THE POTENTIAL OF USING EQUIVALENT COMPARISON STANDARDS TO JUDGE EFFECTIBLE COSTS IN ELECTRICAL DISTRIBUTION TARIFF REGULATION

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ABSTRACT

Sweden will implement a new tariff regulation from 2012. This paper presents results from a project initiated by the Swedish regulator, performed by the RCAM (Reliability Centered Asset Management) research group aimed to review the potential of using equivalent comparison standards to judge effectible costs. The study includes interviews and surveys distributed to every Swedish distribution system operator (DSO). However, no sharp proposal on units appropriate to use in the first regulatory period (2012-2015) could be provided, due to e.g. large variations in response from the DSOs. The study provides several results such as enabling for all parties to contribute their views before implementation; indication of how current units should be modified; increased knowledge for involved parties and an action plan for future work. The regulator's initial idea was to apply this kind of model to 25 % of the effectible cost part during the first regulatory period, but based on this study the regulator changed this plan.

INTRODUCTION

In 1996, the power system operation in Sweden was separated from production and market. Traditionally, distribution system operators (DSOs) more or less had the right to cover all expenses and a reasonable profit. Since the late 90's, the authority initiated a project to develop a performance based regulation [1]. A good tariff regulation requires several difficult considerations [2], e.g. providing incentives for cost efficiency with maintained reliability. Furthermore, a regulation ought to take different objective conditions into consideration, while the model should be manageable and consistent. The authority felt no existing model was suitable enough to adapt to Swedish conditions, so a new model was developed and used from 2003. The result from the new regulation gave indication that the tariff levels in some cases were too high, resulting in decisions on recovery. This decision was appealed and a comprehensive legal process began. In late 2008 an agreement was made. Simultaneously, an EU directive forced Sweden to shift to ex ante regulation. Instead of modifying the existing model and continue to fight legally, a completely new model is developed, which should be applied from 2012.

Currently, Sweden has ~170 DSOs of varying size and ownership structure. Responsible authority is the Energy Market Inspectorate (EI). This paper presents results from a recently completed project [3], initiated by EI, and performed by the RCAM research group at KTH (Royal Institute of Theology). The aim is to review the potential of using equivalent comparison standards to judge effectible costs in the new regulation. The project includes interviews, survey to all DSOs and several analyses to produce a good decision support for EI. A significant part of the project was devoted to description and review of EBR (Swedish abbreviation for "ElByggnadsRationalisering" can roughly be translated as electrical construction rationalization) and EKM (Swedish abbreviation for "EKvivalenta ledningslängdsMått" can roughly be translated as equivalent feeder length measurements), which are introduced later in the paper.

UPPCOMMING REGULATION

The major parts of the new regulation are settled, but details remains to be determined and everything will not be included in the first four-year-period. The tariff framework is based on following parts:

- Capital costs: depreciations and the cost of restricted capital. A constant annuity is calculated based on the estimated net present value and economical lifetime.
- Operating costs, which are divided into:
  - Effectible costs – **this paper presents results of reviewing one possible regulatory model.**
  - Not effectible costs: fully compensated.
- Quality function: limited to affect up to 3 % of the compensation for cost of restricted capital.

The upcoming tariff regulation is described more in detail in e.g. [4] together with additional relevant laws such as individual customer compensation for ≥12 hour outages, 24 hour functional requirement and mandatory annual risk- and vulnerability analysis.

EKM – A COST COMPARATIVE MODEL

Definition of EKM

The *EKM* model consists of units designed to describe operation- and maintenance costs (reinvestments excluded) of power distribution system entities and to facilitate comparisons between DSOs [5]. EKM_i is defined as:

$$\frac{annual\ effectible\ costs\ of\ entity\ i}{annual\ effectible\ costs\ of\ 1\ km\ overhead\ line} \quad (1)$$

Background to EKM

EKM units are developed by Swedenergy, an association representing companies involved in the production, distribution and trading of electricity in Sweden. Swedenergy has since the 1960's annually published EBR, aimed to rationalize planning, investments and maintenance of power systems [6], i.e. to provide rational "standards" when constructing power systems. One important part of the EBR catalogue is the calculated costs for different activities. EKM units are entirely based on costs in EBR. Consequently, to investigate EKM, the underlying EBR calculations must be reviewed. This study has both included interviews with EBR at Swedenergy and studies of EBR materials.

EBR – the underlying calculations of EKM

EBR consists of six aggregation levels (P1-P6), affecting each other from down to top, see Figure 1. P1-P3 and parts of P4 are reported in the annual EBR publications.

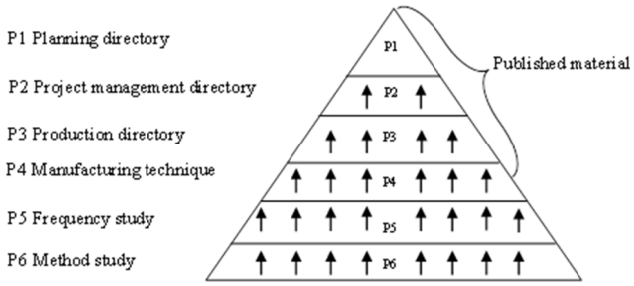

Figure 1 – The structure of EBR

Underlying frequency and time studies (P5 and P6) are partly based on interviews with different DSOs, partly on methodological studies in which Swedenergy conducted field studies. The number of underlying studies differs, but is often only a few. The reason is, according to [7], the difficulty to get voluntary DSOs because it is both time- and resource consuming. In EBR the costs are divided into the following categories: (a) work, (b) material, (c) machine, (d) equipment and (e) other. "Other" e.g. includes building permit costs [8]. EBR do not include common costs such as overall administration and research. The recommendation is to add 3-8 % [7]. EKM estimates are updated about every four years. An expert group investigates if technical means or societal requirements have changed for any of the operations and maintenance activities during the past year. If required, changes are introduced for the calculation of the actual EKM measure; otherwise the measures are updated based on the new EBR values.

Current EKM

The latest EKM version during the project time (2010) was from 2006 (EKM units are presented in TABLE 2). During 2011 a new version will be published. According to [7], there will probably not be any significant changes on local voltage levels, but 36kV to 145kV will be carefully revised. Furthermore, EKM units of customer and market services will be updated thoroughly.

Possible use of EKM-like unit in tariff regulation

Initially EI considered using a model based on units similar to EKM to reallocate 25 % of the effectible costs at the first four year regulatory period with the long term aim of increasing this amount to 100 %. To integrate such model there are several issues that has to be addressed, for example:

- EBR and EKM currently not provide reliable information for higher voltage levels.
- Customer related costs must be clearly defined and investigated.
- EI could not rely entirely on units developed by Swedenergy, representing the regulated DSOs, and has consequently to review the entities carefully and modify if necessary.

The overall idea is to calculate a total amount of EKM for each DSO and to estimate a cost for EKM =1 (based on actual effectible costs reported from the Swedish DSO). The DSO will then be compensated for effectible costs in proportion to its EKM. The aim is that the model will be a "zero-sum game" for the DSOs, i.e. to award cost effective DSOs by taking from less efficient DSOs [9].

ANALYSES

Consequence analysis by optimization

A mathematical optimization analysis method is suggested to identify EKM units that give as little reallocation as possible. The purpose is not to determine new EKM, but to study the potential effects of an introduction of new EKM and indicate how EKM could be adapted to reduce possible problems in the integration to a new regulation. The analysis method should also be used to identify problems, e.g. highlight possible need for a more detailed modeling or to indicate entities that can be merged. It is recommended that this analysis should be performed with all component categories (~60) included in regulation. This can be done only when all companies have reported their detailed assets (March 2011).

Interviews

A delegate from Swedenergy/EBR was interviewed to understand underlying theory. Since EBR is based on less underlying studies at higher voltage levels, a meeting was held with three DSOs, which together own most of the regional Swedish power systems [10].

Survey A

All Swedish DSOs where invited to answer a survey. ~50 % of 170 companies with a good spread between small and big DSOs answered. More entities than existing where included, based on discussions with EI and with DSOs. Figure 2 - Figure 6 and TABLE 1 - TABLE 3 shows results from the survey.

General questions

Figure 2 – Do you prefer a regulation that takes many conditions into consideration, with more comprehensive reporting?

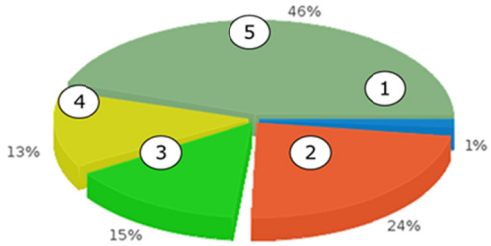

Figure 3 – To what extent is EBR used by the DSO (1=nothing ... 5 = much)

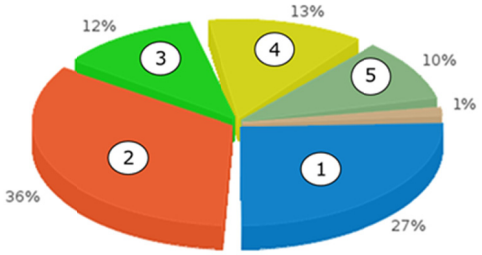

Figure 4 – Knowledge about EKM (1=no knowledge…5 = much knowledge)

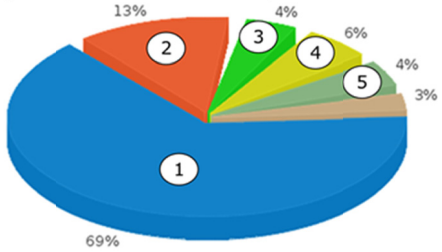

Figure 5 – To what extent is EKM (or similar) used by the DSO (1=nothing ... 5 = much)

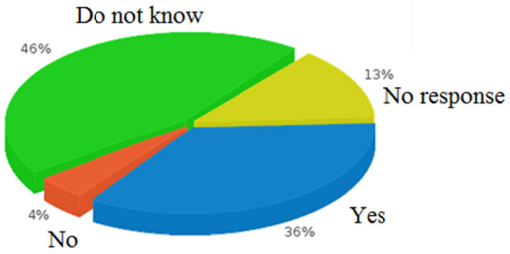

Figure 6 – Is EKM a suitable model to use in the upcoming regulation

TABLE 1 – The conditions that affect your operation and maintenance cost the most

Proportion of forest	40 %
Proportion of rural vs. urban areas	37 %
Proportion of rough terrain	6 %
Other category answered	10 %
No answer	7 %

Analyses on costs and EKM values

All DSOs were asked to estimate EKM values and to estimate their costs (the later indirectly give EKM units). Unfortunately, too few DSOs answered the survey at a detail level needed to estimate EKM statistically good enough to propose sharp EKM units. However, the analyses gave a number of indications for each entity in TABLE 2.

TABLE 2 –Analyses of existing EKM

Entity	Indication	EKM 2006
OH line 0.4 kV	Defined as 1.00	1.00
UG cable 0.4 kV rural	No significant changes needed	0.70
UG cable 0.4 kV Urban	No significant changes needed	0.70
UG cable 0.4 kV City	High spread between responses	0.70
OH line 12-24 kV	Current EKM too low	1.20
Covered OH line 12-24 kV	Current EKM too low	0.90
UG cable 12 kV rural	No significant changes needed	0.60
UG cable 24 kV rural	Current EKM too low	0.60
OH cable 12 kV	Current EKM too low	0.90
OH cable 24 kV	Current EKM too low	0.90
UG cable 12 kV Urban	High spread between responses	0.60
UG cable 24 kV Urban	No significant changes needed	0.60
UG cable 145 kV Urban	Current EKM too low	0.40
UG cable 12 kV City	No significant changes needed	0.60
UG cable 24 kV City	High spread between responses	0.60
Pole mounted transformer	Current EKM too low	0.00
Sec. substation rural	Current EKM too low	0.10
Sec. substation City/Urban	Current EKM too low	0.30
Sec. substation double	Current EKM too low	0.50
Subst. 52-72.5/12-24 kV [1]	Current EKM too low	1.90
Substation 145/12-24 kV [1]	Not included in the survey	1.90
Substation 145/52-72.5 kV [1]	Not included in the survey	1.90
Subst. feeder bay 12-24 kV	No significant changes needed	1.40
OH line 36-72.5 kV	Current EKM too low	1.50
OH line 84-170 kV	Current EKM too low	1,50
UG cable 36-72.5 kV rural	(2)	0,30
UG cable 36-72.5 kV urban	(2)	0,40
UG cable 36-72.5 kV city	(2)	0,60
UG cable 84-170 kV rural	(2)	0,30
UG cable 84-170 kV urban	(2)	0,40
UG cable 84-170 kV city	(2)	0,60
Transf. 52/12-24 kV	Current EKM too low	4,60
Transf. 123-170/12-24 kV	Current EKM too low	4,60
Transf. 123-170/52-72.5 kV	No answers	5,10
Subst. feeder bay 145 kV	No answers	1,60
Subst. feeder bay 52-72.5 kV	No answers	1,60
Customer related costs	Analyzed in survey B	0,06

(1) Excluding apparatus
(2) Could not be compared because different detail levels

TABLE 3 – Entities not included in EKM 2006

Entity	number of answers	mean value
Disconnector 36-170 kV	2	1.14
Disconnector 245 kV	1	1.30
Transformer substation 24-36 kV	1	8.00
Transformer substation 52-72.5 kV	3	3.89
Transformer substation 84-170 kV	3	3.89
Transformer 24/12 kV (note 1)	3	1.72
Transformer 72.5-84/12-24 kV	1	4.00
Transformer 123-170/36-52 kV	2	5.58
Substation switching bay 12-24 kV	4	1.29
Substation switching bay 36-72.5 kV	3	1.74
Substation switching bay 84-170 kV	3	1.74
Capacitor bank 12-84 kV	4	0.52
Capacitor bank 123-170 kV	1	1.00

(1) Voltage regulation transformer included.

Other entities were also within the survey, but without any answers, e.g. sea cable categories.

Correlations between answers

Correlations between the different questionnaires have been calculated. The aim is both to examine whether certain types of companies are over-represented and see the connection between objective conditions and different responses. Examples of indications:

- The desired detail level and assessment is basically uncorrelated with the category of DSO.
- The more knowledge, the more positive of EKM.
- Nothing indicates that the network companies have responded to the survey "tactically".

Survey B

Customer related costs were identified as extra important. Unfortunately, these costs are only roughly handled by current EKM. An additional survey was made, where all DSOs in the first survey that replied interest in continued participation were invited. DSOs have indicated in interviews that all customer-related costs could be divided into three categories: (a) billing cost, (b) customer service costs, (c) electric meter cost. Only a few companies have answered the survey. Estimated cost per customer and percentage distribution between cost categories differs significantly between companies; the choice may depend on several factors such as objective differences, cost effectiveness and ways to count. However, all companies indicated a much higher EKM (0.095, 0.188 and 0.456) than EKM 2006 (0.06).

CLOSURE

Conclusions

Current EKM have carefully been investigated and there are doubts about the reliability of existing measures. The recommendation (if EI decides to use an EKM-like model) became: Update all entities and/or reduce the portion governed by the EKM model in the first regulatory period.

Examples of results

- **Knowledge**: Initiation of activity among the DSOs to increase knowledge and awareness of EKM and future ex ante regulation.
- **Problem Identification**: Only a few DSOs have the current state of knowledge enough to be able to contribute with "sharp" suggestions for EKM values. Two identified areas with extra need of further studies are: 1) Customer-related costs, 2) EKM at higher voltage levels.
- **Suggested Action Plan**, i.e. future work
- **Indications**: The survey provides some indications.
- **Modeling**: There is a wide spread between survey responses regarding EKM. If this is due to objective differences is not possible to ascertain. It is therefore possible that the values of EKM should depend on more conditions than component category.

Consequence

Based on this study EI will not include EKM-like units in the first regulatory period from 2012.

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