\(^2\) \(SAIDI = \frac{\sum U_i N_i}{\sum N_i} \left[ \frac{\text{time (e.g hours)}}{\text{year customer}} \right] \), \(U_i\) is the unavailability and \(N_i\) is equal to number of customers in point \(i\).
Equation 1 is then used to calculate the quality adjustment, \( Q \). The \( E_y \) in the formula stands for the annual average energy consumption in the area and 8760 is the hours of a year. The quality adjustment is shared between the DSO and the customers by multiplying the adjustment with 0.5. The idea is that the cost of quality should be accounted to the DSO and the customers equally. The formula and explanations of the calculations can be found in [8, p. 27].

\[
Q = 0.5 \times \left\{ \left[ \left( \frac{\text{SAIDI}_{UAO,norm} - \text{SAIDI}_{UAO,actual}}{60} \right) \times \frac{E_y}{8760} \right] \times P_{E,UAO} \right\} + \left[ \left( \frac{\text{SAIFI}_{UAO,norm} - \text{SAIFI}_{UAO,actual}}{60} \right) \times \frac{E_y}{8760} \right] \times P_{E,AO} \]

(1)

The announced and unannounced outage SAIFI and SAIDI for the current year are compared to the norm value that were calculated with the historical data. If the reliability is better now than compared to the norm value the result, and adjustment to return of capital, will be positive.

There are limits to how large the quality adjustment can be. In case of extreme weather during a year, the quality adjustment can be much too large for a small company to handle. In order to protect the companies from such events, the deduction can at most be 3% of the revenue framework or the entire return of capital [8]. Too high security of supply is not economically justifiable either and hence an upper limit on the addition to the return of capital has been assigned. It is as well 3% of the revenue framework.

**EVALUATION OF THE NEW REGULATING MODEL**

In a recently finished M.Sc. thesis project [9], the impact of the regulation on different investment projects for better reliability was studied (among other things).

**Description of the M.Sc. thesis project**

In the project, different reliability enhancing investment alternatives for two feeders in the rural Swedish power distribution system were evaluated. The cost-efficiencies of the investments were studied by performing a Life Cycle Cost (LCC) analysis of the different investments, where the costs and income are regarded over the entire life span of the investments. A number of different investments were studied in the project. This was for example changing overhead lines for underground cables, upgrading manual disconnectors to remote controlled ones and to enable secondary feeding, which are common investments in the distribution system. Other, more novel investments were also studied, like for example installing line breakers along a radial line or decreasing the voltage to 1 kV on minor radial lines. Faults on the 1 kV lines can be caught by the protection equipment and do not spread.
Life Cycle Cost analysis

In the LCC analyses five cost/incomes were considered; investment cost, change of the revenue framework due to quality adjustments, repair cost, customer compensation due to long outages and income from the capital base. The life span of the investments was assumed to be 40 years and for every investment the total number of decreased customer outage minutes was calculated and compared to the total cost to produce the business value used by the studied DSO:

\[ \sum_{i} (2) \]

\[ \text{Customer outage minutes} = \sum_{i} U_{i} \cdot N_{i} = \text{SAIDI}[\text{minutes}] \cdot \sum_{i} N_{i} \]  

\[ U_{i} \text{ is the unavailability and } N_{i} \text{ is equal to number of customers in point } i. \]

Customer outage minutes (COMin), defined in equation 2, is a term used by the DSO because it includes both the length of the outage as well as the number of customers affected by the outage. The business value is used to determine whether an investment should be performed or not. The business value and total cost of investment was calculated both with and without the impact of regulation. The result can be seen in Table 2 and
Results

Table 2: Comparison of the cost-efficiency of the investments with and without the income from the capital base in the current regulation for Feeder 1.

<table>
<thead>
<tr>
<th>Investment alternatives</th>
<th>Total cost with Capital base [SEK]</th>
<th>Total cost without Capital Base [SEK]</th>
<th>SEK/COMin with Capital base</th>
<th>SEK/COMin without Capital Base</th>
<th>Change of SEK/COMin when regarding Capital Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote controlled disconnectors</td>
<td>-90 630</td>
<td>126 859</td>
<td>-1.1</td>
<td>1.5</td>
<td>- 171 %</td>
</tr>
<tr>
<td>Cables</td>
<td>15 003 697</td>
<td>20 197 699</td>
<td>197.9</td>
<td>266.4</td>
<td>-26 %</td>
</tr>
<tr>
<td>Line breaker</td>
<td>17 630</td>
<td>171 567</td>
<td>0.9</td>
<td>8.3</td>
<td>-90 %</td>
</tr>
<tr>
<td>Secondary feeding (OH)</td>
<td>175 173</td>
<td>1 197 251</td>
<td>35.1</td>
<td>239.8</td>
<td>-85 %</td>
</tr>
<tr>
<td>Secondary feeding (cable)</td>
<td>159 149</td>
<td>1 294 944</td>
<td>14.0</td>
<td>114.3</td>
<td>-87 %</td>
</tr>
<tr>
<td>1 kV Area 1</td>
<td>31 212</td>
<td>48 964</td>
<td>11.6</td>
<td>18.2</td>
<td>-36 %</td>
</tr>
<tr>
<td>1 kV Area 2</td>
<td>28 531</td>
<td>46 283</td>
<td>4.8</td>
<td>7.8</td>
<td>-38 %</td>
</tr>
</tbody>
</table>
Table 3: Comparison of the cost-efficiency of the investments with and without the income from the capital base in the current regulation for Feeder 2

<table>
<thead>
<tr>
<th>Feeder 2</th>
<th>Total cost with Capital base [SEK]</th>
<th>Total Cost without Capital Base [SEK]</th>
<th>SEK/COMin With Capital base</th>
<th>SEK/COMin Without Capital Base</th>
<th>Change of SEK/COMin when regarding Capital Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlottenberg</td>
<td>Cables</td>
<td>1 670 817</td>
<td>2 019 353</td>
<td>64</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Line breaker</td>
<td>45 655</td>
<td>173 980</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>1 kV Area 1</td>
<td>33 282</td>
<td>51 034</td>
<td>34</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>1 kV Area 2</td>
<td>34 681</td>
<td>52 433</td>
<td>69</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Secondary feeding (OH)</td>
<td>109 509</td>
<td>596 252</td>
<td>9</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Secondary feeding (Cable)</td>
<td>57 382</td>
<td>584 213</td>
<td>3</td>
<td>33</td>
</tr>
</tbody>
</table>

Influence from the regulation

The cost-efficiency of the investment alternatives analyzed in the master thesis project is strongly dependent on the authority’s regulation of the DSO’s. In the calculations it is assumed that the new ex-ante regulation starting 2012 will be the same for the investment’s full 40 year life span. This is however highly uncertain and the conditions will probably change. This affects the quality adjustment as well as the capital base value. The quality adjustment is based on historical values today; the goal for the DSO is to improve the reliability compared to its own values of reliability for the time before the regulatory period. When the period is over and improvements have been rewarded for four years, the reference level is reset and the improved level is now the standard. It is however possible that the regulating authority will develop general standard levels that every DSO will have to reach. Depending on those levels, the incentives for reliability investments may vary a lot.

Just like the rules of the quality adjustment, the methods of evaluating the capital base might change. As discussed in section Capital costs (chapter “description of current ex-ante model”) the current method, where the grid is always considered to be brand new, is questioned. The coming regulation gives very strong incentives to expand the grid and increase the capital base. Replacing old equipment with new is not nearly as profitable as installing more equipment. Some of the investment alternatives are strongly dependent on the generous evaluation of the capital base. This goes especially for the alternatives of adding a secondary feeding. In the results of the analysis a comparison of the total cost and SEK/COMin ratio of the investments for when the capital base is considered in the calculation and for when it is not considered is shown. As can be seen, the effect of the regulation is large. Upgrading to remote controlled disconnectors is no longer a profitable investment. The cost-efficiency of adding a secondary feeding possibility is strongly dependent of the current regulation and loses a large part of the benefits of adding it if the regulation rules are changed.
The analysis in the master thesis project shows the role of the prevailing regulation. The cost-efficiency of the investments will change considerably with changes in the regulation. Power system investments are however done with life spans of 40 years or longer in mind. The investment plans cannot be changed every time the regulation changes. If regulation benefits are considered too much by the net planners at the DSOs there is a risk of investments being done that is not helping the overall reliability of the grid and that also may lose their profitability if the regulation changes.

CLOSURE

This paper has described the upcoming Swedish regulatory model for power distribution system operators, with extra weight on the reliability perspective. The DSOs are rewarded for enhanced reliability of the power supply, and punished if the reliability decreases. However, due to the method of calculating the allowed revenue for the DSOs, investments that may not be optimal for reliability might be favored. A recently performed M.Sc. thesis investigates the impact of the method of evaluating the capital base on the cost-efficiency of the investments. The analysis shows that the method of evaluating the capital base has a significant higher effect on the cost-efficiency than the improvements of the reliability.

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REFERENCES