REGULATION PARAMETERS IMPACT ON DISTRIBUTION BUSINESS REVENUE WITH FOCUS ON DIFFERENCES BETWEEN URBAN AND RURAL AREAS

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INTRODUCTION

The regulation of electricity distribution differs between the countries in Europe, giving different conditions for the actors on the market. The regulation methods are using different types of parameters to estimate the reasonable level of the distribution service tariffs and revenue. The choice and valuation of parameters are of ultimate importance for regulation of electricity distribution.

The objective of this paper is to identify the basic factors of low voltage networks, and determine the differences in value and costs for operating a low voltage network in an urban and rural network. This will indicate those aspects which are relevant to consider in the regulation of electricity distribution revenues and tariffs.

The comparison of the regulation methods in different European countries will also indicate in what way the regulation on the European market has to change to reflect the electricity distribution business in a significant way.

THE PERFORMANCE ASSESSMENT MODEL

The regulation of tariffs for the distribution services was changed from year 2004 in Sweden. Before 2004 the regulator supervised the distribution companies' revenues by comparing them to the company's costs. Since this method was more likely to give the companies reasons to raise their costs instead of decreasing their costs, the regulation was changed. Year 2004 a new model called the Network Performance Assessment Model (NPAM) has been used to evaluate the distribution tariffs [1].
In the new model the tariff is determined regardless of the utility's costs. The profit is what is left when the utility's costs are subtracted: *Profit = Tariff – Costs*

The NPAM is used to evaluate one utility at a time and consists of two main steps. First, a fictitious network is constructed, given the location and consumption of the customers as well as the connections to other networks. The fictitious network is constructed from network components such as cables and substations, but does not consider the actual layout of the network. The second step is to valuate the network. A capital base in calculated given the cable length and number of substations etc. and multiplying these figures with key figures of costs for these network components. Some adjustments are made depending on the density (customer/m cable) of the area. When the capital base is calculated the models can start calculating the "network performance" of the utility. The operation and maintenance costs as well as the cost for capital is calculated from the capital base, which makes the capital base a significant factor for the result of the utility. Costs for losses and costs related to metering and customer service are calculated using key figures. Finally the reliability of the network is also evaluated based on reported figures on SAIDI and SAIFI. When the utility's "Network performance" has been calculated the utility's real revenue for the year is compared to the network performance. The figure obtained from this comparison, "Extent of charge" should according to the Swedish Energy Authority be less than 1,0 for a cost effective utility.

$$\text{Debiting ratio} = \frac{\text{Network company's total revenue}}{\text{Network performance}}$$

The Debiting ratio is used as one of the main objective facts for the Authority's trial of a Network company's total revenue level.

STUDY OF REGULATION PARAMETERS IMPACT

Identified 5 core factors for low voltage network

A low voltage level has different structure depending on in what environment the network is built. A network in a rural area differs remarkably from a network in the countryside. In the countryside there are often room for overhead lines following the roads, and if cables are used they can be laid next to the road or over fields, only requiring ploughing the cable into the ground. In a city area the power cables must be laid in sidewalks that are covered with asphalt or paving stones. The laying of the cables must often be co-ordinated with the laying of other supplies as optical fibre, district heating etc. and must be placed on a special depth not to be effected by the other cables or pipes. The environment that the network is supplying is therefore a very relevant factor affecting the structure and value of the network.

A study was performed to identify the basic factors regarding the value of a low voltage network. Our urban low voltage network was examined and the assets and the cost elements were analysed deeply. Ten expansion projects were also analysed to find the costs generated when constructing the network by the different assets. Through these studies and analysis the following five factors for low voltage networks were identified:

1. Shaft for service connection cables
2. Service connection cables
3. Shaft for feeder cables
4. Feeder cables
5. Disconnection boxes

These five factors are the core of the network and the major costs and value of assets for a network are concentrated to these factors.

When comparing the value of the 5 identified factors for networks in different environment, the influence of the network environment on the cost of the network becomes clear.

In order to analyse the 5 basic factors a case study was performed on the central part of the city Uppsala in Sweden. Figures on length of cables, number and type of disconnection boxes and length of shafts were obtained for the studied area (See Table 1). The figures were allocated to the 5 basic factors. The length of the shaft for service cables were defined as the specific shaft for service cable excluding that part of the cable that is laid in the feeder cable shaft. It also excludes the length of the cable that is laid on costumer property.

TABLE 1 Case study of low voltage network in City environment

Low voltage network basic factors	Cables Length [m]	Shaft Length [m]	Nr
1 Shaft for service cables		16 938	
2 Service connection cables	48 920		
3 Shaft for feeder cables		39 185	
4 Feeder cables	74 200		
5 Disconnection boxes			376
SUM	123 120	56 123	

The factors giving the most evident difference in cost and value between rural and urban network is the shaft factors. The shafts (and also the cables) usually follow the streets in urban areas and are therefore much longer than the actual distance between the two points. But the main reason for the high shaft costs in an urban area is the infrastructure around the shaft and cables. The shafts have to be drawn under pavement and paving stones, and special roadblocks have to be used for the traffic. Usually it is lack of space on the construction site, which also increases the costs, as for example waste material has to be transported to other places. Since these factors do not have to be considered in a rural area, the cost difference in construction and therefore also the value of the network is different in an urban area compared to a rural area.

The existing model has only one basic factor for low voltage. By developing the regulation model with introduction of two network levels on low voltage for service cables and LV feeder cables, and to that disconnection boxes as object, it should be possible to make the model more transparent and objective. With that model design it should also be possible to take the shafts into consideration.

Costumer valued performance

Another way of presenting the difference in operating an urban network compared to a rural network is to consider the customer valued performance.

Some of the most important asset elements in a city network structure are disconnection boxes and service connection cables that in the present design of the Swedish regulation model, NPAM, has no representation at all in the fictive network as objects. The NPAM includes costs of disconnection boxes and service connection cables but the values and the frequency is insufficient. In order to be able to judge the Network performance of a city network in an objective way the network structure and the assets construction in the model must be developed. It's not possible to use the same model design as for rural areas because of the huge differences in the environmental conditions.

As presented in Table 2 the different network elements has different customer value in forms of number of customers and distributed energy. The disconnection boxes and service connection cables strategic importance can be illustrated by comparing the costumer valued performance of different network assets for city respectively countryside costumers. From the costumer point of view the disconnection box in a city network has about the same function and importance as a distribution substation on the countryside. It's about the same or even greater number of costumer and energy provided by a disconnection box in a city compared with a substation on the countryside.

TABLE 2 Assets customer valued performance

Distribution plant	Number of costumer	Energy MWh
Rural distribution		
▪ Primary substation 1 – 5 MW	1 000	15 000
Medium Voltage overhead or cable network		
▪ Pole-/ground substation 0,05 – 0,2 MW	10 - 20	150 - 200
Service connection and feeder LV cables		
Urban distribution		
▪ Primary substation 20 – 60 MW	10 000	200 000
▪ Distribution substation 0,5 – 2 MW	200 - 300	2000 – 3000
Low Voltage feeder cable network		
▪ Disconnection box	10 - 30	150 - 300
Service connection cables		

Urban area characteristics – costumer density

It is obvious that a measurement or parameter has to be created to determine the network environmental characteristics when regulating network business, since that effects the network structure and the cost. The Swedish Energy Authority has decided on a costumer density measurement for defining the environment of the network area. In the NPAM the costumer density is a decisive factor for determination of the geometrical adjustment factor and the cost per meter cable and cost per square meter of space needed for substations. In NPAM the costumer density is calculated by dividing the total length of cables with the number of costumers in the network area. In a study performed and presented previously in this paper it has become clear that it is not only the density that is decisive for the network structure but instead the environment of an area. Research was therefore performed to find a way of determining the environment characteristics instead of using the costumer density. In the research it was found that the Swedish National Land Authority (Lantmäteriverket) has identified all areas in the country considering their environment characteristics. The different area characteristics are indicated by different colors on the map. Examples of characteristics for urban areas:

- Compact formation of high buildings
- Area with high buildings
- Area of low buildings
- Industrial parks

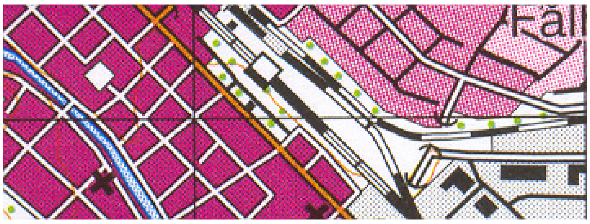

Figure 1. Example of geographic environmental colour codes in a city.

Since an independent authority has determined the characteristics for all areas in the country, there is no obstruction to use this method instead of the costumer density method in NPAM. The Swedish electricity sector's association, Swedenergy, has adopted the method and will use it in their next catalog of cost for network construction, operation and maintenance. The NPAM would give a more realistic representation of the network using the Swedish National Land Authority's determination of area characteristics than using the costumer density measurement.

COMPARISON BETWEEN THE URBAN NETWORK STUDY AND THE REGULATION MODEL

Asset value

As described in the previous chapters the difference in costs and asset value for rural and urban areas is vast. The Energy Authority acting as regulator in Sweden has approved of some difference in costs between rural and urban areas, which are included in their Network Performance Assessment Model. The differences included in the model are not by far comparable to the difference in reality. One of the reasons for the higher costs in urban areas is the cost for space in buildings or on expensive properties, when placing substations in a city environment.

Other costs that are higher in city environment are costs related to construction and maintenance. When cables are placed in the pavement or in the street, special road blocks has to be put up to restrain traffic, and sometimes special side walks has to be constructed for the pedestrians. The restoring of pavement and roads after the project's accomplishment is also a heavy cost element in a city environment.

To analyse the difference between the real costs for an urban network and the costs calculated in NPAM, a case study was performed on the central part of the city Uppsala in Sweden. Figures on length of cable and number and type of disconnection boxes were obtained for the studied area. The network components studied where the 5 basic factors presented in the previous chapters. Now costs for these factors needed to be calculated.

Ten project examples of laying cable in city environment were studied to develop mean cost values for the 5 basic factors being service connection cable, shaft for service connection cable, feeder cable, shaft for feeder cable and disconnection box. From the project examples a mean value for number of cables per shaft was calculated as well as the average cost for each of the 5 basic factors. When multiplying the key figures for costs from the project examples with the network structure for the study area in Uppsala the asset value for the area was obtained. This asset value is comparable to the "capital base" calculated in the NPAM.

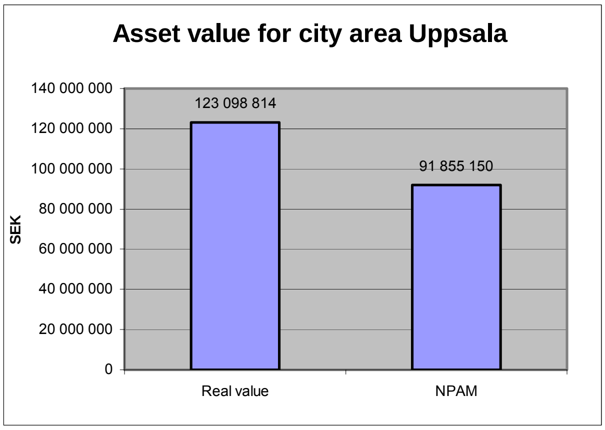

Figure 1. Actual asset value and value obtained in regulation model, NPAM.

The difference in asset value is 34%, and since the capital base in the NPAM is used to calculate the costs for operation and maintenance and capital costs, it has a great influence on the total "network performance value", which is finally calculated in the Network Performance Assessment Model. Since the difference between the real value and NPAM's value is more than 30%, even a very efficient network company would have difficulties to reach the performance level set by the model.

Theories for explaining causes to discrepancies

The defect of the model depends on several simplifications made in the model, which gives an insufficient result.

1. The model only refers to feeder cables, and has not included the Service connection cables. The “geometrical adjustment” factor is not sufficient and not explainable.
2. Shafts for cables are not included as an element, only a cost related to the cable length, which gives an insufficient result.
3. Disconnection boxes which represent an essential part of the network are not included in the model as an object.
4. There is no network structure defined in the model for LV network with disconnection box objects (like MV network with distribution substation object).
5. The costs for assets, especially in city areas, are unrealistically low.

These inaccuracies give errors in several levels of the model and give an incorrect result. Table 3 below is presenting the length of cable for the different network levels, in reality and as they are calculated in the NPAM:

TABLE 3 Comparison of cable length between real values and NPAM

Length of cables of studied network in Uppsala	Real Network (m)	NPAM *Factor 2,4 (m)
LV network	123 120	99 983
MV network	14 100	37 068
Total	137 220	137 051

* Factor with of authority decided parameters for 2003

The fictive network constructed in the NPAM consists of a cable network that is always laid the shortest distance between two points. The Energy Authority has been forced to add an adjustment to the cable length to make the lengths comparable to the actual cable lengths. The adjustment factor is 2,4 for the high-density area in this example, and the fictive cable lengths are multiplied with 2,4. For less dense areas a lower factor is used. The model is over compensating the medium voltage level network to compensate for not generating enough length of the low voltage network. These kinds of adjustments are making the model loosing its transparency and loosing the connection to construction and layout of the real networks.

DIFFERENT REGULATION PARAMETERS IN OTHER EUROPEAN COUNTRIES

The choice of regulation parameters is crucial for the regulatory framework, since the parameters gives incentives to the management how to run the electricity distribution company. Most obvious is the choice of regulation parameters concerning quality of supply. The regulation methods applied in European countries are using different types of parameters and gives different types of incentives for the distribution business.

Examples of regulation parameters used in Europe:

- Quality of supply
- Commercial quality
- Implementation of automatic meter reading, AMR

The regulation example in Italy has focused on Quality of supply and has parameters that give incentives to improve the Quality of supply in both south and north Italy [2]. The demands are different in south and north because great differences in present quality level and circumstances for the distribution. This situation can be compared with the case in Sweden where there are great differences in environmental conditions between rural and urban areas.

In several countries has quality of costumer service, administrative routines and service, costumer switching etc been pointed out as important parts of the regulatory framework (for instance in UK, Ireland, Spain and Portugal). The purpose with this quality aspect, named Commercial quality, is to give network companies incentives to improve or maintain the quality in this field that is essential for the function of the deregulated market. Different types of regulation parameters have been evaluated.

Another example of regulation parameter is concerning monthly meter reading and has been introduced of the Swedish regulator. This parameter is intended to give incentive for investments in automatic meter reading system that also has positive effects for a well working deregulated market.

CONCLUSION

The study performed on a network with rural area environments give strong indications of the difference in cost and value of operating a network in an urban area compared to a rural area. The five basic network factors identified in the study all represent large differences in cost and value for different network environment. It is also important to include the customer-valued performance since this strengthens the fact that an urban network has to bear higher costs than a rural network. The study conclude that it’s possible to improve the Swedish regulation model in order to get better representation of urban areas by introducing objects for disconnection boxes and service connection cables and by using an environment characteristic parameter instead of the costumer density parameter. In the regulation of the network business it is important to use reality based costs and values of operating a network in order to get a well functioning market.

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