REGULATION OF NORWEGIAN DISTRIBUTION GRID COMPANIES

Ivar Wangensteen,
Bård Uthus
SINTEF Energy Reasearch
N-7034 Trondheim, Norway
Tel: +4773597200
Fax: +4773597250
E-mail:
Ivar.Wangensteen@energy.sintef.no
Baard.Uthus@energy.sintef.no

Thor Andre Berg,
BKK
PB 383, N-5051 Nesttun,
Norway
Tel: +4755127000
Fax: +4755127001
E-mail:
Thor-Andre.Berg@bkk.no

Morten Rogn
SKK
PB 80, N-3901 Porsgrunn
Norway
Tel: +4735547500
Fax: +4735559750
E-mail:
Morten.rogn@skk.no

Jonas Kellberg,
Vattenfall AB
SE 162 87 Stockholm,
Sweden
Tel: +4687396032
Fax: +4687396655
E-mail:
jonas.kellberg@network.vattenfall.se

SUMMARY

This paper describes the Norwegian model for regulation of distribution companies. The present model was introduced in 1997, and is based on an income limit. Under this regulatory model grid owners are no longer guaranteed maximum profit, but it creates an incentive for reduced cost. The regulation model has now been in operation for two years, and so far the conclusions are mainly positive. The incentive-based regulation model has affected grid costs. Investments are substantially reduced. Operation and maintenance costs are also reduced. However, there are some major problems concerning the chosen regulation model, which are also addressed in this paper.

INTRODUCTION

Deregulation process

Deregulation and market competition was introduced in Norway with the Energy Act of June 1990. The act was effective from January 1991. It took some time to establish the necessary organisational structure, work out grid tariffs, etc. These arrangements were ready in May 1992 and since then there has been an open electricity market based on competition.

Regulatory framework

Based on the fact that transmission/distribution (T/D) is a natural monopoly, it was found necessary to impose some kind of regulation on prices and income. This is done despite the public ownership of the grids. The regulation was based on the assumption that the grid companies would develop towards profit seeking entities.

The institution responsible for regulation of the (T/D) activity is The Norwegian Water Resources and Energy Directorate (NVE). Governmental Regulations are proposed by NVE and decided on by the Government.

The documents describing the legal and regulatory framework are the Energy Act and Governmental Regulations; the current version is valid from 1999.

The Regulations cover the following subjects:

- *General provisions.*

This covers general objective, definitions, etc.

- *Provisions concerning Reporting etc.*

This contains rules and regulations concerning accounting and reporting to NVE on economic and technical data necessary to meet its needs as a regulator.

- *Income cap.*

The first regulation (before 1997) was based on a rate of return limit (Rate of Return (ROR) Regulation). This type of regulation is widely used, especially in the US. But it is generally recognised that it has serious drawbacks. It will not create useful and effective economic incentives.

The present regulation is based on an income cap [1,2]. The maximum future income is decided by looking at the present expenses and assumes a certain price rise and an efficiency gain. A more detailed description will be given later.

If the income limit is exceeded one year the tariffs have to be reduced next year

- *Tariffs.*

In Norway there is no direct control on prices or tariffs, but certain principles for tariff calculation are regulated. One of the provisions demands that the energy element of the tariff shall be tied to the marginal grid losses. The control of the tariffs is indirect in the sense that, as long as the income limit is not exceeded, the tariffs are not subject to any formal approval by NVE. Only after complaints from customers, NVE will interfere.

INCOME CAP REGULATION

The regulatory model implemented January 1. 1997 implies that grid owners are given an income cap with limits for maximum and minimum returns. This model treats each grid owner individually, by measuring the efficiency of each grid owner. The analysis model used for measuring the efficiency is called DEA (Data Envelopment Analysis). The model will be described later.

The following formula for income cap regulation is used:

$$IT_{e,n+1} = IT_{e,n} \cdot \left(\frac{KPI_{n+1}}{KPI_n} \right) \cdot \left(1 - EFK_{n+1}\right) \cdot \left(1 + \frac{\Delta LE_{a_{n+1}}}{2} \right)$$

where

IT	is the income cap
KPI	is the consumption price index
ΔLE	is the increase in transferred energy (decrease means ΔLE =0)
EFK	is the efficiency improvement requirement

This model is an incentive-based regulatory model. If a grid owner is able to reduce costs more than required efficiency improvement, the return on capital can be increased above the base rate. Likewise, cost increase will reduce the return on capital. Under this regulatory model grid owners are no longer guaranteed full cost recovery, but it creates an incentive for reduced cost. To avoid unacceptable profits, minimum and maximum annual return is set to 2 % and 15 %, In the Norwegian model the grid owners are therefor guaranteed full cost recovery.

NVE has decided that the income cap will be subject to a full assessment every five years, but the income cap as a principle will continue. The first regulation period is from 1997 – 2001.

Figure 1 shows how the income limit will develop

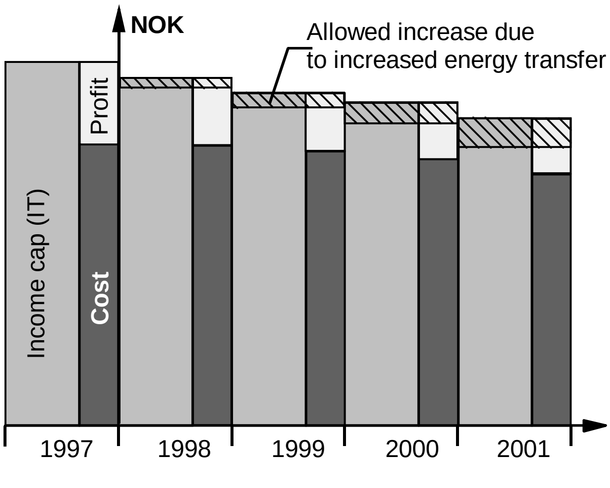

Figure 1 Development of the income cap with a given efficiency demand and increased energy supplied

The respective element in the regulation formula is discussed in the following sections.

CALCULATION OF THE BASE INCOME CAP ($IT_{e,0}$)

The base income cap is the income at the start of the regulation period (1997-2001). It is determined by the costs for each grid owner in two years prior to the regulation period (1994 and 1995), plus a standard rate of return, fixed by NVE to 7,5% for the present period. Figure 2 shows how the base income is calculated.

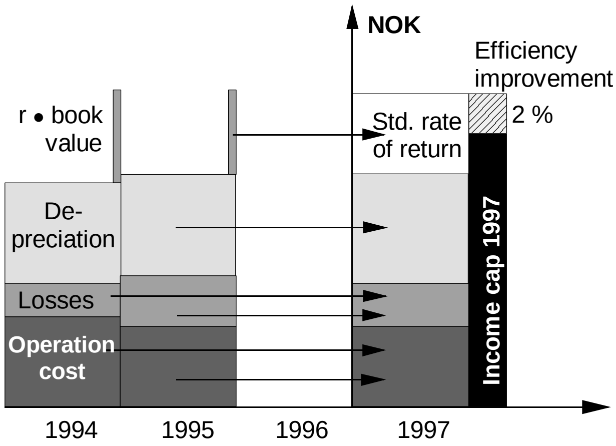

Figure 2 Calculation of the base income cap

The base income cap includes costs of losses, operation, maintenance and capital costs (depreciation plus interest). While the costs of operation, maintenance and capital costs are adjusted to the consumer price index, the cost of losses is adjusted to the actual energy price.

Costs imposed on the customer due to interruptions are presently not included. Therefore, the model does not have any economic incentives to maintain acceptable power quality.

Future regulatory requirement for the grid owners will probably include mandatory economic compensation for energy not supplied. This will increase the costs of the grid owners, and it has to be taken into account when the base income cap is calculated. The mandatory compensation will give the grid owner incentives to maintain and invest in the grid in order to keep a satisfactory quality of service. All details concerning this mandatory compensation are not yet decided.

As previously mentioned, NVE has used reported cost data for 1994 and 1995 to estimate the base income. The advantages of using the grid owner's own cost, are that each company’s different structure, characteristics and surroundings are taken into account. But some grid owners get a more narrow income cap than others, depending, among other factors, on how old the grid is. If the grid is old, needs for reinvestments are large in future years, but the grid owner will probably have a low income cap due to low capital cost in the base years. This may be a problem in the long run.

Grid costs are affected by external conditions, which in some cases are variable over time. One example is a new property tax imposed by the Government. It is important that the income cap is adjusted correctly for this type of changes.

MEASUREMENT OF TECHNICAL AND ECONOMIC EFFICIENCY (1 – EFK).

Depending on the measured efficiency, each grid owner has to reduce its income (improve its efficiency) year by year from 1,5 % for the most efficient grid owners to 4,5 % for the least efficient ones.

The link between the measured efficiency and the required efficiency improvement, can be explained by the following example:

The measured efficiency for a given utility is 78 %, which means that this utility must improve its efficiency with 22 % in order to catch up with the most efficient companies. But it is not expected that all this improvement potential will be reached in the current four-year regulating period. (The current formulae will be used in the period 1998-2001. In 2001 it will be revised). NVE has decided that 38 % of the potential improvement is a reasonable target. For the utility this means 8 % improvement through the four-year period, i.e. 2 % each year. In addition to this individual requirement, there is a general requirement of 1,5 %. For this particular distribution company the annual efficiency improvement required in the price cap formula is 3,5 %.

Present method

The measurement of technical and economic efficiency of the distribution companies, is done by comparing the performance of the companies and picking out "winners". Each individual company is compared with these winners. This is often referred to as a *best practice procedure.* The standard is set by the best-observed practice.

The applied technique is the so-called Data Envelopment Analysis (DEA) [3]. This is a technique where companies are compared with respect to how a set of input variables (production factors) "generates" a set of output variables (products) under certain external conditions. Figure 3 gives an illustration in a one-input-one-output case. Each point in the diagram represents one company. The best companies are the ones that produce maximum output for a given input (or require minimum input for a given output). These companies define the "front", which is shown in the diagram. The other companies are compared with this front.

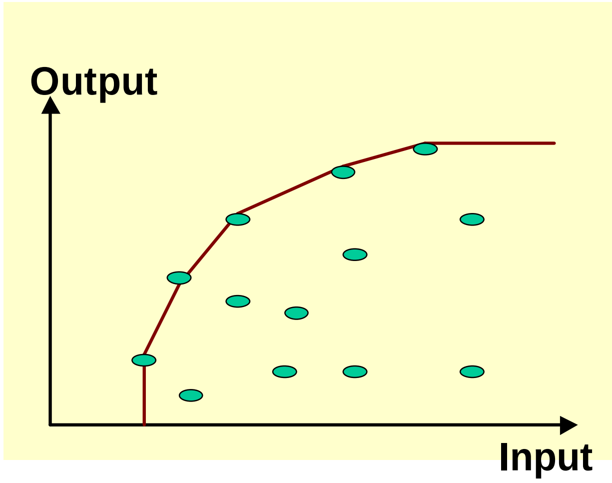

Figure 3 The best practice frontier in a DEA-analysis

The technical efficiency of a company can now be measured as the horizontal distance between the company's position in the diagram, and the front. Companies defining the front, are (pr. definition) 100% efficient.

A company's economic efficiency is calculated by using the total cost of the input variables i. e. the production cost (in stead of the physical quantities). The economic efficiency is always less or equal to the technical efficiency. In the Norwegian regulation model, this measured economic efficiency is used to calculate EFK.

The variables

The choice of variables is an important and difficult problem in this type of analysis. The following input variables are used:

- Labour
- Energy losses
- Capital
- Other input costs (cost of interruptions is not included)

The output variables, which define the "products", are in the currently used version:

- Energy transferred
- Number of customers

As external condition the present model uses:

- Length of power lines/cables

Strengths and weaknesses of the efficiency measurement model

The model has following strengths.

- It is possible to handle multiple-input/output production.
- Differences such as geographical conditions, load density and climate can in principle be taken into account.

- Makes it possible for different companies to be 100 % efficient considering their conditions.

The weaknesses are the following.

- The model demands many objects to be compared (in this case grid companies).
- The quality of data for the best companies is vital.
- A Company with substantially different input variables than the other utilities automatically becomes 100 % efficient.

In practical implementation following problems have been observed.

- It is hard to choose the right data.
- Difficult to measure capital costs.
- Difficult to find appropriate data that describes the external conditions.
- With the chosen data there is a strong correlation between input and output variables.

Ideally, the cost of capital should be easy to find from the accounting. Under the terms of the Energy Act, the grid companies are obliged to follow generally accepted rules of accounting. However, the accounting rules allow a certain freedom of choice. While some companies follow the practice of entering capital costs on the balance sheet as items to be depreciated over several years, other enter capital costs entirety on the current year's profit and loss account. There is a considerable variation in accounting practice of the grid companies. Because of the best practise procedure, this considerably influences the efficiency analysis. NVE has therefore also calculated today's value of an entire new grid, even if this is difficult too. Two analyses have been done, one with this value as a basis for use of capital, and one where the book value is a basis for the use of capital. The grid owners are given the highest measured efficiency of the two analyses.

The length of power lines/cables, split into three; high voltage and low voltage lines/cables, and sea cables, is used as output variables. There are in particular these output variables that have caused discussions. They are chosen to describe the external conditions. It is quite clear that one needs an output variable defining the size and type of supply area covered. But it is hard to find one that is relevant and can be measured precisely and objectively at the same time. The length of power lines/cables was finally chosen, after having tried other alternatives to represent the supply area characteristics.

One of the problems using length of power lines/cables to describe external conditions is that it can be influenced by the utility. Inefficient investments may lead to "a lot of" external conditions. Another problem is that this variable also represents the bulk (but not all) of the capital cost. Thus, there is a close relationship between the production cost and the length of power lines/cables. This has certain implications on how investments affect the measurement of efficiency. Most of the utilities, especially the inefficient ones, take advantage of this relationship.

Quality of power supply is not used as a parameter so far due to lack of data. If a compensation for energy not supplied is introduced, this cost can be used as input in the analysis.

This model of measuring efficiency is interesting since it has the advantages of multiple input/output and considers environmental variables. However, it can be questioned if the model is accurate enough and is able to consider all facts for each company to regulate their incomes.

Possible future procedure

As explained above, the present procedure has proved to have some serious disadvantages. During the present regulating period this will be in focus, and in the following we present some ideas we are working on.

Firstly, we think a split between short-term and long-term efficiency would be advantageous. Long-term efficiency is tied to investments, and inefficiencies caused by wrong investments can only be affected in the long run. That should be reflected in the required yearly efficiency gain, if that type of inefficiency can be demonstrated. We also think that kind of inefficiencies are extremely difficult to demonstrate and we have strong indications that the present procedure is unable to do this correctly.

Secondly, we are looking for alternatives to the DEA-model. A regression model of some kind might be a better alternative. A regression model offers possibilities for dealing with uncertainties in a rational way. It will not have the disadvantage of the DEA-model where some of the grids, the extreme ones, will always come out as 100% efficient.

INCOME INCREASE DUE TO EXPANSION OF THE SUPPLY $(1 + \Delta LE/2)$

The base income ($IT_{e,0}$) shall cover losses, operation, maintenance and capital costs of today's grid. A major problem with any incentive-based regulation of natural monopolies is how to deal with new investments. If there is an expansion of the system, i.e. increased demand for transfer, the income cap must be raised in order to cover the resulting increased costs. In the formula, the term $(1 + \Delta LE/2)$ accounts for that. ΔLE is the yearly increase of transferred energy. The formula is based on an assumption that total costs increase half as much as the increase in transferred energy. For example, when the supplied energy increases by 10 %, the income cap will increase by 5 %. This *scale factor* of 1/2 has been determined by NVE. There are some major problems concerning this scale factor.

There is a discussion regarding the size of the factor. In the present model, the factor 1/2 is used for all grids, distribution as well as transmission. NVE has not yet made any investigation of the actual economies of scale in the grid business, but earlier analysis [4] indicate that the factor should be somewhat higher than 1/2 for distribution grids, and still higher for transmission. We are also looking for better alternatives than supplied energy. Elements like number of customers and power supply, kW, could give a more accurate formula.

Ideally, each investment should be regulated separately, but this is not a realistic option for distribution companies due to the large number of investments. A next step would be to handle each utility separately. All distribution utilities should not necessarily have the same factor. There are obvious differences between them. For example, increased energy transfer through a heavily squeezed system will require larger investments than in systems with considerable free capacity.

There is also a danger that this compensation may result in only specific kinds of investments. The grid owner wants business profitability in each investment, and will avoid unprofitable kinds of investments if possible. If investments are socio-economically profitable, the Energy Act states that investments should be done. It can therefore be a conflict between the Act and the regulation model.

Finally, this factor is the only way for grid owners to raise their income, and it gives therefore the utilities an incentive to transfer as much energy as possible. This can create tariff-structures that are not cost-based, etc. One way to reduce investments in the grid, is to use DSM. By means of DSM one can delay, reduce or omit an investment. The problem with DSM is that if this attempt reduces the total energy supplied, the grid owner will loose some income due to the lower income cap (if the income cap is an effective constraint). This will represent a disincentive for DSM directed towards general energy conservation.

CONCLUSIONS

The present regulation model has now been in operation for two years, and the conclusions so far are mainly positive. The incentive-based regulation model has affected grid costs. Investments are substantially reduced. Operation and maintenance costs are also reduced. At the same time, there is also a move towards more profit seeking grid owners. We have seen and will see even more grid owners wanting to merge to boost efficiency and profit.

The regulatory model will probably have the following effects:

- Reduced transmission tariffs and therefore also reduced customer cost
- Restructuring of the industry, as company size, number, organisation and ownership
- More profit seeking grid owners
- Privatisation of operation and maintenance

However, there are some major problems concerning the chosen regulation model.

The most important element in the regulation formula is the basic income cap ($IT_{e,o}$). This element is based on reported cost data for 1994 and 1995. Depending, among other factors, on how old the grid is, some grid owners can get a more narrow income cap than others. This will influence the ability to survive as an independent grid company, even if the company behaves effective. It is also important that the formula includes incentives to maintain satisfactory quality of supply. If not, the model gives incentive to reduce invest and maintenance costs at the sacrifice of quality of supply, not optimise the quality against investment and maintenance costs.

The Norwegian regulation includes an individual efficiency measurement. Because it is an individual measurement, it must be reasonably accurate. Analysis done on the chosen DEA-model shows that this is not always the case. This is due to both the model and the chosen input data. In the long run, this will lead to unfair individual regulation. A focus on methods that split between short-term and long-term efficiency should solve some of the problems, but alternatives to the DEA-model should also be considered.

The last element in the formula is the income increase due to expansion of the supply ($1 + \Delta LE/2$). Analysis so far indicates that if supplied energy is used as the only explanation for income increase, the scale factor should be more than 50 %. Future activities will try to document this. We are also looking for better alternatives than supplied energy. Elements like number of customers and power supply, kW, could give a more accurate formula.

It is important that the major problems discussed in this paper are taken into account. The model should be adjusted before a new regulatory five-year period. Therefore, we have three years to achieve improvements.

REFERENCES

[1] Wangensteen, I., Uthus, B: “Will the bench-marking and measurements on efficiency of the distribution network companies affect DA/DSM?” NORDAC 98, Stockholm.

[2] Grasto, K: “Incentive-based regulation of electricity monopolies in Norway”. World Energy Council 98, Houston.

[3] Farell, M. J: “The measurement of Productive Efficiency”. Journal of the Royal Statistical Society, 1957, 120, 449460

[4] Wangensteen, I., Dahl, E.: “An investigation of distribution costs by means of regression analysis” IEE 89 TD 420-1 PWRD 1989