Regulation and quality of energy-distribution networks

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Abstract

Energy-distribution networks in many countries have been regulated for a number of years. These regulations mostly focus on efficiency, but in some cases they also include incentives for quality. In several countries, the overall short-term effects of regulation seem to be positive: efficiency of the distribution networks has improved, while the quality of the networks is unaffected or has even improved. However, uncertainty exists about the long-term effects of incentive regulation. This paper addresses the consequences of the long-term nature of investments in electricity networks for the regulation of quality.

The paper describes the regulatory regimes in the Netherlands and a number of states in the USA and analyses the relationship between regulation and quality. The paper concludes that because of the time lag between investments and its effects on quality, incentive regulation faces a high risk of resulting in suboptimal quality levels. The best option to reduce this risk seems to be a system of ex ante assessment of investments based on cost-benefit analysis from a welfare-economic point of view.

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1. Introduction

1.1 Background

Energy-distribution networks in many other countries have been regulated for a number of years. Regulation schemes vary from traditional forms like cost of service or rate of return regulation to advanced schemes giving higher power incentives for efficiency and quality. The effects of these schemes on efficiency and on prices have been extensively studied. There is more literature on other networks, in particular telecom, than on electricity, but both come to similar conclusions: incentive regulation, in its various forms, is generally associated with significant improvements in operating efficiency and often but not always associated with price reductions.[2]

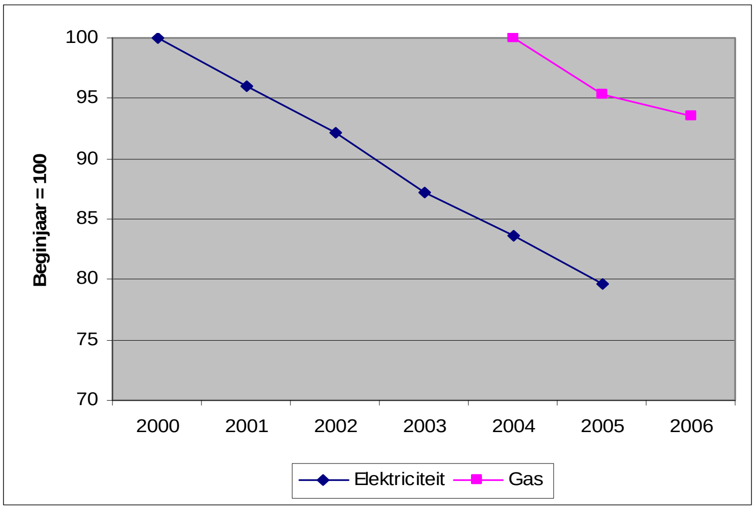
Incentive regulation may also strengthen, however, incentives for quality reductions. This topic has been the subject of a significant amount of research in the telecom industry, and to a lesser extent in electricity. In telecom, work by Tardiff and Taylor (1993), by Clements (2001), and by Ai et al. (2004) illustrate the range of conclusions. Tardiff and Taylor find no impact of incentive regulation with service quality provisions, while Clements concludes that both incentive regulation and service quality standards are associated with lower quality. Ai et al. (2004) report significantly higher quality on some dimensions but equally significantly lower quality on others.

Quality of electricity service has long been a matter of interest in the United States, but there has been only a little systematic effort to address it. Part of the reason is that local distribution service is subject to state rather than federal regulation, leaving each state to address service quality only to the degree and in the manner of its choosing. The other reason is that the data necessary to evaluate service quality have not been available on a consistent basis across the various states in the U.S. over time.

[2] Sappington and Weisman (1996) survey the telecom literature. In electricity, a key reference is Berg and Jeong (1991).

In the Netherlands, the effects of incentive regulation are closely monitored. It appears that the efficiency of the distribution networks has significantly improved, while the quality of the networks seems to be unaffected. In other words, the costs per unit of output have decreased, while the number as well the size of disturbances are still at a relatively low level and haven't changed much over the past years. Figure 1 shows that the costs per unit of output of the electricity-distribution networks decreased by 20% over the period 2000 – 2006. These efficiency benefits were (in principle fully) passed on to consumers via reduction of tariffs of distribution. Zijl et al. (2008) estimate that the cumulative benefit for consumers since the off take of price-cap regulation in 2000 up to and including 2007 amount to approximately 2.5 billion Euros. In the coming years, tariffs for consumers will be further reduced due to improvements in efficiency which have recently been realised (NMa, 2008).[3]

Figure 1 Efficiency (measured by costs per unit of output) of distribution networks in the Netherlands, 2000 – 2006 (2000 = 100)



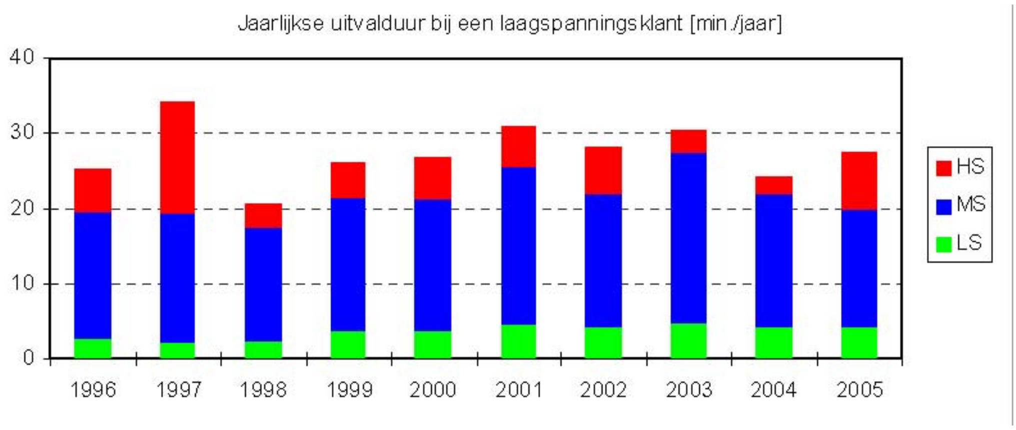
Source: Zijl et al. (2008)

[3] Because of the Dutch regulatory system, efficiency improvements in the current regulatory period determine tariffs in the next one.

Figure 2 shows the development in quality of the supply of electricity to customers in the Netherlands, measured by the average total duration of interruptions per customer per year. It shows that the quality of supply was rather constant over the last decade. On average, customers faced supply disruptions during about 25 minutes per year in all years, which is an outstanding performance compared to many other countries (see ERGEG, 2005).

Figure 2 Average total interruption of supply per customer per year (SAIDI), 1997 – 2006

(in minutes per customer per year)



Source: KEMA Consulting (2006)

(Legenda: HS, MS and LS stand for high, medium and low voltage networks)

The key question in the Netherlands now is whether the currently high level of quality of the networks will be maintained in the future. This concern stems from two factors: firstly the relatively low level of replacement investments done by the network owners and secondly, the absence of strong incentives for quality in current regulation. KEMA (2006) states that the relatively low level of replacement investments over the past period has resulted in a severe aging of the grid. As a result, the quality of the grid itself is threatened if investments remain at the currently low level. Regarding the current regulatory regime, several authors have argued that it is insufficient to safeguard the reliability of the distribution networks in the future. Meulmeester (2008), for instance, states that the system of incentive regulation in the Netherlands makes that network operators postpone their investments, resulting in a deterioration of quality in the future.

1.2 Research questions, scope and method

The paper focuses on one component of quality of networks, notably continuity of supply. The other two aspects of quality of supply, i.e. commercial quality and quality of voltage are ignored, as the current debate, at least in the Netherlands, mainly focuses on the continuity of supply. For the sake of simplicity, the analysis is directed at electricity networks, although the same questions could also be discussed for the gas networks.

The fundamental issue in quality regulation is the very long time horizon for investments promoting service quality. In electricity these might have life times up to 50 or even 100 years. This long-term dimension might complicate incentive regulation for two reasons. The first is that the future effects of current activities are highly uncertain, making it inherently difficult to determine the optimal level of financial incentives to be given. The other reason is related to the assessment of future effects by economic agents. If those agents are myopic, they take suboptimal decisions. In this paper, we analyse to which extent this issue is relevant for the relevant of electricity-distribution networks. The key research question to be answered is: what are the consequences of the long-term nature of investments for the regulation of quality?

1.3 Structure of the paper

The paper starts by given an overview of quality regulation in the Netherlands and in a number of States in the USA (section 2). To which extent and in which way have they implemented regulation to assure the future quality of the energy networks? What were the effects of regulation on quality and what are the key issues of debate? Next, the paper proceeds by giving an overview of some empirical findings in the economic literature on the impact of incentive regulation on quality (section 3). Afterwards, the paper first deals with a number of general topics in designing incentive schemes (section 4), before discussing the consequences of the long-term dimension of infrastructure for regulation (section 5). Finally, the paper concludes by exploring the options for regulation to deal with this long-term dimension (section 6).

2. Experiences with quality regulation in the Netherlands and the USA

2.1 Introduction

The section analyses experiences with regulation of electricity-distribution networks in the Netherlands as well as in several states of the United States. To which extent and in which way have they implemented regulation to assure the future quality of the energy networks? What were the effects of regulation on quality and what are the key issues of debate?

2.2 Netherlands

Regulation of the energy-distribution industry in the Netherlands took off a decade ago (Zijl et al., 2008). During this period, the method of regulating has been developed into a fairly sophisticated tool to determine transport tariffs and to monitor the activities of the network operators. The current system of regulation consists of an incentive scheme plus a set of additional supervisory measures.[4]

The incentive scheme is characterised by price-cap regulation using yardstick-competition to give incentives for both efficiency and quality.[5] Network operators face a bonus (malus) (in the next regulatory period) if their efficiency is above (below) the average efficiency of all operators (in the current period). The same holds for their relative performance in quality, measured by the average duration of disruption per customer per year (i.e. SAIDI).[6] An extra incentive for quality results from compensation payments which operators have to pay to specific customers which have faced a disruption in power supply.

[4] The Dutch system of regulation of the energy-distribution system is comparable to the Norwegian scheme. That scheme also comprises price-cap regulation (CPI) plus incentives (x-factors) for efficiency based on yardstick competition as well as incentives for quality. The Norwegian quality regulation is based on targets for the overall reliability performance of the networks.

[5] The instrument of yardstick competition is chosen as this method is viewed to give incentives which are comparable to those given in a competitive market (NMa, 2008).

[6] For a number of reasons, SAIDI is used as the key indicator in regulation quality in the Netherlands (NMa, 2008). Firstly, as SAIDI (total duration) is the product of CAIDI (average duration) and SAIFI (frequency), it includes several quality dimensions. Secondly, SAIDI is easily measurable in a consistent way. Thirdly, SAIDI had already been recorded for a number of years when the scheme of quality regulation was implemented.

Additional supervisory measures are formulated in the Dutch Electricity Law, which obliges network operators to secure the safety and reliability of the grid and to guarantee that electricity can be efficiently transported. In order to enable the regulator to monitor this task, network operators have to submit bi-annually documents on the quality and capacity of the network.[7] In these documents, the operators have to report their targets as well performance regarding SAIDI, CAIDI and SAIFI, to give their assessment of future utilisation and quality of the infrastructure and to explain which measures they are going to take to realise their targets. The regulator assesses these documents, mainly checking whether it give sufficient information.

Effects

As was mentioned in section 1, the incentive scheme has positively affected the productivity of the network management. The costs per unit of output decreased by about 20% over the period 2000-2006, while also the most recent years show declining costs per unit of output (NMa, 2008). This rise in the efficiency of the networks is caused by improvements in the efficiency of both operational costs and capital costs. The latter effect results, however, partly from the absence of investments as this reduces the economic costs of the asset base.[8] Although this reduction in economic costs does reflect changes in the real world, i.e. the aging of the infrastructure, it is also closely related to accounting rules which are legally prescribed.

The quality performance of the Dutch electricity-distribution networks remains to be at a relatively high level, compared to many other countries (see e.g. ERGEG, 2005). The average total duration of disruptions (CAIDI) currently is approximately 25 to 30 minutes per customer per year, which level has hardly changed over the past decade (KEMA Consulting, 2006).

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[7] In Dutch, KCD's: Kwaliteits en Capaciteitsdocument.

[8] After all, the regulatory asset based (RAB) is a function of investments on the one hand and depreciation on the other. If network operators do not invest (in replacing the existing infrastructure) while annual depreciation continue to reduce the value of the assets, the RAB will be lower (in the next regulatory period). As a result the economic costs as well as the tariffs will be reduced in the next period.

Issues of discussion

The discussion in the Netherlands on the reliability of the electricity-distribution grid focuses on two issues: investments and quality standards.

It is said that the current regulatory regime postpones necessary investments in replacing (components) of the infrastructure. Meulmeester (2008) states that the yardstick scheme used for determining the x-factor creates a prisoner's dilemma Although the regime does reward investments by raising the RAB (in the next regulatory period), it also stimulates network operators to postpone investments as long as other operators do not invest. After all, network operators which invest will face higher economic costs, while operators not investing don't. Because of the yardstick competition, the latter group faces an x-factor (i.e. reduction in tariffs) which is smaller than the improvement of efficiency actually realised, generating a net benefit for this group. The former group (which has invested), on the contrary, sees an x-factor which exceeds the improvement of efficiency actually realised, resulting in a net loss for this group.

The postponement of investment because of the prisoner's dilemma is expected to be temporarily as the same mechanism will create a wave of investments (Meulmeester, 2008). When one operator has taken the lead to invest more, others will follow soon. Such a wave of investment creates another difficulty: given the existing regulatory scheme, tariffs need to increase significantly, but that might be opposed by politicians wanting to protect consumers from (further) increases in energy prices.

Another explanation for the postponement of investments is given by KEMA Consulting (2006). These consultants conclude that the time horizon of network operators is relatively short compared to the lifetime of the infrastructure. In making their risk assessment, some operators seem to focus on the next two years, thereby ignoring long-term effects of their decisions. For instance, several network operators have insufficiently analysed how the future investments can be financed. As the lead time of investments[9] exceeds this period, the reliability is viewed to be challenged by this myopic behaviour.

[9] Including the time needed to settle the financial means and acquiring the additional personnel.

The authors attribute this short-term orientation to, on the one hand, the incentives for efficiency (x-factor) and, on the other hand, the ineffectiveness of the existing incentives for quality, i.e. the q-factor and the compensation payments. Referring to interviews with network operators, they conclude that the quality incentives only affect short-term operational decisions. The consultants therefore conclude that additional specific measures are needed in order to safeguard the reliability of the distribution grid.

The second issue of debate is the determination of quality standards. Currently, the network operators determine which targets should be pursued. The regulator only monitors whether the operators have formulated targets and to which extent they execute activities to realise these targets. Moreover, the q-factor in the incentive-regulation system is based on the relative performance, making quality regulation a zero-sum game. If all network operators show the same performance in quality, no operator faces a bonus or a fine for quality. The question is whether the government should formulate the level of quality to be pursued or that a system of quality incentives is sufficient to generate the optimal (welfare-economic) outcome.

2.3 United States

Quality of electricity service has always been important in the United States, but until fairly recently, it has not been a matter of special policy concern. The reason is that traditional rate of return regulation provided a lot of direct oversight and control over service issues (as well as the price-cost relationship), to that additional methods were not necessary. With industry restructuring, however, as well as with the greater use of incentive regulation and with some examples of major service problems, states have begun to pay more attention to service quality issues. At present, 38 of the 51 U.S. jurisdictions (50 states plus the District of Columbia—all of which will be called “states” for simplicity) have in place some form of service quality regulation. Fourteen states rely upon simple monitoring, while four set quality targets, and the remaining 20 have explicit penalties for quality shortfalls in their plans.[10] It should be noted that even in the remaining 13 states there are often some informal monitoring and oversight of quality.

A considerable number of service quality plans have been adopted in the context of mergers between distribution utilities.[11] As those utilities required state PUC (Public Utilities Commission) approval; the commission imposed as a condition some form of quality surveillance in order to ensure maintenance of service quality. Most states with quality monitoring focus on system reliability. Standard measures are the frequency and duration of service interruptions (SAIFI and SAIDI, respectively), which are require by most states. Reports of momentary average interruption (MAIFI), increasingly important because of home computers and other sensitive electronics, are required in 11 states. Disaggregated reliability indexes—at the circuit level, for example—are required in 28 states. A few states impose system restoration standards that go beyond outage duration.[12]

Another noteworthy phenomenon is that among plans that provide for penalties/rewards, penalty-only plans are somewhat more common. This is likely due to the fact that many of the penalty/reward plans originated with mergers, where the concern was with maintenance of current quality and protection against its reduction, rather than improvement in quality. Penalties may take a number of forms:[13]

(a) absolute penalties, for example, $2 million per one minute increment in SAIDI up to some maximum.

(b) per customer penalties, for example, $1 per customer for failing to meet each service standard.

(c) customer payment per occurrence, for example, $25 credit per occurrence to customers with more than X interruptions in Y months.

[10] PEG, 2007.
[11] PEG lists 31 mergers that resulted in the implementation of quality regulation.
[12] Apart from reliability, a number of states monitor and/or have standards for customer service. These include timeliness of service connections, telephone service indicators (e.g., speed of call answering), meter and billing indicators, and customer satisfaction or complaint measures. Most plans utilize their measures of utility service quality to track such quality over time, that is, implicitly against some base period. There appear to be essentially no examples of the use of benchmarking in U.S. experience, although Massachusetts at one point undertook serious consideration of this before rejecting it as infeasible. PEG notes isolated cases where employee safety was benchmarked, perhaps because of the availability of consistent data across companies.
[13] EEI, 2005

Performance

The effects of incentive regulation in the United States are generally viewed as positive. This view, however, is largely based on some evidence with respect to costs and prices. Less evidence exists regarding the quality effects of incentive regulation, or regarding the effects of adding provisions concerning quality to incentive regulation. As noted above, fully two-thirds of states within the U.S. have been sufficiently concerned about such quality effects that they have adopted some form of quality regulation. A number of them have instituted monitoring and measuring procedures, but these are not standard across states nor in some instances over time. The result is that it is not easy to summarize this experience.

Issues of discussion

The U.S. experience has raised a number of issues. Among these are the following.

First, the various states of the U.S. lack a common definition and measurement of quality. Standard indexes such as SAIFI and SAIDI are widely but not universally used, and even these metrics can be defined differently.[14] Moreover, different of these metrics receive different degrees of emphasis in various states. Some states go well beyond reliability standards and into measures of customer service itself. The lack of standardization handicaps comparisons of performance as well as efforts at common reforms.

Second and in addition, U.S. jurisdictions have substantial heterogeneity in their underlying structural characteristics and therefore in their electricity distribution systems. They differ in size, urbanization,

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[14] For example, even SAIFI and SAIDI are subject to different interpretation since each requires identification of an outage. There is consensus that certain major events such as hurricanes should be excluded since their effects are more exogenous than endogenous, but that observation has simply raised the issue of what constitutes a "major event." An effort was made in 2002-03 by the Institute for Electrical and Electronic Engineers to standardize the definition of "major event days," but the IIEE Standard 1366 has met with only partial acceptance.

demographics, terrain, and other features that affect the cost and desirability of service quality. This implies, among other things, that the optimum level of quality in each jurisdiction need not be the same—indeed, is not likely to be.

A third issue concerns the consequences of falling short of the intended standard. Again, practice across the U.S. states varies enormously, with some plans simply involving reporting without explicit consequences, while others impose actual penalties for falling short of stated standards (and less often, rewards for exceeding). There is a clear lack of consensus as to what is the best approach—or perhaps, whether any single approach is suitable.

A fourth issue raised by the U.S. experience concerns the root problems of quality regulation, namely, uncertainty and myopia. As will be discussed further below, uncertainty with respect to the outcome of investment decisions, and possible myopia by owners or regulators of the utility represent obstacles to the effective operation of incentive regulation. States in the U.S. have had to develop methods of adapting simple incentive regulation methods to accommodate concerns with service quality. We shall discuss this further below.

3. Effects of incentive regulation: empirical evidence

3.1 Introduction

Both theory and empirical work on incentive regulation of energy networks has focused more on cost and price effects rather than on quality outcomes. This is not surprising since cost and price are the core issues of incentive regulation and it is important to understand their key effects. And in fact, the literature concludes that incentive regulation, in its various forms, is generally associated with significant improvements in operating efficiency and often but not always associated with price reductions.[15] This is not at all surprising since incentive regulation creates higher power incentives for

[151515] Sappington and Weisman (1996) survey the telecom literature. In electricity, a key reference is Berg and Jeong (1991). See also Sappington (2005).

cost reduction than traditional cost of service or rate of return regulation. The effects on quality have received much less attention. Below, we summarize the conclusions of studies of the USA as well as Norway.

3.2 Empirical analysis of effects in USA

With respect to cost and price effects, studies generally find beneficial effects from incentive regulation. This is the basic finding of Sappington and Weisman (1996) with respect to telecom. For electricity the evidence is sparset but studies such as that by Berg and Jeong (1991) certainly suggest a favorable effect here as well. Quality effects in electricity have been analyzed by Ter-Martirosyan (2003), who compiled data on the frequency and duration of outages at 78 major distribution utilities in the U.S. between 1993 and 1999. This work is also notable for its examination of the effect of incentive regulation on operations and maintenance expenses, which is a likely intervening variable in the relationship between incentive regulation and the final quality outcome, and also of the possible endogeneity of incentive regulation and quality standards. Controlling for several other influences, Ter-Martirosyan finds that incentive regulation results in increased duration of outages, but not in their frequency. Importantly, use of quality standards appears to offset the increased outage duration, and incentive regulation plans with explicit sharing provisions between consumers and the utility further enhance service quality. Correction for endogeneity reduces the magnitude of the effects, but not their signs or statistical significance. Consideration of O&M expenses finds a significant reduction in the presence of incentive regulation, and further that such reduced O&M results in increased duration of outages.

3.3 Empirical analysis of effects in Norway

In an empirically analysis of the effects of regulation of the Norwegian energy-distribution network over the period 1995-2001, CPB (2004) finds that price-cap regulation had a negative effect on costs, while the effects on the reliability of the network were mixed. While the incentive regulation resulted in a deterioration of quality measured by duration as well as number of the disruptions, it had a positive effect on reliability in terms of ENS (i.e. “energy not supplied”). The authors explain this result from the fact that "companies are not willing to incur the revenue losses that may result from under-performance on this particular indicator". A reduction in the energy supplied would result in a decrease of total returns, which appeared to be an incentive for the network operators to take the level of energy supplied into account.

Regarding the effects of quality regulation on quality, the authors found a positive effect on quality measured by ENS and the total number of interruptions. So, both the price-cap regulation and quality regulation improved the reliability of the distribution network when measured by ENS. In addition, the authors discovered different effects when distinguishing notified interruptions, resulting from maintenance, from non-notified ones, resulting from accidents. It appeared that the impact of regulation on notified interruptions was relatively large, which might "reflect changes in the behaviour of the companies with respect to maintenance".

Burger and Geymueller (2008) also find that explicit quality provisions improve the outcome under incentive regulation in their study of Norwegian electricity distributors.

4. Designing incentive schemes

4.1 Introduction

The foregoing review of experiences in the Netherlands and several states in the USA show that there exist of a number of issues in regulating quality of distribution networks. Here, we briefly discuss some issues which are related to designing incentive schemes, i.e. the economic rationality behind such schemes, and parameters for designing schemes.

4.2 Economic rationality behind incentive schemes

In defining any incentive scheme for quality, two economics principles are important to recognize: First, any economic entity will pursue the course of action for which it is rewarded. Second, quality is generally harder to measure, and perhaps even to observe, than is price. The implication of these two principles is that a regulatory regime that provides high-power incentives for low cost will induce the rational utility to conserve on costs to the maximum extent possible. The utility will eliminate all unnecessary costs for given quantity and quality of output, since that will raise profits dollar-for-dollar. The elimination of those unnecessary costs (so-called "X-inefficiency") are socially desirable and, of course, the very point of incentive regulation.

But these high-power incentives will cause the utility to take other actions with different consequences. The utility will also eliminate costs necessary to produce quality insofar as the resulting quality reduction does not cause a larger reduction in revenues that in costs. As is well known, this criterion of private profitability results in lower quality than socially desirable, essentially because the social benefit exceeds the private (profit) benefit. There are, of course, limitations on the utility's motivation to reduce quality even in this context. Quality may be highly valued or inexpensive to provide, so that reduction in quality quickly becomes unprofitable to the utility. Another restraint on quality reduction might be alternative providers of the service, or some substitute for it. The existence of such alternatives will increase the rate at which revenues of the quality-reducing utility decline, thus preserving incentives for higher quality.

The economic principles underlying quality maintenance through regulation are as follows.

(1) Quality is costly and should be maintained only to the point where its marginal social benefits equal its marginal costs.
(2) The costs—and likely the benefits—of quality maintenance will differ across time and place.
(3) Regulation itself imposes costs both on the utility and society.

It is against these three principles that methods for addressing service quality issues—information reporting, target or standard setting, and penalties/rewards – should be assessed.[16]

[16] See Ajodhia and Hakvoort (2005); EEI (2005); and PEG (2007). As noted, 14 states in the U.S. rely simply upon monitoring and reporting, while four set quality targets and 20 utilize penalties and rewards (PEG, 2007).

4.3 Parameters for designing schemes

In principle, incentives for quality management can be given in several ways. Ajodhia et al. (2004) distinguish indirect instruments, standards and incentive schemes. Indirect instruments include a variety of approaches such customer representation on advisory boards, public ownership of the networks and making the network vulnerable to public criticism. Standards determine minimum performance levels, on group or individual level. Incentive schemes can be seen as combinations of standards and a system of financial rewards and fines.

The effectiveness of any incentive scheme depends partly on the indicators chosen. It appears that the relationship between quality regulation and reliability is not straightforward, depending on the quality indicators used (see e.g. CPB, 2004). After all, quality (i.e. continuity of supply) has many dimensions which can be reached at different costs. Realising quality in one dimension can be more efficiently realised than in another one. Moreover, in designing a scheme of quality regulation, it is key that the quality targets are contractible (CPB, 2004). The disturbance has to be easily measurable while the responsible party has to be identifiable. As not all dimensions of quality meet these criteria, quality regulation generally is only directed at a limited number of dimensions. Several missing factors might be important for future reliability of supply.

Another important parameter in an incentive scheme is the determination of the critical value of the standard. In some countries, including the Netherlands, yardstick competition is used: the critical value is set on the average level of the group (see section 2). It is said that a system of the yardstick competition might result in a prisoner's dilemma (Meulmeester, 2008; see section 2), but is this argument valid? In a prisoner's dilemma the dominant strategy of all players is choosing a strategy which results in inefficient outcomes on group level. Translated to the case of investments in networks, each player would choose the strategy of not-investing no matter what they expect the others are doing. However, if a player expects that other players are going to invest, he would also invest as that would more profitable for him. After all, the investments will be reimbursed through the increase in the RAB, while he will not be 'punished' by a x-factor which exceeds his improvement in efficiency. Hence, the argument that yardstick competition results in a prisoner's dilemma and, hence, in efficient outcomes (for quality) is not true.

5. Incentives for quality: dealing with the long-term dimension

5.1 Introduction

Investments in electricity networks differ from many other activities because of the long time span during which the effects occur. Investments in network have long life times up to 50 or even 100 years. This long-term dimension of investment may complicate incentive regulation since incentive regulation works best when the outcome—higher profit—is closely tied to the action that caused it (e.g., a cost reduction). But with respect to quality, the cause—investment that affects reliability--and the effect on that reliability may be separated in time. To see what difference this separation makes to the operation of incentive regulation, we examine a simple case where there is a single system operator who has perfect information about the future effects of his investments, who is fully responsible for all effects over the whole life time of the infrastructure and who is acting like a social planner maximizing the social-welfare function and thus taking into account the welfare effects of changes in the quality of electricity supply. Suppose further that quality is a function of variable and fixed costs—for example, maintenance labor and infrastructure capital. Labor is a current cost and its reduction causes profit immediately to increase and quality to decline (in accordance with the marginal product of labor in producing quality). On the other hand, a reduction in investment in infrastructure capital will likely have only a very modest effect on quality, since the marginal product of infrastructure investment on current quality is almost surely small. Yet the reduction in investment will reduce current costs by some significant amount.[17] Although, the operator might postpone investments to a large extent, he will take the socially optimal decisions. Hence, the long-term dimension of investments in infrastructure in itself does not create a problem from a welfare point of view. These problems might follow from specific factors related to the long-term dimension. One

[17] The exact amount will depend upon the accounting standards employed and the metric used in incentive regulation. The Dutch example shows that not investing can significantly reduce economic costs and, hence, tariffs (see section 2.2).

particular factor is the fact that uncertainty about the future is positively related to the length of the time period considered. Another factor might also result in suboptimal welfare effects, which is myopic behavior of agents, which means that they do not properly take into account all future effects. Below, both aspects are analysed more in depth.

5.2 Uncertainty about Current Causes/Future Effects

The long life times of infrastructure implies that the economic effects of investments in that infrastructure are highly uncertain. How can these long-term uncertain effects be included in an incentive scheme?

As noted above, the engineering/technological lag between cause (investment expenditure) and effect (quality change) complicates the operation of incentive regulation, or for that matter, any form of regulation. The long life times of infrastructure imply that the economic effect of any particular investment is subject to considerable uncertainty, and as a result incentive regulation methods may not be well-suited to this task. To see this, consider the following simple example. Suppose there is a single system operator responsible for the reliable operation of the distribution system across all time—that is, he lives indefinitely, or at least longer than the infrastructure itself. Moreover, assume in this example that the operator exhibits no myopia in his behaviour. The combination of these assumptions implies that there is no behavioural impediment to optimum regulatory operation. The operator sees ahead to the full consequences of his actions, and the full set of penalties and rewards will flow backward to him once they are realized.

Suppose now, however, that the decisions about infrastructure do not noticeably affect service quality for some period of time—for concreteness, suppose the period is fully 10 years. That is, quality is unchanged for 10 years even if infrastructure investment ceases, since existing plant depreciates so slowly. But after 10 years, the degradation of infrastructure begins to erode service quality. To repeat, if in year 10 these effects emerge and are clearly the result of operator decisions 10 years earlier, incentive regulation faces the formidable task of devising the correct mechanism--but such a mechanism exists, one that now optimally punishes (or rewards) the operator for the causal decisions made a decade earlier.

Uncertainty affects this process in a fundamental way. The uncertainty arises because it will be difficult to be certain that any outcome is due to an investment decision made years earlier, as other factors and random events obscure the particular effect of that one decision. Informational problems in the face of complex causation therefore create uncertainty, and as a result, incentive regulation may not be able to reward and penalize appropriately. Put differently, incentive regulation does not seem to be well designed for settings where actions and effects are separated by the passage of time. Investment in electricity infrastructure creates precisely this setting and this problem.

5.3 Myopic behavior

Operators are supposed, al least according to some authors, to be myopic, ignoring the long-term effects of their short-term decisions. Which evidence can be found for this statement? If this is the case, what would be the appropriate approach by the government or the regulator to overcome this problem?

This disparity between current cost reduction and current quality reduction, looked at myopically, will induce the utility to choose to reduce its infrastructure investment, and quality will over time deteriorate. Of course, these costs are no less linked to quality than current labor expenditure, but investment is probably separated in time from quality degradation to a much greater extent.[18] Under standard incentive regulation that rewards lower total expenditure (or costs), the utility will choose lower cost and higher profit now. The fact that quality may erode considerably at some future point in time may not matter if the utilities' shareholders or managers cannot be kept responsible for the long-term engineering consequences of current investment, or if they simply have a sufficiently high

[18] Even current labour expenses may not be temporarily linked to quality changes either for technological or probabilistic reasons. Some labour expenses take the form of preventive maintenance. Some events, like extreme weather conditions are random and infrequent so that, for example, reducing tree-trimming efforts may not cause service reliability to fall for years.

discount rate that the future is not their concern. In either case, quality will fall short of the socially optimum level.

There are several factors why operators might be myopic. One factor is that the private costs of capital might exceed the social costs of capital because of imperfect working of capital markets. As a result, private operators use discount rates lying above the rates which reflect the real opportunity costs of capital. Another factor stems from the governance structure of firms: if rewarding of managers is not related to the future value of the firm, the managers will insufficiently take into account the long-term effects.[19]

6. Conclusion: consequences for regulation

Above we have argued, mainly on theoretical basis, that the long-term dimension of investments in networks causes difficulties for quality regulation. Both the high uncertainty about the future effects of investments and the fact that operators behave myopically make that incentive regulation has a large risk of resulting in suboptimal levels of quality in the future. This statement is not new, as it is also mentioned by some authors. Quoting Ajodhia et al. (2005): "When the period between cost investment and quality outcome is long (…) quality regulation (…) may not be sufficient."

In principle, there are three methods by which regulation can be adapted to prevent these negative consequences: [20]

- improvements within the incentive-regulation scheme;
- improvements within other quality measures;

[19] Note that is not equal to saying that the management should be appointment for a period of time which is equal to the "quality feedback timeframe" as Ajodhia et al. (2005) do. Key is that there exists a mechanism by which the remuneration of managers is related, in one way or another, to the future value of the current (and past) decisions.

[20] Ajodhia et al. (2005) mention three options to deal with the time lag: 1) closely monitoring the expenditures by the network operator, 2) prescribing rules for asset management and 3) requiring the operator to report in detail the performance of the network. Although each of these options could be valuable, none of them solves the fundamental problem of the time lag. I.e. these measures might reduce the uncertainty for the regulator about the status quo of the network and the activities of the operator, but they do not necessarily result in internalizing the long-term effects in managing the network.

- specific regulatory treatment of investments.

First, the regime may be able to link the time-separated phenomena of lower current cost and lower future quality. For short time lags—e.g., a year or two—the incentive-regulation mechanism might automatically incorporate any adverse effects on quality through revenue reductions. For long time lags, however, reductions in distribution investment do not result in quality changes for years. In order to internalize these effects in the incentive scheme, short-term quality payments or fines could reflect the benefits/costs occurring in the more distant future. Such an approach requires the regulator to determine the present financial value of these future effects. As the abovementioned uncertainty also holds for the regulator, the risk of choosing the wrong levels of incentives is significant.

The second method is to employ some form of quality regulation, prescribing specific quality levels to be pursued by the operator. This approach might solve the myopic problem, but does, however, not solve the fundamental problem of the uncertainty. Just as in the former method, this approach requires that the regulator is able to define an optimum standard or penalty which would just offset the distortion of the current system, and thereby result in optimum quality. The regulator is not only uncertain about the future benefits of quality, but also suffers from lack of information regarding the costs. Therefore, identifying and implementing this optimum standard or penalty is very difficult, and perhaps impossible.

The third and most promising method seems to be a mechanism which focuses on current investments in stead of (future) quality. Key is the fundamental recognition that the level and timing of optimal investments can only be determined by making cost-benefit analysis from a welfare-economic point of view, using scenarios to deal with the uncertainty about future circumstances. There are several options to implement this approach. One example is the procedure chosen by OFGEM to use incentive regulation for operational activities and a process of investment approvals to regulate long-term effects of quality (see Joskow, 2006; Meulmeester, 2008). In this procedure, operators are requested to submit investment plans to the regulator which uses that information to determine the optimal level of investments. A sliding-scale scheme is used to stimulate network operators to invest timely and efficiently. Based on our analysis, we think this option is best suited for policy purposes.

Further research is needed to empirically test the statement made in this paper that quality regulation is not well suited to take care of network reliability in the long term. Moreover, additional research is desirable to design appropriate mechanisms for ex ante approvals of investments resulting in efficient levels of investments in the electricity-distribution network.

References

- Ai, Chunrong, Salvador Matinez, and David Sappington (2004). "Incentive Regulation and Telecommunications Service Quality", *Journal of Regulatory Economics.*
- Ajodhia, V. and R. Hakvoort (2005). Economic regulation of quality in electricity networks, *Utilities Policy* 13, pp. 211-221.
- Berg, Sanford V & Jeong, Jinook (1991). "An Evaluation of Incentive Regulation for Electric Utilities", *Journal of Regulatory Economics*, Springer, vol. 3(1), pages 45-55, March.
- Burger, Anton, and Geymueller (2008). "Can We Measure Welfare? Dynamic Comparisons of Allocative Efficiency before and after the Introduction of Quality Regulation for Norwegian Electricity Distributors," Vienna University of Economics and Business Administration.
- CPB (2004). *Better safe than sorry? Reliability policy in network industries*, CPB-Document 73, The Hague, December.
- Edison Electric Institute (2005). *State of Distribution Reliability Regulation in the United States,* Washington, DC.
- ERGEG (2005). Third Benchmarking Report on Quality of Electricity Supply 2005, Brussels.
- Joskow, P. (2006), Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks, CWPE 0607 and EPRG 0511.
- KEMA Consulten (2006), Evaluatie Elektriciteits- en Gaswet: Technische aspecten, Arnhem, July.

- Meulmeester, P. (2008). “Lange termijn investeringen in elektriciteitsnetwerken niet gegarandeerd”, TPEdigitaal, 2(2), pp. 93-113.
- NMa (2008). Methodebesluit regionale netwerkbeheerders elektriciteit vierde reguleringsperiode, Den Haag, nr. 102610.
- Pacific Economics Group (PEG) (2007). “Service Quality Regulation for Detroit Edison: A Critical Assessment,” Madison..
- Sappington, David, Johannes Pfeifenberger, Philip Hauser, and Gregory Basheda (2001), “The State of Performance-Based Regulation in the U.S Electric Utility Industry,” *The Electricity Journal.*
- Sappington, David (2005). “Regulating Service Quality: A Survey,” *Journal of Regulatory Economic.*
- Ter-Martirosyna, Anna (2003. “The Effects of Incentive Regulation on Quality of Service in Electricity Markets,” George Washington University.
- Zijl, G., R. Haffner and M. Mulder (2008), Energiemarkten laten werken: een onvoltooide missie, in: NMa, Trust en antitrust; beschouwingen over 10 jaar Mededingingswet en 10 jaar NMa, Den Haag.