Regulating Energy Networks to facilitate the Transition in the Energy Industry

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8th BIEE Academic Conference "Energy in a Low Carbon Economy: New roles for governments and markets", Oxford, 22-23 September 2010

Abstract

The growing attention for the environmental effects of using (fossil) energy calls for an evaluation of current regulatory regimes. In the past, regulation of electricity and gas networks was mainly meant to foster competition and improve efficiency, resulting in lower prices for energy users. Currently, it is generally believed that regulation also has to facilitate the process of decarbonisation. In order to deal, for instance, with the growing significance of distributed generation, distribution network operators have to upgrade their network. The key question now is whether the existing regulatory frameworks should be adapted in order to enable these types of developments. In this paper we assess the past performance of regulating energy networks in terms of efficiency and reliability. In addition, we analyse to which extent the current Dutch regulatory framework is able to facilitate the transition of the energy industry. The paper concludes that several mechanisms exist by which the current framework fosters efficient investments, possibly including investments directed at the transition in the energy industry. However, the framework also includes some mechanisms potentially hindering efficient investments. By adding more flexibility to the framework, this inefficiency in regulation is likely solved adequately.

1. Introduction

The energy industry is facing major changes. In the near future, substantial investments in the gas infrastructure are needed due to the gradual depletion of domestic natural-gas supplies, the necessity to substitute fossil fuels for renewable energy sources, and the necessary replacement of aged network segments. Both energy producers and network operators face these daunting tasks. In this paper we focus on network operators.

In order to deal with the growing significance of distributed generation (such as micro CHP systems), distribution network operators have to upgrade their network. The networks have to deal with the growing volatility in load as well the growing supply of electricity to the grid. The grids should for instance be able to charge huge numbers of electric cars or to transport the strongly fluctuating electricity produced by wind farms. In principle operators have two technological options to tackle

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these developments. The first one is extending the grid, making the grid sufficiently large to facilitate both peak demand and peak supply to the grid. The other option is making the existing grid smarter, which mainly means using information technology to optimize the utilisation of the grid.

The key question now is whether the existing regulatory frameworks are designed to enable these types of developments. Various parties in the Netherlands, such as the Dutch Scientific Council for Government Policy (WRR, 2007) and the Dutch Energy Council (AER, 2009), have stated that the existing regulatory framework is inadequate for facilitating this transition in the energy industry. They argue that the regulatory framework so far has focused too much on efficiency and on tariff reduction at the expense of the necessary investments in, the maintenance of, and the expansion of the grids. Several key elements of the framework should therefore be revised in order to ensure that these investments can still be made. Instead of the current system where energy transport tariffs are based on the network operators' efficiency levels, there should be a system where the network operators have more (ex-ante) financial certainty when investing.

In this paper we assess to which extent the current regulation in the Netherlands is able to facilitate the transition of the energy industry. The analysis is structured as follows. After briefly summarizing the economic principles regarding regulation (section 2), we describe the characteristics of the current regulatory framework in the Netherlands (section 3). Then we present the results of an empirical research into the past effects of regulation on investments (section 4). That research includes an analysis of data on historical investment patterns by operators and in-depth interviews with all Dutch network operators about their investment activities in relation to the current regulatory regime. Using the results of the analysis of the past performance of the regulatory framework, we analyse its ability to facilitate the transition in the energy industry (section 5). The conclusions are presented in section 6.

2. Regulatory theory

2.1 Regulatory principles

If networks firms could operate in competitive markets, there would be no need for regulation at all. The functioning of the market would guarantee that profit-maximising behaviour of individual firms together with utility-maximising behaviour of consumers result in the optimal outcome from a welfare-economic point of view. Because of the huge fixed costs of networks, competition between operators is in most network industries and countries not feasible, which gives them a (natural) monopoly. It is basic economic theory, that a monopolist will not automatically produce the products which are needed by society, that it has limited incentives to be as efficient as technically possible and that it will generally use its market position to charge relatively high (monopoly) prices. Regulation is therefore needed to give network operators the incentives to realise the products which are needed by society, to operate as efficiently as technically possible and to let networks users benefit from efficiency improvements within the networks.

Another principle in regulating any industry is the existence of information asymmetry between regulator and regulated firms. This asymmetry is related to information about the precise characteristics of the firm as well as information about its precise behaviour.[2] It is impossible (or highly expensive) for a regulator to acquire the same level of information and knowledge as regulated firms have about their activities. Therefore, regulated firms are in principle better equipped than regulators to choose the optimal production technique, including size and type of investments, and to determine the optimal level and type of production. Therefore, the regulatory framework should be directed at setting the appropriate constraints and giving adequate incentives.

2.2 Searching for optimal regulation

Based on these principles, the challenge for regulators is to pursue three different (policy) goals:[3]

1. The operators should be incentivised to conduct all those investments which are efficient from a welfare-economic point of view. This means that network operators should invest when the overall benefits of a project exceed the overall costs (including effects on competition, security of supply and environment). The flip side of this coin is that operators should also be prevented from making socially inefficient investments. Taking care of the welfare effects of investment projects can generally be done in two ways: by giving incentives to operators or by conducting social cost-benefit analysis.
2. The operators should be incentivised to conduct those investments which are viewed to have a positive social cost-benefit outcome as efficient as possible from a production-technique perspective. This means that operators need to have incentives to look for the best technique available and to design investment project in such a way which maximises the utilisation per unit of costs.
3. Finally, regulation should be such that networks users benefit from technical efficiency improvements in the network. This means that the tariffs which users have to pay for using the grid should reflect the efficient costs of the operators, including a market-based reward for capital, leaving no room for economic profits[4] of the network operators.

[2] This first component is called hidden information and may result into adverse selection, which means that the regulator makes the wrong assumptions about for instance efficient cost level. The second is called hidden behaviour and may result in moral hazard, which means that the regulated firm is less inclined to do its utmost as the regulator is unable to monitor and reward that behaviour sufficiently.

[3] These three policy goals can also be summarised as dynamic efficiency, productive efficiency and allocative efficiency.

[4] Note that 'economic profits' are the profits on top of the normal profits which are rewarded by, for instance, the WACC. In economic terms, normal profits are viewed to be the reward for the opportunity costs of capital, which is related to the systematic risk.

The challenge for the regulator is, therefore, to realise the socially optimal level of investments, in a productively efficient way while network users pay no more than is needed to recoup the costs. Given the existence of the abovementioned information-asymmetry, it is highly complicated to realise all these goals in the same extent. Because of these trade-offs, the regulator (and politicians, through the legal framework) has to choose which goals are more important than others. Consequently, this choice can be translated in the kind of regulation applied to the industry.

Three main types of regulation can be distinguished, which have different impact on the above goals (see e.g. Cambini et al., 2010). Rate-of-return regulation, which gives operators ex ante certainty on the rate of return on their investments, is viewed to be most suited to foster investments in new infrastructure (policy goal 1). Pure price-cap regulation, where the operators have certainty about the revenues but face all the risks related to the costs, gives the maximum incentives to foster efficiency (policy goal 2). Cost-plus regulation, where the revenues of the operator are directly related to its costs (including capital costs), realises that network users pay no more than the realised costs (policy goal 3).

Each of these forms of regulation also have some disadvantages. Rate-of-return regulations likely results in a too high level of investments (from a welfare-economic point of view) while incentives to operate productively efficient are soft. Pure price-cap regulation is generally seen as a disincentive for investments in new infrastructure, as investments increase (capital) costs while the revenues of the firm are constant and independent of the realised costs (i.e. equal to the price cap). In addition, pure price-cap regulation might result in positive economic profits for the operator, implying that grid users pay more than is needed to recoup the costs. Cost-plus regulation, finally, gives weak incentives to the operator to be efficient, because of the absence of the option to make additional profit, while the incentives for investments are not necessarily high.

2.3 Regulation, investments and risks

Because of the long-life of network infrastructure and ex-ante uncertainty about ex-post revenues, network operators might be inclined to hold up investments. The different kinds of regulation differ in the way they deal with this hold-up problem.

In case of rate-of-return regulation this hold-up problem seems to effectively solved. The more the guaranteed rate of return exceeds the opportunity costs of capital (i.e. the return to be achieved in the market, given the risk), the more this type of regulation will foster investments.[5] Hence, in this framework, raising the (guaranteed) rate of return will trigger new investments. If investors in

[5] Note, however, that rate-of-return regulation does not favour investments in cost-reduction.

networks are assured they will earn a given rate of return, there is no risk of stranded assets on micro-level, i.e. on the level of the firms. On macro-level, however, there is still a risk that investments will appear to be socially inefficient, resulting in stranded assets from that perspective. In this type of regulation, network users pay for this risk, as the tariffs for using the network rise if the utilisation of the networks reduces. So, rate-of-return regulation seems to be an effective solution to foster investment and to reduce the risk of stranded assets for network operators, but in fact this risk is shifted to network users. In addition, rate-of-return regulation creates relatively high risk of stranded assets for users because of the relatively high likelihood of socially inefficient investments.

In case of price-cap regulation, the firm has a high-powered incentive to reduce costs including investments. The operator faces however the risk that it will not be fully rewarded, while there is also a chance that the reward exceeds realised costs. It is therefore key to choose the optimal level of the price cap, balancing between the risk of financial distress of the regulated firm on the one hand and the risk of above-normal profits and too high tariffs for network users on the other. In a pure form of price-cap regulation, the regulated firm will only sufficiently invest, if the regulation is completed with (legal) obligations regarding quality of the network in terms of reliability and absence of bottlenecks (see Ajodhia et al. (2006), Burger et al. (2008), Ter-Martirosyna et al. (2010)).

The more the price cap is related to realised costs, the stronger the certainty that the operator will be fully reimbursed, and the lower its risk of stranded assets. This certainty has its price, as free lunches don’t exist. The price includes reduced incentives for the operator to increase the productive efficiency. In addition, as the risk for the operator is relatively low in case of such a cost-based form of price-cap regulation (which can also be seen as a form of cost-plus regulation), the reward for capital costs should be lower as well. Hence, the price for the certainty and the resulting lower risk on stranded assets to be paid by the network operator is a lower reward (WACC) on capital. The networks users face, however, this risk of stranded assets as their tariffs will be related to the utilisation of the network.

Incentives to operators to be careful in developing investment projects can be given through menu regulation (see e.g. Joskow, 2006). In this form of regulation operators can earn a higher profit the more their investment plan is viewed to be socially efficient. In addition, the more productively efficient the investment plan is realised, the more the profit rises. The idea here is that network operators can choose between different investment plans and different types of implementation, but that the menu triggers the operators to make efficient decisions. The menu prescribes the rate of return operators can make, which means that they will not face a risk of stranded assets. The stranded-asset risk for users is mitigated through the incentives given to make only socially efficient investments.

In stead of giving the operators the freedom to choose an investment plan (regarding size, timing, etc.), the operators can be asked to submit several, alternative plans to the regulator (or government) which are analysed from a welfare-economic perspective. The standard method here is social cost-benefit analysis, in which all effects of the (proposed) investments are taken into account, preferably but not necessarily in monetary units. The investment plan with the highest, positive outcome can be approved, which means that the operator will be allowed to make the investment with the guarantee that in principle all costs will be reimbursed.
As a matter of fact, conducting social cost-benefit analysis is not an easy exercise as it is often pretty difficult to determine all social costs and benefits of a project. One of the key issues which has to be discussed is the counterfactual: what would happen if the investment project would not take place? Another difficulty often arising is that not all effects, such as on security of supply, can be directly expressed in monetary terms because of the absence of market prices. Nevertheless, a social cost-benefit analysis enables us to think systematically of the welfare effects of an investment project.

To conclude, to define the optimal regulatory system regarding investments, the treatment of risks is an essential component. If investments in networks are viewed to be highly important, the risk of the investment can be fully shifted to society (by giving financial support from government funds for instance) or network-users (by implementing a form of cost-plus regulation, raising the regulatory asset base or shorten the depreciation period). As the risk for the operators are relatively low in this approach, the reward (i.e. the WACC) should be downwards adapted. The disadvantage here is that the operators only face soft (or no) incentives to be productively efficient, which likely results in higher tariffs for end-users. Therefore, in discussing rewards for risks on investments attention has also to be paid to incentives for the firm to operate efficiently. In addition, at the end of the day users of the network should benefit from investments and efficiency improvements by getting lower tariffs and/or a higher quality.

3. The Dutch regulatory framework

3.1 General principles

The Dutch regulatory framework can be characterised as intermediate or output-oriented regulation. This basically means that the regulation is directed at the outcome of the networks in stead of the inputs. The main outcome parameters include total revenues and the reliability of the supply of energy. Revenues are determined by the regulatory framework on aggregate level, while the network operators can decide on their own costs.
Another principle of the current regulatory framework is that network operators must have the opportunity to make all the investments that are socially profitable or desirable, while at the same time not being forced to make investments that are neither. The regulatory framework thus has to provide

for revenues that cover efficient costs, but it should offer no room for unnecessary investments nor for excessive profits. A third principle is that the regulatory framework does not only need to be focused on the network operators' revenues and the affordability for customers, but also on the quality of energy transport, and the security of energy supply. This combination of tariff regulation and quality control may help in bringing about optimal network management.

These characteristics of the framework are based on the principle that the regulator does not interfere with operational and investment decisions of network operators, but that it sees to the statutory tasks being performed as efficiently as possible. The general idea is that operators have far more knowledge about efficient network management than the regulators have. As a consequence, the operators should face the full responsibility of the network management. Hence, the well-known problem of information asymmetry between regulator and network operator is solved by giving the operator the freedom as well as the incentives to choose the optimal technical options in its specific situation. In principle, benefits of realising a more efficient solution can be reaped by the operator. In order to prevent that too many efficiency benefits remain within the network firm, however, the revenues of the operator are subject to the yardstick which is frequently reassessed.

Another argument, besides the information asymmetry argument, of giving operators freedom of operation follows from the fact that ex ante nor the regulator neither the operators know which technique will appear to be the most efficient one. Prescribing one technique, therefore, creates the significant risk that this technique would appear not to be the best or the most efficient one. When each operator is able to make its own technological choice, the benefits of a decentralised organisation come to the fore (see Kay, 2005). This means that there is a higher chance that ex post the best technique will be chosen (or developed) by at least one of the operators. In a centralised system, without such freedom and variation on firm level, innovation would be likely less developed.

3.2 Tariff regulation

A major component of the regulatory framework is the tariff regulation. This regulation is designed in such a way that the total revenues of networks are set on the level of efficient costs. These efficient costs are based on a yardstick which is calculated as the average of the costs of all operators at the end of the (next) regulatory period. The yardstick for efficient costs includes both capital costs (CAPEX) and operational costs (OPEX), implying that the framework can be characterised as TOTEX-regulation.

As a consequence, operators are fully free to allocate the total revenues among capital and operational costs. Some operators having a relative capital-intensive operation may use the revenues as compensation for their relatively high depreciation costs and costs of capital (equity and debt capital). Others, having a relatively old network, might use the revenues as compensation for operational costs like labour costs on maintenance and so. So, network operators that operate more efficiently than the average operator will earn higher profits, because they incur lower costs than others – and vice versa. A consequence of this form of benchmark regulation is that all of the network operators' costs are incorporated into the tariffs, but that each individual network operator will not necessarily be able to cover its own costs because that depends on the relative efficiency of each individual network operator.

The revenues also depend on the performance of the network with respect to quality. Although the framework does not precisely prescribe standards for quality of energy supply, it does include incentives to optimize the level of quality. These incentives comprise a bonus-malus system and a compensation mechanism. Operators receive a bonus if the quality of their network (measured by SAIDI) exceeds the average quality of all operators in the previous regulatory period. And vice versa: if the quality of an operator is below the average level in the previous period, it receives a malus. Both bonus and malus are capped at the level of 5% of total revenues in the previous period. The compensation mechanism says that the individual energy users should be financially compensated if they have experienced a serious disruption. The bonus/malus are captured by the q-factor in the revenue formula.

The quality incentive (i.e. the q-factor) and the efficiency incentive (i.e. the x-factor) together determine the development of the total revenues (TR) in real terms:

$$TR_{i,t} = (1 + cpi - x + q) * TR_{i,\, t-1}$$

The total revenues of an operator are set on the level of this efficient cost level by the so-called 'x-factor'. The x-factor takes the total revenues of an operator at the beginning of a regulatory period to the level of the efficient costs at the end of this period. In order to compensate for inflation, a cpi (consumer-price index) is also included in the formula.

3.3 Quality regulation

In addition to the bonus-malus scheme, the regulatory framework includes rules regarding the reliability of the network and the services to be provided to energy users. Network operators have to take care of the network in such a way that energy users have the guarantee that they will be connected if they wish (i.e. the obligation to connect) and that the supply of energy will hardly be disrupted. Network operators are required to submit twice a year so-called quality and capacity documents (QCDs) to the NMa. In these QCDs, network operators are required, among other things, to explain what actions they will be taking to maintain their networks' reliability. Furthermore, the NMa, in close consultation with network operators and users, sets codes, which stipulate how network operators are supposed to behave towards each other and towards other parties connected to the networks. These codes also provide for compensation fees. In case of failures that last for more than four hours, network operators are required to compensate customers for these interruptions in transport.

4. Effects of regulating the energy industry

4.1 Prices and productivity

Undoubtedly, yardstick regulation has significantly reduced the tariffs consumers have to pay for using the networks. The impact of regulation on tariff can be calculated by making an assumption about the development of the tariffs in case of no regulation (the so-called 'counterfactual'). It can safely be assumed that in that case tariffs would annually increase by at least the rate of inflation. Without regulation, the network operators could use their monopoly power to raise prices even above that level, but one might assume that political pressure would cap the price increases to the level of the rate of inflation. See Kemp et al. (2010) for more details about the calculation of the outcome of regulation.

In 2009, the total savings on transport tariffs for energy users amount to approximately 1 billion euros (see Figure 1). The cumulative savings since the start of the regulation are calculated to be approximately 6 billion euros (see Figure 2).

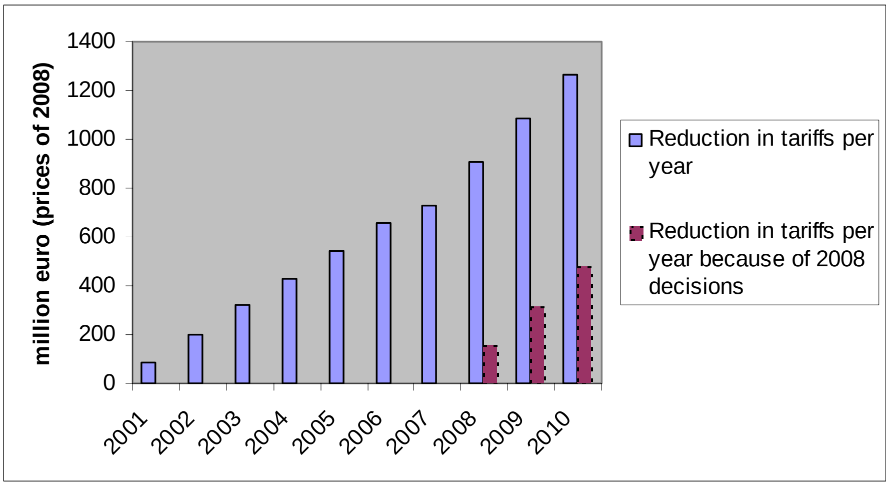


Figure 1 Annual reduction in total revenues due to regulation, all Dutch energy networks, 2001- 2011 (Source: Plug et al., 2009)

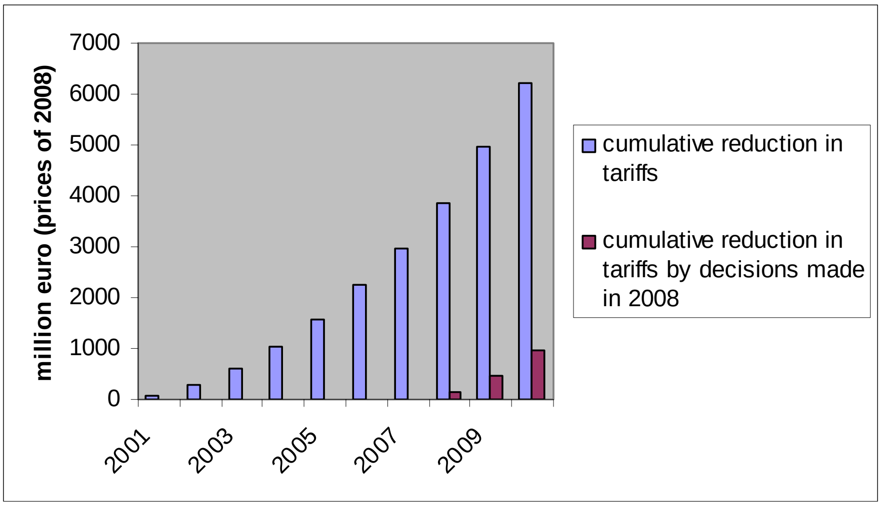


Figure 2 Cumulative reduction in total revenues due to regulation, all Dutch energy networks, 2001-2011 (Source: Plug et al., 2009)

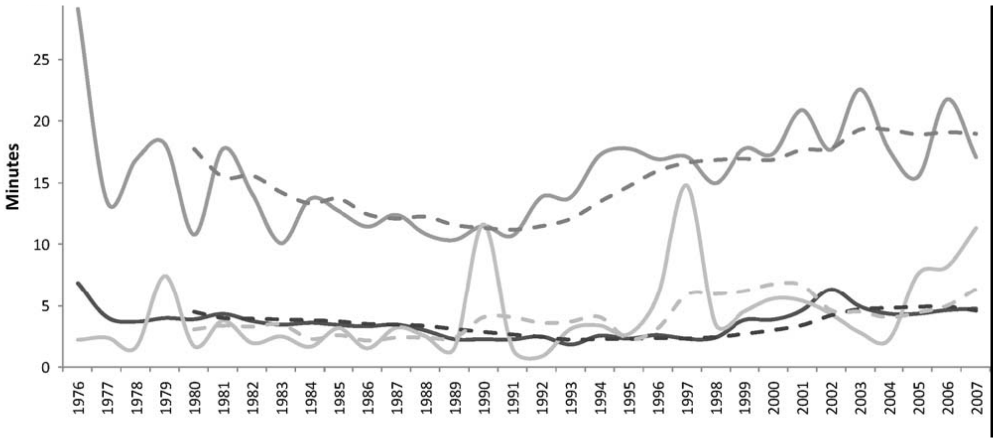
The reduction in tariffs reflects the reduction in total costs per unit of output. This higher efficiency results partly from higher productivity of the network operators, but it is partly also the result of lower capital costs (CAPEX) due to investments which were below the level of depreciation. If network operators raise their level of investments in the future, an increase in the tariffs might be necessary.

4.2 Network quality

Economic literature includes a number of papers finding a negative effect of incentive regulation on quality (see Granderson et al. (2002), Jamasb et al. (2008), Pollitt, M. (2005) and Ter-Martirosyna (2003)). As a result, one might expect that the realised reduction in costs in the Dutch electricity networks has hampered the quality of the infrastructure. On the other hand, there are also several papers concluding that the negative effects of price-cap regulation can be compensated, at least partially, by quality regulation (see Ajodhia et al. (2006), Burger et al. (2008), Ter-Martirosyna et al. (2010)).

In order to get more insight in the quality of the networks, the NMa commissioned three research agencies to carry out an in-depth empirical study. Movares Nederland (Movares), Kiwa Gas Technology (Kiwa) and PricewaterhouseCoopers Advisory (PwC) met with all of the network operators, sat down with those closely involved with investment and financing decisions, and collected as much empirical data as possible on the factual quality of the grids and the actual investment behaviour of the network operators (see Movares/Kiwa, 2009, PwC, 2009 and Haffner et al. 2010).

This research did not find evidence that the quality of the regional networks for electricity and natural gas has deteriorated in recent years. In fact, the quality of Dutch networks has hardly changed since the introduction of competition and regulation (see Figure 3). The average consumer experienced approximately 30 minutes of disturbances in electricity supply per year. These disturbances were mainly caused by the high-voltage network; the low-voltage (distribution) network was responsible for no more than 5 minutes of disturbance on average per consumer per year. In addition, compared to other European countries, the performance of the Dutch energy networks is still at a high level (Plug et al., 2009).



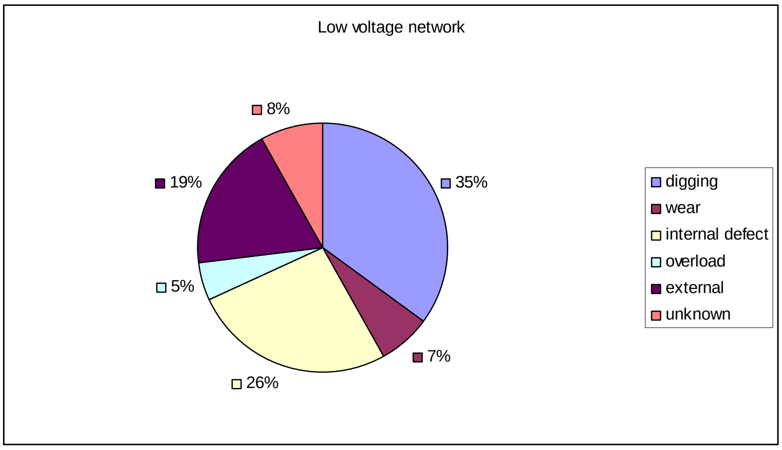
Notes:

- *black line: low voltage network; grey line: medium voltage network; white line: high voltage network*
- *dotted lines: 5 years moving average*

Figure 3 Average minutes of disturbances in the Dutch electricity network, 1976-2007 (source: PwC, 2009 and Haffner et al., 2010)

Looking at the causes of disturbances within the network, it appears that wear is only responsible for 7% (Low voltage network) to 16% (medium voltage network) of the disturbances (see Figure 4). Most disturbances are caused by digging activities (by construction or other network companies) and external factors like accidents.

Although, the actual performance of the Dutch electricity networks is quite good, there is some reason to be concerned about the future performance. The empirical research revealed that network operators lack a comprehensive picture of the grids' actual condition. This lack of sufficient reliable information is making it difficult for network operators to determine the right moment for making replacement investments. After all, having a complete and reliable registration system of fixed assets is vital for effective and efficient network management.



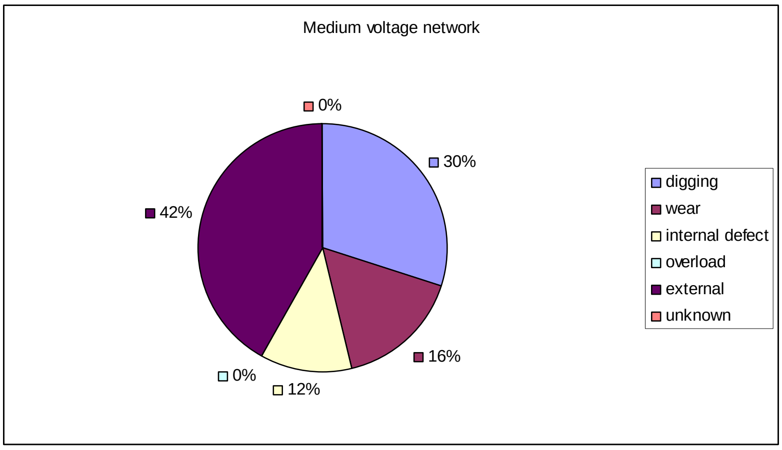


Figure 4 Causes of disturbances in distribution networks, in % (2008) (Movares/Kiwa, 2009)

Regarding the impact of regulation on investment decision PwC (2009) concluded that there is no evidence that the regulatory framework has resulted in the necessary investments in the network being postponed or even being cancelled. The regulatory financial incentives have had no appreciably negative effect on the investments in quality and safety. There is also no evidence that operators wait for each other in making investments. Figure 5 shows that there is a huge spread in the investment pattern among the group of network operators. This finding refutes the common statement that a system of yardstick regulation acts as an incentive to wait on each other. After all, according to that argument, firms would only invest if others would do the same, otherwise they would only be partially reimbursed for the increased costs. However, even if other operators invest, the incentive for an individual operator to reduce costs (and postpone investments) remains as investments by others do not change the (marginal) profitability of specific investments projects.

In addition, the empirical research gives convincing evidence that the regulatory framework has been an incentive for operators to adopt a more rational approach with regard to investment policy. Network operators have taken a more critical attitude towards investments, which in practice has led to the implementation of risk-based asset management, and to increased professionalization of operational processes. This finding is fully in line with conclusions in economic literature (like Jamasb et al. (2008), Pollitt, M. (2005) and Cambini et al. (2010)).

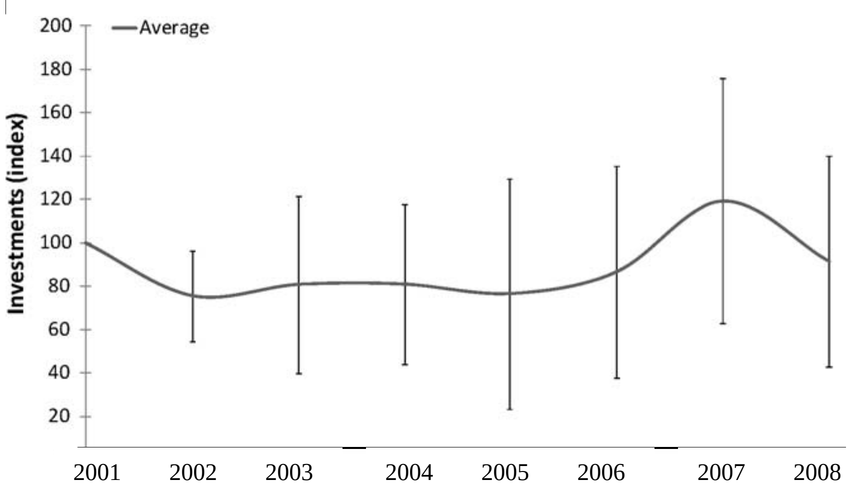


Figure 5 Spread of investments among electricity distribution operators, 2001 – 2008

(Source: Haffner et al, 2010)

Concluding, the regulation of the Dutch energy networks has had a significant effect on the tariffs energy users pay for using the grid. In addition, up to now there isn't any evidence that this pressure by the regulatory framework has negatively affected the quality of the networks. However, past performance is no guarantee for future results, which also applies to the regulation of energy networks.

5. Regulation and energy transition

The topical question is whether the current regulatory framework is also adequate to facilitate the transition in the energy industry. This transition is meant to reduce the role of fossil fuels as primary energy source, which has to result in less emissions of carbon dioxide as well as enhanced security of supply. In order to reach this transition, distributed generation (such as micro CHP systems) is perceived to be of key importance, fundamentally changing the role of distribution networks. In addition, the emergence of electric cars also creates a challenge for these networks, because of the resulting significant bi-directional flows. Networks have to deal with the growing volatility in load as well the growing supply of electricity to the grid. The grids should be able to charge huge numbers of electric cars or to transport the strongly fluctuating electricity produced by wind farms (see e.g. Veldman, et al., 2010).

In principle operators have two technological options to tackle this development. The first one is extending the grid, making the grid sufficiently large to facilitate both peak demand and peak supply to the grid. The other option is making the existing grid smarter, which mainly means the use of information technology to optimize the use of the grid. Either way, significant investments have to be made, increasing the (mainly capital) costs of the network operators. How does the current regulatory framework deal with these costs?

Given the nature of the yard stick regulation, all costs made by network operators enter into the yard stick, increasing the future revenues of all operators. If all network operators would make comparable investments, they will all be fully reimbursed. Their revenues would increase by the costs made for energy transition. In other words, the system of yardstick compensation has as consequence that the operators together will be fully reimbursed for all projects, no matter whether they are welfare enhancing or not, as long as all other operators conduct the same type of projects.
However, if only some of the operators would make these costs, the yardstick would only rise by the share of these operators in the total industry. Consequently, these operators would only be partly compensated for the costs they made. So, uncertainty about the investment behaviour of other operator creates uncertainty for each operator about its revenues. This uncertainty might hamper investments in smart grids or network extension, not because operators are waiting on each other, but because they are uncertain about the benefits of a specific investment.

If all operators believe that a specific technique, like smart grids, is the most efficient technique to solve the future challenges they are facing, this view on the future technological challenges will likely appear to be true. In that case, rewarding all costs of smart grids seems also to be the optimal approach, even if the future benefits of these investments are still uncertain. If, however, some operators believe that investing in smart grids is the optimal approach, while others are more sceptical about the efficiency of such an investment, a different case appears. Then, the efficiency of the investments is unclear ex ante. If the investments appear to be efficient, operators having chosen for this technology will reap the benefits while others, who were hesitant to invest in the uncertain technology, will have higher costs.

Seen from this perspective, yardstick regulation effectively deals with investments with uncertain benefits. The higher the number of operators believing that this technique will have positive net benefits, the higher the number of operators that will actually make the upfront costs and the more the costs will be rewarded by the yardstick regulation. Given the uncertainty operators have about the investment behaviour of other operators, they will only invest if they expect that the investment would create benefits within the operator it self, such as savings on network extension.

However, the regulatory framework might hamper investments in smart grids (or other technologies) if these investments create externalities, i.e. if other participants benefit from the investments without sufficiently rewarding the network operator. In such a case of positive externalities, the operators would invest too less. This might be the case when a new technology (or infrastructure) creates new products (such as energy-saving services or charging options for electric cars) for which no tariff products have been defined. This externality or inefficiency in the framework can be solved by defining the appropriate products in the tariff decisions.

In addition, the system of yard stick regulation might also hamper investments if network operators face significant differences in structural circumstances. After all, this system of regulation presumes that all operators operate in a level playing field. Whether this assumption holds has to be continuously checked. It is conceivable that, in the future, network operators will have to deal in varying degrees with energy developments, such as distributed generation, or requests for electric-car charging stations, which will likely force them to adopt different investments patterns. Network operators that need to make substantial investments therefore incur more costs that are not sufficiently covered through the current tariff regulation. Such a development would call for flexibility in applying the yard stick regulation.

The current regulatory framework already has the option of offering some flexibility, in particular by allowing to incorporate special investments in the tariff composition in more cases through an expanded use of the instrument of 'considerable investments'. It goes without saying that, in such cases, it is essential that there is a clear definition of what kinds of investments are considered to be 'considerable investments.'

6. Conclusion

The empirical study has revealed that the current regulatory framework so far has improved efficiency, and that it has not posed any obstacle for making the necessary investments. The combination of tariff regulation, which covers all efficient costs, and quality control acts as an incentive for network operators to working efficiently and to keeping an eye on the networks' reliability.

Regarding investments in energy transition, if these investments are generally believed to be the optimal technique to deal with the future challenges of the distribution grids, the costs of investing in these grids will be fully reimbursed by the regulation because of the yardstick. However, if this technique is not generally accepted among network operators as the optimal technological choice, not fully rewarding the upfront costs seems to be appropriate.

Inefficiency in regulation might exist, however, if the investments create positive externalities as a result of which operators would invest too less or when operators face significant differences in structural circumstances. Creating specific product categories in the tariff decisions and adding more flexibility to the yard stick scheme seems to be adequate measures to solve these inefficiencies.

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