MASTER

Incentive regulation of electricity distribution networks

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Award date:
2010

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August 2010

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Preface

This report is the final thesis for the Master program Innovation Sciences from the University of Technology in Eindhoven (TU/e). For the last eleven months I have been an intern at PricewaterhouseCoopers (PwC) in Amsterdam where I have spend 80% of my time writing my thesis and 20% working at projects for PwC. I can look back at an enjoyable period where I have learned many things about the work of a distribution network company, electricity regulation and more in general the economics of regulated sectors. Being an intern has provided me with the opportunity to see and experience the working environment of a large consultancy firm. This has been a great learning experience for me; both intellectually and personally.

After spending seven years at the TU/e, of which six for my finished Bachelor and Master programs, it is hard to realize that I have reached the end of this stage of my life. Fortunately every end leads to a new beginning and I can't wait to put everything I learned about the energy sector and myself into practice in hopefully a good start of my career.

This thesis has been a lot of work and would not have been possible without the excellent supervision of Wim Wenselaar and Geert Verbong from the TU/e and Paul Nillesen from PwC. They have provided me with valuable insights, guidance and knowledge through their extensive experience in the energy sector and legal frameworks. Furthermore, their enthusiasm for the topic of my thesis made our meetings a source of inspiration for me. For all their work and efforts I would like to thank Wim, Geert and Paul very much.

I would like to thank the colleagues at PwC for providing me with valuable information for my thesis and by giving me opportunity to work side-by-side with them, and of course the enjoyable time at the office. Moreover, I would like to thank the interns at PwC for the endless discussions we had about our theses and providing each other with inspiration and feedback when progress was slow.

Last, but certainly not least I would like to thank Carlijn, my family and my friends for their never ending interest, support and encouragement during these last eleven months.

Utrecht, august 25th 2010

Bram Gelissen

Executive summary

Distribution Network Operators (DNO's) are increasingly confronted with a changing environment. Changes resulting from different technologies that are used to generate electricity and different technologies used to use electricity. New sources of renewable energy like photovoltaic power, wind power and (micro) CHP units have a profound effect on the distribution grid due to their small-scale nature which is the opposite of centrally generated electricity based on fossil fuels that is currently in place. The increased use of high electricity demanding technologies like the electric car, heat pumps and air-conditioning units have an effect on the distribution grid because of their similar load profiles resulting in a substantial increase of (peak) load. Every renewable electricity generation technology and most of the electricity demanding technologies are, despite their effect on the distribution grid, technologies that are beneficial from a societal point of view and are mandatory as a result of European regulation and the set 20-20-20 energy targets.

The distribution grid does not have enough capacity to handle the extra up- and downstream electricity flows and it is designed as a pass-through grid from the higher hierarchical grid levels to the end consumer, it is not designed to be an active grid that has to manage supply and demand on its own. Combine this problem with grid assets reaching the end of their expected life-span. The result is that changes to the grid are required; changes that require large lump-sum capital investments. Replacing and strengthening the grid requires tremendous investments that could be mitigated by innovative technologies to balance supply and demand more efficiently.

The Energiekamer is the regulator of electricity and gas networks in the Netherlands. Unbundling of vertically integrated energy companies led to the separation of electricity generation from the transport of electricity. Distribution grids are now separate companies, independent from generation and they are operated by network operators, the DNO's. The networks are natural monopolies and are therefore regulated by the Energiekamer to ensure efficient operations against the lowest possible tariffs for consumers.

The Energiekamer sets the regulatory framework for DNO's. It is based around benchmarking the DNO's against each other to derive the average cost level the DNO's are allowed to remunerate. Every year the cost level decreases to account for efficiency improvements and increases to account for inflation and a reasonable profit margin. This benchmarking has a major downside: costs that are unequal from other DNO's are considered above-average in the benchmark and are therefore not remunerated. The electricity supply and demand technologies and their subsequent effects on the grid are costs that are unequal between DNO's. The result is that DNO's are unable to remunerate their costs and are unwilling to make the necessary investments (although some investments are mandatory by law to maintain a highly reliable electricity supply). This thesis analyses the existing options to remunerate investments and discusses if and what improvements are possible.

Firstly, a framework comparison between the United Kingdom and the Netherlands is made. Eight concepts have been compared: 1) national electricity regulation; 2) level of unbundling; 3) regulatory period; 4) regulatory mechanism; 5) efficiency of operation factor; 6) level of quality factor; 7) incentive instruments and 8) connection regulation. Several conclusions are drawn on

this comparison of which the level of detail in the Electricity Act, the way cost-projections are made and the timing of asset inclusion in the Regulatory Asset Base are most important. The UK Electricity Act is much less detailed which leaves more options to swiftly change the policy decrees containing the details. The UK system does not benchmark capital expenditures, only operational expenditures, which increases flexibility in the regulation to add capital incentives. Furthermore, the capital projections for the upcoming period are based on future cost projections instead of historical data as in the Netherlands, which increases options to remunerate realistic cost levels. Lastly, the UK framework includes assets (thus investments) faster in the Regulatory Asset Base and that results in faster remuneration for DNO's. In the Netherlands this takes many years in the worst case.

Secondly, the incentives currently in place in the regulatory framework are analyzed. There are two incentive instruments in place that are able to remunerate investments without the need to benchmark them. The Objectifiable Regional Differences instrument remunerates investments that cannot be influences by the DNO's because they are the result of regional differences like a high percentage of water crossing in a service area which costs more money than ground crossings. The 'substantial investment' instrument remunerated one-off large investments that are unique in character and too large to be made by the DNO's without any extra remuneration. Both instruments in their current design are not able to remunerate the costs resulting from the supply and demand load technologies. Other instruments that used to be active have been considered like the distribution losses incentive and a generator tariff (including the potential for locational pricing). Furthermore, the newly designed composite output is discussed. Options to improve the current regulatory framework are largely based around the Tariff Code which is reasonably easy to change.

Thirdly, an analysis of incentives aimed specifically at innovative investments is made. Innovative investments are divided in three stages: 1) the Research & Development stage; 2) the small-scale field-testing stage and 3) the large-scale deployment stage. The Netherlands have no incentives specifically for innovative investments. The United Kingdom on the other hand has got two instruments; the Innovation Funding Incentive (aimed at the first stage) and the Low-Carbon Network Fund (aimed at the second stage). Whether these instruments result in benefits for the consumers (or less costs) is not certain yet, but they are designed around consumer benefits. A translation of these instruments to the regulatory framework in the Netherlands is not easy, but possible by altering the 'substantial investment' instrument and consequently the Tariff Code. Within the low-carbon network fund a large sum of money is reserved for flagship projects for which the DNO's have to compete, like a public charging infrastructure for electric vehicles. Competition for these projects might have lesser effects than a cooperative action by the DNO's, which is possible in the Netherlands through Netbeheer Nederland.

Lastly, a chapter is dedicated to the reduction of regulation to allow third parties on the electricity distribution market. Partly based around the premises that competition is the best stimulus for innovativeness, and party based around the premises that third parties can complement DNO's in their efforts to mitigate the effects of electricity supply and demand technologies. A sector comparison is made between the electricity and telecommunications sector because the telecommunications sector has been very successful in allowing third parties access to the grid. Three types of competition are discussed: 1) facilities based competition; 2) use of unbundled network elements and 3) resale (competition on services). The second type is most promising in the electricity sector. By unbundling of the local loop (the last part of the grid to the actual point of usage) third parties are allowed to own and operate a part of the grid, thus making them fully responsible for both costs and benefits. There are three main arguments why this system would provide both DNO's and third parties (private networks) with benefits, a win-win situation: 1) better allocation of costs and benefits which can be beneficial to all involved stakeholders; 2) by carte blanche regulation the private networks and DNO's could learn a great deal about balancing demand and supply load changes and private networks are able to implement changes that they consider necessary and 3) the DNO would be responsible for balancing a group of balanced small private networks that makes their job easier.

The comparison between the electricity and telecommunications sector provided some other useful concepts. The DNO is able to diversify the services it provides by adding value added services to their lines of services. DNO's and/or the holding they belong to are allowed to diversify their services as long as it is related to the operation of a network and it does not interfere with any of the mandatory activities of the DNO. Examples are heat, cold and water networks.

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1 Introduction

We can't imagine a life without electricity being freely available to us. Electricity is used to power all electrical appliances; it is used for lightning and even for cooking (depending on the availability of gas). Traditionally, this electricity is generated by central power plants driven by fossil fuels. It is transported over the transmission and distribution grid to the final consumers, both industry and households. Transportation was provided by the same companies generating the electricity. Vertically integrated companies provided all services of the electricity value chain; from generation to transport to delivery. Day-to-day operations were fairly static without any major disruptions. Unbundling of the vertically integrated companies led to the creation of competition in several stages of the electricity value chain.

Generation and delivery were considered to be markets with potential for competition while transmission and distribution were labeled as natural monopolies and a regulatory framework was designed to govern them. Nowadays there are many electricity providers present on the market. TenneT, the Transmission Network Operator (TNO) takes care of transportation of electricity through the main grid. Several independent, geographically separated Distribution Network Operators (DNO's) are appointed to operate transportation to the final consumers, the last mile. Since both the TNO and DNO's are considered natural monopolies they are price and quality regulated by the Energiekamer, the regulator appointed by the Dutch government.

Electricity transportation used to be a static sector with electricity demand being the main variable having an impact on the development of the physical network, but things have changed. Network assets are reaching the end of their expected life-span, network extensions (both national and international connectors) are increasing, the transition towards a renewable electricity supply and finally the transition towards a smart grid as a result of new supply and demand technologies are the four main factors shifting the static sector towards a highly dynamic one (figure 1.1).

Figure 1.1: four factors of the shift towards a dynamic sector for electricity transportation

The transition towards a renewable electricity supply and the transition to a smart grid go hand-in-hand with changes to the supply and demand load. Demand technologies like the electric car, heat pumps and air-conditioning units will have a significant effect on the distribution network because of their large and simultaneous demand for electricity. Supply technologies like solar panels, wind mills and combined heat & power units (CHP), generally considered as distributed generation, generate electricity on a small and local scale which is being fed back into the distribution network. The network is designed to pass down the electricity it receives from the transmission grid to the consumer; it is not designed to manage demand and supply on its own.

The four factors in figure 1.1 all require substantial investments from the TNO and DNO's. The capital problems associated with the transition of the grid, as well as network replacements and expansions could all be solved by replacing and reinforcing the grid, but since the consumer ultimately pays for them this is not desirable. The costs of these investments are paid for by the consumers through the transportation tariffs. The regulatory framework by the Energiekamer is aimed at increasing the efficiency of operation within the network operators, thus keeping costs and tariffs as low as possible, while still maintaining a high level of quality.

Innovative solutions can provide an alternative to the problems; replacements and expansions could be mitigated and the network transitions require innovative solutions that redeem the need for costly network strengthening. Unfortunately the regulatory framework only provides reimbursement for investments leading to an increase in operating efficiency. The first question in this thesis is therefore aimed at improving reimbursement options for innovative investments:

Question 1: what are the current options to incentivize innovative network investments and how can these incentives be improved within the regulatory framework?

As said, the regulatory framework only reimburses investments that lead to an operating efficiency for the TNO and DNO's and subsequently lead to a tariff reduction for the consumer. However, there are investments that do not increase the efficiency of network operators but are still beneficial from a societal point of view (i.e. lower carbon emissions increased security of supply). This kind of investment is desirable but reimbursement is not possible through the regulatory framework i.e. the investment will not take place. Bottleneck is the allocation of costs and benefits between DNO's and consumers.

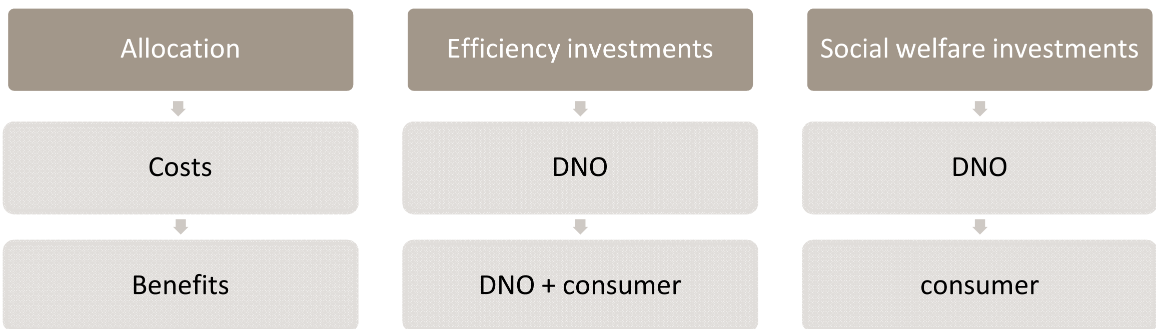

Figure 1.2: cost and benefit allocation for two kinds of investments

The bottleneck causes benefits that do not increase efficiency to be captured by the consumer while the DNO is responsible for making the initial investment. The benefits are supposed to be allocated to the DNO who subtracts his costs and passes any further benefits down to the consumer through a reduction in the tariffs. The sub question in this thesis is embedded in the main question and it is aimed at improving cost and benefit allocation between the DNO and users.

Question 1a: how can cost/benefit allocation be improved within the regulatory framework?

The main research question and the embedded sub questions will be answered in this thesis using several analyses and discussions. The results will be provided by a set of conclusions and policy recommendations.

2 Research rationale

The global energy market is subject to large expected changes from an environmental, affordable and reliability point of view. Energy regulation is all about affordability and a reliable energy for everybody, but a third and fourth aspect are becoming more important in current regulation, the care for the environment and a security of supply. These last two aspects have always been present but were fluctuating in their importance. Their current upswing is caused by changes to the environment, the realization that fossil fuels are slowly depleting and geopolitical instability as witnessed by recent problems with the import of Russian natural gas. The extended regulatory concern will be designed around a transition from a high-carbon to a low-carbon based economy.

Global aspirations have been translated in targets set by the European Union that have been ratified by all Member States, including the Netherlands. The transition towards a low-carbon economy can be envisaged in a large variety of possibilities. A common understanding between them is the necessity of renewable energy technologies that will be implemented into the society, be it on the demand and/or the supply side. On the supply side one can envisage that renewable energy sources will provide the future electricity demand (at least for a substantial share). On the demand side the saving of energy will play a large role, both in domestic use and transportation.

Changes to both the demand and supply side regarding renewable energy generation and energy preservation will have a large impact on the top-down structure of the current electricity network. Up until now, most electricity is still generated in large centralized power plants which are located far from the place where the actual consumption takes place. The network provides the transportation of electricity from the power plant to houses and the industry. The demand and supply changes will change the electricity networks compared to their current design, as will be explained in sections 2.1 and 2.2.

The electricity network is subject to governmental regulation since it is considered a natural monopoly and is therefore susceptible to strategic behavior which increases prices for final consumers. Regulation is designed for a fairly static situation without major design alterations that require large lump-sum investments, changes that are bound to occur within the next decade. A regulation problem thus exists as will be explained in section 2.3, and changes to the regulatory framework are necessary to cope with future changes as will be explained in section 2.4. The layout of this chapter is provided in figure 2.1.

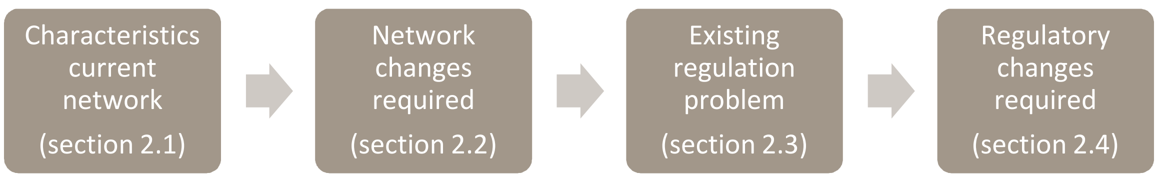

Figure 2.1: layout chapter 2

2.1 Characteristics current network

The electricity network can be described by several characteristics; economies of scale, capital intensity, peak-load based and location specificity. These characteristics can explain why the electricity network is so rigid in its ability to react on large changes.

The electricity grid is a capital intensive structure to construct, but once it has been built, it is fairly cheap to operate as compared to the initial lump-sum investment. Furthermore, the grid experiences economies of density because the more people are connected; the cheaper it becomes to use the network since initial costs are socialized amongst all users. The implementation of new connection to the existing network is not that expensive compared to increasing the coverage of the network itself or increasing the capacity. Another result of economies of scale is that is economically not feasible to build a second electricity network beside the existing one, causing the network to be a natural monopoly and thus requiring regulation.

The current grid is designed for a certain capacity (including spare capacity) that is based on a peak-load. Once the peak-load is greater than the available capacity, congestion occurs. Congestion can be solved by either reducing the peak-load (thus reducing consumer demand) or by reinforcing the existing grid. Reducing consumer demand is the preferred option since reinforcements are capital intensive but this is difficult to realize.

Every major change to the electricity network, besides connecting new consumers, is capital intensive. Increasing or strengthening the current network requires large lump-sum investments by the system operator. Increasing or strengthening the current grid is not a process which is evenly spread over the Netherlands; there are regions that require more and/or earlier adaptations, adaptations that can be substantial i.e. the Westland region where electricity supply by greenhouse owners using CHP technology caused congestion in the grid.

Three economical characteristics are present that explain the rigidness of the current electricity network to large changes: 1) enlargement of the network is capital intensive; 2) strengthening of the network is capital intensive and 3) investments are likely to differ between regions.

2.2 Network changes required

Changes to the network can be expected in the near future because on the one hand networks are reaching the end of their expected life-span, and on the other hand the transition towards a low-carbon economy will bring about changes in the way networks are used.

Ageing of the network

The technical state of the electricity network is important to maintain a high quality grid. The security of supply and reliability of the grid are important qualities and are therefore (partly) regulated by the Energy Board through the quality factor in the benchmark. Furthermore, the technical state of the grid is important to ensure safety for TSO and DSO personnel working on the lines. While safety and security can be ensured during the normal life-span of the networks, hereafter the high level of quality will be more difficult to keep without replacements and consequently investments.

The components of the Dutch electricity grid have been constructed and developed in the 1950s and 1960s. The current transmission and distribution grids usually have an average life-span of about 60 years. There is thus an increasing problem of network assets reaching the end of their designed life-span According to SenterNovem (2006) and the NMa (2010) the technical state of the electricity network contains for a large percentage parts that have reached the end or will reach the end or their expected life span soon. According to Grubb et al. (2006) The problem is also present in the United Kingdom where most of the current transmission and distribution network was constructed in the 1960s and 1970s (Grubb et al., 2008) (SenterNovem, 2006) (NMa, 2010).

Without technological advances the capital expenditure curve from the initial network construction in the 60s and 70s would have to be repeated to replace the entire network. That investment peak would be in the present, something which is clearly not the case, although this is largely the result of delays in the replacements of assets due to life extension techniques, asset management and condition monitoring. The investment curve from the past is unlikely to be repeated in a similar manner but it is clear that one cannot keep delaying replacements that are inevitable in the long run. Replacements are very expensive (inherent to the electricity grid characteristics) and are considered lump-sum investments.

When assets have to be replaced due to their ageing, this provides an excellent opportunity to invest in new assets that contribute to a transition towards a low-carbon economy.

Transition to a low-carbon economy

Changes to networks can be divided in changes to the demand load curve and the supply load curve. Supply load curves will alter as a result of more distributed generation, thus localized feed-in to the network. This is a diversion from the traditional, central way of electricity generation in which large power plants generate electricity located far from the end-consumer and then transport it through the transmission and distribution grid. Distributed generation in this research is considered small scale generation connection to the distribution network. The distribution grid is designed for electricity pass-through from the transmission grid to the consumers; it is not designed for active management of supply and demand. Active managements will require changes to the networks, changes that have large uncertainties to them regarding expected costs and/or benefits.

Changes to the load curves are the result of 'new' technologies; technologies like heat pumps, electric vehicles and air-conditioning units. While these technologies in themselves are not new at all, their large-scale implementation would be. Supply and demand loads are likely to increase because these technologies are expected to substantially change load profiles and focus the consumption of electricity instead of spreading it. For example, heat pumps are controlled through a thermostat and will start-up when the temperature reaches the set temperature floor. This floor temperature will not differ substantially between consumers. Heat pumps have a large electricity load and a start-up at the same time will have a large demand on total capacity. The same goes for the electric car and air-conditioning units.

2.3 Existing regulation problem

The current regulatory framework imposed by the Dutch Energy Board on the electricity system operators is based on a system yardstick competition, an incentive regulation mechanism. The Dutch incentive regulation (also called RPI-X) allows for remuneration of total expenditures (TOTEX), which include both operational expenditures (OPEX) and capital expenditures (CAPEX). The OPEX includes all operational and maintenance costs while CAPEX is comprised of replacement, acquisition and expand costs necessary to maintain a functional and high quality electricity grid. This mechanism works well when OPEX and CAPEX are stable, but the required network changes described in the section above require large lump-sum capital investments. These investments in innovative solutions have a high degree of uncertainty. The lump-sum characteristics and the high level of uncertainty cause problems in the current system of yardstick competition.

Currently, investments in the RPI-X system are based on either short or long term profitability. DSO's are benchmarked and an average efficient TOTEX investment level is derived to which the individual DSO is compared. By outperforming the benchmark profitability increases and vice versa, by performing below the benchmark profitability decreases. Investments increasing cost-efficiency in the short run result in an outperformance of the benchmark. Investments increasing the cost-efficiency in the long run results in a temporary underperformance compared to the benchmark but are expected to generate greater efficiency levels in the future that compensate for the temporary unprofitability. The incentive to invest only works in case revenues of investments can be remunerated by the same network operators that make the initial investment, but what in case the benefits are going to society? Innovative investments are desirable from a societal point of view but lack remuneration options.

In the latest consultation document (16-10-2009) by the Energiekamer this possible investment barrier is recognized but nothing is done about it because the Energiekamer argues that the regulatory framework contains enough incentives for innovative investments to occur. According to the Energiekamer, remuneration of innovative investments is possible through four options (NMa, 2009):

1. Remuneration through the regulatory framework, thus the RPI-X system (direct reimbursement).
2. Remuneration in case revenues immediately follow investment which creates extra profit to be kept by the network operator (indirect reimbursement).
3. Remuneration through the acquisition of intellectual property rights for innovations.
4. Remuneration through governmental grants and tax benefits.

The second to fourth options are quite straightforward. The first option requires more explanation; remuneration through the RPI-X system is possible in three different ways as defined in the Electricity Act (1998): 1) reimbursement based on the yardstick competition (the benchmark); 2) reimbursement based on the 'objectifiable regional differences' article (regional differences which cannot be influenced by the network operators) and 3) reimbursement based on the 'substantial investment' article. According to the Energy Board, within the current regulatory framework remuneration for innovative investments is not possible based on the two exemption articles, ORV and AI, presented in the Electricity Act (1998). The first option, reimbursement through the yardstick competition mechanism, is the only option within the RPI-X system. It is the RPI-X system that does not facilitate investments because benefits are captured by society, resulting in losses being borne by the DNO's. The other options reimburse investments outside of the incentive regulation.

Summarized, the Energiekamer does recognize that there are investments which may not be able to be remunerated through the current regulatory framework but it states that in general the current framework gives sufficient incentives for innovative investments to occur. The Energiekamer considers yardstick competition to be based on open market principles, that is, investments will be made in positive business cases. The problem is thus that remuneration is only possible through the RPI-X system but this same system does not facilitate remuneration in practice like it is supposed to do.

2.3.1 What are innovative investments?

What is meant by innovation? According to Utterback & Abernathy (1975) innovation can be stimulated on three levels; 1) market; 2) production or 3) new technology. Slootweg, a professor at the TU/e (Slootweg, 2009) also acknowledges that in a competitive market innovation can lead to three possible benefits for companies which are largely comparable with the levels of Utterback & Abernathy: 1) through an increase of efficiency (and thus reduction of costs); 2) through increased value of the product (thus an increase in costs) and 3) diversification into other markets (thus an increase in quantity).

The Energy Board assumes the yardstick competition to represent a competitive market situation. This statement implies that the artificial competition in itself leads to investments in innovations and therefore additional stimuli are not required. In reality, only efficiency improvements are realized while there is underinvestment for the product and market level. The Energy Board holds on the statement that the yardstick competition is both able to achieve efficiency improvements and to improve innovation investments, among others; Slootweg disagrees with this statement.

Innovation is a broad concept that cannot be used in every situation and context; differentiation between different aspects of innovation is desirable. Chapter 2 describes that the lack of incentives for innovative investments is partly caused by profits that are beneficial to society as a whole instead of the investor. A differentiation between innovations can be made according to the actor that gains most from them; and simultaneously, this differentiation goes for the type of innovation (efficiency, product or market). Several reactions on the Energy Board's Consultation Document (2009) make a notice of the differentiation between 'endogenous' and 'exogenous' innovations. Endogenous innovations are aimed at the first type of innovation, the improvement of efficiency levels to increase internal profits. Exogenous innovations have a societal profit; they facilitate the transition to a low-carbon economy and thus facilitate a structural change for system operators.

The above desired definition inclusion of 'exogenous' and 'endogenous' innovation in the definition is not (yet) in use by the Energy Board; they use the definition provided by the Ministry of Economic Affairs which is "renewal precipitated in products, services, organizational processes or models of organization". This innovation should be a change in the 'things' that companies provide or the way in which they create and deliver them while the change in itself is beneficial to the organization itself, the customers or the society and environment.

2.4 Regulatory changes required

The electricity sector as it is currently designed is unable to react to large changes, changes that are expected in the near future due to ageing of the network and the transition towards a low-carbon economy. The current regulatory framework is unable to cope with the large lump-sum investments required for these changes because the network operator must pay the costs but is not able to receive the benefits; the benefits go to society. This leads to the description of two research questions which are to be answered in this research:

Question 1: **what are the current options to incentivize innovative network investments and how can these incentives be improved within the regulatory framework?**

Question 1a: **how can cost/benefit allocation be improved within the regulatory framework?**

3 Thesis outline

The introduction in chapter 1 and the extended research rationale in chapter 2 have set the landscape for this thesis as the problems and obstacles in the changing environment for electricity transportation network companies, and the lack of corresponding change within the regulatory framework to cope with these problems. This has led to two main research questions that have a broad scope which needs to be reduced to a manageable size.

The next sections are dedicated to the reduction of the scope and the explanation of used research methods in this thesis. Section 3.1 starts by providing a short breakdown of renewable energy policy that explains the importance of a renewable energy supply on a European and national level. Section 3.2 elaborates on the use of scenario's studies for the selection of the distribution network companies (DNO's) and distributed generators as being important stakeholders in the transition towards a renewable energy supply. Section 3.3 explains the importance of DNO's by citing several respected scientific authors and papers in this field that propose five big issues facing both the DNO's and the regulatory framework. The following two sections finalize this chapter by introducing two means of comparison that will be used throughout this thesis to analyze the five issues raised before and can therefore be considered the research approach of this thesis. The two comparisons are: 1) the regulatory framework of the Netherlands versus the United Kingdom (section 3.4) and 2) the introduction of competition in the telecommunications sector versus the possibilities for competition for DNO's in the electricity sector (section 3.5).

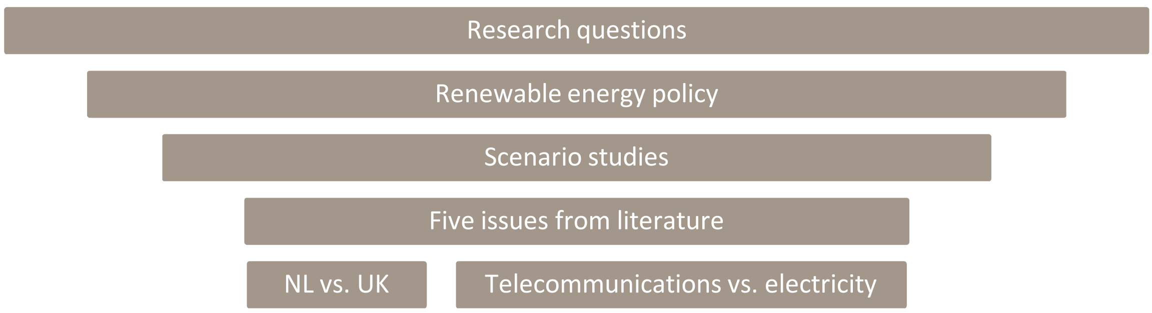

Figure 3.1: reduction of used methods to define the research scope

3.1 Breakdown of renewable energy policy

A broad overview of policy is provided to show what is the rationale behind the need for policy changes and how these policy changes are narrowed down from a European level, to policy on the national level and then in several steps to specific well-defined programs that are (partially) aimed at energy. This narrowing of policy is visualized for energy in figure 3.2:

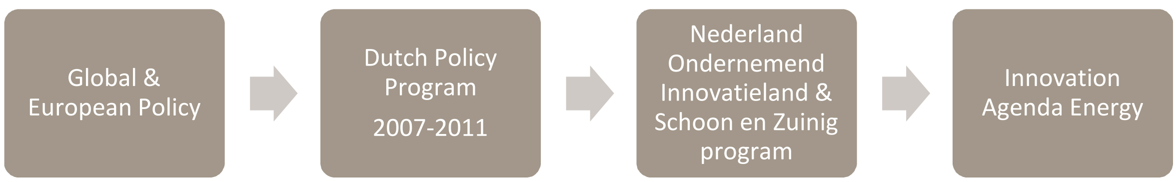

Figure 3.2: breakdown of Dutch energy policy

European Policy

European regulation can best be described by mentioning the series of demanding climate and energy targets that the EU heads of State and Government have set to be met by 2020. These three targets are: "1) a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels; 2) 20% of EU energy consumption to come from renewable resources and 3) a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency". These targets combined are known as the 20-20-20 targets of the EU. In January 2008 the European commission proposed binding legislation to implement these targets. The law enacted in June 2009. Amongst others, the legislation comprised of proposals for a revision and strengthening of the EU trading system for CO2 and binding national targets for renewable energy. The targets have been set for individual countries and are not the same for every country. Lastly, the promotion development and use of Carbon Capture and Storage technologies is part of the legislation (EC, 2007), (EU, 2010).

Dutch Policy Program 2007-2011

On June 14th 2007 prime-minister Balkenende and both vice-prime-ministers presented the Policy Program 2007-2011. The program consists of six pillars of which the second pillar is called 'An Innovative, Competing and Entrepreneurial Economy' and the third pillar 'Renewable Living Environment' (Rijksoverheid, 2010).

The second pillar of the 2007-2011 policy programs is divided in four challenges of which the second challenge partly falls within the scope of this research; "to increase and strengthen the innovative ability of the Dutch economy". Regarding this challenge a project to make better use of innovation to resolve societal issues is initiated, which is called: 'Dutch Innovation Country' (NOI)[1] and it incorporates a part about innovation in the energy sector.

The third pillar states four challenges of which the first challenge falls within the scope of this research "the reduction of greenhouse gases and an accelerated transition towards more durable energy sources". The project initiated by the government to address this challenge is: Climate and energy: the 'clean and economical'[2] program. The project encompassed three goals: 1) energy savings increase from 1% to 2% per annum; 2) an increase of the renewable energy share in the energy mix from 2% to 20% in 2020 and 3) a reduction in greenhouse gas emissions (preferably in a European context) of 30% in 2020 compared to 1990. Ultimately, the ambition of the 'clean and economical' program is to break with the traditional paradigm of how society produces and uses energy (VROM, 2007).

The energy challenges defined in the pillars of the governmental policy program 2007-2011 are translated in an overview of themes that are actively pursued by the government. The innovation agenda for energy combines the innovation policy and the 'clean and economical' and NOI programs should result in a coherent policy agenda for innovation in energy.

[1] The 'Dutch Innovation Country' program is called 'Nederland Ondernemend Innovatieland' in Dutch.
[2] The 'clean and economical' program is called 'schoon en zuinig' in Dutch.

The Innovation Agenda Energy

The innovation activities deployed in the energy field from 2008-2012 will be concentrated on themes presented in the innovation agenda, these themes are: 1) 'green' commodities; 2) new sources of gas; 3) a renewable electricity supply; 4) renewable mobility; 5) chain efficiency; 6) the build environment and 7) greenhouses as energy sources. The focus of the Innovation Agenda Energy is not specified to a single stage in the innovation process but rather its full spread, comprised of: R&D of new renewable energy technologies and systems; application of new renewable energy systems to stimulate 'learning by doing' as to reduce the costs; and implementation of renewable energy systems by means of removing barriers (SenterNovem, 2010).

3.2 Scenario studies

Scenario studies are used to distinguish possible transitions and developments of a technology, sector, company etc. Scenario studies are able to project future problems prematurely in order to be able to prepare for them. Scenario's are not prognoses like the prognoses used by the DNO's to provide information to the Energiekamer; neither are scenario's focused on the prediction of events. The scenario studies useful for this thesis are designed to project the future transitions of electricity generation and supply; whether it will be fossil fuel based or use renewable sources. The transition towards a renewable energy supply system does not have a fixed pre-determined path to follow. There are various options possible that could initiate and accelerate the transition. In available scientific literature several scenario studies appear when discussing the transition to a renewable energy supply system; TenneT (2008), Meeuwsen (2007), Energie Rapport (2008) and Scheepers (2008).

Most scenarios are based around the different possibilities for electricity supply that are divided between fossil fuel based generation and renewable generation, and the range between scenarios is very large. The largest differences between fossil fueled power plants and most renewable generation units is the size, location and connection point to the grid. These differences are very interesting because they are very diverging from the current situation of large-scale centralized electricity generation. This is the reason that this scenario will be used as a base of reference to continue with. Chapter 4 will describe the nature of distribution generation and its characteristics. The size, location and grid connection point impose problems for the network operators, both on the national and regional level (TNO and DNO).

This thesis will focus on the effects of distributed generation on the distribution grid because the effects of small-scale distributed generation on the distribution grid are much more diverging from the current situation than large-scale distributed generation would pose on the transmission grid since it is comparable to implementing a new fossil-fueled power plant. The problems and solutions are better known for large-scale distributed generation as with small-scale units. This poses an interesting problem and will therefore be the starting point for the analysis in this thesis.

3.3 Five issues from literature

A transition towards a renewable energy supply requires many changes; changes in the way electricity is generated and consumed. The changes have to be facilitated by present technology, by the regulatory framework and by sound economic principles. Generation and consumption patterns result in an average supply and demand load around which the electricity network is designed. Altering supply and demand load patterns has repercussions on the electricity network, on both the transmission and distribution level. The issues facing networks have been listed by several authors (Pollitt, Jamasb & Grubb, 2008) as are the considerations for regulators to address these issues.

Based on scenario studies there are several broadly stated changes that affect electricity networks: 1) the transition to a smarter network; 2) the ongoing transition of international network linkages and 3) the introduction of more distributed generation to the network, thus the transition from central to distributed generated electricity. These three transitions are expensive and require much investment. Investments necessary in the long run but which already have to be made in the present. The long term nature of these investments and the substantial capital expenditures related to these investments makes that forward planning, forecasted demand growth and demand patterns will play a very important role when determining where and when capital should be invested. Uncertainty about required future network changes leads to a regulatory framework that avoids lock-in to a single path and does not discriminate against some of the paths. These problems lead to a key challenge described by Grubb, Jamasb & Pollitt (2008): "a key challenge for network regulation is that incentivizing efficient investment in situations of uncertainty about the nature of demand growth is not very well understood".

There are many authors that propose improvements for DNO's and the regulator. In general these views by are quite similar and complementary and can be divided in two main categories, these are: 1) a need to increase involvement by customers in investment and output decisions and 2) a need for the network operators and regulator to facilitate the move to a low- carbon economy.

More detailed views by authors on these two categories include the following subjects which are aimed at the creation of more competition on the local level between: 1) centralized (renewable) generation; 2) local generation at the bloc/city level and 3) local generation at the household level. Pollitt (2010) suggested in a presentation for a PwC regulation master class the following:

1. More use of negotiating. Is the creation of a demand side for network services possible? What facilitates sensible and timely negotiation?
2. Extension of auctions (tendering). Inducing new entry of stakeholders. Minimizing the building costs of networks.
3. Attention to access terms. Elimination of barriers to experiment with access. Encourage efficient new connections.
4. Innovation in/across networks. Encourage innovation in the use of networks. Incentivise incumbents to facilitate new business models.
5. Role of unbundling and ownership. What do current market dynamics mean for the optimal degree of integration? Are there new entrants possible and coming? What is the role of public and cooperative ownership?

Grubb, Jamasb and Pollitt (2008) suggest five areas to Ofgem, the UK regulator to consider and improve the design of the regulatory framework: 1) the current approach to RPI-X regulation needs to be updated; 2) the regulation of new investment needs to draw on emerging ideas for 'constructive' user engagement from other regulated sectors and other countries, incorporating more use of competitive tendering of network investments; 3) the issue of locational pricing signals should be examined; 4) ownership unbundling of networks from retailing could be extended and 5) innovation in networks needs to be encouraged.

The areas and topics suggested by Grubb, Jamasb and Pollitt will be used as a starting point to answer the answer the research questions from the second chapter. The five issues from literature are considered to be the key problems and solutions for the UK regulatory framework, a framework as section 3.4 will describe is quite similar to the framework in the Netherlands. This thesis uses these areas as strongholds, ideas and possibilities to improve the Dutch regulatory framework in order to answer the research questions.

3.4 Why compare the UK and NL

Comparing the Dutch regulatory framework to international regulatory frameworks is possible but only with a select group of countries; countries most comparable to the current situation in the Netherlands. The choice of countries is a questionable one to make since one on one comparison between countries is not possible, therefore a parameter must be chosen. In general, the regulatory framework in the United Kingdom is considered to be the most advanced one in Europe. The Netherlands and the Scandinavian countries are countries generally assumed to be comparable to the United Kingdom considering the level of maturity in the regulatory framework (i.e. Jamasb & Pollitt, 2005-2009). To base this choice on more thorough scientific reasoning, the traditional model of electricity reform is used. This model explains the degree of reform in the electricity sector by using several elements. Countries that have more elements of electricity reform in common are more likely to be comparable than countries that differ in these 'basic' elements. The model had four key elements as it first emerged in countries like Chile (1982), the UK (1990) and Norway (1991), these elements are: 1) the introduction of a competitive wholesale power market; 2) the gradual extension of competition in the retail market; 3) the regulation of network services via RPI-X regulation and 4) the introduction of additional incentives for quality of service and los reduction.

All electricity wholesale markets in Europe are liberalized but there are still large differences in the levels of concentration between Member States because in many countries the energy companies are still in governmental hands. In the European Union, the three largest generators still control over 70% of the capacity to generate electricity in 15 member states. This high level of concentration is confirmed by a recent paper by the Commission of the European Commission (2009) in which it was concluded that in only eight Member States a moderately concentrated market existed (regarding the gas wholesale market, the concentration was even greater). A commonly used measurement index for the competition in a market is the Herfindahl-Hirschman Index (HHI), the lower the concentration and thus the HHI, the higher competitive pressure in the market can be assumed. The market concentration of the electricity wholesale market in Europe can be seen in figure 3.3 below; based on this figure the most comparable countries to the Netherlands are: United Kingdom, Norway, Sweden, Finland, Poland, Austria and Hungary.

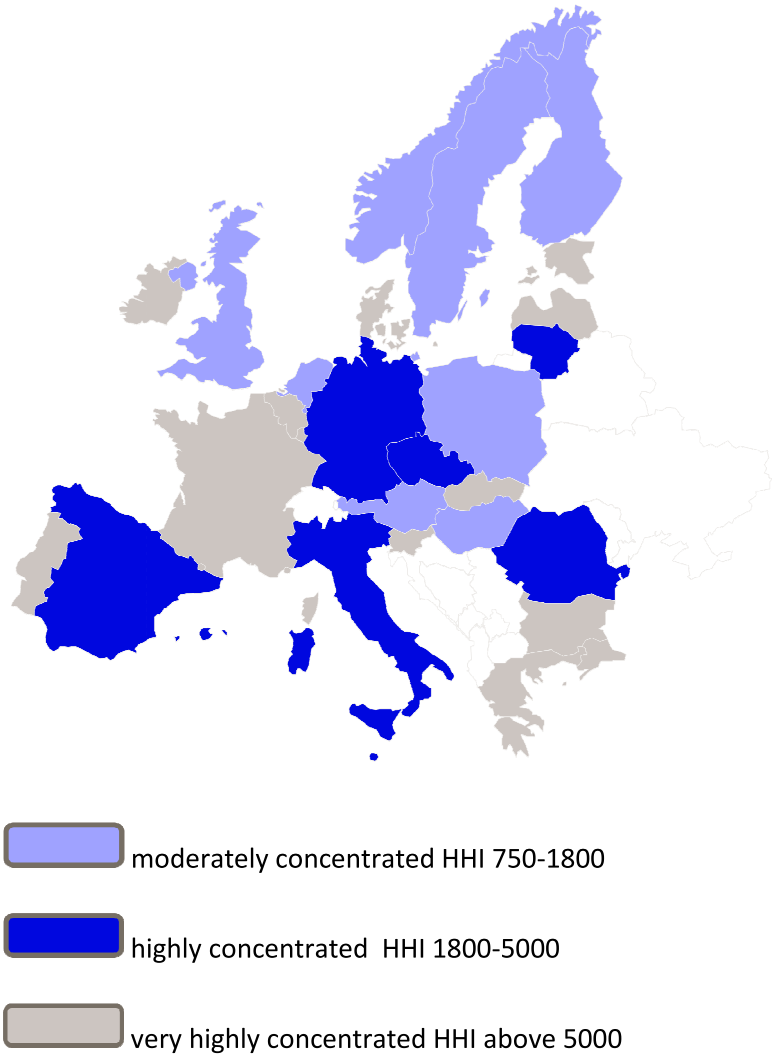

Figure 3.3: level of electricity market concentration in the EU

In the comparison of the second, third and fourth element of the traditional reform model several similarities can be seen as well. These other elements will not be described in great detail in this section; further sections will describe the regulation in both the United Kingdom and the Netherlands. The United Kingdom has also introduced competition in the complete electricity value chain excluding the natural monopoly parts of the transmission and distribution grid (element 2). Furthermore, the United Kingdom has also introduced a system of RPI-X regulation, although a building blocks approach instead of TOTEX, combined with quality incentives (element 3) and incentives aimed at loss reduction (element 4). The rationale for choosing the United Kingdom over countries like the Scandinavian ones and Austria is the degree to which the UK is implementing directives and incentive instruments to cope with dynamic changes like the expected CAPEX increase and an increased share of distributed generation in the grid, as will be further explained in this thesis. In chapter 7 there will be some reflection on incentive instruments that have been implemented in other countries like Norway and Germany.

3.5 Why compare telecommunications and electricity?

The rationale for using the telecommunications sector as a comparison for the electricity sector is the lead position it has in introducing competition in the sector with the use of regulation (Green et al, 2006). The introduction of competition has stimulated “large amounts of innovation, customer choice, price reduction and quality improvements. Incumbent telecoms firms have become significantly more efficient and innovative, while entrants have made substantial investments in both infrastructure and in the development of new consumer products” (Pollitt, 2010). This quote is precisely the reason why electricity regulation is compared to telecommunication regulation. Especially chapter 10 is aimed at deducting possible regulation adjustments from looking at telecommunications.

4 Distributed generation

There are several questions concerning distributed generation (DG) that are important for this thesis. The first question, what DG is, is described in section 4.1. Among the most important characteristics of DG are the different supply and demand load projections and their impact on the distribution grid, explained in section 4.2. The layout of chapter 4 is represented in figure 4.1.

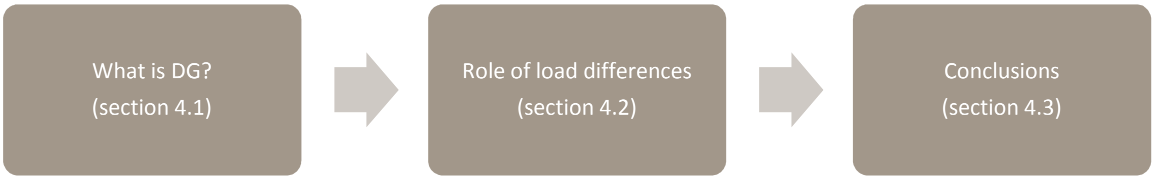

Figure 4.1: layout chapter 4

4.1 What is DG?

The question what DG exactly is will be described by providing a definition as a hold-on for future referring. Section 4.1.1 will go deeper into the definition of DG and section 4.1.2 lists several sources of DG.

4.1.1 Definition of DG

The European Directive concerning the common rules for the internal market in electricity (EU, 2003) states in Article 2-17 that distributed generation means:

Generation plants connected to the distribution system

The EU definition of DG is very limited; a different distinction between DG and other generators can be made based on the provided level of power which depending on the organization, institute or author can range from a few kW up until 100MW. There is thus a broad range of possible definitions for DG. Ackermann et al. (2001) have therefore created a more elaborate definition using nine different parameters: purpose, location, power level of DG, power delivery area, technology, mode of operation, environmental impact, ownership and penetration of DG. Most parameters are not relevant to distinguish in the definition, they are important characteristics to be considered but have no impact on how DG is defined, except for the first and second parameter; purpose and location. When implementing these two parameters in the definition by the EU (2003), DG means:

Electric power generation plants connected directly to the distribution network or on the customer side of the meter

This definition is also partly used by the IEA (2002) to state the difference between DG and large generating plants. The IEA defines DG as “a generating plant serving a customer on-site or providing support to a distribution network, connected to the grid at distribution-level voltages. The technologies generally include engines, small (and micro) turbines, fuel cells and photovoltaic systems. It generally excludes wind power, since that is mostly produced on wind farms rather than for on-site power requirements”. In this research no distinction is made between different technologies, thus that part (including the wind power statement) will be neglected. The definition stated above stays.

4.1.2 Sources of DG

Distributed generation entails, according to the definition stated above, the generation of electricity from small-scale of micro-unit production. The input in the electricity grid should be on the distribution level or at the household directly. The scheme below shows the different sources of electricity input at the transportation grid and finally the consumer.

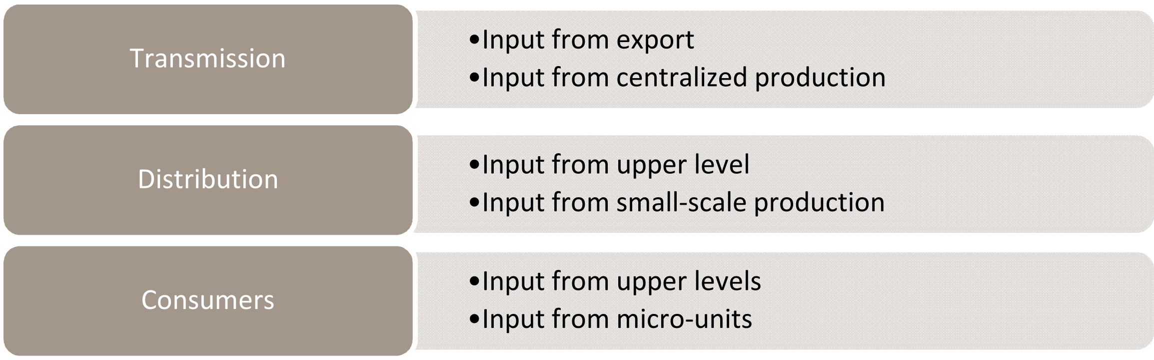

Figure 4.2: listing of different electricity input levels

Distributed generation can be further divided (large distributed generation plants are already excluded by the definition) into their source of 'fuel' used to generate electricity. It can be either fossil fuel sources used in energy efficient ways or renewable energy sources. Due to economies of scope, large fossil fuel generation would not be economical; therefore fossil fuel sources are only used in co-generation plants on the distribution level. The scheme below shows the division of DG in co-generation and RES. Within co-generation a distinction can be made between the numbers of services provided while for RES a distinction can be made between the different sources of generation.

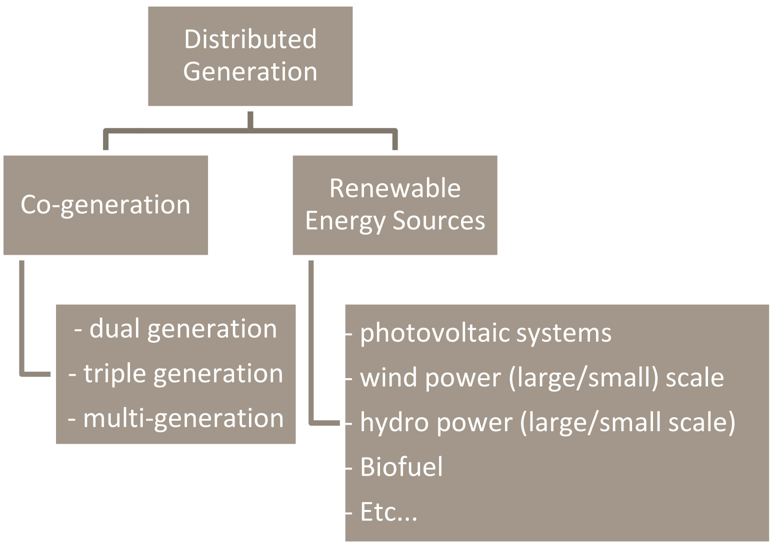

Figure 4.3: listing of distributed generation sources

4.2 Load differences

Differences in load occur in several dimensions. There are future differences in demand and supply load as well as temporal and location load differences. All four dimensions will be described in the following sections.

4.2.1 Electricity demand and supply load technologies

According to Scheepers (2007) "a technology which is new in the supply or demand of electricity or a technology which has a substantial change in performance as a result are innovative". Technologies currently in use which are not expected to change radically in the future (change in technology or change in usage) are not relevant in this thesis since they do not propose immediate problems on the electricity grid, in contrast to innovative technologies that are relevant in this research.

Changes in the demand load for electricity are bound to occur compared to the current load situation where electricity loads are still reasonably predictable in time (seasonal and daily) and location. Furthermore, generation of electricity is balanced on the current load projections, but with large changes in the future, these projections will change largely. The technologies most likely to influence the demand load projections are according to Scheepers (2007): plug-in hybrid electric vehicles (PHEV), electric heat pumps for spatial heating and air-conditioning units. The same demand technologies are mentioned by the Energieraad and by Geert Verbong at the TU/e.

A diversion from the traditional (central) way of electricity generation cause changes to the electricity grid. Centralized generation is very economical due to the utilization of economies of scale. A transition towards decentralized electricity generation leads to a very different supply load profile as a result of several possible innovative technologies. Scheepers (2007) describes seven technologies: 1) on-shore wind; 2) off-shore wind; 3) photovoltaic (PV) solar energy; 4) biomass; 5) coal gasification with CO2 capture; 6) large-scale fuel cells and 7) micro CHP. The TenneT report (2008) about their vision for 2030 they distinguish between technologies close to and technologies located further from the end-consumer. Far from the end-consumer technologies are: 1) large-scale biomass; 2) coal plants with CO2 capture and storage; 3) nuclear energy; 4) off-shore wind and 5) international renewable energy trade (thus import). Close to the end-customer technologies are: 1) micro CHP; 2) solar PV on roofs; 3) on-shore wind and 4) small-scale biomass. The scenario's studies performed by the Energieraad (2008), the WLO (2006) en Meeuwsen (2007) all show similar results for the future use of renewable technologies although their respective percentages differ heavily among described scenario's. It is however remarkable that the combined heat and power (CHP) technology is not acknowledged by all scenarios as a possible technology, often either micro or large-scale CHP is the only technology considered for the future.

There are several technologies that have a clear large-scale application; off-shore wind (often also on-shore wind), large-scale CHP, nuclear energy, biomass and fossil (coal) fuel plants are examples of large-scale technologies. Technologies with obvious (household level) small-scale characteristics are micro CHP and PV solar energy. There is however a third category in between household and large scale application; generation at the local level (thus in between centralized and domestic). Generation at the local level is still considered to be decentralized because the applied definition in section 4.1 states that generation connected to the distribution grid is decentralized. Technologies in this category are CHP generation on a local scale, on-shore wind and biomass.

In short, the innovative supply load technologies within the scope of this research are: 1) micro CHP; 2) small-scale CHP; 3) on-shore wind power; 4) PV solar energy; 5) biomass co-firing for CHP.

4.2.2 Electricity temporal and locational load differences

The world would be perfect (for TNO and DNO's) if every region would consume exactly as much electricity as generated in that region. Even more perfection would be reached if consumption would be equally divided over the hours in a day. Unfortunately, there are temporal load differences due to daily and seasonal load profiles and there are locational load differences because some regions generate more electricity than is being consumed. Both differences will be described in this section.

Temporal load differences

Electricity is a demand driven commodity. This demand driven relationship between electricity generation and its demand describes a core problem of distributed generation. In an ideal situation, the generation potential is optimally designed to follow the load trends in time. However, this ideal situation does not exist, there is discrepancy between generation and load, and both attribute to the problem. Electricity load is unpredictable and uncertain of nature, although there are recurring patterns of load. Basically, there patterns follow two curves. Firstly there is a seasonal curve where the electricity load differs between the seasons, commonly having a larger load in winter times when the temperatures are lower. Secondly there is a daily curve following the day and night activity pattern where there the largest load occurs in the evening period outside office hours. Electricity generations unpredictability is depending on the technology used. Wind power is most often used in examples of load generation unpredictability since electricity is only generated when there is wind available. Another example is CHP generation, a technology which has the ability to control its output precisely but not all of its output. CHP is mostly heat driven and therefore electricity is secondary generation commodity. The demand for heat experiences similar temporal differences as electricity (seasonal and daily).

Temporal load differences are important because distributed generation is generally subject to larger unpredictability compared to centrally generated electricity. Recent policy discussions have ensures that renewable energy supply will get priority access to the grid in case of congestions on that same grid. The Minister of Economic Affairs, has implemented several changes to the Gas Act and the Electricity Act of 1998. Mandatory compliance with European regulation was the basis for the change in the E-Act. Specific regulation about who has priority access over whom and the associated costs is regulated in a policy decree. There are four criteria to determine who gets priority access in case of congestion: 1) the extent to which the renewable source is storable; 2) the extent to which the production units uses renewable energy sources; 3) the extend of greenhouse gas emissions and 4) the extent to which negative external effects can be avoided by reducing the emission of CO_2 (Rijksoverheid, 2008), (Rijksoverheid, 2009).

Locational load difference

Electricity losses occur when electricity is transported, the larger the transported distance, the larger the losses are. In theory, distributed generation is able to generate electricity close to the demand load and as so to reduce the transportation distance. Centrally generated electricity is fed in to the transmission grid and from there cascaded down to the distribution level; thus the customer level. Generation and demand can be located on opposite sides of the country and electricity losses occur on all levels. However, distributed generation can be located close to the where the actual demand is occurring; depending on DG being small-scale or domestic generation, supply takes place at either one hierarchical level above (MS) or on the same level as demand.

In practice, this theoretical balancing ability of DG is not that realistic. There will be little situations imaginable where both temporal and locational differences are mitigated by DG; perfect circumstances would be required to fully balance supply and demand. However, this does not mean that DG can’t be of assistance to mitigate balancing problems, especially with the recent priority access for renewable supply sources. Small-scale technologies like solar PV panels and micro CHP units are able to reduce the transportation distance and thus decrease losses, but because there is a lack in storage technologies, these small-scale technologies supply electricity that is not required back into the grid.

4.2.3 Temporal vs. locational load correlations

The positioning of locational correlation of load demand and supply (on the X-axis) against the temporal correlation of load demand and supply (on the Y-axis) can be used to describe several characteristics of distributed generation. This differentiation is also used in a second opinion by E-Bridge on the report by Netbeheer Nederland (2009) about cost compensation methods for network operators with distributed generation. E-Bridge does however interpret locational correlations as “DG connected largely via new assets in new areas” or as “DG connected largely to existing demand areas” while in this research locational correlation is interpreted as demand and supply of electricity being located in close proximity (or not) to each other which leads to the following differentiation in quadrants:

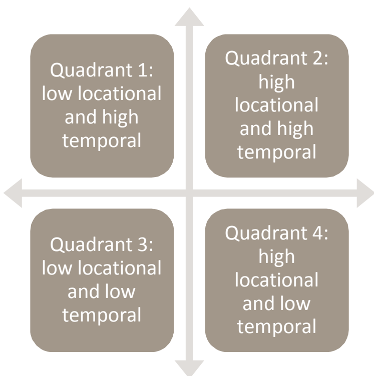

Figure 4.4: locational and temporal load correlation matrix

Quadrant 1 – low locational and high temporal load correlation: in the first quadrant, the high temporal correlation of supply and demand indicates that demand and supply occur at the same time while the low locational correlation with supply and demand is a sign that demand and supply are not located at close proximity to each other which requires the use of a higher hierarchical grid level, from distribution LS to distribution MS or even transmission TS and HS.

Quadrant 2 – high locational and high temporal load correlation: the second quadrant describes a situation in which demand and supply are both located in close proximity to each other and also occur at the same time. This could be considered as the ideal situation in which all distributed generation is consumed locally and where supply and demand is in perfect balance. In this situation there would be limited to no need for the usage of higher hierarchical grid levels.

Quadrant 3 – low locational and low temporal load correlation: in the third quadrant the most pessimistic situation is described in which demand and supply are not located in proximity to each other and furthermore do not occur at the same time. On the one hand, in times of high distributed generation the use of a higher hierarchical grid level would be required to supply electricity to other locations at the time it is needed. On the other hand, in times of low distributed generation the use of upper grid level(s) would be required to fulfill the demand for electricity.

Quadrant 4 – high location and low temporal load correlation: the fourth quadrant describes the need for upper grid levels because demand and supply do not occur at the same time on the same grid level. However, the supply of distributed generation is in close proximity to demand.

4.3 Conclusion

As the matrix shows, there is only one quadrant of the four that has both positive locational and temporal correlations. Only in this situation can DG provide a real reduction in transmission losses and improved balancing. This situation is however the one situation that will hardly ever occur, especially without electricity storage technologies.

5 Liberalization of the electricity market

The Dutch electricity sector as one integrated entity does not longer exist. The recent decades have transformed the sector from a completely vertical integrated company towards a sector where unbundling has created individual companies at each level of the electricity value chain. The following sections will outline the electricity sector before and after unbundling of the value chain with a section about unbundling in general in between. Subsequently, a section is dedicated to the need for regulation. The layout of chapter 5 is represented in figure 5.1.

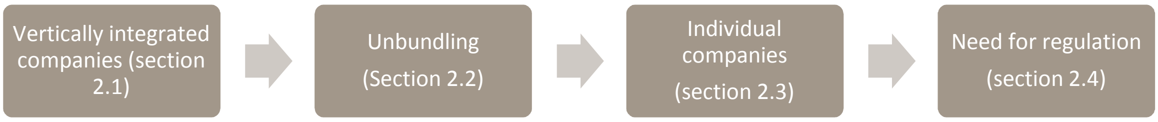

Figure 5.1: layout chapter 5

5.1 Regulation before unbundling

Before the Electricity Act of 1998 the Dutch Electricity sector was publicly owned and controlled by the government ministry responsible. Determination of prices, investment programs, quality and other relevant objectives were made in a formal process between the government ministry and the regulated companies. Companies were vertically integrated which translates to an electricity value chain where all steps could be performed by one single company having all necessary expertise in house. The value chain consists of at least six steps from 1) generation; 2) transmission; 3) distribution; 4) metering; 5) sales to 6) customer. Additional steps can enlarge the model to include more detailed stakeholders like the inclusion of a regional voltage level (MS). Furthermore, end-consumption is not limited to the end of the value chain but is also possible directly from the transmission grid (although there is still some sort of transformer to decrease the electricity voltage level down to a usable industrial level). Lastly, in the near future the introduction of an eighth step is possible, the ‘fuel/energy storage’ step (Fens et al, 2005).

Figure 5.2: electricity value chain before unbundling

5.2 Unbundling

Unbundling of networks can take place on several levels; amongst others according to Künneke et al (2007) these levels are: 1) administrative unbundling; 2) management unbundling; 3) legal unbundling and 4) ownership unbundling. The level of economic and legal separation increases with level 1 only requiring separate financial accounts but where all other operations and activities are shared within one company. Level 2 increases with separation of staff to different business units functioning independently from other units while still having a central management staff, as opposed to level 3 where all activities are separated in a separate legal entity but still within a single holding that include generation and sale of electricity. Level 4 is a full ownership unbundling where there is no umbrella holding anymore but where the entity is completely self-sufficient.

5.3 Regulation after unbundling

The liberalization of the Dutch electricity sector in 1998 was the major result of the enactment of the Electricity Act (E-Act) in the Netherlands in 1998. The E-Act was the national consequence of two Directives by the European Union, Directives 92/92/EC and 96/30/EC concerning common rules for the internal market in electricity. Several benefits aimed for by the EU were higher efficiencies, price reductions, higher quality levels and an increased level of competitiveness. The E-Act required inter alia the appointment of a regulator (the DTe) and a mandatory tariff split-up in a network and retail component where the transport component was composed from the cascaded costs of the higher hierarchy network levels and the distribution level that entails the household connection. Finally, the E-Act required the appointed regulator to set efficiency targets for the companies being regulated. [3]

Textbox 5.1: liberalization vs. privatization:

Economic liberalization is often compared to or put equal to privatization but this is certainly not the case, both are quite different processes. Liberalization is the transition from a fully regulated market towards a free-market. This does not imply that the sector is deregulated but quite the opposite, the need for regulation has increased.
Privatization is the transition of ownership from the government towards private companies. While liberalization is the case in the Dutch electricity network sector, privatization is not. The networks remain in governmental (thus public) ownership. According to the Rijksoverheid (2010) there are several arguments for public ownership: 1) the security of supply to companies and consumers is guaranteed; 2) a guaranteed infrastructure, indifferent of exploited commercial activities and 3) it is easier for the government to set targets regarding the innovation of the infrastructure to ensure a transition towards smarter grids and a better international embedded grid.

The European Directives were altered by two new Directives in 2003; 2003/54/EC and 2003/55/EC. Directive 2003/54/EG, regarding the internal market for energy which covers the entire vertical range from generation to consumption, requires legal unbundling of all electricity networks from the preceding and following steps in the electricity value chain. Furthermore, the Directive requires that by July 1st 2004 all business customers must be free to choose the electricity supplier of their choice and the same goes for residential customers from July 1st 2007 onwards. Finally, the 2003/54/EC Directive implements the right to impose restrictions and obligations to all companies in the electricity value chain, i.e. public service obligations, ensuring

[3] There was a long process preceding the enactment of the E-Act in 1998. Amongst others this process included the 1996 Energy White Paper. The inclusion of the entire process does not fall within the scope of this research but can be read in greater detail in the article “Liberalizing Dutch Energy Markets – Champions and governance, rules and regulations: the 1995-2005 stories” by Jacques de Jong, written in September 2006 for the Clingendael International Energy Programme.

the supply of electricity with a certain quality at a reasonable price and implementation of third party access to all networks. The 2003 EU Directives are required by law to be implemented in national regulation. Although this Directive covers all member states, not all of them have or will fulfil the set requirements. The EU has the right to impose penalties on these member states.

The national regulation regarding the unbundling of the electricity networks is written down in the WON directive (Wet Onafhankelijk Netbeheer), an addition to the Dutch E-act of 1998. The WON directive was implemented on January 16th 2007 and July 1st 2008, depending on the different elements. There are three elements in the WON: 1) the transfer of the operation of (not ownership) transmission grids to the independent transmission operator TenneT (grids between 110-150 kV) in order to centralize all transmission grids under one operator; 2) the creation of so-called 'fat' system operators that own all assets and are furthermore responsible for all strategic decisions being made with limited possibilities for outsourcing; 3) the implementation of a ban on the formation of groups and holdings, combining regulated networks and commercial activities. The first and second elements were implemented in 2007 while the third element was implemented in 2008. The implementation of the ban on group and holding formation is a still ongoing process which has to be completed by January 1st 2011 (this third element was in first instance put on hold and would only become active in case system operators like Delta, Essent and Nuon would engage in European joint ventures) (TenneT, 2010), (WON, 2009), (Rijksoverheid, 2007), (Rijksoverheid, 2006)(Rijksoverheid, 2010).

A short recap, the Dutch system operators are all legally unbundled as required by the EU directive 2003/54/EG and are required by the WON directive of the E-act 1998 to be fully (ownership) unbundled by January 1st 2011. The enactment of the E-Act and its additions consequently changed the electricity value chain. The steps of the chain are no longer connected to each other as was the case with vertically integrated companies. Unbundling made sure that these companies were separated into separate entities (several separations are possible). Of these entities several nowadays act in a competitive market place, for instance the generation, trade and sale of electricity. Other entities are however considered to be natural monopolies; the transmission and distribution steps are such entities. The electricity value chain after unbundling looks as follows (Fens et al, 2005):

Figure 5.3: electricity value chain after unbundling

5.3.1 Natural monopoly

Natural monopolies like railways, electricity and gas grids, and airports can show monopolistic behaviour. A monopolist is able to ask higher prices compared to a market with normal competition which leads to an undesirable situation from a societal point of view. The strategic behaviour of monopolists is thus based on fewness in the market and a lack of competition to drive prices down. Monopolistic behaviour leads to cost inefficiency and an unequal distribution of income between the producers and consumers (van Dijk, 2007). The Dutch electricity and gas infrastructures are considered to be a natural monopoly due to the initial lump-sum investments that are required to construct a national grid. Once the infrastructure is in place there are relatively low secondary investments required to connect new users to the grid. These high one-time investments and low further investments make this a sector that is best served by one organization instead of two or more. According to van Dijk (2007) there are four forms of strategic behaviour conceivable by monopolistic owners of the infrastructure grids: 1) too little capacity on the infrastructure at too high prices; 2) (more than) enough capacity at too high a price; 3) gold plating (overinvestment) and 4) too little, too late (underinvestment).

To summarize, the absence of competition and consequently the possibility of strategic behaviour in the electricity infrastructure sector require regulation imposed by the government.

5.4 Need for regulation

The presence of a natural monopoly in the electricity value chain and subsequently the possible disadvantages of strategic behaviour explain the basic need for regulation. The intended results of regulation are twofold; first it has to protect the interests of consumers and eliminate the inefficiencies caused by monopolies. Secondly, regulation should help to fulfil the requirements set by the Directives by the European Union and the E-act (including the WON addition) in the Netherlands; requirements like efficient price and quality levels, the creation of a level-playing field, non-discrimination of all market participants and an increased level of competition. The following figure 5.4 schematically points out the rationales for regulation of electricity networks.

Figure 5.4: the need for regulation

The different requirements for regulation in the figure above can be divided in two basic groups; requirement external and requirements internal to a network company. The figure below depicts this division and also introduces a subdivision in price, quality, market and various regulation instruments. The protection of consumer interests cannot be put in a single square since regulation by definition is based on the protection of consumers. The elimination of monopolistic inefficiencies and the creation of competition etc belong to the external requirement of market regulation while efficient price and quality levels obviously belong to the internal requirements of price and quality regulation. A simplified hierarchy or electricity regulation is provided in figure 5.5.

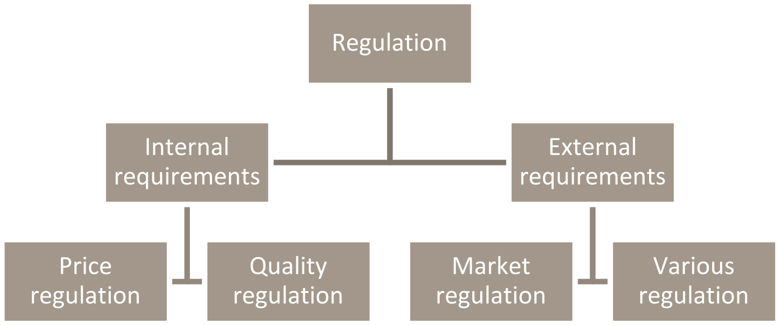

Figure 5.5: hierarchy of electricity regulation - simplified

6 Electricity network regulation

Regulation of electricity networks has to comply with a various range of internal and external requirements, as indicated in section 2.4. This scheme can be extended to include specific topics of the four kinds of regulation, an extension made by KEMA & Leonardo Energy (2009) but adapted to suit this research. The following sections in this chapter will describe these topics in greater detail except the fourth one; unbundling has already been mentioned in section 2.2 and cross-border connections are not included in the scope of this research which is solely the Dutch situation. The extended scheme is provided below:

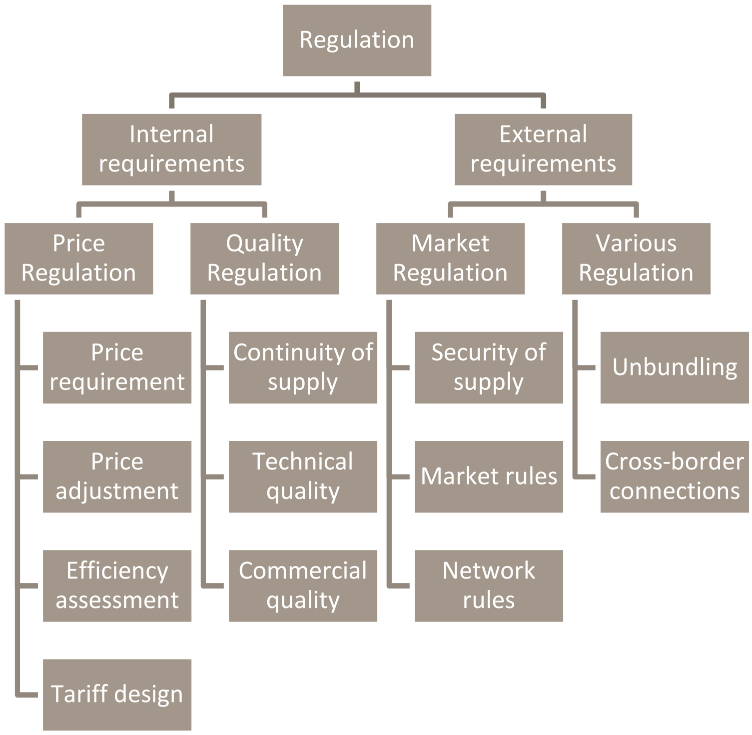

Figure 6.1: hierarchy of electricity regulation – extended

A necessary inclusion before the different regulatory instruments are described is the problem of information asymmetry. Every regulation is based on the principle of a government regulating companies and it is within this principle that information asymmetry exists; in an ideal situation both parties require equally perfect information but in reality this is never the case. Information asymmetry has a significant impact on regulation since it is based on the information available to the regulator while the regulated company has more information available. Section 6.1 will therefore start by explaining information asymmetry.

6.1 Information asymmetry

The agency theory refers to difficulties which could potentially arise when two parties engaged in a contract or agreement has different goals and access to different levels of information. These parties are the principal who pays an agent for a delivered good or provided service. The contract or agreement between the principal and agent can either be a provided service or a representation of the agent to the principal. According to the agency theory there are two characteristics important regarding the relationship between the principal and agent: (IEA, 2007), (Eisenhardt, 1989).

- There is asymmetry of information between the principal and the agent.
- Agents try to maximise their own interests at the expense of principals which gives rise to a conflict of interests.

Applying the agency theory to the electricity and gas infrastructure market leads to producers and consumers (the regulator takes care of their interests) being the principals and the DNO's as the agents. Since this market is considered to be a natural monopoly, the second characteristic of the principal-agent relationship can never be met. The agent does not have to try to maximise its own interests at the expense of principals because it is a monopolist and thus by definition able to maximise its own interests. Regulation is therefore introduced by the government to create an artificial competition in the market. The principal is thus assumed to be the government because its installed regulation is aimed at protecting the interests of the consumers; the government therefore gives rise to a conflict of interest with the agents. The principal-agent problem arises because the principal (government) possesses less information then the agent (DNO's) while symmetric information is required for the principal to fully protect the interests of consumers.

6.1.1 Adverse selection and moral hazard

There are two more examples of information asymmetry closely related to the principal-agent dilemma; the problem of adverse selection and moral hazard which will be described below:

Adverse selection is commonly explained with the use of the insurance sector. There are two correlations related to adverse selection; firstly the correlation between a person's demand for an insurance and this person's risk or loss aversion and secondly the ability for the insurer to incorporate the previous correlation in its insurance prices. Simply stated this means that people with higher risks will buy more insurance while the insurance prices can't be adjusted for increased costs.

Moral hazard is the problem which arises when somebody behaves differently depending on their exposure to risk. Moral hazard is form of information asymmetry in which the person having most information is not paying for the risk but where the risk costs are paid by somebody else. Like in the adverse selection case, the insurance sector is best to exemplify this hazard; if one does not have to pay for the consequences of his actions because they are insured against this risk, one could be less observant to this risk and be more negligent towards it. When somebody has mobile phone insurance for possible damage, this person is likely to be less careful with the phone.

6.2 Price regulation

The regulation of price/revenue levels comprises several steps; from the establishment of the appropriate regulatory mechanism and the price/revenue control formula to the method of efficiency assessment and prices related to connections. Similar steps can be found in analyses performed by KEMA & Leonardo Energy (2009) and PricewaterhouseCoopers (2009). The individual steps will be analyzed in the following sections; general information in section 6.2.1, the regulatory mechanism in section 6.2.2, the efficiency assessment in section 6.2.3, connection regulation in section 6.2.4. A summary is provided in figure 6.2 below:

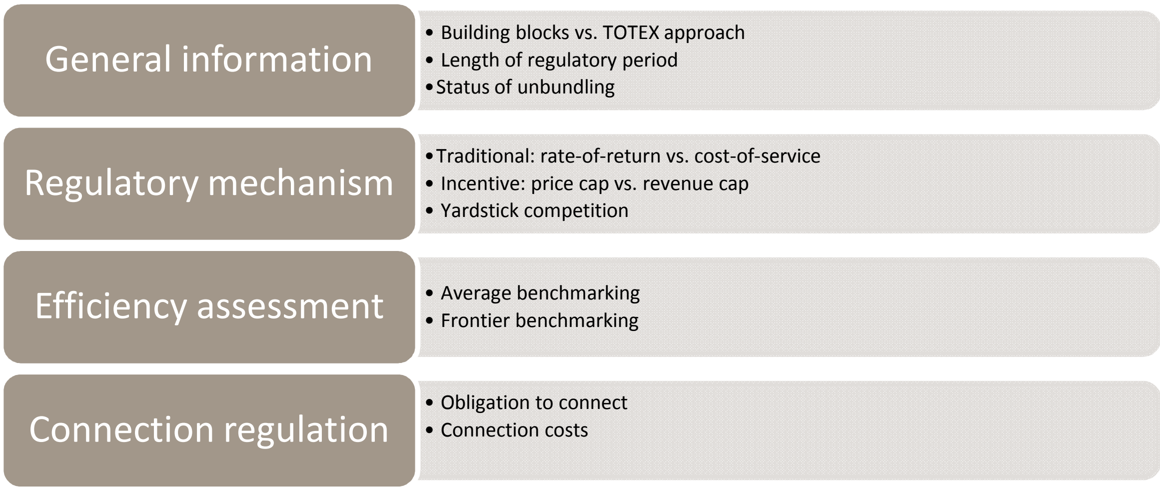

Figure 6.2: topics in electricity regulation

6.2.1 General information

There are two common approaches of setting a cap for both price and revenue cap mechanisms: 1) building blocks approach and 2) TOTEX approach. The first approach deals with the components of the revenue separately i.e. OPEX and CAPEX. The X-factor is applied to these different components individually; they are thus also assessed individually. The second TOTEX approach there is no distinction between OPEX and CAPEX, the entire TOTEX is determined from the benchmark. In most countries, the annual TOTEX reduction is set equal to the X-factor while a different form of TOTEX regulation used a smoothing procedure that allows the regulator to add non-controllable costs to the maximum allowed revenue.

The length of the regulatory period is dependent on the chosen regulatory mechanism. With a fixed-price or cost-of-service mechanism the regulatory period will be fairly short and frequent because strict control is required since all costs experienced will be remunerated including a fair rate of return. In a price or revenue cap mechanism the regulatory period differs between 3 and 5 years depending on the country. The regulatory lag (the time it takes before assets are incorporated in the asset base) is longer but the level or regulatory stability is far greater.

6.2.2 Regulatory mechanism

In the regulation literature, two views exist regarding the way price regulation should take place. The first view is a traditional one which is based on cost-minimization of firms. The second view is a more recent one which complements the traditional theories and is based on incentives to improve cost-efficiency levels or on other incentives that improve other firm dimensions.

According to Joskow (2006): “The traditional textbook theories of optimal pricing for regulated firms <…> assume that regulators are completely informed about the technology, costs and consumer demand attributes facing the firms they regulate and can somehow impose cost-minimization obligations facing the firms”. There are two characteristics of these traditional theories that are important to this research: 1) completely informed regulators are a textbook utopia and do not exist in real life and 2) the focus is on cost-minimization of the firms and not on incentives to improve cost-efficiency levels or incentivise other firm dimensions to improve (i.e. quality). Incentive theories are manifold but all have two things in common, the first one being similar in their criticisms to the traditional theories; 1) completely informed regulators are a textbook utopia and 2) the focus is on incentives to improve cost-efficiency levels and the improvement incentivising of other firm dimensions.

In traditional cost minimization price regulation the information to the regulator is based on the problems of information asymmetry mentioned in section 6.1; principal-agent problem, adverse selection and moral hazard. Translated to the situation of a regulator and regulated sector, Joskow (2006) derived two disadvantages, each having its own implications: 1) firms have different cost opportunities, high or low, based on among others their inherent characteristics like cost variations that differ between geographical locations and differ over time (adverse selection); 2) firms actual realized costs (expenditures) also depend on the decisions made by managers instead of completely depending on a firms cost opportunities. Managers may exert different levels of effort depending on their own satisfaction to create more or less benefits from the cost opportunities (moral hazard). Uncertainty about these two disadvantages leads to information asymmetry between the regulator and the regulated sector where the sector would like the regulator to believe that costs are higher than they actually are to incur more profits from higher prices.

There are several possibilities for regulation to react to these problems of information asymmetry. A description by Joskow (2006) fits this regulation search best: “faced with these information disadvantages, the social welfare maximizing regulator will seek a regulatory mechanism that takes the social costs of adverse selection and moral hazard into account”. [4] The following section will describe the trade-off between the two most extreme regulatory mechanisms which might be applied to a network company that is considered a natural monopoly; a fixed price or cost-of-service regulation.

6.2.2.1 Traditional regulation: fixed price vs. cost of service

In this section, both the fixed price and the cost-of-service regulation mechanisms will be analyzed and their pros and cons regarding the information asymmetry (adverse selection and moral hazard) will be described. These pros and cons are also depicted in the table below:

	Fixed-price mechanism	Cost-of-service mechanism
Costs of adverse selection	Costs for society	Nullified
Costs of moral hazard	Nullified	Costs for society

Figure 6.3: costs of adverse selection and moral hazard

[4] Besides the search for mechanisms that take the social costs of information asymmetry into account, the regulator could also search for possibilities to decrease the information disadvantages.

Fixed price regulation

A fixed price regulation mechanism involves the setting of a fixed price which the regulated company is free to charge to their customers. This price can either be completely fixed or can be adjusted according to some set exogenous factors like price changes or a benchmark that affects their own internal cost-level. These changes can then be passed on to the customers through the price level. Important to notice is that internal changes do not trigger a change in the price level but will be regarded as loss/profit for the firm.

The advantage of a fixed price regulation mechanism is the neutralization of the moral hazard problem. The prices are fixed and are thus either not being influenced at all (fixed price) or are influenced by exogenous changes only. There are no endogenous, internal changes causing the price to change. Decisions taken by managers do affect the actual realized costs of a firm but they do not affect the price charged to consumers. The moral hazard costs are eliminated because managers have very good reasons to exert all effort to exploit cost opportunities since all endogenous cost reductions are considered profits for the firm.

The disadvantage of a fixed price regulation mechanism is already mentioned briefly; the lack of dropping cost levels and thus prices for the customer in the case of a fixed price. Although the dynamic fixed price reduces these excess rents for the firms they are still present since the regulator is not able to fully estimate the firm's inherent costs. The welfare loss to society is still present to some extent, rather more than less; therefore the costs of adverse selection are still born by society.

Cost-of-service regulation

A cost-of-service regulation mechanism in its most perfect form involves the remuneration of all costs incurred by the network operator, thus all costs will be compensated through the prices/tariffs. [5] Because all costs will be compensated for, there is no excess profit left at the firm which could be considered as welfare loss to the consumers and society. In the cost-of-service mechanism, only the actual incurred costs are remunerated which does not give the company an incentive to invest capital because they do not receive a reasonable return on their capital, only their actual costs, which makes a capital savings account more interesting to a firm than an investment or expenditure. Therefore, the cost-of-service mechanism is also known as rate of return (ROR) or cost-plus regulation. The cost-plus mechanism allows a system operator to recover its operating and capital costs as well as a return on capital. The regulator thus sets a price based on the actual costs and a reasonable return on capital. The calculation of the required revenue for a firm with a rate of return based on projected costs is shown in the following equation: ((Jamasb & Pollitt, 2000), (van Dijk, 2007), (Joskow, 2006)

[5] In its most perfect form, cost-of-service regulation does not have any ex-post efficiency analysis to check whether investments or expenditures have been efficient or unnecessary.

$$RR_{i,t} = OE_{i,t} + D_{i,t} + T_{i,t} + (RB_i * ROR)_t$$

where:

RR_i = required revenue
OE_i = operating expenses
D_i = depreciation expense
T_i = tax expense
RB_i = rate base
ROR_i = rate of return

The advantages of a cost-of-service/cost-plus regulation are that there are no excess profits left at the firm as welfare loss to the consumer or society; therefore the costs of the adverse selection problem are nullified. Furthermore, the lack of welfare loss indicates an improvement towards the social optimum for consumers and society. A second advantage is the stimulation of investment for firms i.e. in innovations because all costs can be remunerated; an advantage which could easily change to a disadvantage due to the danger of overinvestment.

The disadvantages of this kind of approach are firstly a lack of incentives for managers to exert effort into cost reductions because all costs will be remunerated. Managers are inclined to put in minimum levels of effort to fulfil their own satisfaction. The costs of the moral hazard problem are present and are financed through the prices/tariffs and thus born by society. Secondly, the risk of overinvestment is a disadvantage of this approach since all investments by the firm can be recovered through the tariffs.

Sliding scale regulation

The sliding scale mechanism is a form of profit sharing between the regulated firm and the consumer/society. This mechanism has a price/tariff which is partially responsive to the actual cost level of the firm and partially fixed ex ante. Characteristics of both fixed price and cost-of-service can be found in this mechanism, depending on the sliding scale which carries the most weight.

Cost-of-service bandwidth regulation

This mechanism is a combination of the cost-of-service and sliding scale mechanisms. It is basically a cost-of-service regulation but there are limits to the amount of costs which will be compensated for i.e. the bandwidth. When this bandwidth is exceeded a sliding scale mechanism takes over in which the excessive profits will be shared by both the firm and the consumer/society. This mechanism induces a fair use of the provided freedom in cost reimbursement.

6.2.2.2 Incentive regulation

According to Joskow (2006) and Jamasb & Pollitt (2007) there are several questions that regulators should answer in order to successfully applying incentive regulation. These questions are: 1) what are the regulators objectives; 2) what does the regulator know ex-ante and ex-post about the firm; 3) what instruments are available to the regulator and how the regulator and the regulator firm interact over time.

Regarding the first question about the objectives of the regulator, they are equal to the objectives in the traditional theories; a decrease of the costs related to information asymmetry (both adverse selection and moral hazard). A decrease of these costs leads to an increased welfare level for the consumer and society. The difference between incentive and traditional regulatory is that incentive regulation always has to make "the trade-off between incentives and rent extraction". If all effort would be placed on the extraction of rents then no incentive would be left for the firms to invest capital. Vice versa, too much emphasis on incentive creation creates a situation in which too much rent is kept at the firm and is not being shared between the firm and the consumer and society. Furthermore, the regulator wishes to establish a price/tariff structure in which the costs are allocated as efficiently and honestly as possible. The second question is related to the first one, what the regulator does and does not know ex-ante and ex-post is important to design a proper regulatory instrument.

The third question is related to the instruments available to the regulator to regulate the firm having a natural monopoly. Since the objective is twofold, reduction of the information asymmetry and incentive creation, the instruments should be twofold as well. A reduction of information asymmetry is often achieved with the introduction of some sort of competitive benchmark or yardstick regulation. According to Schleifer (1985) if there are multiple non-competing but otherwise identical firms, an efficient regulatory mechanism can involve price setting based on the costs of the other firms. The theory behind this is that "each individual firm has no control over the price it will allowed to charge (unless the firms can collude) since it is based on the realized costs of other firms". This benchmark characteristic basically means that the firms have a fixed price contract since they are identical and are not able to compensate for costs higher than the other firms.

In short, using the benchmark data available in a yardstick competition leads to a fixed price mechanism (= no adverse selection) but since a perfect benchmark does not exist these data will not be perfect either. Imperfect information and lack of managerial effort (= moral hazard) in a fixed price mechanism result in higher cost levels and therefore an incentive is needed to correct for these imperfections. Additionally, a quality incentive must be included as well to keep companies from cutting down costs that lead to a quality reduction.

The incentive regulation mechanisms can be divided into cap mechanism and a yardstick mechanism. A subdivision in the cap mechanisms has been made by KEMA (2009) and for the sake of this research; their subdivision structure is sufficient and similar to other papers so application in this research is justified. KEMA suggest the cap mechanism to be divided into a price cap and a revenue cap, with a subdivision structure of price cap: 1) individual price cap; 2) tariff basket Cap and revenue cap: 1) average revenue cap; 2) variable revenue cap and 3) fixed revenue cap. The scheme is provided below in figure 6.4, only the difference between a price and revenue cap will be explained since it is sufficient for the understanding of this research:

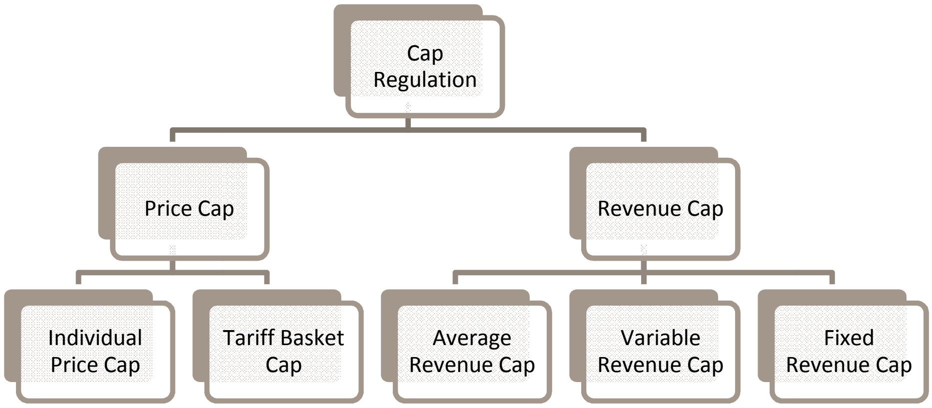

Figure 6.4: hierarchy of cap regulation

Price cap regulation

The price-cap mechanism (also called the RPI-X mechanism) decouples the profits of a firm from its costs by the installation of a price ceiling. The price cap is normally set for a fixed period ranging from 3 to 5 years (the regulatory period) in which the price cap is based on the Retail Price Index (RPI). The price cap is then adjusted with an efficiency factor, the incentive. The achieved cost savings are kept by the system operator. To account for exogenous extraordinary events like one time influences of extreme weather conditions, a correction factor Z is implemented. The formula starts with a base price level Pi_{t-1} which is established through some sort of regulation and is adjusted after each regulatory period by the creation of a new base level and a new X-factor. The calculation of the price cap is shown in the following equation: (Jamasb & Pollitt, 2000), (van Dijk, 2007), (Joskow, 2006)

$$Pi_t = Pi_{t-1} *(1+RPI - Xi)+ / -Zi$$

The price cap regulation mechanism has a larger welfare loss compared to a cost-of-service mechanism because extra profits are kept by the firm instead of given back to society. Incentive regulation does however incentivise firms to be cost efficient and society as a whole does also benefit through annually reduced price caps. A negative characteristic is the danger of underinvestment because increased investment costs are not reflected in an increased price cap but decreases a firm’s profit.

Revenue cap regulation

This approach imposes a cap on the maximum allowable revenue that a system operator can earn. Comparable to the price cap regulation, incentives are in place to incentivise the firm to be cost efficient. Cost savings are kept by the firm to maximise profit. A criticism of this approach focuses around the limiting effect of the incentive because revenues per consumer are already set at a fixed level. This results in a reduced incentive to increase sales and competition. The calculation of the revenue cap is shown in the following equation:

$R = R + CGA * \Delta Cust,i * 1 + RPI - X + / - Z - D$

Where:

R_i = authorised revenue
CGA_i = customer growth adjustment factor ($/customer)
$\Delta Cust,i$ = change in the number of customer
X_i = efficiency factor
Z_i = adjustment factor for events beyond management control

Yardstick regulation

When using yardstick regulation the performance of a system operator is compared to a group of comparable system operators. Yardstick regulation is a form of benchmarking and promotes indirect competition among the regulated system operators which operate in geographically separate markets. A main concern with this approach is the degree to which the geographical areas, operating environments and overall characteristics of the system operators are comparable. Adjustments for differences are possible but are based on internal data provided for by the operators which increases information asymmetry. The main elements of a cost-based yardstick regulation are given in the following equation:

$P_{i,t} = \alpha_i * C_{i,t} + (1-\alpha_i) * SUM (f_j * C_{j,t})$

where:

P_i = overall price cap for firm i
a_i = share of firm's own cost information (p=0 representing pure yardstick regulation)
C_i = unit cost of firm
f_i = revenue or quantity weights for peer group firms j
$C_{j,t}$ = unit costs (or prices) for peer group firms j
n = number of firms in peer group

6.2.3 Efficiency assessment

Benchmarking is a method used to compare the performance of one system operator to the performance of the benchmark (thus the other system operators in the market) given a certain level of compatibility. Jamasb and Pollitt (2007) describe two main classes of benchmarking, each having its own perspective of what the benchmark should represent.

The first perspective is a benchmark that represents the 'best (frontier)' practice. Frontier benchmarking identifies or estimates the efficient performance frontier from a sample of firms, the best practice of an industry. Other firms will be compared and reviewed to this frontier benchmark. Within this perspective several benchmark methods exist like Data Envelopment Analysis (DEA), Corrected Ordinary Least Square (COLS) and Stochastic Frontier Analysis (SFA). If falls without the scope of this research to discuss these in greater detail but these methods are all operational benchmark methods in some countries to measure/estimate the performance of electricity and gas system operators.

The second perspective is a benchmark that represents a mean or average performance. The efficiency performance of a firm will be compared to the mean of a peer group. Methods used within this perspective are Ordinary Least Squares (OLS), Yardstick regulation and Total Factor Productivity (TFP).

There is no golden rule when using one of the mentioned methods; they can either be used to address total performance efficiency or to address specific aspects like the quality level of the grid.

6.2.4 Connection regulation

There are two kinds of regulation relevant with connections; 1) the obligation to connect and 2) the connection costs. The connections costs can be divided into one-off connection costs for the physical connection and costs related to usage, thus transportation of electricity. Ancillary service costs complete the connection costs. A breakdown of the connection costs is given in Article 36 the E-Act (1998) and the Tariff Code (2009) and is scheduled in figure 6.5 below.

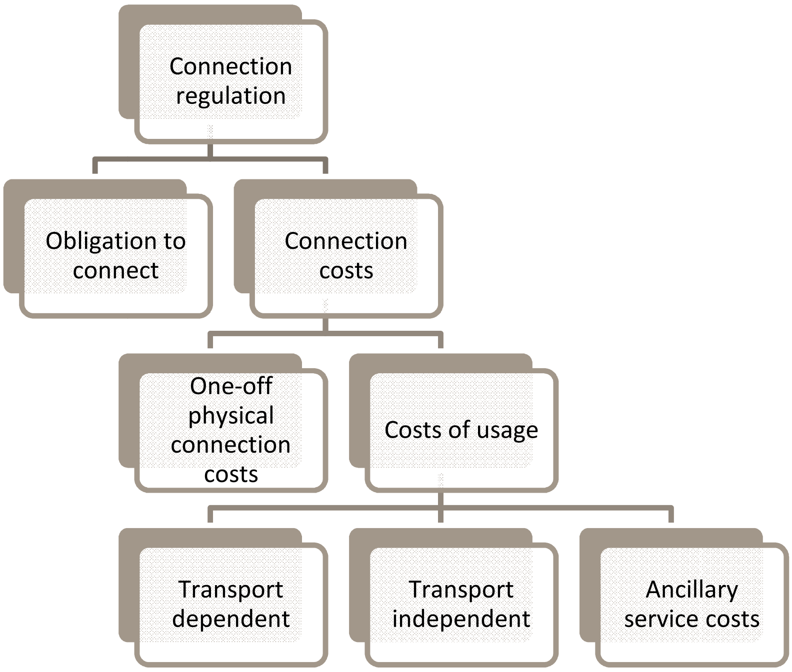

Figure 6.5: Breakdown of connection regulation

The obligation to connect is depending on the country under investigation there can be either an obligation or not to incorporate newly requested connections in the grid. In Europe the Directive 2003/54/EC concerning the common rules for the internal electricity market obliges network operators to connect new users through the Article regarding a Public Service Obligation. The most important point to notice is whether the obligation to connect goes for all connections or only for demand load connection. Supply load connections (defined as distributed generation) are not instantly ensured of a connection.

The one-off connection costs can be allocated in several ways: 1) shallow costs; 2) shallowish costs and 3) deep costs. Allocation of connection costs on a shallow basis means that all costs related to the physical connection to the nearest connection point in the grid are to be paid by the customer. Reinforcements to the grid as a consequence of the additional connection are socialized among all users of the grid. Allocation on a deep basis means that customers are to pay for all system costs caused by their additional connection, including possible system reinforcements at the distribution level. Allocation of costs on a shallowish basis is a mixture of shallow and deep; costs are allocated to the customer for both the connection and grid reinforcements but only the proportion used and needed by the customer (Cossent, 2009).

The costs-of-usage are recurring costs for existing connections that are caused by maintaining this connection. The usage costs can be divided in a transport dependent and transport independent part. Firstly, the transport dependent part is based on the quantity of electricity consumed; smaller and larger consumers pay according to their level of consumption. Transportation costs are associated with i.e. the compensation for net losses and solving transport limitations. The difference between small and large consumers exists because system operators have to balance demand and supply to ensure network reliability. To do so larger customers are required to engage in annual contracts in which the yearly demand requirement is stated, as well as the peak load. Secondly, there is a transport independent tariff that is equal for every system operator. This tariff is used to reimburse all extra costs not associated with the grid directly i.e. invoices and administration.

As chapter 7 will explain, connection regulation in the Netherlands has somewhat changed since 2009 because the capacity tariff was introduced. The capacity tariff changed the way transport tariffs are calculated, changing the transport dependent part into a fixed tariff depending on the connection capacity.

The ancillary service costs are all associated with the transmission system operator (TSO). Examples of costs covered by this tariff are: black-start provisions; reserve power provisions and general TSO costs to ensure system stability. An important aspect of this tariff is that everybody who consumes electricity and has a connection to a grid operated by a system operator is required to pay. The costs are cascaded down to the distribution system operator and finally to the consumer.

6.3 Quality regulation

The quality factor or q-factor can be based on three dimensions as is explained in the CEER reports about the quality of electricity grids (CEER, 2001), (CEER, 2008); these dimensions are 1) commercial quality; 2) continuity of supply; 3) voltage quality. Commercial quality is often based on guaranteed standards which require a kind of reimbursement to the consumer in case of non-compliance.

Whether quality problems to the grid associated with distributed generation exist is still an unclear issue. Currently the network operators are tempted to see DG as a source of trouble instead of having potential beneficial characteristics. In this section the current network quality regulation and the pros/cons of DG will be described.

The quality of the electricity grid is of great importance to the regulator and the customers; therefore it is therefore extensively regulated. The regulatory incentive (RPI-X) framework in the Netherlands and the United Kingdom includes besides an X-factor also a Q-factor that incorporates the quality level of the grid. The rationale behind the Q-factor is quite straightforward; under incentive regulation it is easier for network operators to reduce investments in the quality of the grid instead of increasing TOTEX efficiency. The Q-factor is introduced to defer degradation of the grid and maintain the high level of quality that it currently has. Quality of an electricity grid can normally be measured on two levels: 1) continuity of supply and 2) electricity quality. Only the continuity of supply is included in the Q-factor.

The continuity of supply is measured by the frequency and duration of supply interruptions. The standard measurement methods are called SAIFI (System Average Interruption Failure Index) and SAIDI (System Average Interruption Duration Index) and CAIDI (Consumer Average Interruption Duration Index). In the Netherlands, SAIDI is used to measure reliability since it is the product of CAIDI and SAIFI. The electricity quality is measured with a variety of parameters, including the voltage of power and its changes, the flicker effect, the harmonics, the voltage dips etc. The electricity quality parameters have minimum values set by the EN-50.160 European standard and its derived national standards, in the Netherlands the NEN-norm (NEN EN 50160. The continuity of supply is as said included in the Q-factor and is incentivised with a bonus-malus system of rewards and penalties in case the supply continuity was better or worse given the regulatory installed Q-factor. The reward for outperforming the Q-factor is keeping the extra profits and vice versa; profits decrease with underperformance. There can other complementary quality measures be installed to ensure a constant high level; these other measures include the publication of performance criteria and individual customer compensation in case of supply interruption duration over a certain amount of time (12 hours in the Netherlands).

The voltage quality is based on fixed ranges that the voltage level can fluctuate within and these ranges are described in the associated NEN-standards (NEN EN 50160). The continuity of supply is included in the q-factor and is based on a SAIDI index. The q-factor influences the tariffs in relation to the level of quality provided. The factor is based on a bonus/malus system in which outperformance of the standard results in an increase of total allowed revenues and vice versa. The bonus/malus system is capped and floored on 5% of the allowed revenue.

7 Regulatory comparison NL and UK

Electricity regulation in the Netherlands and the United Kingdom is quite comparable as will be explained in section 7.1. The comparability makes the United Kingdom very suitable as a supplier of ideas to alter regulation. Sections 7.2 and 7.3 will describe both regulatory frameworks in several relevant concepts whereas their main similarities and differences are listed in section 7.4. The transferability of the comparison to the Dutch regulatory framework is discussed in the last section 7.5. The layout of chapter 7 is represented in figure 7.1.

Figure 7.1: layout chapter 7

Sections 7.2 and 7.3 will be analyzed using eight concepts: 1) national electricity regulation; 2) level of unbundling; 3) regulatory period; 4) regulatory mechanism; 5) efficiency of operation factor; 6) level of quality factor; 7) incentive instruments and 8) connection regulation. Sections 7.3 and 7.4 compare and discuss several interesting concepts (some are similar or of no further interest) except for the seventh and eight concept; these are very interesting and will be discussed separately in chapters 8 and 10.

7.1 Current regulation in the Netherlands

The Dutch regulatory framework can be described best using a short series of concepts related to electricity regulation in general like national electricity regulation (chapter 7.1.2), the level of unbundling (chapter 7.1.2), the regulatory period (chapter 7.1.3), the regulatory mechanism (chapter 7.1.4) and concepts related to specific characteristics of the framework like the efficiency of operation factor (chapter 7.1.5), the level of quality factor (chapter 7.1.6), incentive instruments (chapter 7.1.7) and connection regulation (chapter 7.1.8).

7.1.1 National electricity regulation

The Electricity Act (E-Act) enacted in 1998 is concerned with all aspects of the electricity value chain; from production to transport and delivery of electricity. Chapter three is dedicated to the transport of electricity, most important discussed topics are: the appointment of a network operator in Article 10 and its exemptions in Article 15, the tasks and obligations of this network operator in Article 16, the obligation to approve all connection requests in Article 23 and the obligation to transport electricity against a set tariff in Article 24. These tariffs are explained in greater detail in paragraphs five and six of the E-Act but the general concept is stated in Articles 41a and 41b.

7.1.2 Level of unbundling

The levels of unbundling are described in chapter 4.1 and the Dutch situation in chapter 4.2. In short, the Dutch DNO's are legally unbundled as required by the EU directive 2003/54/EG and are required by the WON directive to be fully (ownership) unbundled by January 1st 2011.

7.1.3 Regulatory period

There have been four regulatory periods since the liberalization of the electricity market. The current fourth period started on January 1st 2008 and is due to end on December 31st 2010 (the WON introduction shortened the third period to one year). The fifth regulatory period will take off on January 1st 2011 and last until December 31st 2013. In general the regulatory period has to last anywhere from 3 to 5 years but in practice it is limited to the legal minimum of three years (Article 41a of the Electricity Act of 1998).

7.1.4 Regulatory mechanism

The Dutch regulatory framework is based on a TOTEX approach which entails that no differentiation is made between OPEX and CAPEX. Dutch DNO's have the possibility to decide where their focus lies as to their efficiency target; either operational cost can be reduced or investment costs can be increased to result in benefits (outweighing the investment). While DNO's are able to balance their investments between OPEX or CAPEX efficiency, regulation is not. Regulation can only be based on total expenditures without making a differentiation to either OPEX or CAPEX.

For each regulatory period the Dutch regulator sets tariffs according a fixed regulatory mechanism. The mechanism used in the Netherlands is a yardstick regulatory mechanism that creates an artificial market including competition between the DNO's. The yardstick acts as a benchmark between the geographically dispersed DNO's. The regulator states three numbers for each DNO that are unequal and are restated in each regulatory period: 1) the discount factor for an efficient operation; 2) the quality factor and 3) the volume for each tariff carrier subject to a regulated tariff. Combined these numbers create the allowed revenue per DNO, and with the use of the following formula these are determined:

$TI_t = (1 + CPI - x - q) * TI_{t-1}$

Where:

TIt = total revenues from tariffs in year t
TIt-1 = total revenues from tariffs in year t-1
CPI = change in consumer price index
x = efficiency of operation factor
q = level of quality factor

Chapters 7.1.5 through 7.1.7 describe specific characteristics of this regulatory mechanism.

7.1.5 Efficiency of operation factor

The efficiency of operation factor or X-factor is based on the average change in productivity as realized in the previous regulatory period. In the current fourth regulatory period, the X-factor is thus based on the average productivity change of the third regulatory period. The measurement of this average productivity change is executed by the Total Factor Productivity Growth (TFPG) which is the ratio of an output index divided by an input index (TFP = output index / input index). The output and input indices are composed of the weighted averages of all output and input parameters. According to KEMA (2009) the input is based on the standardized costs and the output is based on the composite output ('samengestelde' output). The composite output is "an approximation of the realized sales on the various sections of the grid expressed in Euros".

The composite output is "calculated by weighting the output of an individual network operator with the average sector tariffs" (Energiekamer, 2007). The composite output is determined using the following formula:

$SO_{i,2007} = \sum p_{j,2007} * rv_{i,j,2008\text{-}2010}$

Where:

$SO_{i,2007}$ = the composite output at the start of the regulatory period
$P_{j,2007}$ = the standardized average sector tariff for section j of the grid
$rv_{I,j,\ 2008\text{-}2010}$ = the volumes for section j of the grid of network operator i

7.1.6 Level of quality factor

The level of quality can be based on three dimensions as mentioned in chapter 6.1.3. The dimensions are: 1) commercial quality which is stimulated in the Netherlands through a reimbursement for consumers in case an interruption in the network lasts over 12 hours; 2) continuity of supply is included in the composite output as the level of quality factor, or Q-factor, and is for the Netherlands based on a SAIDI index; 3) voltage quality is in the Netherlands regulated through the associated NEN-standards, NEN EN 50160, which is allowed fluctuation range for the voltage level.

The q-factor influences the tariffs in relation to the level of quality provided. The factor is based on a bonus/malus system in which outperformance of the standard results in an increase of total allowed revenues and vice versa. The bonus/malus system is capped and floored on 5% of the allowed revenue.

7.1.7 Incentive instruments

There are two incentive instruments present in Dutch regulation; 1) objectifiable regional differences (ORD's) and 2) the exceptional investment instrument. Both are explained in chapter 8. Additional incentive instruments are non-existent at the moment. The Energiekamer acknowledges the fact that changes in the way electricity is generated and consumed are bound to cause network alterations, requiring large lump-sum investments. In the light of preparations for the fifth regulatory period the Energiekamer has requested Netbeheer Nederland (2009) to investigate new propositions to allocate costs of distributed generation more honestly among the DNO's.

7.1.8 Connection regulation

General connection regulation as explained in chapter 6.2.4 is valid for most countries in the European Union, and it was valid for the Netherlands before the capacity tariff was introduced in 2009. The division in capacity groups can be found in textbox 7.1. The main rationale by the Energiekamer for the switch from the actual amount of electricity transported to capacity groups is to allocate costs fairer between lower and higher capacity connections. The capacity groups only apply for connections up to 3*80A, thus small domestic consumers (SenterNovem, 2009).

All transport tariffs only apply to the demand side; there are no generation side charges.

Textbox 7.1: Dutch capacity tariffs

	Tariff 2010 (EUR)	Volume for calculations	Capacity for calculations	# Connections
Transport tariffs				
Vastrecht t/m 1*6A op geschakeld net	0,54	596.813		
Vastrecht t/m 3*80A	18,00	1.869.299		
kW tarief	26,2800	9.178.109		
t/m 1*6A op geschakeld net	1,314	29.841	0,05	596.813
t/m 3*25A + alle 1-fase aansluitingen	105,1	7.207.748	4	1.801.937
> 3*25A t/m 3*35A	525,6	707.060	20	35.353
> 3*35A t/m 3*50A	788,4	346.680	30	11.556
> 3*50A t/m 3*63A	1051,2	543.480	40	13.587
> 3*63A t/m 3*80A	1314,0	343.300	50	6.866

Regarding the obligation to connect there is no difference in the Netherlands between consumers and generators. The DNO is obliged to connect all units requesting access to their network on a non-discriminatory base.

7.2 UK regulation

The same eight concepts as for the Netherlands will now be discussed for the United Kingdom.

7.2.1 National electricity regulation

The regulatory framework for electricity networks started with the enactment of the Electricity Act in 1989 and reforms of the sector continued with the enactment of the Utilities Act in 2000, the Competition Act in 1998 and the Enterprise Act in 2002. These acts resulted in an unbundled and privatized electricity sector.

Part II of the Electricity Act is based around the reorganization of the industry; the unbundling of the vertically integrated companies and the respective ownership structures. The E-Act of 1989 introduced a competitive market in generation and supply. To ensure competition and protection of the customer regulatory bodies were installed which would merge into Ofgem in 1999.

Further unbundling of distribution and supply came with the Utilities Act (U-Act) in 2000 which is a amendment to the E-Act. A principal objective of the Act was to protect consumer interest through extended competition where possible. It was the U-Act in 2000 that installed the network operators as they are known today. From 2001 onwards it was no longer allowed for DNO’s to hold a supply license. Statutory duties have been placed on the DNO’s that require them to “facilitate competition in generation and supply, to develop and maintain an efficient, coordinated and economical system of distribution and to be non-discriminatory in all practices.”

Important articles in the U-Act are nr. 28 and 29: the prohibition of unlicensed distribution of electricity and its exemptions. The duty to connect on request is stated in Article 44. It is important to notice that these Articles have not specified any conditions to which one for instance could obtain an exemption under Article 29. In this case, Article 28 states a general prohibition while exemptions are dealt with on either individual or group basis by the responsible Authority (often either the secretary of state or Ofgem).

7.2.2 Level of unbundling

The United Kingdom is together with the Netherlands one of the few countries where unbundling has been established on an ownership level as explained in chapter 3. The ownership structures have been established in the Electricity Act of 1989 and were amended in the Utilities Act of 2000. A distributor of electricity is not allowed to hold a supply license.

7.2.3 Regulatory period

Regulation in the United Kingdom is in its fifth regulatory period; the fifth Distribution Price Control Review (DPCR5) started on the 1st of April 2010 after the fourth regulatory period that lasted from April 1st 2005 until March 31st 2010. Regulatory periods are generally set for a five year period in the UK.

7.2.4 Regulatory mechanism

The regulatory mechanism in the United Kingdom is based around a building blocks approach, thus CAPEX and OPEX are not treated combined but separately. OPEX is normally based on historic data and is therefore being benchmarked. CAPEX is not based on historic data but on future cost projections. Forthcoming is the need for efficiency analysis of an investment since there is no CAPEX benchmark which leads to firms being able to gain from under spending.

The building blocks approach enable Ofgem to install much more incentive aimed at specific investments i.e. distributed generation or network innovations. The revenue control formula uses base demand revenue that is based on regulatory asset base (RAB) and includes future cost projections. Upon this base demand there are several build-on factors including adjustments to the base demand revenue that are not foreseen. These factors include non-generation and generation effects as well as specific incentives for network innovations.

The formula used to calculate the revenue cap for UK DNO’s is the following:

ARt = BRt + PTt + IPt – Kt (for DPCR4)

ARt = BRt + PTt + IPt + LCNt + IGt – Kt – AUMt – CGSSPt + CGSRAt (for DPCR5)

Where:
ARt = allowed demand revenue
BRt = amount of base demand revenue
PTt = the revenue adjustment for allowed pass through items
IPt = total amount of incentive revenues
LCNt = revenue for the purpose of the low carbon networks fund
IGt = incentive revenue for distributed generation

Kt = correction factor
AUMt = aggregate amount of sums unpaid one year after being issued with clawback direction
CGSSPt = correction if DNO does not comply with new connection standards before October 1st
CGSRAt = correction for payment if DNO does not comply with new connection standards that exceed the penalty cap

The UK offers a menu of contracts to the DNO's. This menu entails two extremes with a range of middle options to choose from. The DNO can either choose to have a larger CAPEX allowance but in that case the remuneration for the DNO is close to the actual costs (the DNO can invest if it needs to but they do not gain from under spending). The other choice for the DNO is a smaller CAPEX allowance but the remuneration is bigger, thus the sharing between DNO and consumer is less even.

The rationale behind a menu of contracts is to reward DNO's having a low CAPEX with increased benefits while still providing DNO's having a large CAPEX to make the necessary investments. Based on differences between the

Chapters 7.2.5 through 7.2.7 describe specific characteristics of this regulatory mechanism.

7.2.5 Efficiency of operation factor

The revenue cap setting mechanism is based on a separate assessment of OPEX (benchmarking) and CAPEX (future cost projections). The combination of OPEX and CAPEX results in an initial price cut P0 after which the revenue path for the regulatory period is set. The first year of the period is given by the initial price cut and in years 2 to 5 an x-factor is applied.

7.2.6 Level of quality factor

The level of quality factor is not present in a similar way as the x-factor or the q-factor in the Netherlands but quality is maintained through a number of incentive instruments. These instruments are designed as a bonus/malus system so they penalize or reward the DNO in case of under/over achievement of set targets by Ofgem.

Quality incentives include the IQI (information quality incentive) that should ensure proper provision of information by the DNO's to Ofgem regarding their future costs projections. Over or underestimations result in penalties or rewards for the DNO. Further quality incentives include: 1) a proper information provision to distributed generation; 2) guaranteed standards of performance for connections; 3) customer satisfaction, telephony incentive, worst served customer incentive, interruptions incentive scheme, guaranteed standards of performance and customer service reward scheme. Each based on either a bonus, malus or bonus/malus systems.

7.2.7 Incentive instruments

As a result of the building blocks approach there are many options for incentive instruments to be installed. The most important being the distribution losses incentive; the innovation funding initiative, the low-carbon-networks fund; the information quality incentive and distributed generation incentive. Not all incentives are included in the regulatory mechanism; only mechanisms having an impact that can be estimated by Ofgem are included.

7.2.8 Connection regulation

The connection tariffs are based on the schedule of chapter 6. Consumers and generators have to pay shallow connection costs, while deep connection costs are socialized. Electricity DNO's have the obligation to offer terms upon request for a connection to any generator wanting to connect to the local network. This obligation applies also for exit connections. There is no connection priority for renewable generation.

7.3 Conclusions

Although the Netherlands and the United Kingdom are comparable on a broad level, on a detailed level they do things quite differently. The regulation of the electricity sector, the level of unbundling and the operated regulatory mechanism are similar for both countries but the details are filled in based on different concepts. These details make a big difference in facing the dynamic situation in the electricity sector nowadays.

The Electricity Act (and amended Utilities Act in the UK) describes for both countries the same topics like the level of unbundling and the requirement for DNO's to get a license. The difference becomes clear in the way these Articles are defined; in great detail for the Netherlands and quite generally for the UK. This results in a situation where there is no room for movement in the Netherlands because the E-Act (1998) seals off most options for an exemption. For instance, the obligation to appoint a DNO on every network and the exemptions to this rule are have fixed condition in Articles 10 and 15 of the Dutch E-Act while the E-Act in the UK only states the obligation for a DNO and the possibility of an exemption. To whom and on what conditions such an exemption is granted lies with the responsible authority.

The regulatory period ranges between three and five years in the Netherlands and is five years in the United Kingdom. The regulatory mechanism in operation has its influence on the optimal length of the regulatory period. The Dutch system is based on an ex-post efficiency analysis and uses historical data to calculate the tariffs. After each period, the regulatory asset base (RAB) is updated to include efficient investment from the previous period. This kind of ex-post assessment requires a shorter regulatory period because large investments pose a risk on the companies if they do not receive benefits for them and are not able to increase the tariffs. Faster inclusion in the RAB reduces this risk.

A reverse explanation goes for the United Kingdom: their regulatory mechanism is based on an ex-ante efficiency analysis and uses future cost projection to calculate the tariffs. Incentives are in place to ensure correct projections. The demand base revenue is updated after every period and in an ideal situation it would be updated with exactly the amount of the projections. A longer regulatory period gives the DNO an opportunity to improve its projections because there is more flexibility the timing of the investments. Moreover, a longer period increases the stability of incentive put in place and increases their chances of success.

The general idea of the regulatory mechanism is similar for both countries; a RPI-X based mechanism. The major difference is the way that both countries treat their OPEX and CAPEX. The Netherlands uses a TOTEX approach where OPEX and CAPEX are treated as one. The UK uses a building blocks approach where OPEX and CAPEX are being treated separately. Although they both have their own advantages and disadvantages, there is an overall view that a TOTEX approach is better suited for static situations and a building blocks approach for a dynamic situation. The ability to adapt the UK mechanism to expected changes in the future has been far greater than the Dutch ability to adapt their model. The DNO's in both countries face uneven asset age profiles, different service territories and different CAPEX forecasts; all of them increasing the importance of planning future investments and it is this planning of investments which is a major difference between the TOTEX (based on historical data) and building blocks (CAPEX based on projections) approach.

A final difference between the mechanisms is the menu approach in the United Kingdom which has been introduced in the fourth regulatory period (DPCR4 from 2005-2010) and has been successful according to Ofgem. The menu approach for CAPEX is based on offering DNO's a 'menu' of options for their CAPEX allowance. On the hand one hand they can choose a larger CAPEX allowance that has a sharing between consumers and DNO's that is close to the actual spending. This gives DNO's the possibility to invest in case they need to but they don't benefit from any under spending. On the other hand they can choose a smaller CAPEX allowance that has a sharing between consumers and DNO's where the DNO's are able to keep a larger share of their benefits. This menu of contracts induces the DNO's to provide the regulator Ofgem with unbiased investment forecasts. If a company has a cost projection that is variable (not fixed) and if they are able to quickly remunerate revenues from their investments they should choose a lower CAPEX allowance where they are allowed to keep more of their benefits. Vice versa, if a company has a cost projection that is fixed (not variable) and if they are not able to quickly remunerate revenues from these investments they should choose a higher CAPEX allowance that ensures remuneration of costs but does not provide the keeping of benefits in case of under spending (this is the discussion between fixed price and cost-of-service regulation as described in chapter 6).

7.4 Transferability of conclusions

The differences between the Dutch and United Kingdom regulatory frameworks as described in section 7.4 are fixed but they do still retain some flexibility to be altered. This section will describe the flexibility in secondary regulation, the regulatory period, flexibility in the ex-ante vs. ex-post assessment of investments and possibilities for a menu approach in the Netherlands. Transferability of different foreign approaches to the Dutch framework is guidance.

The main difference between the Dutch and UK Electricity Act is the degree of detail. The result is a large flexibility in the UK and little options for flexibility in the Netherlands. The E-Act is a law and is therefore subject to a long alterations period. A redesigned E-Act having less detailed Articles and more options for adaptation to dynamic situations is not very likely in the Netherlands. There is no transferability of 'primary regulation' from the UK to the Netherlands. There are Articles in the Dutch E-Act that are not written down in detail but are more elaborately defined in AMVB's, the 'secondary regulation'. Although UK regulation is much more based on these AMVB's[6], there are situations in Dutch regulation where AMVB's have potential to facilitate investments (i.e. the Tariff Code). The Energiekamer, the Dutch regulator, could learn from UK

[6] Regulation in the UK is in general much more created by the National Regulatory Agencies, for all sectors being regulated by the government (i.e. Ofgem and Ofcom).

regulation that less specifically defined regulation allows for more flexibility in coping with dynamic situations. This leads to the following recommendation:

Recommendation 1: implement more/new regulation in Codes and Decrees instead of the Electricity Act

The Dutch regulatory framework only allows for remuneration of investments after the regulatory period because of the ex-post efficiency assessment. The tariffs are altered after the regulatory period using the X-factor to include investments (where these are considered efficient by the benchmark). Depending on the precise moment of investment and the length of the regulatory period this could take between 4 and 10 years[7]. There are several possibilities thinkable to reduce the time between making and remunerating an investment, and they will be followed by two recommendations:

- A transition towards an ex-ante efficiency assessment (like the UK system of cost projections) would resolve this problem but has its own disadvantages like a reduced efficiency incentive.
- A mechanism like the one being used in Norway (visualized in figure 7.2). This system discards the use of a regulatory period and an X-factor but instead sets the tariffs yearly based on weighted average (thus benchmark) of the efficient costs and the cost incurred by the DNO's. Allowed revenues are set for 60% by the benchmark and for 40% by the DNO's. The RAB is adjusted annually. Two year old data are used which is compensated for by the regulator. Regulation in Norway started off with a cost-of-service mechanism followed by a revenue cap (including X-factor) and a revenue cap (excluding X-factor) mechanism, proving that such a shift is possible in theory (Neurauter, 2006), (NVE, 2007).

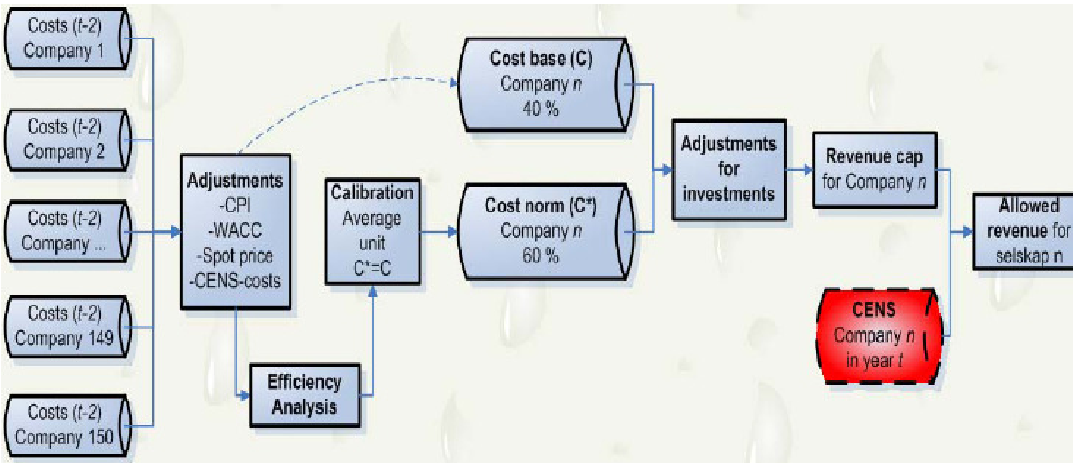

Figure 7.2: Norwegian mechanism for allowed DNO revenues

[7] If for instance an investment is made in the last year of the regulatory period, this will not be included in the next period but in the period thereafter using the X-factor to increase the tariffs. In the case of a five year period, this could result in a maximum delay of 10 years before the investments are fully included in the tariffs (the X-factor is applied over the entire period).

- The allowed revenues can be altered during the regulatory period to allow for additional revenues based on changes of certain parameters. The German mechanism allows for additional revenues during the regulatory period if for example the number of connections, the service area or the peak load increases. Although Dutch regulation already provides for such an option (the Objectifiable Regional Difference instrument) there are possibilities to increase the number of additional revenue drivers. Especially the peak load, both demand and supply, could be useful to partially mitigate the effects described in chapter 2. This mechanism is comparable with the 'automatic revenue driver' mechanism being used in the UK. For instance, a driver could be the number of connection; if the number increases, the allowed revenue will too.

- The efficient cost level derived from the benchmark is reimbursed in the tariffs through the X-factor but this process last over the entire regulatory period. The X-factor is applied over the three years of the period thus full reimbursement is only guaranteed at the end of the regulatory period following the one in which the investment is made. As said before, this could take at least 4 years. This period could be shortened by altering the tariffs without the use of the X-factor but by setting the revenues and tariffs at the efficient cost level in the beginning of the regulatory period. The X-factor will still be applied afterwards to incentivize efficiency improvements.

- The last suggestion for the timing of reimbursement is the moment at which new assets are included in the RAB. In the Netherlands new assets are included in the RAB when they are finished and are put to work. There is also the possibility of including them while they are still work in progress because from that moment onwards costs are incurred by the DNO's. According to KEMA and Leonardo Agency (2009) authorities can base the costs of construction work in progress (CWIP) on several factors like: the duration of the project or whether the investment is significant enough to impair financing. KEMA and Leonardo Agency state that 'some form of recognition of cost of capital committed during construction appears appropriate'. The Energiekamer can consider including assets earlier in their construction period which inevitably requires the Energiekamer to assess investments earlier.

Recommendation 2: reduce the time lag to include investments in the RAB

Recommendation 3: adjust the allowed revenue during the regulatory period

The previous section already described several options to alter the reimbursement mechanism and period for investments. More generally speaking, the ex-post efficiency assessment mechanism can be altered to mitigate the reimbursement problem. It is not completely accurate to state that countries assess efficiency either ex-ante or ex-post, there is some flexibility and movement towards a combination or convergence to a mixed mechanism. Two options exist; ex-ante implementing some sort of ex-post assessment or vice versa. One recommendation results from the ex-ante vs. ex-post discussion:

- The countries using an ex-ante mechanism, as depicted in figure 7.3, often use ex-post assessment for measuring quality levels. Furthermore, the UK assesses projected costs ex-ante but unforeseen costs are ex-post assessed. There are two main reasons to include ex-post assessment: 1) improvement of ex-ante assessment and 2) include incentives (aimed at whatever the regulator deems important).

Figure 7.3: countries using ex-ante or ex-post efficiency assessment

- The Netherlands uses an ex-post assessment mechanism with two exceptions: 1) the costs of ORD's which are not assessed at all and 2) the exceptional investment instrument for large one-off investments which are assessed ex-ante and if considered to be efficient by the Energiekamer they are included in the RAB but excluded from the benchmark. A similar instrument is active in Germany.

Recommendation 4: increase the use of cost projections to estimate investment levels

The last possibility to improve the Dutch regulatory framework based on a concept proven to be successful in the UK is a menu approach. This mechanism is only applicable in a situation with ex-ante efficiency assessment where the DNO's have to submit cost projections. Otherwise there is no menu to choose from. The transferability of such a mechanism to the Dutch regulatory framework is therefore not possible.

The possibilities that have been described are for the better part transferable to the regulatory framework in the Netherlands; being as it is in its current state or with alterations that are allowed within the E-Act. Sub-section 6.5.1 deals with the regulatory opportunities and obstacles in more detail.

7.4.1 Regulatory opportunities and obstacles

Changing the moment of the efficiency assessment and the subsequent inclusion in the regulatory asset base (RAB) is possible within the regulatory framework in the Netherlands. The E-Act does not know any specific regulation regarding this topic, but the Method Code (2006) does.

The most relevant Article in the E-Act related to the method of setting the tariffs is Article 41 which states the following in the first paragraph: "the members of the board of the NMa notes after consultation with the DNO's and representatives from stakeholders in the electricity sector – while considering the increase in the efficiency of the operation of electricity transport (excluding the transmission grid) – the method to set the efficiency of operation factor, the level of quality factor and the calculative volume of each tariff carrier for which a tariff will be set".

Article 41a of the E-Act state in the first paragraph that the NMa sets the three figures mentioned in the quote above for each DNO separately for a period ranging from three to five years. Article 41b follows with a statement about the relation between these three figures, a relationship in the shape of the following formula: $TI_t = (1 + (cpi - x + q)/100)) * TI_{t-1}$. There is no further elaboration in the E-Act about the details of the formula. In other words, the E-Act only states that the regulatory mechanism should be incentive based.

The Method Code (2006) on the other hand contains all the details and specificities needed to calculate the tariffs. As said this Code is negotiated by all stakeholders combined but the NMa (Energiekamer) makes the final decisions. The Method Code provides both the opportunities and the obstacles to mitigate the reimbursement problem for some investments.

Obstacles

The main obstacle is obviously the regulatory framework as it is currently in place. The second obstacle is the Energiekamer; they have researched the effects of the regulatory framework on the level of investment by DNO's but refrain to take preventive action. PricewaterhouseCoopers performed the economical part of the research while Movares and Kiwa Gas Technology performed the technical part. There were five conclusions drawn by the Energiekamer: 1) the yardstick mechanism is effective; 2) the DNO's have to little information to provide proper underpinned investment plans so historical costs level still provide the best estimations; 3) it is valid to use a short regulatory period and use most recently available data; 4) a continuation of the reimbursement of capital costs (WACC) is desirable; 5) the Q-factor has to be improved.

The first, second and third conclusions are within the scope of this thesis but in the writers opinion the Energiekamer has insufficiently looked at the possibilities to improve the regulatory framework. The aim of the research by PricewaterhouseCoopers was whether the framework was effective but it did not contain improvements for the future. The first, second and third conclusion contain opportunities for the Energiekamer to improve its regulatory framework.

Opportunities

The opportunities for the regulatory framework are in my opinion aimed at two points. Firstly, the regulatory framework may be effective at the moment but this could change within a couple of years and the Energiekamer should prepare for changes with adaptations that are non-discriminatory to the possible scenarios. Secondly, the effectiveness of the framework at the moment does not imply that improvements are not possible.

The first conclusion about the effectiveness of the yardstick competition is especially true for static market conditions since this kind of framework provides the best efficiency incentives. In dynamic market conditions as they are predicted in the next couple of years this framework is less suitable since it lacks flexibility towards the reimbursement of capital investments. Opportunities for the Energiekamer exist to improve the yardstick competition for dynamic situations through improving the moment of efficiency assessment and the inclusion in the RAB as well.

The second conclusion about the lack of information to make proper underpinned cost projections is not accurate enough. The same problem occurred in the United Kingdom but solutions were implemented there to succumb to this problem: the information quality incentive and the menu of contracts.

The third conclusion about the validity to use a short regulatory period and to use most recently available data is incomplete too. Although the Energiekamer uses the data from the last year of the previous period to calculate the allowed revenue base these revenues are still being spread out over the entire next period (three years) which results in a time-lag of four to seven years before full reimbursement is provided for additional investments outside the projections based on historical data. This period could be shortened by adding these additional investments to the allowed revenue base at the beginning of the regulatory period (which would result in a three year time benefit for the Dutch DNO's).

8 Incentive instruments: old and new in NL

The incentive instruments in the Netherlands regarding the remuneration of innovative investments are limited. The regulatory framework where the remuneration options are embedded in is structured in such a way that it does not leave a lot of room to remunerate investments which are different from the standard operational and capital expenditures. As already mentioned in chapter 2 there are four options stated by the Energiekamer to remunerate innovative investments, depicted in figure 8.1: 1) remuneration through the regulatory framework, thus the RPI-X system (direct reimbursement); 2) remuneration in case revenues immediately follow investment which creates extra profit to be kept by the network operator (indirect reimbursement through the RPI-X system); 3) remuneration through the acquisition of intellectual property rights for innovations and 4) remuneration through governmental grants and tax benefits. Each will be shortly described, starting with the last, to explain the rationale for choosing the RPI-X system as being most promising to incorporate new or adapted incentives.

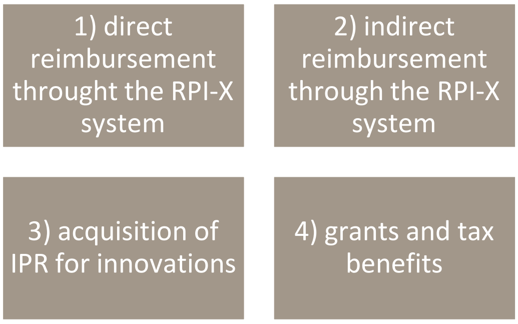

Figure 8.1: a DNO's remuneration options for investments

Governmental grants and tax benefits are no long-term solution to the problem. Grant and tax benefits are all temporary solutions for the short term while the problems facing DNO’s are not short term at all; they are present over decades while grants and tax benefits are normally capped at a certain number of years. There is too little certainty for DNO’s that their investments will be reimbursed in the future. [8] One could reason that grants and tax benefits are only necessary for the initial kick-off investments and that after a while when benefits are shown to be realistic, the market takes over but this is not likely to happen since the benefits do not reach the DNO’s but end up at the consumers. Furthermore, grants and tax benefits are so far all aimed at the renewable technologies (both at the supply and demand side) but not at the DNO’s. The DNO’s are supposed to facilitate all load changes in their network but to do so without innovations would mean that costs increase dramatically due to the required reinforcements to the network. Grants and tax benefits could provide strong incentives to connect distributed demand and supply loads in preferable locations, but these incentives are not intended for the DNO’s and thus considered not relevant for this research.

The acquisition of intellectual property rights for innovations is potentially able to remunerate costs for DNO’s but this solution copes with the same problem that is causing the lack of remuneration with the RPI-X system. The acquisition of IPR for innovations has to be completely

[8] Even with tax benefits for R&D investment (through the innovation box) there is a requirement that they result in revenues or else the DNO’s are not eligible for tax benefits.

funded by private capital (from the DNO's) and benefits have to return to the DNO through a lower cost level and to the consumer through lower tariffs. This is exactly the problem of the research question as defined in the research rationale in chapter 2. DNO's do not have enough incentives to make these investments. In case these investments are stimulated through incentive instruments this would basically mean that public money is used to fund the expenditures. It would be in conflict with European regulation concerning state aid when public money would be used to fund the costs while benefits would return to the DNO instead of society. Intellectual property rights resulting from public money belong to society and must be shared amongst all DNO's.

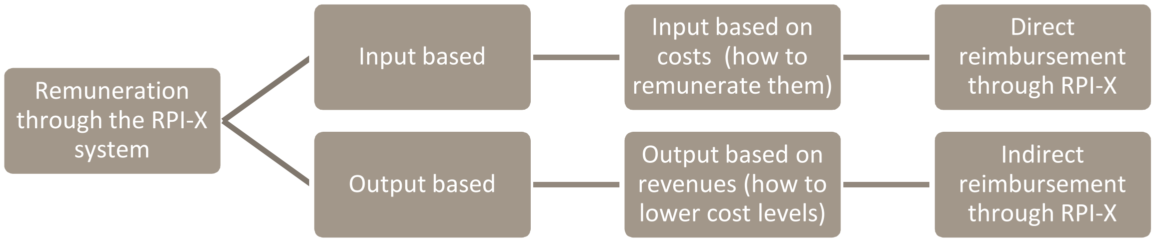

Figure 8.2: remuneration options through the RPI-X system

The first and second options are based around remuneration through the RPI-X system, both direct and indirect as can be seen in figure 8.2. The second option is the indirect one and consists of one simple idea; if a DNO makes an investment that immediately results in benefits, remuneration would be ensured for the DNO at first and after inclusion in the Regulatory Asset Base (RAB) the consumer would benefit as well through lower tariffs. This option does not require any incentive instruments since DNO's do not have problems remunerating these investments, benefits are ensured. An investment where benefits do not immediately flow back the DNO is problematic.

The first option; direct reimbursement through the RPI-X system is possible if all network operators have to make similar investments as to increase the benchmark evenly for all DNO's. Irregular investments as the investments under discussion in this thesis are not (always) reimbursable through the benchmark but there are exception rules for some types of expenditures. Currently two rules exist through which DNO's are allowed to deviate from their revenue cap: 1) objectifiable regional differences (ORD's) and 2) exceptional one-off investments. The revenues for the network operator are based on the total capacity of connections while the cost levels are calculated through the benchmark. Costs outside of the benchmark are the ORD's and exceptional investments. The product of the total capacity of connections times the sector average cost level is the total amount of revenue available for one network operator. Additional revenue as a result of the ORD's and exceptional investments are excluded from the benchmark and will be added to the revenues of the individual network operators.

This chapter will describe the Dutch incentive instruments currently in place and will elaborate on intentions of the Energy Board to create new incentives for distributed generation. Furthermore, this chapter will elaborate on incentive instruments in electricity markets abroad, defining the intentions and possibilities to incorporate these incentives in the current Dutch incentive instruments.

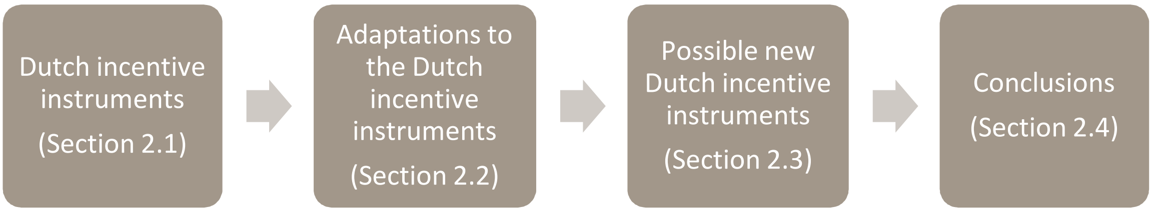

Figure 8.3: layout chapter 8

8.1 Dutch incentive instruments

The Dutch regulatory framework does not provide for a lot of incentive instruments to remunerate costs incurred by i.e. distributed generation. The current framework has two instruments incorporated to ensure some remuneration for investments eliminated by the benchmark; ORD's are explained in section 8.1.1, the exceptional investment instrument is described in section 8.1.2 and distribution losses incentive in section 8.1.3.

8.1.1 ORD's

The network operators are benchmarked to set an average cost level on which the tariffs are based. It is therefore important to create homogeneity because otherwise the DNO's cannot be compared to each other. There are however several differences that result in objective (outside the influence of the DNO's), structural and significant cost differences between operators. These costs are fixed and can't be altered by the operators. By correcting the total costs for these differences the regulator is able to create more homogeneity to benchmark the operators. At the moment there are two ORD's included in the tariffs; water crossings and local charges. Water crossings are defined as geographical differences where the electricity grid has to cross open water which requires higher investments. Local charges are charges (like encroachment rights) levied by the communalities which can differ greatly between them. Both water crossings and local charges are included in the tariffs. Important to mention is that these ORD's are not based on a zero-sum mechanism through which some network operators have a benefit and thus have lower tariffs and some network operators have more costs and thus have higher tariffs. Both current ORD's can increase the cost-levels without a possible reduction for others. As a result, network operators do not have to pay for regional differences in another area (Energiekamer, 2006).

The ORD instrument as defined by the Energiekamer (2006) is at the moment not suitable for the remuneration of innovative investments. There are however discussions going on about the inclusion of more ORD factors in the tariffs; i.e. the connection density (number of connections per square kilometer). A different density could indicate higher/lower costs levels.

8.1.2 Substantial one-off investments

This instrument is based on article 41b.2 of the E-act. Article 41b describes the regulatory mechanism used to set the tariffs and section 2 of the Article mentions the possibility for network operators to hand-in a proposal to increase their allowed tariffs as a result of exceptional and significant investments for the expansion of the grid operated by the company making the proposal (E-Act, 1998). The policy rule set out by the NMa (NMa, 2005) regarding the one-off investments limits the possibilities for proposals to only those deemed necessary by the regulator. The NMa firstly limits significant investments to large-scale investments (for multiple investments there should be an inextricable relationship between them). Secondly, exceptional investments are limited to proposals having a unique character, proposals which could otherwise not be executed economically and to proposals necessary due to the existing policy (especially Article 16 of the E-Act that describes all tasks and obligations of the network operator) or force majeure. Thirdly, proposals must either increase grid capacity or increase the total length of the grid. Once an investment is allowed by the Energiekamer as an exceptional investment then the tariffs will be increased and the investment will be added to the regulatory asset base (RAB).

The one-off investment instrument as defined by the E-Act (1998) and the NMa (2005) is subject to some uncertainty regarding the limitations. These limitations are defined by the Energiekamer. Firstly, the one-off investments must be unique. The NMa specifies uniqueness as an investment that only has to be made (or is expected to be made) by less than 50% of DNO's. Benchmarking can be used to judge whether a proposal possesses a certain degree of uniqueness. With distributed generation this is highly unlikely to be the case since one of its characteristics is electricity generation close to consumption. Electricity generation close to final consumption means that it is almost inherent that all network operators will have to deal with this investment burden. Uniqueness is thus not applicable to distributed generation. Secondly, the proposal must be large-scale, which is not the case for a large part of distributed generation technologies. Thirdly, investments must increase the capacity or length of the grid. DG investments are partly caused by required increases in capacity and grid length, but not all DG investments are (i.e. the facilitation of active management). Fourthly, although the DG investments are new when compared with the investment history, individually they are not large enough to pose a serious restrain on the financial situation of the network operators. Individually, these investments can be remunerated through the tariffs.

Based on the definition of one-off investments by the NMa (2005) and the E-Act (1998) and on the characteristics of distributed generation it can be concluded that the 'substantial investment' instrument as it is currently designed is not suitable for the remuneration of innovative investments because they do not comply with the limitation stated above.

8.1.3 Distribution losses incentive

The RUN ('Regeling Uitgespaarde Netverliezen') is an instrument based on the premises that distributed generation saves transport losses on the high-voltage grid of TenneT (DTe standpuntendocument, 2004). The RUN instrument reallocates the costs of network losses between consumers and distributed generation. It is a zero-sum mechanism which means that TenneT does not receive more or less money as before, it is only redistribution. Consumers pay for transport losses and these payments are transferred to distributed generators (defined as generators feeding electricity in on a level below 110 kV). The heights of the payments to distributed generation are calculated using the following two formulas where payments are limited to connections with a capacity of 3*80A and above (DTe Regeling Uitgespaarde Netverliezen, 2004):

$$\text{Total DG savings} = \frac{\text{Total net losses on the transmission grid (TenneT)}}{\text{Central generation}} * \text{DG generation}$$

Height compensation = $\frac{Savings\ by\ DG}{DG\ generation}$

The RUN instrument as an incentive for distributed generation is generally positive. Saved network losses are reallocated to the distributed generators that actually ensure these savings. The downside to this instrument is that only generators with a capacity of 3*80A and above are compensated, while a small consumer ('kleinverbruiker') has a capacity of max 3*80A (and normal households normally have max 3*25A). The instrument is thus beneficial to distributed generation but only at a larger scale, not the individual situation.

8.2 Adaptations to the Dutch incentive instruments

Several options to alter the current instruments have come up, they will be discussed below; additional ORD's in section 8.2.1, a redesigned exceptional investment instrument in section 8.2.2 and a redesigned distribution losses incentive in section 8.2.3.

8.2.1 Additional ORD's

In recent years there has been discussion about adding an additional factor as an ORD; the connection density. A different density could indicate higher/lower connection cost levels. The connection density is depending on geographical characteristics; densely populated urban areas vs. sparsely populated rural areas. Several network operators would like to see connection density be included as an ORD. The current ORD's included in the regulatory framework are water crossings and local charges, two factors that have been proven significant by a report from the Brattle Group. This report tested several possible ORD's on whether they are substantial and sustainable (thus persistent over time). Connection density failed to result in significant results without a clear reason for this difference and therefore the connection density is not considered an ORD by the Energiekamer (Brattle, 2006).

Distributed generation was also considered as an ORD by the Brattle Group report but based on data provided by two network operators, no substantial regional differences were found. Distributed generation is too broad and vague to be considered an ORD. For instance, the use of micro CHP units is not bounded to regions nor is the use of photo-voltaic units while wind power is located in regions having a higher load factor like the North Sea area. Distributed generation should either be exactly defined or it should be broken down into smaller characteristics which are possible ORD factors. Wind power generation could possibly be an ORD, especially large-scale wind power since is it located off-shore, in a bounded region which means that not all DNO's would have these costs since it is geographically dependent. Finding the appropriate proxy for additional ORD's may prove to be very difficult.

The Energiekamer can derive useful insights from similar instruments in Germany and the United Kingdom, the automatic and additional revenue drivers. These instruments have been described in the conclusions of chapter 7. Both instruments are able to mitigate regional differences and subsequently partially the cost/benefit allocation problem. An important characteristic of these instruments is the ability to be adjusted during the regulatory period which enables a faster remuneration of costs.

In short, options to change the Dutch ORD instrument are limited, partly as a result of finding an ORD and partly as a result of finding a suitable proxy. There are however additions to the instrument possible with looking at foreign comparable instruments.

There are several DNO's that argued to make the purchasing costs of electricity from TenneT an ORD because they cannot influence these costs. These costs are necessary because extra electricity is required to compensate for distribution losses and DNO's are not allowed to own or operate generation units. The Energiekamer did not comply with this request to create an additional ORD but it partly exempted DNO's from the prohibition of generating electricity. DNO's are now allowed to generate electricity used to compensate for distribution losses (Energiekamer, 2009)

8.2.2 Redesign exceptional investment instrument

This instrument is potentially able to accommodate changes like distributed generation. The E-Act (1998) only mentions the existence of the exceptional investment instruments as following: "a network operator is able to hand-in a proposal (complementary to the tariff proposal) that compensates for the costs of exceptional and substantial investments to increase the network operated by the network operator". There are no details described in the E-Act, these are specified in policy by the NMa (2005) regarding exceptional investments. Laws take time to change, but a policy rule could be altered in a shorter time period. According to the NMa (2010), exceptional investments are investments that result in an increased use of the network and thus more revenues. However, these revenues are considered to have a time lag before actually reaching the operators. The time lag is the result of i.e. the slow development of industrial areas and residential areas, and the non-existence of new product groups like distributed generation.

Netbeheer Nederland (2009) makes a suggestion to the Energiekamer to alter the policy rule as to compensate for exceptional investments on a project base. These projects should favor several goals; 1) the connection of distributed generators to the network; 2) the unlocking (ontsluiting) or governmental planned areas where generational will develop in the near future i.e. agricultural areas and large-scale wind parks and 3) the facilitation of a transition towards a low-carbon economy. The Energiekamer has decided not to change the instrument for the fifth regulatory period but it remains under discussion for further analysis.

In short, it should be possible to alter the policy rule since it does not have to pass the government and the senate. The Energiekamer is able to change this policy rule as long as the policy rule remains in compliance with European regulation and more importantly with the Dutch regulation as defined by the E-Act.

Textbox 8.1: 'substantial investment' for Delta Netwerkbedrijf

Up until 2010 all 'substantial investment' assessed efficient ex-ante by the Energiekamer have been initiated by the TNO TenneT. There have been no positive assessments by the Energiekamer of DNO initiatives. In 2010 the first positive assessment has been awarded to Delta Netwerkbedrijf (DNWB) to facilitate the construction of a new high-to-middle-voltage (50/10 kV) transformer station near Schouwen Duiveland, project Oosterland. This transformer station was necessary because there was an increase of DG resulting from horticulturists and the old station from the 1950s was no longer sufficient (DELTA Netwerkbedrijf, 2009).

The Energiekamer received a proposal for a 'substantial investment' of €1.437.864 and allowed a tariff increase to remunerate these one-off costs for the strengthening of the grid (one-off connection compensation) as a result of DG connections. The tariffs for 2010 will be adjusted for the necessary investments made in 2010. There is some discussion between DNO's (through Netbeheer Nederland) and the Energiekamer about the validity of this assessment since the Method Code states that the tariffs can only be based on costs that have been made in the period before the tariffs are said or in the year of the tariff setting (before or in 2009). For now, the proposal has been granted because the Energiekamer has interpreted the Method Code in a different way, namely the costs that have been made in the period before the new tariffs are applied or in the year of the tariffs (before or in 2010). This would make the proposal valid (NMa, 2010).

8.2.3 Redesign of the distribution losses incentive

A redesign of the existing incentive would have to be based around one characteristic of the incentive; the inclusion of distributed generation at levels lower then 3*80A like is the case at the moment. This would ensure that one of the benefits resulting from distributed generation would accrue back to the generator. This would be ideal weren't it for a problem metering the actual flows of electricity. The problem is that with current metering technology it would be very hard to measure the avoided distribution losses since electricity being generated locally does not necessarily mean that it is used locally. Temporal and locational load differences exist that could result in electricity being generated locally but consumed in a different region.

The Dutch incentive is based on compensation for distribution losses by consumers and ensuring that this compensation ends up with the distributed generator instead of the DNO, a reallocation of costs and benefits. The UK regulator Ofgem has introduced a distribution losses incentive that is aimed at the network operator instead of the distributed generator. By ensuring a zero-sum incentive the DNO's are stimulated to implement measures that reduce distribution losses which in the end result in lower tariffs for the consumer. A more detailed explanation of the UK incentive is given in the next paragraphs.

The distribution losses incentive in the UK is based on three losses occurring to DNO's: 1) variable losses; 2) fixed losses and 3) non-technical losses. The variable losses are based on the cables actually transporting the electricity. It is long known that current through a copper cable goes with a certain loss of current. To provide for the same power at the end of the line, the current has to be increased. However, a 1% increase in current leads to more than a 1% increase in costs (quadratic relationship). Ofgem (2003) suggests several possible options to decrease variable losses: 1) higher voltages; 2) shorter or more direct lines and 3) demand management. Fixed losses do not vary according to current differences, these losses occur in transformers between the different voltage levels. Basically, there are two solutions to this problem and that is to either turn off some transformers during periods of low demand or to reduce the number of transformer stations needed, thus to reduce the number of voltage levels in the network. Non-technical losses are losses not related to the network itself, but comprise of differences between delivered electricity and electricity recorded as a sale. Meter errors, errors in measurement, unmetered supply and illegal abstraction of electricity are causing these differences. Solutions to non-technical losses are difficult since i.e. the network operators do not have the possibility to react to illegal abstraction of electricity.

A reduction of variable and fixed electricity losses is possible by DG by a significant percentage. Based on the main characteristic of DG – generation located close to the final consumption – there is a potential to lower both variable and fixed losses. By generating electricity close to the consumer, the distance that electricity has to travel shortens and less electricity is transported over the lines previously used. Both result in a decrease of variable losses. Furthermore, a second characteristic of DG is the feed-in level which is the distribution grid (in the Dutch situation this is 'Middenspanning or Laagspanning'). Electricity being fed in on a lower hierarchical level leads to a reduced need for transformer stations which lowers fixed losses. The remaining assets have either reached the end of their life span and are therefore fully depreciated or they continue to be depreciated which reduces the time it takes before cost-reductions trickle down to the final consumer.

Alterations to the distribution losses incentive can be based on either the distribution network companies themselves or the final consumer; both parties are able to reduce the losses. On the one hand, when replacing existing technology, the network operators can invest in technological solutions or change their grid design to reduce losses. On the other hand, network operators can invest in demand side management to smooth the electricity demand load profile from consumers.

Important with all alterations to this incentive is the allocation of costs and benefits. For an incentive to be successful, the benefits should (partially) end up at the network operator. In the research justification it has been mentioned that there is a lack of options for network operators to remunerate some of their investments since benefits often arrive at the consumer side. Consumers can share in the costs and benefits by actively pursuing a reduction of their peak use. The incentive should be designed in such a way that both the generators and the consumers can reap the benefits of investments. The incentive regulation already makes sure that the benefits arrive at the consumer side eventually because of efficiency increases and cost reductions for all network operators. A larger share of the benefits for the network operators increases the strength of this instrument.

The distribution losses incentive could be executed as a zero-sum incentive for the distribution operators. The costs of electricity losses are cascaded down from the transmission operator to the distribution operators and finally the consumers as part of the tariffs. The investments required by the distribution operators to reduce losses can be compensated for by the cost savings. Although benefits have to trickle down to consumers, not all benefits have to, it is a matter of fair and improved cost allocation.

In short, DNO's, final consumer and distributed generator benefit from reduced distribution losses.

8.3 Possible new Dutch incentive instruments

In the consultation towards the fifth regulatory period for the regional network operators the Energiekamer asked the joined network operators (Netbeheer Nederland) to come up with new possibilities within the RPI-X regulation mechanism to compensate for distributed generation. Several options have come up; a redesigned aggregated output in section 8.3.1 and feed-in tariffs & locational pricing in section 8.3.2. All options will be discussed below.

8.3.1 Extended aggregated output

This approach developed by Netbeheer Nederland (2009) opens up new possibilities for network operators to increase their allowed revenues as a result of capital expenditures incurred by the implementation of distributed generation to their grid. The approach suggests an additional factor to the aggregated output ('samengestelde output'), a factor for distributed generation. This proposed change of the aggregated output is determined with the use of the following formula in figure 8.4:

$$\underbrace{SO_n}_{5} = \sum_j \left(\underbrace{\frac{\overbrace{\sum_i \ddot{\bar{p}}_{i,j} \cdot \ddot{rv}_{i,j}}^{1}}{\sum_i \ddot{rv}_{i,j}}}_{ST_j \; (2)} \cdot \ddot{rv}_{n,j} \right) + \sum_k \underbrace{ST_k^{DG}}_{3} \cdot \underbrace{Vol_{n,k}^{DG}}_{4}$$

SO = aggregated output
$\ddot{\bar{p}}$ = tariffs
$\ddot{rv}$ = volume
i = network operator
j = tariff element (demand)
k = tariff element (generation)
ST = sector tariff

Figure 8.4: design of the composite output

The composite output has always been solely based around electricity consumption, a downstream electricity flow. The composite output is used to calculate the amount of revenue that every DNO is allowed to earn through the tariffs and is based on costs of connections and transportation costs. Since the upstream electricity flow has been increasing the last years, the composite output formula is not completely accurate anymore; electricity being bed into the grid should be included and that is exactly what Netbeheer Nederland suggests.

The downside to this extension of the composite output is that it is still based around a sector tariff, thus a benchmarked tariff and that does only improve the allocation of costs and benefits for a small part. There are differences in cost levels between technologies and between regions (as a result of different technologies) that are not included in the aggregated output.

In short, this extension of the composite output provides for a partially improved cost-benefit allocation but can be further improved by differentiating between technologies. The best thing about this extension is that the joint DNO's made the suggestion and the Energiekamer implemented it which provides options for more suggestions like this one.

8.3.2 Generator tariff and locational pricing

The Netherlands had a generator tariff in the past; the 'Landelijke Uniform Producententarief (LUP)'. Article 3.5 of the Tariff code described the uniform generation tariff. This tariff dealt with the transportation tariff of 25% paid by generators on the high or extra-high voltage level. This tariff did not exist for generation at lower levels and due to European harmonization the tariff was set at 0 for all generators in order not to create a competitive disadvantage for Dutch generators (DTe, 2000). Before the incentive had been set to 0 for all generators it was only applied for generation on the high-voltage or extra-high-voltage level. Since distributed generation is defined as being connected to the distribution grid this incentive in its old design does not have any benefits to the DNO's. What was interesting about this generator tariff was its non-discriminating character, thus both renewable and fossil fuel based generators had to pay the tariff (Article 3.5 of the Tariff Code).

Since distributed generation is obligatory connected to the networks, the network operators incur costs; these cost levels are not equal among them. Operators having more distributed generation connected to their network have higher costs for which they are not compensated. The current calculation of the aggregated output is based solely on consumption and not on generation. The tariffs are based on the aggregated output but the costs are not accounted for in the individual situation. The extra costs incurred by distributed generation are included in the regulatory asset base and are therefore included in the benchmark. These costs are remunerated through a sector wide increase of the tariffs but this means that there is compensation for all network operators where only one incurs costs. An unfair allocation of benefits thus exists.

The tariff structure in general is proposed by both the NMa and the joined network operators after which the proposal design has to be approved by both the government and the senate. The E-Act provides options to alter the tariff structure. Article 32.1 describes that a joint effort by one-third or more of the DNO's to hand-in a proposal to the NMa can alter the tariff structure or the conditions that currently apply as long as Articles 27 and 31 of the E-Act remain valid. If these Articles need to be changes, the E-Act as a whole changes which needs to be approved again by the government and senate. The Tariff Code described the rules and conditions in greater detail; the Tariff Code is a policy rule and can be altered more easily.

Regarding distributed generation, there seem to be options to alter the tariff structure as to include tariffs that allocate the remuneration of costs of distributed generation more fairly among the network operators. Implementing a generator tariff for distributed generation should be able by a small change to Article 3.5 of the Tariff Code, a change from generation on the high or extra-high voltage level to generation at all levels or only the lower hierarchical levels (this would mean that the LUP has to be reinstated again but redesigned).

Including a generator tariff for the lower hierarchical levels would have several important benefits. First of all, remuneration of costs of distributed generation would be allocated more properly between the network operators. Secondly, the rationale by the Energiekamer to discontinue the generator tariff on grounds of keeping a competitive position in Europe for Dutch electricity generators would still be valid for large-scale central generation units. Small-scale distributed generation does not have a competitive European position to keep since it is locally based. Local generated electricity is not intended for transport to the surrounding European countries.

Thirdly, a generator tariff offers possibilities for location based tariffs. Introducing differentiation in the generator tariff could potentially have a large impact on the electricity network since the

DNO's gain some control over where generation units are connected to the grid. Capacity problems in the distribution network will occur when for instance a lot of distribution generation is connected at the same transformer. Some areas are better suited and some are less suited for the introduction of distributed generation. Most of the time a simple micro CHP unit can be connected to the grid without problems but introducing a larger generating unit could pose problems. A locational generator tariff is able to stimulate connection of problematic generating unit on the best suitable locations. An example of a preferential locational area for a biomass based CHP plant is Sittard. In this city a distributed generation unit was build on the grounds of Chemelot, a company in the chemical industry. The installation of the plant in this location meant that access to reinforced network cables was within arm's reach thus avoiding large investments.

Would a generator tariff pose a disincentive for distributed generators to even commence on such a project? Probably this would be the case, which proves the importance of complementary incentive instruments even more. Combination of a generator tariff with for instance an incentive to remunerate distributed generators for avoided distribution losses could compensate for the feed-in-tariff.

To conclude, the reinstatement of the generator tariff in an altered design could have positive effects for the DNO's as to their remuneration options for the costs of distribution generation in their network. The DNO with the highest DG cost level receives more compensation while the DNO's having little DG costs get less compensation because they do not actually have these costs. A generator tariff combined with an incentive to compensate distributed generators for avoided costs could nullify the disincentive for these generators.

8.4 Conclusions

In this chapter three groups of incentive instruments are discussed within the Dutch regulatory framework: firstly, the incentives currently active in the framework. Secondly, the incentives that can be changed or be reinstated (formerly active incentives that can be redesigned). Lastly, the newly developed incentives are discussed, incentives that can be introduced in the framework.

There are two active incentives in the Dutch regulatory framework; the Objectifiable Regional Differences instrument (ORD) and the 'substantial investment' instrument. The ORD instrument excludes investments from the benchmark in case they can't be influenced by the DNO's. Examples are water crossings and the connection density in the service area. Substantial investments have a one-off character and require large investments for either increasing the network length or the capacity. Options to use these instruments in their current design for the remuneration of innovative investments are very limited. The Energiekamer has reviewed the option to include additional ORD's but only the connection density is included as a result. It is important to continue reviewing the ORD's and if certain investments can't be influenced by the DNO then the Energiekamer has to come up with a proxy to make it an ORD. The 'substantial investment' instrument is very limited in its current design, making it difficult for DNO's to apply for reimbursement. Since these are the only two existing instruments in the framework, the Energiekamer has to be continuously trying to improve or change them to cope with the changing environment.

Recommendation 1: **the Energiekamer should keep on reviewing the ORD and 'substantial investment' instrument to respond swiftly to changes if necessary**

These two incentives can be redesigned to accommodate the changes described in chapter 2. Furthermore, there is a possibility to reinstate incentives that were previously active within the framework. The ORD incentive is as said difficult to change because it is hard to prove if something is outside the control of the DNO. It is even more difficult to find a suitable proxy. A similar solution has been described in the conclusions of the previous chapter 7; the additional revenues mechanism in Germany and the automatic revenue driver mechanism in the United Kingdom. Both mechanisms are able to mitigate regional differences and mitigate the changes described in chapter 2. Examples of revenue drivers are number of connections (both supply and demand), increase of the service area and peak load increases. Because the Dutch regulation is TOTEX based and thus fully benchmarked, these revenue drivers need to be kept outside the benchmark and an ORD incentive is suitable for that.

The 'substantial investment' instrument is only briefly mentioned in the E-Act, in Article 41. Only the existence of the instrument is mentioned but there are no specific details provided, these are listed in Article 3.5 of the Tariff Code. The Tariff Code is a policy decree by the Energiekamer that is designed in cooperation with the DNO's and other involved stakeholders. The Tariff Code and thus the instrument can be redesigned after every regulatory period. It therefore provides opportunities for future inclusion of innovative investments by DNO's.

Another instrument mentioned in the Tariff Code is the distribution losses incentive. At the moment this incentive is only available for connections at the high or extra-high voltage level. A redesign of the incentive to include low-voltage levels would improve allocation of benefits to the stakeholders actually making the costs. The stakeholder can be both the DNO and the consumer (renewable energy supplier). A DNO is able to invest in technologies that reduce distribution losses and a redesign of this incentive would allocate the benefits to the DNO's. The frame of reference for the redesign is the UK distribution losses incentive. A similar reasoning goes for consumers; by supplying electricity they can reduce transmission and distribution losses.

Recommendation 2a: **the additional revenue mechanisms of Germany and the UK can provide useful insights to improve the ORD instrument**

Recommendation 2b: **the Tariff Code and therefore the 'substantial investment' incentive can be redesigned after every regulatory period by joint decision of all stakeholders,**

Recommendation 2c: **the distribution losses incentive can be changed to include distributed generation at lower voltage levels, as well as improve allocation of benefits to DNO's investing in technologies that reduce losses (implementation as a zero sum instrument)**

The Energiekamer is investigating new means of improving allocation of costs and benefits as well as providing DNO's with options to remunerate costs resulting from distributed generation. One of these means is an additional factor in the 'composite output' calculation. The composite output determines the revenues each DNO gets and it is completely based around electricity demand as the cost driver. With increased small-scale generation the composite output is not a complete reflection of costs anymore. The Energiekamer tries to improve this reflection starting from the fifth regulatory period. A supply factor is added to the formula to reflect costs of supply. The downside to this instrument is still uses an average sector tariff which does not completely reflect the regional cost differences as a result of different technologies (i.e. DNWB incurs much higher cost levels as a result of CHP plants in the greenhouses).

The Dutch regulatory framework used to have the LUP instrument which is a generator tariff for feeding their electricity in the grid. Several reasons led to its discontinuation but in a redesigned form it could be reinstated. Previously only large-scale generators had to pay this tariff and the downsides of the instrument were only relevant to large-scale generators, not to small-scale. Reinstating a generator tariff but only for small-scale generators would improve cost and benefit allocation between the DNO's. Furthermore, a combination with a locational pricing is possible. Placement of distributed generation units in better suitable locations can be stimulated.

Recommendation 3a: **investigate the possibility of technology differentiation in the supply factor of the composite output as to improve it**

Recommendation 3b: **a reinstatement of a redesigned generator tariff for small-scale generators would increase cost-benefit allocation between DNO's and provide options for locational pricing as to stimulate optimal unit placement**

9 Incentive instruments: stimulate innovation

Are innovations in networks really necessary? Aren't network companies able to continue their practice in the future like they currently do? The changes described in chapter 2 – ageing of the grid and the transition to a low-carbon economy – require large initial capital investments that can be considered sunk costs once they have been made. This capital could be invested in traditional ways: reinforce the network when dealing with demand/supply load changes and replace existing network parts when they reached the end of their lifespan. However, these traditional solutions would be very costly and since (almost) all costs are cascaded down to the consumers it would be very costly to society. Isn't there another solution besides the traditional ones? Yes, there is, namely innovation. Innovation has the potential to deliver a similar outcome but at lower costs to consumers, but this potential must be translated into real time solutions which takes time and money and will not happen without incentives to do so. What kind of incentive instruments need to be developed?

The innovative capacity of network companies has decreased as a result of the efficiency requirements by the regulatory framework. Most innovations developed and implemented by the network companies are aimed at either reducing the costs of operation (OPEX) or at decreasing the capital expenditures (CAPEX). There is thus a demand for the development and implementation of innovations but this demand already describes a difficulty which should not be ignored: not all innovations are similar. Some innovations still need to be developed while others are ready to be field-tested or rolled-out at a large scale. What categories for innovations will be distinguished?

Early research in the 1980s by Kline (1985) and Kline & Rosenberg (1986) about the 'chain-linked' model describes the path of an innovation process. This model is given below in figure 9.1 and one can see in the model that there is a potential market at the start of the path and through several design and testing stages the final stage of distribution on the market is reached. The arrows on the bottom part of the model visualize the feedback loops and the arrows in the top part of the model visualize the knowledge flows back and forward between the company and the general societal knowledge base (i.e. research departments at universities).

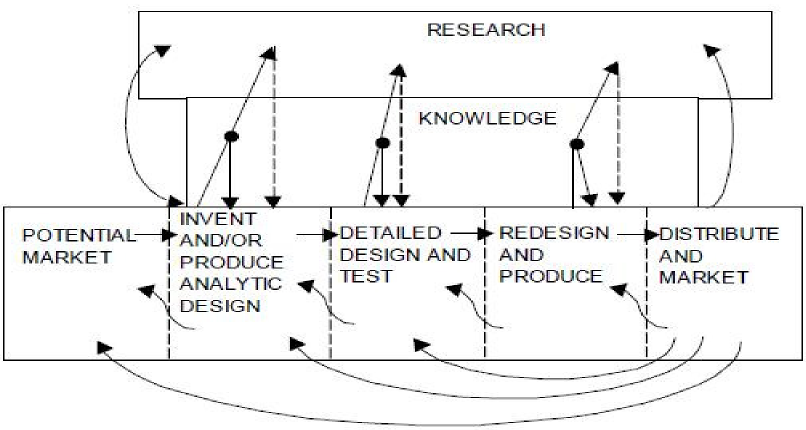

Figure 9.1: Chain-linked model by Kline & Rosenberg (1986)

A similar division has been made by ICCEPT & E4tech Consulting (2003) in a report to the DTI and the model they used is provided in figure 9.2. The model below split up the commercial stage in three sub-stages being: pre-commercial, supported commercial and commercial. There are several interesting things to be seen in this model. Firstly, through collaboration between universities and companies the innovation chain starts and ends at the consumer. Secondly, while the need for investments increases with each stage, the need for policy intervention decreases. Lastly, the first stages of the model are based on a technology push while this slowly transfers to a pulling of the technology by the market. The first point is quite straightforward, new knowledge is produced at the intersection between universities, knowledge centers and the network companies. Points two and three are intertwined and give an indication of how and where incentive instruments should be designed and positioned to stimulate innovations.

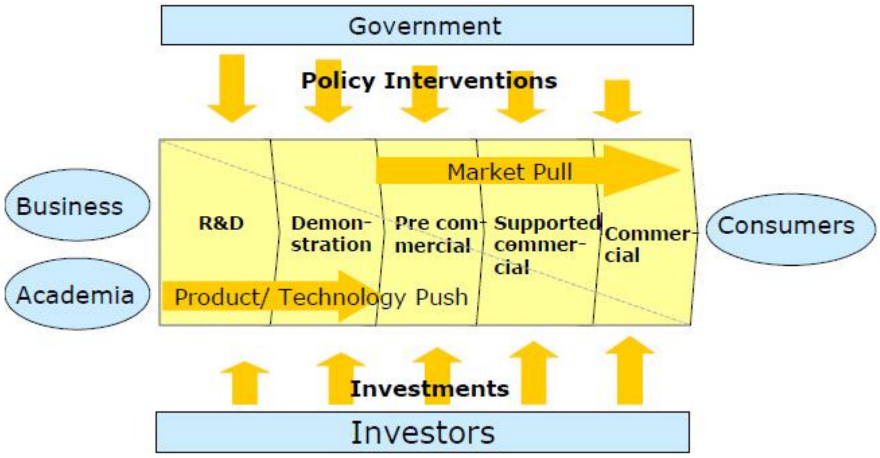

Figure 9.2: Model derived from chain-linked model by E4tech Consulting

In chapter 2 the problems arising with the development of innovations in the Netherlands have already been described as being a lack of incentive instruments and a disproportionate allocation of costs and benefits. In greater detail, the innovation problems are:

- In the first stages of the innovation chain the innovation needs to be pushed by the network companies and therefore these stages require more regulatory interventions (thus incentive instruments). Investments are relatively small in the first stage but increase quite strongly once innovations reach the field-testing phase. There should be options for the network companies to remunerate these investments.

- In the later stages of the innovation chain the innovation is field-tested and if proven to be good enough the other network companies (the market) should start implementing the innovation in their networks too. Proven innovations should be pulled by the market which reduces the need for regulatory intervention. Investments in the last stages are high because they require a roll-out over the entire network, and without proper remuneration options these investments will be held off by the network companies.

An adaption of the model by ICCEPT & E4tech (2003) will be used in this report. The model will be reduced to three stages and the final three stages of commercialization will be considered as one stage, the sector wide deployment. Justification for this reduction into three stages can be found in the relative importance of regulatory incentive instruments which is highest for the first and second stage. The model as used in this research can be found in figure 9.3 and is composed of an R&D stage followed by small-scale field-tests and a large-scale deployment stage. Each stage will be described in a separate section.

Figure 9.3: layout chapter 9

The sections will be build-up of a listing of incentive instruments for that stage and after each description of an incentive instrument the regulatory implementation possibilities in the Netherlands will be described (for Dutch incentives the possible adaptations and for United Kingdom incentives the transferability to the Dutch situation).

9.1 Research and Development

The research and development stage is the first stage in the innovation chain model and it is in this stage that the innovations are actually being developed. Incentive instruments aiming at this stage should therefore not be bothered with actual field testing the innovations. The Dutch regulatory framework does not have any incentives that are specifically aimed at the first stage of the innovation chain. The only way for network companies in the Netherlands to remunerate the costs they incur by investing in innovations is through the normal regulatory framework, thus the RPI-X regulation. Because the cost levels are regulated through the benchmark, a network company is not able to remunerate the made investments at all (unless all network operators make equal investments in time and size). The RPI-X regulation actually discourages investments in innovation but the reasoning from the Energiekamer is different, they assume that investments will occur naturally in case they result in benefits in the future. The discrepancy between this reasoning and investments in the R&D stage is that the network operator is not sure at all whether the investment will accrue benefits and is therefore not willing to spend the capital required. In short, the Dutch situation lacks incentive instruments.

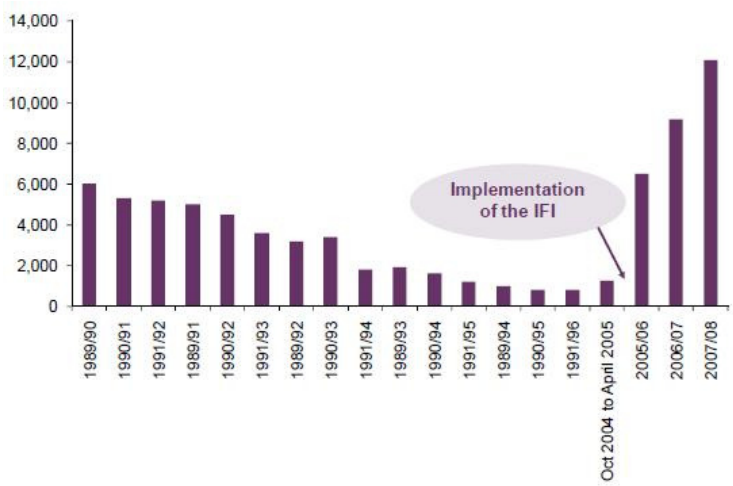

Figure 9.4: Declining R&D spending in electricity distribution sector

The regulator in the United Kingdom, Ofgem, did realize this discrepancy between the need to innovate and the lack of remuneration options. Although the regulatory framework is different in the UK (only OPEX is benchmarked opposite to TOTEX for the Netherlands) the options for CAPEX remuneration did not facilitate R&D investment previously which resulted in declining spending in electricity distribution R&D as can be seen in figure 9.4. Ofgem installed an incentive that is called the Innovation Funding Incentive. Section 9.1.1 will describe this incentive and the transferability to the Dutch situation is discussed in the conclusions in section 9.4.

There are other alternatives to the funding of innovative investments and that is through subsidies. These subsidies are granted by the government and are thus paid for by the people paying tax. There are several subsidy programs that organization and/or DNO's could apply for, being (Agentschap NL, 2010):

- EOS (Energie Onderzoek Subsidie): this energy research subsidy stimulates the development of research and knowledge in the Netherlands by stimulating new technology that is aimed at the realization of a renewable energy supply and demand. Both companies and knowledge institutions can apply for subsidy.

- IAE (Innovatie Agenda Energie): the innovation agenda for energy can subsidize up to 438 million euro for energy innovation in the period 2008-2012. The subsidy program is based on goal of the government to increase a sustainable and secure energy supply. An example of an IAE subsidized program is the 'experimental arrangement for wind at sea', a program that is interesting for DNO's.

- UKP (Unieke Kansen Programma): this subsidy offers subsidy for large-scale investment projects in the energy sector that fit within the transition to a low-carbon economy.

- IOP (Innovatiegerichte Onderzoeksprogramma's): this subsidy is aimed at innovative research programs. This research can consist of amongst others fundamental (basic) research and industrial research for (products, processes or services).

Whether an organization or a DNO is eligible for a subsidy program is decided by Agentschap NL (former Senternovem). It do not necessarily have to be DNO's that apply for these programs but any organization of company willing to invest in innovation is able to apply. Not only the DNO's have to invest but the scope for innovation in distribution grids can be wider (i.e. knowledge institutions).

9.1.1 The UK Innovation Funding Incentive (IFI)

The main objective of the IFI is "to provide funding for projects primarily focused on the technical development of the networks, to deliver value (e.g. financial, quality of supply, environmental, safety) to end consumers." [9] The network operator is allowed to spend up to 0.5% of its 'Combined Distribution Network Revenue' with a minimum of 500.000 pounds on projects that are eligible under the IFI rules (Energy Networks Association, 2007). Once projects have been

[9] The IFI is regulatory described for DSO's in the Special License Condition but the British network operators made a good practice guide, and this guide will be used as input for this research.

proved to be eligible under the IFI, the network operators can pass 80% of their costs through to the consumer in the tariffs. Not all projects are eligible for the IFI; projects that are subject to high uncertainty and a high estimated probability for success. Specific criteria are described in the next paragraph (Ofgem - RIGs, 2004).

Projects applying for the IFI are eligible when they comply with the following three criteria: 1) required technical development; 2) certain degree of innovation and 3) sufficient consumer value. The first criteria, the required technical development is tested against the following definition: "being of a scientific and/or engineering nature and benefiting the design, construction, commissioning, operation, maintenance and decommissioning and/or improving the direct environmental interactions of the Primary plant and equipment employed in the distribution of electrical energy, transmission of electrical energy and transmission of gas and/or of the secondary plant and equipment employed to control, protect and maintain such Primary plant and equipment". For instance, projects that improve the quality of supply, improve loads and storage are eligible under the IFI as long as they provide technical development of the network. The second criteria, the degree of innovation can be met when a project aims to produce: incremental innovation; technological substitution; significant innovation and radical innovation (all in either a beginning, intermediate or final stage of development). The third criteria, the consumer value has to be fulfilled because the consumer has to receive the benefits; benefits that can exist of quality of supply, financial, environmental or safety benefits. These benefits will trickle down to the consumer through the adjusted tariffs while the producer receives benefits through both the IFI and outperforming the price control.

Projects applying for the IFI have to supply a cost-benefit analysis (CBA) of their proposal, and this CBA has to contain the following calculations: "1) an estimation of the potential benefits – both direct and avoided costs – from the proposed project if successful; 2) an estimation of the potential improvements from the proposed project for each type of non-financial benefit; 3) an estimation of the likely probability of success of the project; 4) an expression of the potential improvements as an expected percentage increase in that type of benefit and 5) a usage of the result as the predicted benefit in the company's standard R&D investment appraisal methodology. The calculation of benefits and risks necessary for the CBA proposal is subject to guidelines; there are benefit and risk assessment criteria with weighting factors to come to a overall project score (project benefit rating + risk rating).

The proposals will not be approved or disapproved by Ofgem (the UK regulator) but the network operators have to openly report on their IFI projects on an annual basis. There is no administrative burden on the regulator to assess whether projects have been efficient or whether they have provided the results they promised. There is an implicit incentive in the guidelines to let network operators only undertake beneficial projects with a high change of success (since their own benefits depend on this success). The lack of ex-post assessment ensures partial compensation for the project without the risk of being denied remuneration in the end. Although there is no ex-ante or ex-post assessment, the regulator still reserves the right to audit all IFI projects themselves when deemed necessary for the interests of consumers.

The results of the IFI in the United Kingdom are quite good. In the annual report by Ofgem the two parameters used to measure the impact of IFI (IFI spend and R&D intensity) show a steady increase for almost all distribution network operators (Ofgem, 2009). In figure 1, the increase in capital spend on IFI is shown. The main message is that spend capital increased from nearly zero before 2005 when the IFI started, to 12.1 million pounds in 2007/2008 and 10.7 million pounds in 2008/2009. These numbers translate to a R&D intensity of 0.33% in 2007/2008 and 0.3% in 2008/2009 (where the incentive is capped at 0.5%). Furthermore, Ofgem measures the Net Present Value (NPV) of each network operator's IFI portfolio which is positive (as required by the Good Practice Guide). The total NPV for all network operators is 67 million pounds in the UK. Although results for the DNO's and Ofgem are quite good, it remains to be seen whether the benefits actually trickle down to the consumer, but according to Ofgem this will eventually occur because DNO's can better facilitate the transition to a low-carbon economy.

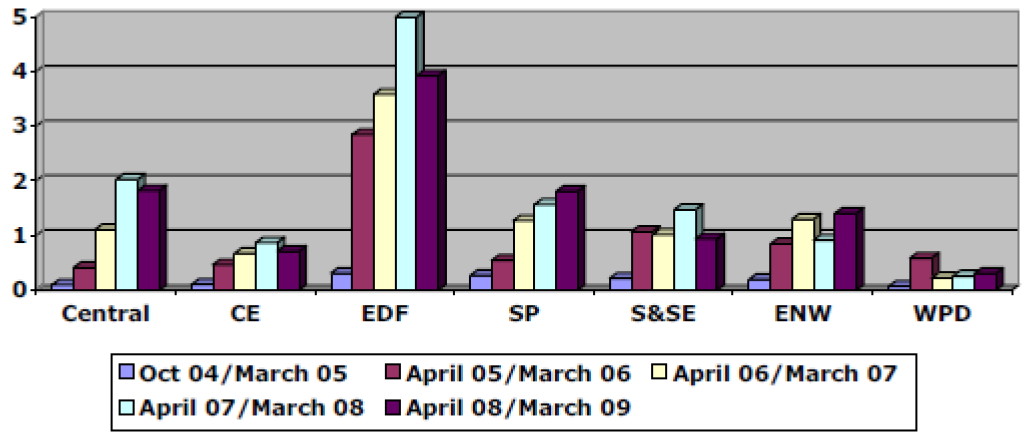

Figure 9.5: IFI spend (in millions of pounds)

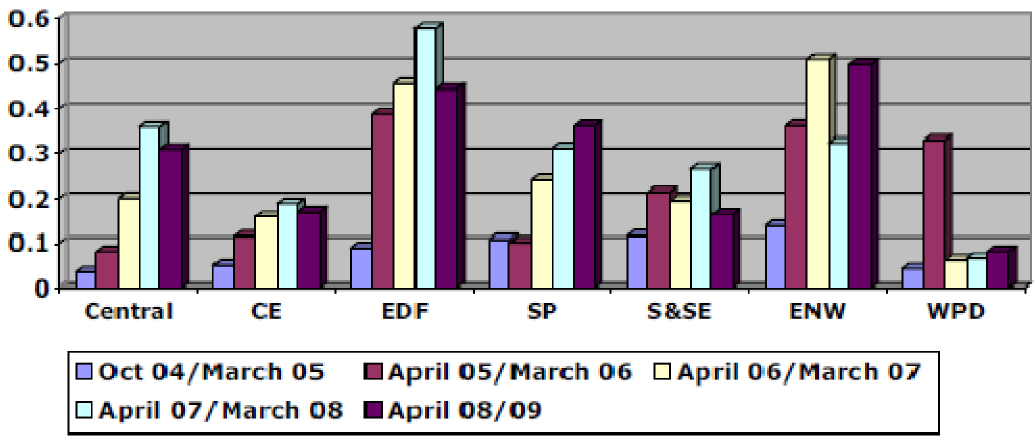

Figure 9.6: R&D intensity (%) (IFI cap is 0.5%)

9.2 Small-scale field testing

Incentives instruments in the second stage of the chain model are aimed at technologies that are ready to be field tested. Newly developed innovations coming from the R&D stage are proven to work in controlled environments, but this stage is all about testing the innovations in the real world, the distribution networks.

9.2.1 Low-Carbon Network Fund (LCN fund)

The purpose of this fund [10] is to increase the willingness of DNO's to innovate in solutions necessary for the transition towards a low-carbon economy. The fund is intended by Ofgem as a starting point in the fifth regulatory period (DPCR5) to make the necessary preparations. In terms of innovations, the fund is intended for final stage innovations, innovations that are ready to be field-tested. These test projects should enable DNO's to gain experience is the transition towards a low-carbon economy as well as incentivizing demand side management options.

The LCN fund is based on two tiers amongst which the amount of 500 million pounds is divided. The first tier is intended for small scale projects and the money is allocated between all DNO's to a total sum of 80 million pounds. The second tier is intended for a restricted number of flagship projects and the capital allocation is not based on equality between the DNO's but is based on the proposed project. The DNO's have to compete with each other to claim this money which is capped at 320 million pounds. First tier funding is given to the DNO's to be spend on projects they think are necessary and right while the second tier funding is allocated by Ofgem and is based on project proposals. These two tiers use 80% on the fund money, the remaining 100 million pounds is used as a 'discretionary reward' which will be allocated to projects that have great success and provide large value to the set goals of the LCN fund. The reward is thus used as an incentive to deliver successful projects.

Projects able to apply for LCN funding have to comply with several criteria: 1) they need to accelerate the development of a low-carbon electricity system; 2) they need to impact the performance of networks directly; 3) they need to deliver benefits to existing and future consumers that are expected to outweigh the costs of the project and 4) they need to generate new knowledge that can be shared amongst all DNO's. This last criterion implicitly regulates two possible problems: the duplication of projects and the creation of intellectual property rights which deny other DNO's the opportunity to benefit from projects. Innovativeness is an important characteristic of this fund and the fund is paid for by public money and thus the intellectual property rights should benefit all consumers.

A big hurdle to overcome was the reimbursement of costs incurred by the DNO's. DNO's are not keen on risks regarding investments and therefore the LCN fund put in place several safeguards for costs reimbursement. There is a maximum of 90% of costs that can be applied for funding, 10% of costs have to be paid by the DNO's but the projects are also expected to gain benefits; these benefits are subtracted from the costs. DNO's have to fund a maximum of 10% themselves unless the benefits exceed this 10%. All further incurred benefits are subtracted from the costs and consequently the maximum amount to be funded by the LCN fund. A second safeguard to ensure qualitative good project proposal is the ability for DNO's to assign 20% of the first tier funding to the preparation of second tier project proposals.

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[10] The LCN fund has taken over the function of the Registered Power Zones instrument. Both instruments have a similar goal to fund innovative distributed generation projects. Starting from DPCR5 the LCN fund will be the only active instrument. Textbox X will describe the previous RPZ incentive.

9.3 Large-scale deployment

Once an innovation has proven to be successful and results in benefits there are different requirements compared with innovations in earlier stages of the chain. The effects of policy interventions are far less for innovations ready to be employed on a large scale. The investment requirement however is far more important due to the large-scale character.

The regulator should no longer be focused to push an innovation to the DNO’s but in this stage of the chain the innovation should be able to be pulled by the DNO’s and consumers because it results in benefits for the DNO and consequently the consumers.

Although the innovation themselves are ready to be employed on a large-scale, and although they result in benefits, this is still no guarantee that they will be implemented. The research rationale explained the problem of benefits arriving at the consumer and society instead of the DNO which in itself is a good thing but not if a DNO has to make all necessary investments for the innovations that result in the benefits.

In the Netherlands there are no incentives in place for this stage, neither are there any in the UK regulatory framework. Although this stage is often considered most important because of the actual changes it can result in, it is left to the consumers and DNO’s to request and implement the innovation on a large scale based on the benefits they are supposed to accrue.

9.4 Conclusions

The three successive stages in the innovation chain are characterized by an increasing capital demand, a decreasing necessity for policy interventions and a shift from technology push to market pull. These dynamics are translated to three stages for the implementation of an innovation: 1) the R&D stage; 2) the small-scale field testing and 3) large-scale deployment of the technology. Each stage requires a different approach by the regulator.

The R&D stage takes place at both DNO’s and at knowledge institutions like universities and KEMA. The development part of an innovation mainly takes places at these institutions and the actual fitting-in of an innovation into the existing situation is for a large part done by the DNO’s. For instance, a new efficient transformer is developed at the university and the DNO executes the necessary research to implement the transformer in their network. The R&D part required by DNO’s can be remunerated with the same options (and subsequent obstacles) as any other investment. Only indirect reimbursement as described in chapter 2 would result in remuneration of costs. Direct reimbursement is only possible when all DNO’s have equal cost levels which results in an increase of the benchmark.

The Innovation Funding Incentive (IFI) in the UK is specifically aimed at the innovative investments by providing an 80% pass-through allowance for up to 0.5% of annual DNO revenues. Transferability of the IFI to the Dutch framework is possible by altering the ‘substantial investment’ incentive in the Tariff Code to include innovative investments. The resulting recommendation would be:

Recommendation 1: **transferability of the UK IFI is possible within the ‘substantial investment’ instrument by changing the Tariff Code**

The small-scale field testing stage is in my opinion the most important stage because at this stage the successful innovations are separated from the unsuccessful ones. Innovations that are considered mature are field-tested by implementing them in real-life situations. The remuneration problem is similar as in the first stage; only indirect reimbursement results in remuneration of costs. A difference is that second stage cost levels are much higher than in the first stage.

The UK Low Carbon Network Fund (LCN Fund) is specifically aimed at innovations that are ready to be field-tested. The LCN Fund consists of two tiers: the first tier aimed at small-scale projects available to all DNO's and a second tier aimed at flagship projects for which the DNO's have to compete. All projects have to be aimed at low-carbon network solutions. Transferability of such a fund to the Dutch regulatory framework is twofold. First tier projects could once again be placed under the 'substantial investment' by changing the Tariff Code. Second tier projects are different because they offer more possibilities. On the one hand, large-scale flagship projects can be treated in the same way as first tier projects. On the other hand, flagship projects in the UK are based on competitive offers but there are possibilities for DNO's to cooperate. Instead of changing the current regulatory framework, cooperation would make the sure that no changes are required. Remuneration would be possible by direct reimbursement; if all DNO's would participate in a project, their costs would increase proportionately and so will the benchmark.

Cooperative projects already exist: in general the DNO's are combined in 'Netbeheer Nederland' and more specifically they are cooperating in the 'e-laad' foundation that aims to facilitate a renewable energy supply. The foundation initiated the construction of 10.000 charging points for electric vehicles within the next three years. Consumers and communalities can request a connection point which is installed and paid for by the 'e-laad' foundation. Such a project fits within the flagship structure of the LCN Fund. There are more projects that have a similar aim and scope like the national deployment of smart meters. All DNO's had their own pilot projects regarding these meters while standardization provided some benefits. A joined pilot project could have avoided mistakes and increased the cost-benefit ratio. The above described second stage translations result in the following recommendations:

Recommendation 2a: **transferability of the UK LCN Fund is possible within the 'substantial investment' instrument by changing the Tariff Code (for first and second tier projects)**

Recommendation 2b: **transferability of the UK LCN Fund is possible if DNO's would cooperate for large-scale flagship projects that facilitate a renewable electricity supply (second tier projects)**

The large-scale deployment stage is the stage incurring the largest capital demand, the least regulatory involvement and is driven by a market pull. The innovation should drive itself because there are certain benefits to be gained, as proven by the field-testing stage. The reason why I think this stage is less crucial to the previous one is that in this stage the uncertain character of innovations is gone; they have proven themselves to be economically viable. There should be a pull from the market that will initiate the take-off of these investments, which does not imply that the take-off will happen since the same remuneration options exist as with every investment. Several options exist to remunerate these investments:

- Firstly, large-scale deployment of projects in a cooperative action by the DNO's (as within the second tier LCN Funding) can be remunerated by direct reimbursement through the benchmark).
- Secondly, projects by individual DNO's can be remunerated by the 'substantial investment' instrument that requires a change in the Tariff Code.
- Thirdly, a zero-sum instrument is able to stimulate certain investments like the transformers that have been mentioned before. A combination with the distribution losses incentive from chapter 8 is possible. The new efficient transformers reduce electricity losses for DNO's and by providing the DNO's with these cut costs, they can remunerate the investments that are needed to do so.

The options for the third stage result in the following recommendations:

Recommendation 3: **remuneration for investments in the large-scale deployment stage is possible, either by direct reimbursement, by changing the 'substantial investment' instrument or by introducing zero-sum instruments**

In general the current regulatory framework in the Netherlands is unsuited to incentivize innovative investments that do not have immediate benefits or that have benefits that do not trickle back to the DNO's but to society as a whole. However, there are possibilities to improve the situation but this would require changes in the Tariff Code (changes that can be realized on short notice by a joined stakeholder effort).

10 Incentive instruments: creation of competition

This chapter consists of two sections of which section 10.1 describes the connection competition incentive installed by Ofgem in the UK and its transferability to the Dutch regulatory framework. Section 10.2 deals with the possibilities (if any) for increased level of competition in the electricity market and uses the telecommunication market as a frame of reference as explained in chapter 3. Finally, section 1.3 discusses possibilities for DNO's that are derived from the two previous sections. The layout of chapter 10 is represented in figure 10.1.

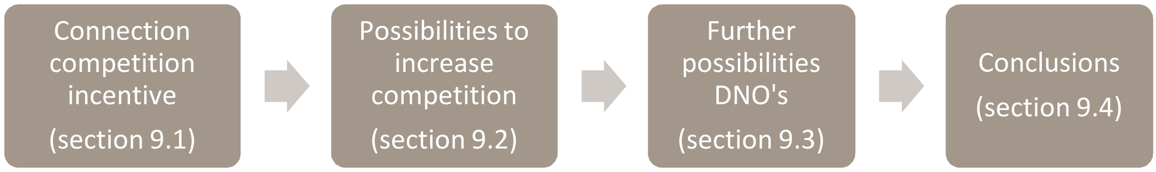

Figure 10.1: layout chapter 10

10.1 Connection competition incentive

The electricity distribution network in the United Kingdom is divided into fourteen licensed areas based on former area boundaries. These licenses are being held by the DNO's, thus fourteen DNO's in total but with seven companies actually owning the licenses (www.ofgem.gov.uk, 7-6-2010). Besides these fourteen licensees there are four independent distribution network operators (IDNO's) who own and operate smaller parts of the distribution network that are embedded in the distribution network of one of the licensees; besides the four IDNO's there are also DNO licensees operating in small areas of other DNO licensees. The IDNO's primarily focus on extensions connected to the existing distribution network like new housing development projects (and it is also the IDNO that ensures the connection to the distribution grid operated by a licensee.

Consumers requesting a new connection must apply for this connection with the DNO having the license for their area or with an IDNO. This (I)DNO is then required by law to connect the consumers (obligation to connect) to the already existing distribution network. The work needed to connect a consumer the network can be divided in two categories. The first category is non-contestable work; work that can only be done by the (I)DNO operating the network one is actually connecting too. The second category is contestable work; work that can be done by either the (I)DNO or by an accredited Independent Connections Provider (ICP). The contestable works are thus open for competition between the incumbent DNO and other IDNO's and ICP's. Within the contestable work category the market is segmented to exclude those segments which are not viable for competition. In the United Kingdom the market for demand connections at the low voltage level is not open for competition for "small scale low voltage domestic connections 1-4 premises" and not for "one-off industrial & commercial single or three phase whole current metering". Other low-voltage connections are open for competition. On the distributed generation side, all connections at the low voltage level are open for competition. This market segmentation is part of an incentive introduced in the fifth regulatory period DPCR5 by Ofgem. The incentive is aimed at the promotion of competition in connections due to expressed concerns by consumers about the levels of service and prices of connections. The exact intention of Ofgem is “to remove barriers to competition and provide an incentive for DNO’s to proactively facilitate competition where competition is viable” (Ofgem, 2009) (Ofgem, 2004).

The incentive is build up of three parts: 1) segmenting the market to identify the markets where competition is more likely to develop; 2) allow a regulated margin of 4 percent on those market segments that are likely to become competitive (the margin is provided ex-ante to provide for accelerate the creation of competition) and 3) allow an unregulated margin in market segments where competition is proven by the DNO through a competition test defined by Ofgem. In all parts, compliance with the regulatory framework is mandatory regarding undiscriminating access terms and quality standards.

The incentive instrument is furthermore supposed to provide information about barriers to competition in general and possibilities to open up non-contestable activities to competition. Two important things should be kept in mind; the costs to consumers should not increase under competition (since competition is intended to do the opposite) and the awareness of consumers is important in the success or failure of the incentive. Awareness should be provided by the DNO’s because they are supposed to proactively facilitate competition and thus suggest the possible alternatives to their consumers.

10.1.1 Transferability to regulation in the Netherlands

Within the Dutch regulatory framework there is presently no competition in connection services. There is however no specific article included in the Electricity Act (1998) that actually forbids such an incentive from being installed. The E-Act has several articles in place that are concerned with extensions and replacements to the electricity network. Articles 16.1 and 16.2 describe the tasks and responsibilities of the network operator. Article 16.3 describes a general prohibition for anybody who is not a network operator to perform a task as listed in Article 16.1 and 16.2. This general prohibition has some exemptions to it, which are described in Article 16c (consumers requesting a connection larger than 10 MVA to be used for public transport, mining activities, public services like streetlights and services regarding drinking water and sewage), Article 15.1 and 15.2 (electricity networks with a voltage level of maximum 0,4 kV and a usage of maximum 0,1 GWh per year, and electricity networks with a Ministerial exemption from Article 13.3 regarding the installation of a network operators for all electricity networks). Furthermore, Article 20.3 is an exemption of Article 16.3 (with a general administrative rule ‘Algemene Maatregel van Bestuur’ the government can rule that a network will only be constructed as a result of a public tendering procedure). All these exemptions have a common rule; the network operator is obliged to give his approval unless the reliability of the electricity network can’t be guaranteed.

Apart from the prohibition (and exemptions) in Article 16.3 there are possibilities for the network operator as a result of Article 16Aa to perform his tasks and obligations alone or together with one or more other network operators. Furthermore, the network operator is able to tender some of the tasks to the market, listed in Article 16Aa.2. The importance of this Article is not its content in itself but the consideration that this kind of tendering is not the same as the incentive as proposed by Ofgem in the UK. In this Article it is the network operator that writes out the tender instead of the consumer as it is supposed to be since only then competition exists for the consumers. The Dutch article does not guarantee that competitive tender prices eventually result in lower prices for the consumers.

Regarding connections to the electricity network, Article 23 of the E-Act mentions the obligation for the network operator to provide a connection for everybody (undiscriminating) that requests one against a set tariff and set conditions that are described in paragraphs 5 and 6 of the E-Act. If the text in Article 23 is taken literally it can be interpreted that the network operator is only obligated to facilitate a connection to the network it operates. It does not specify the way that this connection needs to be constructed, it is thus possible for a third party to construct the connection and then leave it to the network operator to make the physical connection to its network.

Regarding the incentive installed by Ofgem in the UK there are two important characteristics: 1) the contestable works are open for competition and 2) there are IDNO's that are allowed to construct and operate an electricity distribution network which is connected to a DNO's network and there are ICP's that are also allowed to compete for contestable works but these works will then be operated by the DNO. The first characteristic is not completely prohibited in the Dutch regulatory framework, there are exemptions to this prohibition in which some works could be open to competition. The second characteristic is also further researched. ICP's could be allowed based on the exemptions of Article 16.3 and IDNO's could be allowed based on the exemptions in Article 15.1 and 15.2.

The Dutch regulatory framework in the form of the E-Act does not rule out a connection competition incentive. There are possibilities to use an 'Algemene Maatregel van Bestuur' to create public tendering of network constructions. What needs to be established is whether this will prove to create a better result in price for the consumer.

10.2 Possibilities for increased competition

Partial competition in network connections as proposed by Ofgems incentive is a good start to introduce competition into the electricity network sector. Creating competition in sectors comprising of natural monopolies is not unheard of; on the contrary, it is common practice in the telecommunications sector since the European Union made it partially mandatory. The layout in figure 10.2 visualizes the creation of competition in natural monopolies, thus regulated markets. This figure explains the possibilities (if any) for the creation of competition in electricity networks which will be described in the following sections. Section 10.2.1 deals with competition between different telecommunication and different electricity technologies. Section 10.2.2 deals with competition within a technology and does so by using three categories and relating them to both the telecommunication and electricity sector one by one.

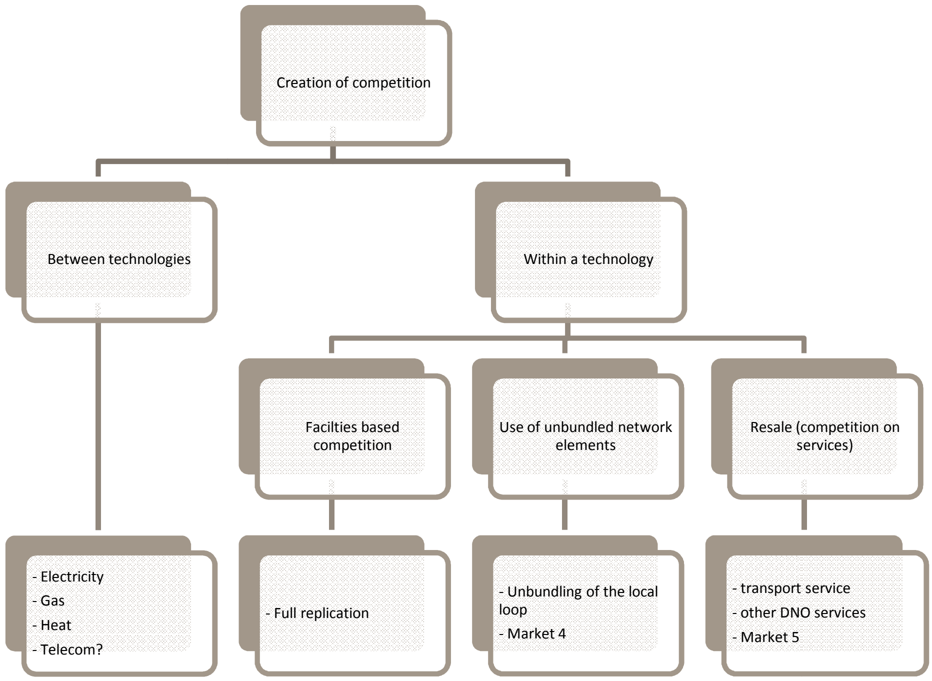

Figure 10.2: the creation of competition between and within technologies

10.2.1 Competition between technologies

Competition can exist between competing technologies and within a technology. In case of competing technologies there is less need for ex-ante regulation since the principles of a competitive market create the necessary incentives for cost and quality efficiency (assuming that the best competitor will win). Ex-post regulation by the NMa is still applicable and will always be to react to situations where market power is abused to create higher costs for the consumer. Examples of competing technologies in the telecommunications market are: copper wire (DSL), cable, fiber to the home (FttH) and wireless technologies like WIFI and WIMAX. In general for the provision of energy to households in the Netherlands, competing technologies exist and are: electricity, natural gas and heat networks. The major difference between the competitive technologies in the telecommunications and energy sector is that for telecom the technologies are fully competitive which basically means that if a household is connected to an FttH network it does not necessarily require a connection to either cable or DSL. For energy on the other hand, the competitive technologies are partially supplementary; heat can be produced by all three technologies but electricity can only be delivered by gas and of course the electricity intake. The statement about energy technologies being partially complementary is not completely true; a second product generated in CHP plants is electricity which is transported through the regular electricity network. Whether the technologies are fully competitive or not is actually not that important. For technologies to be competitive they have to be able to extend their service to the same range of customers like for DSL and cable that both have nation-wide expanded networks. This is not the case for heat networks in the Netherlands. Electricity and gas both have nation-wide networks but these networks are not fully competitive since there are hardly any customers that produce heat solely through the use of electricity. In short:

Competition between technologies for energy has a very limited scope in the Netherlands.

10.2.2 Competition within a technology

While competition between technologies does not require any ex-ante regulation, competition within a technology usually does but not for all competing technologies. If the technologies for telecommunications are narrowed to DSL and cable, it can be calculated that for the Netherlands, KPN has market power within the DSL technology which is therefore ex-ante regulated by the regulator (OPTA). For the cable technology, there is no stakeholder that has a market power large enough to require ex-ante regulation and therefore the technology is only subject to ex-post regulation by the NMa. So the scope has narrowed to DSL networks that are being regulated, but since regulation differs between the different services that the incumbent DSL operator provides (telephony, broadband internet, broadcasting services) the European Union has divided the market into relevant product groups. The relevant product groups are broadly defined in telephony, broadband internet and the broadcasting services (these product groups were defined in times when the services were not as integrated as is nowadays the case i.e. triple service providers offer telephony, television and internet in one package over one technology, the relevant product groups are therefore not as easily distinguishable like they used to be). In this research the broadband internet market will be used as an example to introduce the concepts used in telecommunication regulation since this market is most clearly defined.

It has been established that competition exists within the DSL technology and that several relevant product groups exist of which in this research only broadband internet will be analyzed. The competition within the DSL technology can be divided in three categories: 1) facilities based competition; 2) use of unbundled network elements and 3) resale (competition in services). These categories will be described by using the concept of the 'ladder of investment' that has been developed by Cave (2006) and which is further described in textbox 10.1. The following paragraphs will shortly describe all categories including their origin in the telecommunication sector and their transferability to the electricity sector.

Textbox 10.1: Ladder of investment

This concept by Cave (2006) is based on the different levels of networks being replicable or not. As the concept is based on the telecommunications sector the different levels are defined for the broadband sector. The ladder of replicability is given in figure 10.3:

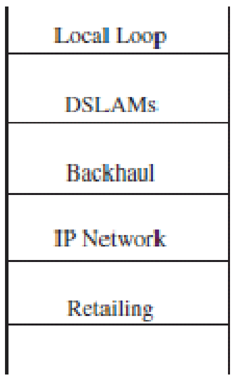

Figure 10.3: the ladder of investment concept

Replicability is highest on the bottom on the ladder where retailing takes place. The reselling of services i.e. TELE2 for telecommunications and NEM for electricity is also called wholesale and does not require any infrastructure to be owned by the reseller. The higher one climbs on the ladder, the lower ones connects to the incumbent's network and thus is assumed to own the higher levels in the network. The rationale behind climbing the ladder is that higher levels of the network are easier to replicate and therefore offer more options for competition. The top of the ladder consists of the local loop which is least replicable by an identical network. The local loop for telecommunications consists of the copper cable to the individual household and also for electricity it entails the last part of the distribution network, the actual connection of the households to the distribution network. Once a network has access on one of the lower steps of the ladder it can use its revenues to invest in lower networks up until a point where duplication of the network is no longer viable since the investments can't be remunerated anymore.

10.2.2.1 Facilities based competition

Facilities based competition is based on the replication of (parts of) the network to create competition between physical networks. This kind of competition is for telecommunications partly possible but to replicate a network completely, including the local loop is far too expensive and useless to society. The local loop, the last part of the network towards the individual household is the most extensive part and therefore also the most expensive part to replicate. Furthermore, the local loop is most often perfectly able to deal with the requested capacity so the need to replicate does not exist. This goes for both telecommunications and electricity networks. Full replication of a network would be a waste of money and would mean a lot of discomfort for consumers since the construction of a network involves opening up roads and sidewalks. Even for new network extensions like new housing areas, full duplication would not be economically viable. In short:

Facilities based competition for electricity is economically not viable in the Netherlands

10.2.2.2 Use of unbundled network elements

The use of unbundled network elements is introduced to succumb to the problem which occurs in facilities based competition; the costs of replicating the local loop are far too expensive. Using unbundled network elements ensures that the incumbent network operator of the local loop is required to allow third parties to gain physical access to their network. Characteristics of this kind of regulation for the local copper loop in the telecommunication sector are according to Sunderland (2000): 1) incumbent operators are required to provide competitors with unbundled access to their local copper loops (both exclusive and shared use) on fair, reasonable and non-discriminatory terms; 2) physical access must be granted at any technically feasible point on the copper loop; 3) the price for unbundled access to the local loop must be cost-oriented and 4) operators must publish a reference offer for unbundled access to the local loop including prices, terms and conditions.

In the regulatory framework of the European Union, unbundling of the local loop is provided for relevant product group market 4 which applies to DSL broadband access. Market 4 allows physical connection to the network infrastructure on a wholesale broadband level and in a fixed location (OPTA, 2010). Figure 10.4 shows market 4 regulation; the competition (green cloud) operates its own network until the connection point of the incumbents network (blue cloud) after which the competitor gains physical access to the incumbents network. That's the situation for the telecommunication sector, but what are the parallels and differences between telecommunications and electricity? Are there any parallels to be drawn since the differences are quite substantial? And if not, can the model still be of any use in electricity distribution network regulation?

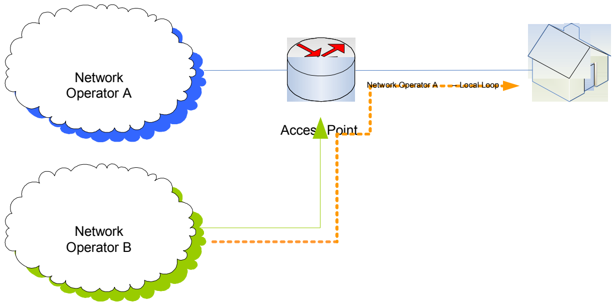

Figure 10.4: Use of unbundled network elements (Strijers, 2010)

The most important difference is that companies in the electricity network sector are not allowed to provide 'services' which will be defined as generating electricity (without distinction to the source or technology). Unbundling in the electricity sector ensured that all incumbents in the electricity network sector are solely transporters and not generators; therefore access to the incumbent's network can't be the question of since the incumbent does not generate himself. All electricity generators have guaranteed access to the transmission and distribution network on a non-discriminating basis. The result of unbundling is thus that differentiation in relevant market product groups is no longer possible as it is with telecommunications. Access to market 5 is granted as it is the basic task of the network companies to transport electricity generated by thirds but it still isn't the same since the 'green cloud' in the figure above is not a network operator.

Unbundling of the local loop for telecommunications is based on the 'ladder of investment' by Cave (2006) which is explained in greater detail in textbox 10.1. Trends and expected changes to the network in the future also need to be accounted for in this concept; do they fit within these concepts or is it necessary to alter the concept to fit the electricity sector better? The concept of climbing the ladder is a concept that could theoretically be applicable to the electricity sector if it would retain the current structure and design layout. The design of the grid will change from centrally generating large electricity plants to locally generated electricity by means of smaller generating units. This reduces the scope for the ladder of investment since it is based on climbing the ladder by constructing and owning higher hierarchical levels of the network and then use generated revenues to replicate the lower hierarchical network levels and eventually own a duplicate grid with unbundled access to the local loop. In a perfect case scenario, distributed generation is able to fully balance local demand and supply and thereby decreasing the role that the transmission network plays (the higher hierarchical network level). Furthermore, an increase of distributed generation will increase the supply load on the network while a demand load increase is also to be expected (as a result of the electric car and heat pumps); these load increases threaten the capacity and reliability of the distribution grid. If all, network investments should be aimed at the distribution network level instead of replication of the transmission grid.

From a legal point of view, the replication of higher hierarchical levels is prohibited by the Electricity Act (1998) which states in Articles 10.2 and 10a.1 that there is only one network operator of the transmission grid and this operator does not own the network itself; the transmission network is state owned.

Is it safe to state that unbundling of the local loop is not a viable idea for the electricity sector? If the regulation would be based on the telecommunications sector this is quite safe to state. But what if the concept is adapted and applied to the electricity sector in a different way? In the telecommunications sector there are centrally produced services that are cascaded down through a top-down structure from higher hierarchical levels to the local loop. As mentioned before in this section, the current trends and scenario's for the electricity sector describe a different future compared to telecommunications. What would be the implications of this different future for the model?

If the electricity sector would no longer be structured around centrally generated electricity that is cascaded down to the consumer but would be build up of distributed generation that is transported to consumers in the same region, the transmission network would provide a bigger role as a back-up connection to households. In reality, the transmission network will never loose its function as electricity provider to the industry and as back-up provider for distribution grids since perfect balanced supply and demand is not realistic. The 'ladder of investment' concept would no longer be applicable to the electricity sector, but the problems with the local loop to create facilities based competition would remain, resulting in a lack of competition. In the next paragraphs two situations will be sketched with differing requirements for unbundling of the local loop. These situations are:

1) A situation in which distributed generators of electricity in a certain (new or already existing) region would group together to form a network of generators who are able to balance local supply and demand loads while the initial investment would still be made by the DNO. How could the unbundling of the local loop be of assistance to these generators?
2) A situation in which the distribution network in a local region like a newly developed housing area would be financed by private investors. Either solely an investor could construct the network or the people actually generating electricity to feed in this network could construct it. How could the unbundling of the local loop be of assistance to these investors?

Situation one

In the first sketched situation, the DNO would still be responsible for the initial investment to construct the local loop network. Local loop unbundling would ensure that every third party is able to lease (thus temporarily own) and operate a part of the network originally build and operated by the DNO's. A group of distributed generators that is geographically located close to each other would be allowed to lease the local network they require to fulfill the local demand load for electricity. In the current situation the DNO's are obligated to connect all distributed generation to their network and facilitate the feed-in of electricity that is locally generated but for large demand and supply load changes this would require alterations to the network. Costly alterations which are not reimbursable by the DNO's, but this sketch propose to 'outsource' the network alterations to third parties.

The big difference between the proposed local loop unbundling for the electricity sector and the implemented unbundling in the telecommunications sector is that the third parties that lease and operate small pieces of the local loop do not own higher hierarchical network levels as the 'ladder of investment' dictates because this is not allowed by the E-Act and would be too expensive for the private network owners.

There are several rationales that explain the results of this sketched situation. The first rationale would be that the creation of these 'private networks' would transfer the costs of altering the network as a result of distributed generation back to the consumers that actually require and use the alterations. Simply stated this would mean that cost allocation would be improved and that the 'user pays'. But would this not create a strong disincentive for third parties to engage in the creation of a 'private network'? This depends on the regulation applied to these networks; what their legal status would be; how they would be able to divide costs and benefits etc. The European and Dutch regulation towards private networks is elaborately outlined in Appendix A. Based on European regulation (excluding the Citiworks arrest) the creation of private networks is allowed for networks serving fewer than 100.000 connections. Furthermore, the Third Directive defines direct lines and closed distribution networks of which the last could be considered a 'private network', again excluding the Citiworks arrest which is further explained in textbox 10.2. However, regulation in the Netherlands in the E-Act (1998) does not define any possibilities for direct lines or closed distribution networks, but it does define in Article 15.1 and 15.5 the option for small networks to be exempted from the requirement to appoint a network operator for their network and consequently exempt these networks from the tasks and obligations associated with a network operator. The exemption rule has been granted by the Ministry of Economic Affairs several times (around 100), all of them to areas like Schiphol, hospitals, large industrial complexes and business areas that are private property. Exemptions have been granted because these areas require a standalone grid in case of grid failure and the private networks do not involve any crossing of public property. All exemptions currently granted are listed in appendix B (NMa, 2009).

The allocation of costs and benefits would be placed at the stakeholders that actually making the costs and earning the benefits which could potentially benefit all involved stakeholders, these costs and benefits are explained more thoroughly in chapter 4 that deals with the characteristics of distributed generation, but summarized they result in; 1) the DNO's have to make fewer investments to redesign the network which results in lower tariffs for the consumer; 2) the benefits for society can be equal since the integration of renewable distributed generation on the network increases in a similar trend as would otherwise occur, but the costs are partially diverted to third parties; 3a) third parties engaging in a 'private network' are responsible for the alterations to and quality of the network. These parties pro-actively choose to do so and are involved with their own money is at stake. Therefore it is reasonable to think that 'they know what is best for them'; 3b) since third parties are actively engaged in the network and its balancing management they are much better able to implement certain rules to create a balance between demand and supply in which the role of the DNO is reduced to providing necessary back-up. Point 3a and 3b lead to the second and third rationale to explain the positive results of this sketched situation. ‘Private networks’ are not bound by the tasks and obligations of DNO’s and the small scale of the ‘private networks’ is preferable to large scale distribution grids. The summary of the first rationale is:

Better allocation of costs and benefits can be beneficial to all involved stakeholders.

The second rationale for unbundling of the local loop is that the ‘private networks’ that are created do not have to comply with the set of tasks and obligations defined by the E-Act (1998) for DNO’s. As far as the E-Act is concerned, the private networks can do whatever they like as long as they do not interfere with the DNO’s performance (Article 15.3 of the E-Act). This carte blanche could be limited by making certain DNO requirements also mandatory for ‘private networks’. By giving these networks carte blanche they are for instance able to implement demand side management measures like for instance the ability to control the timing of demand and supply loads. For DNO’s this could be a large source of information about how the effects of demand and supply load changes can be mitigated. Carte blanche regulation is in fact the provision of a regulatory holiday for these small networks. Chapter 9 deals with incentives aimed at the creation of innovative network solutions, and the creation of ‘private networks’ by unbundling of the local loop can be considered “small-scale field testing”. A summary of the second rationale is:

By carte blanche regulation the private networks and DNO’s could learn a great deal about balancing demand and supply load changes.

The third rationale for unbundling of the local loop is based on the small-scale nature of ‘private networks’. Balancing and managing an entire distribution network that has to deal with changing demand and supply load demands is a massive undertaking. The flows of information would be very large and many stakeholders are involved. A small ‘private network’ would be able to balance a lot of these flows and loads because it is easier on a small scale then a large scale. Although the differences between supply and demand in time could be greater due to smaller group of stakeholders to level the differences, the carte blanche regulation of ‘private networks’ could ensure that there many more options exist to deal with these differences. This rationale could be summarized as:

The DNO would be responsible to balance a group of balanced small private networks.

Textbox 10.2: Citiworks arrest 2008

A recent decision (May 22, 2008) by the European court of Justice regarding the case of Citiworks AG against the Airport Leipzig/Halle could have substantial impact on regulation regarding private electricity networks. The operator of the Airports network applied for the status of private network based on German energy regulation but electricity supplier Citiworks AG asked whether they were allowed to supply electricity to consumers connected to the Airports network. The Airport reasoned that the status of private network exempted them from the obligation to provide third parties undiscriminating access to the network. Citiworks AG did not agree and reasoned that undiscriminating access to all networks (including private) is guaranteed based on Article 20 of the Second Energy Directive. The court ruled that private networks are to be considered as distribution networks as defined in the Directives and thus all obligations also apply to private networks (access to third parties). According to the court, there is only one precisely defined reason why third parties could be denied access to the network and that is in case of a lack of capacity (Pigmans, 2008) (de Vlam, 2010).

Situation two

The second sketch is quite similar to the first one, except that it involves private investment for the construction of the network instead of investment by the incumbent DNO. Investments by the DNO to construct the network would be mandatory by the E-Act but the Articles are only concerned with the mandatory connection of a consumer with a voltage level as requested. The E-Act does not provide for Articles to state that a DNO should be prepared for future demand and supply load changes and should therefore construct a network which is pre-designed to cope with these changes. Even if the E-Act would provide for such an Article, there would be no way to know for sure what the future will bring; the uncertainty and consequently risk (risks associated with the long lifespan of networks and short lifespan of distributed generation)for DNO's would be very high. If a DNO would construct the new network extensions, the same problem are faced afterwards while preventive actions were possible. Private investors on the other face similar problems of uncertainty which do not have to be a problem if the expected revenues are high enough to compensate for the risk. The E-Act states that networks build by private investors are also subject to the mandatory appointment of a DNO and therefore have regulated tariffs. Articles 15.2 and 15.3 describe the exemptions to this rule.

The private investment of the construction of a network including this third party gaining the status of DNO creates competition between network operators. Ofgem has already got some experience in this field with the possibility for Independent Distribution Network Operators (IDNO) to compete with the incumbent owner of the distribution grid. Ofgem describes this competition as:

"Independent network operators (IDNOs) compete with the incumbent monopoly owners of electricity distribution assets (DNOs) to build and adopt network extensions. Through competition, IDNOs are potentially able to provide faster connection to the network for customers and generators and offer innovative services." (Ofgem, 2010)

Competition for new network extensions like new housing areas would in theory be viable since it would entail a larger number of consumers and there is not yet an established grid by the incumbent. Furthermore, a network operator has to comply with a set of demand in order to get the distribution license, a certain economies of scale are necessary to comply. So far there are only 3 IDNO's in the United Kingdom that are really independent. They state that they are only able to compete through their experience in the construction of networks and that they do not seek to make a profit out of the construction but out the long-term ownership of these networks.

In the Netherlands communalities that make the decision to develop i.e. new housing areas can decide to tender the electricity infrastructure to the market. The decision is allowed by the

'Algemene Maatregel van Bestuur – Besluit Aanbesteding Energie-Infrastructuur' which is a general Governmental rule for the tendering of energy infrastructures. There is no mandatory article stating that communalities have to tender the projects or give them to the incumbent network operator. There are however several factors that slow down the tendering in the competition for new infrastructure: the fear at the tendering party for difficult procedures; the problem of a lack of competitors able to comply with the requirements set by the communalities and lack of competitors willing to get involved in the tendering process. This lack of willingness is based on the difficulties to earn back the initial investments because the network companies have to comply with the regulation by the Energiekamer. There are no high revenues possible with operating the networks, but there is good money to be earned constructing the networks and then giving over the operating to the incumbent operator. There is too much risk of investing capital in fixed assets that will not be remunerated for.

IDNO's do not have large future prospects in the Netherlands

So far, private investors have been considered to be unbundled from the generation of electricity but when these private investors are vertically integrated with distributed generators it would become a 'private network'. Of course they would have to comply with the exemption rules of Articles 15.2 and 15.3 of the E-Act. Unbundling of the local loop would make no difference in this example since the local loop is already owned and operated by private investors.

10.2.2.3 Resale (competition on services)

Competition on services in the telecommunications sector is provided for by the European Union through the defined relevant product group market 5 which is the market for wholesale broadband access which only encompasses virtual access to the network instead of actual physical access. Figure 10.5 below shows access in market 5. This market entails access of the competitor (green cloud) over the network of the incumbent (blue cloud) without actually owning a part of the network itself.

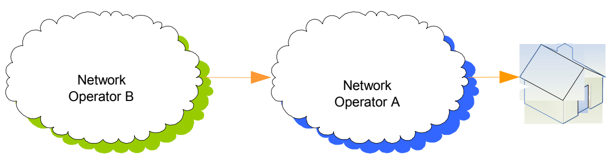

Figure 10.5: Resale (competition on services) (Strijers, 2010)

The electricity sector is characterized like this since the unbundling of vertically integrated companies was finished. The only difference is that the operator in the 'blue cloud' above is not able to provide services himself (the main service is the provision of electricity). All electricity generators are present in the 'green cloud' and use the incumbent's network although they aren't network operator themselves. The incumbent is not considered a competitor in the market since they are not allowed to generate electricity themselves; both clouds serve different parts of the electricity value chain (as explained in chapter 5).

Is competition on services entirely impossible in the electricity sector? This depends on the definition of services: or more specifically who provides the services. For telecommunications, the network is only used as a means of transporting the services (broadband internet) to and from the consumer. The number of services is of no influence to the network which can transport any kind of data until the capacity limit is reached. Electricity networks transport one main commodity; electricity. The number of services provided for by an energy generator is limited to electricity, gas and heat but since each requires its own network they are therefore not considered competition on services but competition in technology. The question is whether competition in services between DNO's could exist?

A DNO is theoretically able to provide differentiated service packages. In the past this kind of packages were provided in the form on a differentiated high and low tariff. At the moment, DNO's only provide transport of electricity on one regulated tariff based on the connected capacity. However, this would not create competition in services since the creation of a relevant product market like Market 5 for telecommunications requires a service being provided over the incumbents' network which is resold to a competitor. The service provided by the DNO can't be resold since there would be nothing left except a physical network without any tasks or revenues.

Differentiation of the services provided by the incumbent DNO is possible though; either by differentiating electricity transport packages or by the creating service packages that include competing technologies like gas and heat. These ideas will be described in the following sections. To conclude this section shortly:

Competition in services is not possible in the Netherlands but differentiation of DNO services creates possibilities.

10.3 Ideas derived from the telecommunications sector

The telecommunications and the concepts used with its regulation provide several leads for translation into the electricity sector. Terms like the 'ladder of investment' and the 'relevant product group markets' have been explained in section 10.2.1 and 10.2.2 but these concepts are also useful to derive more general ideas from. Moreover, in addition to the explanations in the previous sections, the importance of other innovations becomes apparent. Further paragraphs will elaborate on these views. The ideas are tested against the regulatory framework; therefore some of them could be contradictory with current legislation.

10.3.1 Business ideas based on the 'ladder of investment'

The core idea behind the 'ladder of investment' concept is that higher hierarchical levels are easier to replicate than the lower levels with the local loop being least easy to replicate. A large increase in distributed generation and changing supply and demand loads put a great strain on electricity distribution networks. According to representatives of TenneT and KEMA the bottleneck in distribution networks are the transformers that transform high voltage electricity to low voltage that is ready to be used in households. The rationales according to these representatives is that "with a standard battery capacity of 20 kWh, a charging time of eight hours and a million electric vehicles this would require 'only' 2,5 GW while 25 GW is the total Dutch generating capacity", thus the total required amount of extra electricity would not be that large. Moreover, "most households have a maximum capacity of 16 Amp and with a 220V connection this translated to a maximum capacity of 3.52 kW where a charging electric vehicle would require 2.5 kW (=20 kWh/8 hours)”. This would be the capacity within a house, but for the network a similar reasoning goes; “the average capacity for households in the Netherlands is 10 kW but most transformers are not designed for situations in which all households demand maximum capacity, they are based on historical load profiles. Transformers are designed for an average capacity of 1.2 kW per household”, according to KEMA this is the bottleneck in the distribution network. Replacing the cables or the transformers would be very costly and balancing a distribution network is difficult, it would be better if the bottleneck could be (partially) avoided.

To avoid the bottleneck in the distribution grid the previous suggested idea of ‘private networks’ could be helpful. Balancing these networks creates less strain on the transformers. This would be avoiding the bottleneck from the downside, but are other business cases possible that (partially) avoid this problem by providing solutions that avoid the bottleneck?

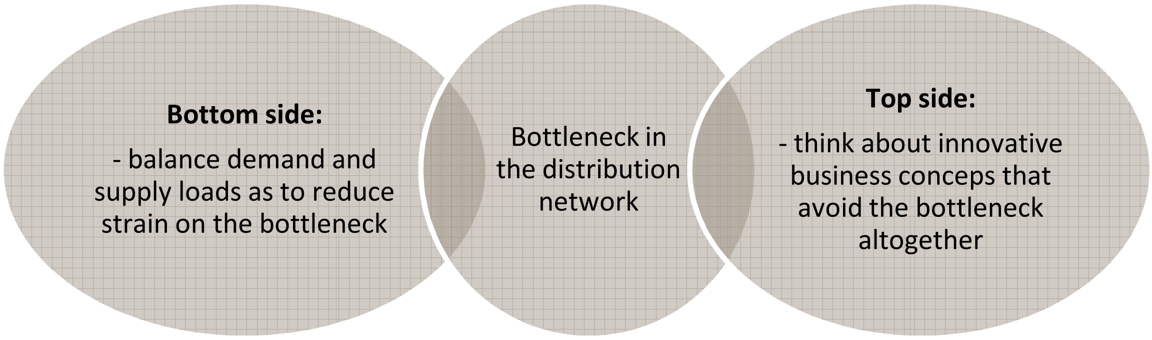

Figure 10.6: Top and bottom side bottleneck in the distribution grid

Again, the electric vehicle will be used as an example. At the moment there is no large electric fleet on the road yet, which leaves the DNO’s in a position of luxury; pro-active involvement could steer the development and implementation of this new technology in society. There is no single charging method yet, technologies differ from charging them in a plug at home to actually changing an entire battery pack. On strategic locations in cities and near highways it could be possible to install stations where empty battery packs could be switched for full ones. This is of course a very large assumption, but in case such an infrastructure could be established this would have several positive results: 1) the electricity demand load as a result of electric vehicles at the households level would be reduced; 2) these service stations need to recharge the batteries too, but these companies can be connected to higher hierarchical levels of the network as to avoid the local loop completely; 3) in case these stations are operated by all DNO’s together, this would avoid the remuneration problem because the costs could be remunerated through the benchmark. Many business models can be designed around such a service station idea.

In the previous described ideas, one should always keep the ‘ladder of investment’ in mind; higher hierarchical levels are cheaper and easier to reinforce and/or construct than lower hierarchical levels.

10.3.2 Business ideas based on 'relevant product group markets'

The DNO's provide at the moment only one service; the transportation of electricity from the generator to the consumer. In the telecommunications sector the regulation is based on the creation of relevant product groups in the market, the DSL network for instance is used to transmit telephony, broadband internet (domestic and business are separated) and broadcasting services. Each service is considered a separate product group and per group the regulator (OPTA for the Netherlands) checks whether the incumbent operator possesses market power or not. In previous section 10.2.2.3 the conclusion was that competition in services is not possible for electricity networks but the differentiation of the transportation service could be a viable idea. Already mentioned is the former differentiation in a high and low tariff for electricity where a part of the day that has a high demand load had a higher electricity price and vice versa. The translation of such an idea to the transportation service would create price differentiation based on the capacity of the network. During night times when electricity demand is low the price for transportation could be lower to peak-shave demand and supply loads.

The previous example is quite straightforward but the differentiation could be extended to provide service packages based on innovative business ideas. One could develop service packages that better suit the individual consumer, not only using the transportation of electricity as a service but include gas and if present heat transport too. One example would be: a consumer that uses a micro CHP installation could be provided with a package in which he pays less for the transport of gas but more for electricity since he dominantly uses gas. By doing so, the DNO can stimulate or to discourage the use of certain problematic areas in its network.

The concept above is just one example of an alternative strategy that could be pursued by the DNO. Value added services could be very valuable to extend the lines of services, benefitting both the DNO and consumer. These value added services will be discussed in the next section.

10.3.2.1 Value added services

DNO's provide one main service to their customer; transportation of commodities like electricity and gas from a generation unit to a customer. Although this service is and will remain the main task of a DNO it does not imply that there is no room for extending the services provided. It is a process that is evolving quite fast within the energy generator like Essent, Eneco and Stedin; they have extended their initial service of electricity generation/delivery to include i.e. the provision of consultancy services to save energy, the provision of consultancy regarding renewable energy technologies, the provision of a leasing service for micro CHP units and normal boilers. They have extended these consultancy and leasing services with quality improvement services like a full installation service and the provision of feedback regarding achieved savings. This is an extension of services which can be envisaged for DNO as well. There is however one major difference: the companies generating electricity are commercial and unregulated while the DNO's are regulated by the Energiekamer and this has its consequences as will be explained. This section will be ended with a textbox describing the current discussion about whether unbundling was justified or not, which could obviously change a lot of things in the future if it appears that it can't be justified.

DNO's are not completely free in the commercialization of new business cases and services. There are certain activities that a DNO can deploy within the holding it is a member of and there are certain activities it is not allowed to deploy. The listed activities do not have fixed boundaries but are somewhat flexible to what is allowed and what isn't. The Minister of Economic affairs has developed a framework by which activities are assessed on whether they are allowed by a DNO (or the holding the DNO belongs to) or not. The concept of this assessment framework is written in the 'Notitie Visie Netwerkbedrijven Elektriciteit en Gas' which has been send to the organization of DNO's 'Netbeheer Nederland'. This 'notitie' sketches a list of activities mandatory for a DNO (so-called white activities) and a list of activities that are forbidden for a DNO (so-called black activities). In between are the gray activities that have to be assessed by the framework mentioned above.

The white activities consist basically of the operation and maintenance of the possessed network assets. Tasks like construction, maintenance, connections and interconnections, quality assuring, transport and all tasks related to them. The black activities consist of tasks that are forbidden for the DNO and its holding to deploy. Examples are: 1) strategic tasks that a DNO has to perform by itself (Article 16Aa of the E-Act); 2) trade and production of electricity and gas (Article 10b.1 of the E-Act) and 3) tasks or activities that constrain the DNO from performing its tasks and obligations (Article 17 of the E-Act). The gray activities are those that do not belong to the tasks of the DNO but are still allowed to be deployed by the umbrella holding. These activities are assessed with the help of a framework containing rules.

The Energiekamer is currently designing the above mentioned lists of activities and it uses the 'kruisjeslijst' as a guide to their design. The 'kruisjeslijst' was used by the former DTe to list all allowed activities. The 'kruisjeslijst' is attached to this thesis as Appendix D. (Janssen & Pigmans, 2008), (DTe, 2004)

Now that is established (from a legal point a view) what the possibilities are for a DNO or its holding to expand their services, we can have a deeper look into these services; what would be possible?

In line with the value added services by the energy generators, a DNO is able to provide consultancy services to their household or industrial connections. The DNO has most information and knowledge available about how to build, operate and maintain an infrastructure network. They are able to provide consultancy services to third parties requesting access to the local loop of the network as suggested in this chapter. The third party would be responsible for investments and eventual decisions but the DNO can provide valuable know-how.

One step further would be the provision of operating services to the third parties owning the private network. Private investors build/alter the existing network but since they are characterized by their small size, it may not be realistic to manage the demand and supply themselves; this is a service that could be purchased from the DNO that once again already possesses management knowledge. Cost and benefit allocation would remain with the private investor. The roles would be reversed; the DNO would become the third party active in the private network.

A further service provided by the DNO to private networks is reliability and security of supply. Demand and supply load differences exist, as explained before in chapter X. These differences reduce reliability and increase the need for a reliable back-up connection to the distribution network. The DNO provides reliability in case supply and demand can't be balanced.

In the examples above the DNO is still only envisaged in the gas and electricity infrastructure sector. The know-how incorporated in the DNO's allows them to expand their competences and expertise to other sectors like the transportation of heat, cold, water, CO2, steam and hydrogen. According to Stedin this is a prerequisite in their future plans; the transition towards renewable energy. As long as an infrastructure is concerned, the DNO's are able to do it! A bold statement but it points out that DNO's are able to look beyond the traditional sectors in which they operate at the moment. The 'kruisjeslijst' already mentions three additional infrastructures in which a DNO is allowed to expand (heat, cold and water).

1.5.1	Aanleg, beheer of onderhoud van warmtenetten	Uitbesteed	Geen taak, wel toegestaan
1.5.2	Aanleg, beheer of onderhoud van koudenetten	Uitbesteed	Geen taak, wel toegestaan
1.5.3	Aanleg, beheer of onderhoud van waternetten	Uitbesteed	Geen taak, wel toegestaan

Figure 10.7: Part of the 'kruisjeslijst' regarding additional infrastructures

There is a layered structure (figure 10.8) in the sectors that can be served by the holding of which the DNO is a member. The inner layer would be the DNO itself that is only allowed to serve the regulated electricity and gas markets with set tasks and obligations. The layer above is the holding to which the DNO belongs. The holding is allowed to diverge into commercial markets related to the tasks of the DNO like heat, cold and water. This list could be extended by i.e. CO2, steam and hydrogen. The outer layer is diverging completely, it is no longer related to energy but it could contain all kinds of infrastructures like roads, railway etc. This idea converges completely from the previous ones but in a basic shape all networks are similar. They transport a service from A to B against a set tariff, either regulated or commercial. Although this idea might not be very realistic is does show the possibilities to extend the lines of services.

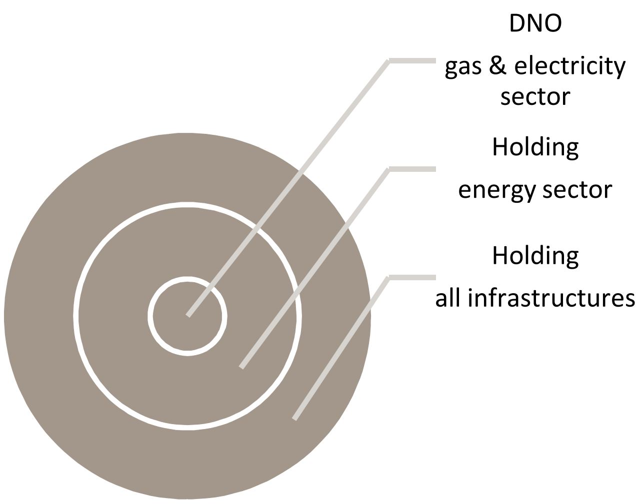

Figure 10.8: layered structure of infrastructure involvement

A further consideration is the traditional relationship between a DNO and the consumer which is a passive one. The consumer requests a connection and the DNO complies with this request. The roles could be reversed to allow a DNO to take initiative. For instance, PricewaterhouseCoopers has performed a research for Stedin related to their intended construction of a steam-pipe between a company where steam is a secondary product and a company that could use this steam as to reduce their costs. Stedin is able to fill the infrastructural gap between these companies and provide transport and the necessary operational services. This is not a traditional supplier-customer relationship but one that is created by Stedin.

There are several tasks that are explicitly forbidden for DNO's to engage in; generation and storage of electricity. It has been the main result of unbundling that generation units are separated from the transportation companies. This resulted in two problems:

- DNO's are subject to network losses on their distribution network. These losses have to be compensated for by an enlarged supply. A DNO has to buy the electricity required to compensate for these net losses from TenneT who in its turn buys the electricity on the spot market. The prices for electricity on the spot market are very volatile and cause different costs levels for the DNO during the day. The problem has been addressed by allowing DNO's to generate the required electricity to compensate for net losses.

- The storage of electricity is forbidden for DNO's because they would have to buy electricity from the generators, store it, and sell it to the customer at a later stage. This task does not belong to the DNO but there is scientific discussion about what to do if and when storage technologies become more sophisticated, mature and economically viable. Electricity storage would provide DNO's with a solution to their supply and demand load differences. It would help to balance distribution networks more easily.

Note: According to a very recent arrest by a court in the Netherlands, the required unbundling is not valid on legal grounds; this would indicate that DNO's and generators are once again allowed to reintegrate into one company. However, the Dutch government has appealed to this decision and the court date for this trial has yet to happen.

10.3.3 Energy storage technologies

In the discussion about the possibilities for local loop unbundling in the electricity sector two situations were sketched that both involved 'private networks'. Besides regulatory advantages, these networks offer the possibility of small-scale field testing of new innovations. 'Private networks' have to be balanced and managed locally to become viable alternatives to the distribution networks of the DNO's. The field testing and balancing characteristic combined result in options for energy storage technologies (figure 10.9).

Figure 10.9: the need for energy storage

The importance of energy storage technologies is very high. Perfectly balancing supply and demand loads within a small ‘private network’ is very difficult since the temporal and locational load profiles are in many cases not easy to balance. Locational load correlations means that demand and supply occur in close proximity to each other, temporal load correlation means that demand and supply occur at the same time. Locational load differences can be solved when third parties in the ‘private network’ are prepared to cooperate (which they are since they will invest in the network together). Problems like “not in my back yard” can be avoided when stakeholders will cooperate to choose a proper package of technologies (both supply and demand) to ensure that locational load differences are mitigated. Temporal load differences are a somewhat other story; cooperation and good balancing technologies are not able to fully mitigated temporal load differences since they are not in their control, they depend on sun or wind for instance. The storage of electricity would theoretically be able to mitigate temporal load differences. In scientific research, electric vehicles are seen as potential energy storage devices.

10.4 Conclusions

This chapter is based on the premises that competition is the best incentive to stimulate innovative investments. As frames of reference the UK ‘connection competition incentive’ and the telecommunications sector in both the Netherlands and the United Kingdom are chosen for its successful implementation of competition in a regulated market.

In section 10.1 the UK connection competition incentive is discussed. This incentive provides for competition in contestable areas with unregulated margins, as defined by Ofgem. In its current design there is only partial competition and only for the connection of larger projects. Although it is intended as a trial there are benefits to gain, but whether these are in comparison to the costs is unclear. A specialized company will be able to provide the connection at smaller costs which would benefit the consumer. In case the ICP is only able to reduce costs by 10% this would mean a reduction of 48 euro (10%* €479.57), and considering the total costs per year for the transport of electricity this would be around one third (for a basic 3*25A connection). The incentive would only be active for areas with more than four premises, mostly new construction projects that often require higher connection capacities to begin with. With higher connection capacities, the tariffs increase rapidly and thus possible savings increase too (cost remain mainly similar since labour is the biggest cost driver).

The regulator should consider two negative aspects; 1) the incentive increases administration costs and 2) the consumer (or project developer) should put out a tender to be able to choose the lowest bid but there is a big chance that consumer won’t put in this effort to save a fairly low amount of money. The opening of the electricity delivery market gave consumers the possibility to switch from energy but this actually did not occur as often as was expected .There is no reason to think that this switch would be more effective, on the contrary. Households can often tell you the name of their electricity provider but fail to provide the name of their DNO. Based on the point above I conclude that such an incentive does not have a large chance of success in the Netherlands.

Recommendation 1: a connection competition incentive would have a little chance of success in the Netherlands

The UK incentive is also used as a trial for the creation of competition. The incentive should therefore be seen in the broader context of identifying existing barriers and possibilities for competition. Section 10.2 discussed the broader context of competition with telecommunications as a sector where competition is introduced successfully.

A first division is made between competition between technologies and competition with a technology. Gas, electricity and heat networks could be considered competitive technologies but are in fact more supplementary. This supplementary position could change in the future as a result of technology conversion, for instance: a micro CHP plant is able to use gas to produce the electricity for a household or a solar array on the roof is able to provide part of the hot water demand. Full conversion of technologies is not likely to happen since the technologies are subject to load differences. Demand of electricity, gas and heat is not the same as supply of these commodities. Energy storage would increase conversion by providing a buffer between demand and supply.

Recommendation 2: competition between technologies has little scope in the Netherlands

Recommendation 2a: the scope for competition between technologies could change as a result of progress in energy storage technologies that reduce demand and supply load differences

Competition within a technology can be based around three concepts that are often used in scientific literature to describe competition in natural monopolies: 1) facilities based competition; 2) use of unbundled network elements and 3) resale. The concept of facilities based competition is quite pointless since it would entail full replication of a network which is useless and is very costly. Resale as a concept has been very useful as a ‘first step’ in the telecommunications sector to divide the service provided from the network used to deliver this service. Unbundling in the electricity sector already provided this division. A resale of services is therefore not an option in the Netherlands. However, as we will see a little bit further, the services provided by the DNO are very important as a differentiation or an expansion of them creates new possibilities for a DNO.

Recommendation 3: competition within a technology is partially possible and is based around a win-win situation between the DNO and a private network (result is that competition would no longer be the correct term)

Recommendation 3a: facilities based competition for electricity is economically not viable in the Netherlands

Recommendation 3c: competition in services in not possible in the Netherlands but an increase of DNO services provides opportunities

The third concept is the use of unbundled network elements. It is this concept that provides most strongholds for the electricity sector. Unbundling like has taken place in the telecommunications sector is not possible for electricity since the underlying idea from Cave is not valid. The ladder of concept is based around replicability of network assets and assumes that higher network levels are cheaper/easier to replicate. The local loop is least replicable and therefore needs to be unbundled. Higher electricity network levels can't be replicated because the E-Act prohibits it. Although the entire concept is not applicable, there are still elements that can be useful like the conditions of local loop unbundling. In this thesis there are three rationales explained why local loop unbundling should be pursued by the Energiekamer.

Firstly, the allocation of costs and benefits would shift from the DNO to the consumer or its representative. This would reduce the required investments by the DNO; it would therefore be beneficial to society that gains from reduced costs and still profits from less CO2 emissions; it would allow third parties access to the network and treat it like they see fit. Secondly, a private network operator does not have to comply with the tasks and obligation of a DNO since it is not. This would provide the private network with carte blanche regulation (of course with quality and price conditions regarding the back-up connection to the main network). Thirdly, there is an advantage for DNO's that reduce the number of connections that require managing, an advantage that follows from the small-scale nature of private networks. The explanation of the second concept of unbundling of the local loop results in the following recommendations:

Recommendation 3b: use of unbundled network elements creates possibilities to

- **better allocation of costs and benefits which can be beneficial to all involved stakeholders**
- **by carte blanche regulation the private networks and DNO's could learn a great deal about balancing demand and supply load changes**
- **the DNO would be responsible to balance a group of balanced small private networks making balancing easier**

The recommendations above are applicable to a private network where the investors are also the operators of the private network. Another option would be to have private investors build a network and afterwards operate it, therefore requiring a DNO since it is no longer a private network (the investors do not own the generation units). In this case the operator would be an independent DNO, an IDNO. The rationale would be that an IDNO would be more willing to take a risk and face the uncertainty of demand and supply faced in new network extensions. Although in theory private investors would be more willing to do so, in practice they would face the same problems as incumbent DNO's; regulated tariffs, low margins and uncertainty about what to build. Therefore, the willingness of private investors to step into the electricity network sector would be marginal at best. Most willing would be the incumbent DNO's that want to expand their operations to a different geographical area. In general the following recommendation is stated:

Recommendation 4: IDNO's do not have (large) future prospects in the Netherlands

The comparison between the telecommunications and electricity sector led to the following concepts being explored: 1) the ladder of investment by Cave (2006) and 2) the relevant product group markets. Section X.3 used these concepts to derive further options that DNO's could explore.

The first concept resulted in several derived ideas that are based around the idea that the bottleneck in the network as a result of distributed generation could be avoided all together or at least be mitigated. Several business cases are intended to show the importance of a joined effort to provide a pro-active solution. The transition to a renewable energy supply and demand involves new technologies that can be steered in a preferable direction by the DNO's. Basic ideas regarding this concept are demand-side management and the design of new business cases. The following recommendation is the result:

Recommendation 5: increased stakeholder collaboration could pro-actively provide solutions by introducing demand-side management and innovative business cases

The second concept is based around the creation of new services, new relevant product groups. There are substantial results to be gained by DNO's if they could increase their lines of services beyond transport of electricity and gas. DNO's are able to exploit their know-how in several levels; from offering consultancy services to private networks, to actually take part in them as a third party to provide consultancy services in other sectors characterized by an infrastructure. Furthermore, changing the passive role in supply-demand relationship to an active one where the initiative for economically viable business cases lies with the DNO could all result in benefits. The above ideas are summarized in the following recommendation:

Recommendation 6: DNO's could extend their lines of services within the possibilities of the E-Act to include services with added value to both the DNO and consumer

11 Conclusions and recommendations

The research question in this twofold is twofold; the main research question is "**what are the current options to incentivize innovative network investments and how can these incentives be improved within the regulatory framework?**" and the sub question is "h**ow can cost/benefit allocation be improved within the regulatory framework?"** The sub question is embedded in the first one.

The analysis, discussions and recommendations made in this thesis show that there is potential to improve reimbursement for innovative network investments and to improve cost/benefit allocation in several ways. Although the current regulatory framework knows little options, this could be improved with relative minor interventions. Every incentive and improvement would be welcome to the DNO's since there are none at the moment.

Both questions are analyzed using the five issues for DNO's raised by Pollitt (2010) and Grubb, Jamasb and Pollitt (2008) as guidance: 1) the current approach to RPI-X regulation needs to be updated; 2) the regulation of new investment needs to draw on emerging ideas for 'constructive' user engagement from other regulated sectors and other countries, incorporating more use of competitive tendering of network investments; 3) the issue of locational pricing signals should be examined; 4) ownership unbundling of networks from retailing could be extended and 5) innovation in networks needs to be encouraged. Drawing on the second idea proposed by Grubb, Jamasb and Pollitt (2008) two comparisons are made; the first being between the regulatory framework of the United Kingdom and the Netherlands, and a second comparison between the telecommunications and electricity sector.

The first step in the analysis is the broad comparison of the Dutch regulatory framework with the UK one. Albeit they are both based on a revenue cap, they are quite different in detail. The Dutch tendency to lock all regulation in the E-Act results in a framework that lacks the ability for swift adjustments. The UK framework is based on filling-in the details with policies written by the regulator, a system that can be beneficial to the Dutch framework too. Furthermore, remuneration of innovative network investments differs massively as to their efficiency assessment. The UK is based on ex-ante assessment which provides security to DNO's as to whether their investments are reimbursed. Although ex-ante assessment in the Netherlands is not possible, because investments are ex-post assessed on efficiency through the benchmark (yardstick competition), there are several options to reduce the time between allocation of costs and benefits. Reducing the time-lag to add investments to the RAB and adjusting the allowed revenue during the regulatory period (by a set proxy) being the two most important and realistic options on a shorter term. They can be implemented by altering the 'Method decree'. On a longer term it would be beneficial to both the DNO and regulator to start using cost projections for either all investments or just certain kinds like CAPEX or specific investments i.e. for DG.

Conclusion: **the lock-in of regulation in the E-Act disables swift adaptation to the changing environment**

Conclusion: **the ex-post efficiency analysis of investments and their subsequent late inclusion in the RAB reduces remuneration**

Recommendation: **implement more/new regulation in Codes and Decrees, not the E-Act**

Recommendation: **reduce the time lag to include investments in the RAB**

Recommendation: **adjust allowed revenues during the regulatory period**

Recommendation: **increase the use of cost projections to estimate investment levels (long term)**

The second step is the identification of Dutch incentive instruments; being currently or previously embedded in the regulatory framework or considered/adjusted for the upcoming fifth regulatory period. The ORD and 'substantial investment' instruments are the only two currently active in Dutch regulation. Prospects of including additional ORD's regarding DG are very limited because finding an objective proxy proves to be very difficult. However, insights might be derived from the UK and German additional revenue mechanism. There are prospects for increased allowances of 'substantial investments' with an adjustment of the tariff code. There are several instruments that were active in the previous regulatory period and could be reinstated (albeit in a new design). The distribution losses incentive could provide a zero-sum allocation improvement for innovative network improvements executed by either DNO's or consumers through a redesign of the tariff code. A second inactive instrument that could be reinstated is a redesigned feed-in-tariff for distributed generators (LUP); also a zero-sum allocation improvement that could result in benefits being allocated to the DNO's actually incurring the costs. An important side-effect of the LUP is the possibility for locational cost pricing. Generation units contributing to congestion would have to pay more than units actually relieving congestions.

Conclusion: **the ORD and 'substantial investment' instruments provide very little opportunities to remunerate innovative investments in their current design**

Recommendation: **the additional revenue mechanisms of Germany and the UK can provide useful insights to improve the ORD instrument**

Recommendation: **the Tariff Code and therefore the 'substantial investment' incentive can be redesigned after every regulatory period by joint decision of all stakeholders**

Recommendation: **the distribution losses incentive can be changed to include distributed generation at lower voltage levels, as well as improve allocation of benefits to DNO's investing in technologies that reduce losses (implementation as a zero sum instrument)**

Recommendation: **the reinstatement of a redesigned generator tariff for small-scale generators would increase cost-benefit allocation between DNO's and provide options for locational pricing as to stimulate optimal unit placement**

So far, recommendations are based on the regulatory framework and thus investments in general. **The third step** in the analysis is an incentive specifically designed for innovative investments. In the Netherlands there is a complete lack of incentives regarding the second and third stage of the innovation cycle, the field-testing and roll-out stages. Ofgem in the UK has implemented two incentive instruments directly aimed at innovations; the IFI and LCN Fund. The IFI is aimed at the technical development of networks using innovative solutions. The instrument is designed to allow DNO's an 80% pass-through of costs through the tariffs. Translation to the Dutch framework is possible by inclusion of the incentive in a redesigned 'substantial investment' instrument. A change of the tariff code is required to do so. The second instrument, the LCN fund, has two tiers; one for small-scale projects and one for big flagship projects. All projects have to be aimed at low-carbon network solutions which is a commitment of Ofgem to a renewable energy supply. The first tier is similar to the IFI and could be possible by inclusion in the 'substantial investment' instrument which requires a tariff code alteration. The second tier has large-scale projects that can be considered flagships. The costs will be carried by society as a whole which is immediately the bottleneck for translation to the Dutch framework. There are no incentives that could enable such a large-scale investment and have the costs redirected to all consumers. There is however potential to redesign this second tier and so provide funding for flagship projects that are a joined effort by the DNO's, in the Dutch case by 'Netbeheer Nederland'. The roll-out of the smart meter and a possible roll-out of an infrastructure to charge electric cars could be funded through this tier (assessment of positive business cases is vital as to ensure that benefits will return to the consumer).

Conclusion: **current regulation is not able to include instruments specifically aimed at innovative investments like the UK IFI and LCN Fund instrument**

Recommendation: **transferability of the UK IFI is possible within the 'substantial investment' instrument by changing the Tariff Code**

Recommendation: **transferability of the UK LCN Fund is possible within the 'substantial investment' instrument by changing the Tariff Code (for first and second tier projects)**

Recommendation: **transferability of the UK LCN Fund is possible if DNO's would cooperate for large-scale flagship projects that facilitate a renewable electricity supply (second tier projects)**

All incentives and recommendations discussed so far revolve around improving reimbursement and cost/benefit allocation options for DNO's. **The fourth and last step** in the analysis is a discussion of the general economic concept that competition is the best incentive to innovate, a concept proven to be successful in the telecommunications sector. A comparison between these two sectors results in several recommendations that are possible within the limits of the regulatory framework. Two concepts appear to be promising; the use of unbundled network elements and the extension of lines of services by the DNO's. Firstly, using unbundled network elements has several advantages to the DNO's: it creates possibilities for an improved allocation of costs and benefits between the DNO and consumer benefitting them both; the 'regulatory holiday' provided for private networks could benefit DNO's by providing a field-test area for new innovations without them actually bearing costs or uncertainties; a perfectly balanced private network would reduce the number of bottlenecks and problems in the network because a DNO will be responsible for balancing a group of balanced small private networks. Secondly, an extension of the lines of services (within the possibilities of the E-act) will add value to both the DNO and the consumer. Furthermore, an increased collaboration between stakeholders could stimulate pro-active solutions like introducing demand-side management and innovative business cases.

Conclusion: **concepts related to competition in the telecommunications sector can be partially translated for the electricity sector**

Recommendation: **competition within a technology resulting from the use of unbundled network elements is partially possible and can lead to a win-win situation between the DNO and a private network**

- **better allocation of costs and benefits which can be beneficial to all involved stakeholders**
- **by carte blanche regulation the private networks and DNO's could learn a great deal about balancing demand and supply load changes, private networks can be a field-test area for DNO's**
- **the DNO would be responsible to balance a group of balanced small private networks making balancing easier**

Recommendation 5: **increased stakeholder collaboration can pro-actively provide solutions by introducing demand-side management and innovative business cases**

Recommendation 6: **DNO's can extend their lines of services within the possibilities of the E-Act to include services with added value to both the DNO and consumer**

A recurring theme in the recommendations provided in the previous paragraphs is the Dutch tendency of fixing regulation in the E-Act which reduces or even cancels a lot of viable options to alter the regulatory framework. Many recommendations are not possible in the framework as it is currently designed but by implementing small changes to several 'policy decrees' and/or 'policy codes', the Energiekamer would be able to adjust to dynamics in the market. The current regulatory framework would be excellent in a static sector without major expected changes. However, in a dynamic situation the framework is inadequate.

The five issues mentioned in the beginning of this chapter by Grubb, Jamasb and Pollitt (2008) have been used as a guidance in this thesis and have either been confirmed or refuted (on a preliminary explorative base) for the Dutch situation. The **first issue** has been confirmed in all chapters; the current RPI-X approach needs to be updated. The **second issue** has been partially confirmed; the idea of constructive user engagement has been especially important for the suggested private network recommendations. However, more use of competitive tendering has been refuted in this thesis based on the little chance of success for a connection competition incentive and lack of prospects for IDNO's. The **third issue** has been confirmed; locational pricing can have benefits for DNO’s and could be integrated in a feed-in-tariff for generators. The **fourth issue** has been confirmed; ownership unbundling of network from retailing is almost fully accomplished in the Netherlands and by using unbundled network elements this can be taken one step further. Although a recent court arrest has raised doubts about whether unbundling is justified, it remains to be seen whether vertical integration will be allowed again or not. The **fifth issue** is confirmed; problems arise with the increasing ‘smartness’ of the distribution network that demand innovative solutions.

12 Discussion and further research questions

A recent decision by the Court in The Hague has decided that the vertical separation of electricity companies was not justified. Because the government appealed to this decision, nothing changes yet. DNO's like Stedin and DNWB have decided to stop the separation process from their energy generation activities immediately while waiting for the results of the appeal decision. In case the appeal confirms the previous decision the effects on the electricity market would be tremendous. Companies would be allowed to integrate back into a large energy company both generating and transporting energy. The impact on the regulatory framework would be massive. If and how the market will transform in case of a positive decision is unknown and open for discussion.

Discussion point: **what are the possible consequences of the recent court decision that the separation of generation and transport is not justified?**

Balancing supply and demand load has been a recurring topic throughout this thesis. It is difficult trying to assess whether DG has a positive effect on the use of transmission and distribution networks or not, and what this effect would be. Distribution losses can in theory be avoided by DG but in practice (without storage technologies) these can remain the same or even increase. A similar discussion goes for the benefits of DG regarding the reliability and security of supply of the grid. There are many scientists that have written a paper about this topic, but the actual cost and benefits of DG are still unknown (Quazada, 2006), Mendez et al, 2005), Gulli, 2004), (Pepermans, 2003). The available information and the topic are too elaborate to be included in this thesis but are very interesting for further research.

Further research question: **what are the actual costs and benefits of DG?**

In several chapters electricity storage technologies are mentioned. Storage technologies have very large potential regarding solving the locational and temporal demand and supply load problems. Electricity produced during the day from PV panels could be stored to be used in the evening when electricity demand is high but supply low. Subsequently this would mean that electricity generation could be much closer to electricity consumption, thus reducing the locational load problems. Further research can extend this thesis by analyzing the effects of different storage technologies and how this would affect the proposed recommendations, and ultimately, how electricity storage would affect the regulatory framework. The role that DNO's play in the introduction of storage technologies is very interesting; what is allowed by the regulatory framework and what would be beneficial to change?

Further research question: **how would electricity storage technologies affect the proposed recommendations and ultimately the regulatory framework?**

Further research question: **what would be the (regulatory allowed) role of DNO's?**

The European regulatory framework and subsequently the Dutch E-Act of 1998 include Articles regarding the non-discriminatory character of policy. A comparison between the telecommunications and electricity was made in chapter 10. The regulatory framework for telecommunications sector is differentiated for several consumers groups. For example, regulation regarding fiberglass connections is different for households and offices. Fiber-to-the-home is regulated through unbundling of the local loop and fiber-to-the-office is not regulated but incurs competition through facilities based competition. There is a parallel between the telecommunications and electricity sector as chapter 10 already showed, and it would be an additional to this thesis to analyze whether differentiated regulated would be an option in the electricity sector; either differentiation between consumers groups (i.e. industry vs. households) or technologies (i.e. large-scale vs. small scale).

Further research question: **can the electricity sector benefit from policy differentiation like in the telecommunications sector?**

A recommendation in chapter 10 was to allow the creation of private networks (more extended than current regulation) through the use of unbundled network elements. This would give third parties the ability to own (and operate) part of the distribution grid. These private networks can range from a few households to an entire bloc. At the moment there is one organizational structure, the DNO, who owns and operates the distribution grid. The proposed use of unbundled network elements introduces possibilities for new organizational forms to enter the electricity sector. Further research is required to see what kinds of organizations are possible within the proposed recommendations. This could be reversed to see what kind of regulation would be required for different organizational forms.

Further research question: **what kinds of organizational form are possible with unbundled network elements regulation?**

This thesis proposes several recommendations to the existing regulatory framework, but these recommendations are still general. It would be a valuable deepening to this thesis to extend it with a thorough analysis of how the different recommendations should be formed. For example, a main recommendation is that the Tariff Code and the ‘substantial investment’ incentive can be changed quite easily. What should and could be the design of this instrument?

Further research question: **what should and could be the design of the changed incentive instruments mentioned in the recommendations?**

Finally, in this thesis the telecommunications sector and the electricity sector are compared to each other. Furthermore, the regulatory frameworks of the Netherlands and the United Kingdom have been compared. There are more regulated sectors that can be compared to the electricity sector like rail, road and air travel. Besides the United Kingdom it would be very interesting to compare the regulatory framework of more countries to try and find improvements for the Dutch framework. Countries like Norway, Sweden, Denmark and Germany could provide useful insights into the results of different regulatory approaches.

Further research question: **can useful ideas be derived from a comparison between the electricity sector and other regulated sectors, and between the Dutch regulatory framework and that of other countries?**

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Appendix A – EU and Dutch regulation regarding 'private networks'

To increase competition between electricity distribution network operators beyond the normal artificial yardstick competition, the regulatory framework should be facilitating towards private networks and the companies owning them. There is a heavy financial and administrative burden on companies when they are required to become a network operator; there are many tasks and obligations for those companies even in case they are very small and only serve a small selected group of consumers. Three very important tasks and obligations are: 1) the requirement to appoint a network operator that is independent from the generator, thus unbundled; 2) the requirement to set tariffs and 3) the requirement to allow new connections on the network that request one. These three characteristics will be described in greater detail and will include the regulatory framework of the EU and the Netherlands as well as recent regulatory discussions.

Directive 2009/72/EG of the European Parliament and the Council regarding the common rules for the internal electricity market (also called the third energy directive as it is the successor of directive 2003/54/EG, the second energy directive) describes the requirements for distribution network operators i.e. unbundling, requirement of an independent network operator etc. These requirements are translated in greater detail in the Dutch E-Act which is based on this European Directive. Where important and relevant, specific EU regulation will be mentioned.

Independent network operator

Regulation regarding unbundling is described in Article 26.1, 26.2 and 26.3 of the Third Energy Directive, it demands unbundling on an increased level compared to the Second Energy Directive, which is in the Netherlands translated into the WON, but the EU Directive also provides for exemptions regarding small networks. Already present in the Second Energy Directive was Article 26.4 that describes that member states are allowed to not apply unbundling to vertically integrated companies with less than 100.000 connected consumers or vertically integrated companies that serve a small, isolated network. Consideration (29) of the Directive describes that small networks should not encounter unreasonable financial and administrative barriers. The member states are therefore allowed to exempt these companies from the requirement to unbundle, thus an allowance for these companies to be vertically integrated.

Based on Article 10 of the Dutch E-Act all distribution networks owners are required to appoint an independent network operator. Unbundling of electricity networks has already been described in section X; the Dutch network operators need to unbundle from generators on an ownership level. A generator, supplier or trader of electricity is not allowed to be appointed as a network operator. Article 15.1 of the E-Act lists the exemption of this requirement for networks having a voltage level with a maximum of 0.4 kV and consumption with a maximum of 0.1 GWh per year. The second is exemption is Article 15.2 of the E-Act that describes the possibility for a Ministerial exemption when at least the following requirements are met: 1) the network is intended to supply electricity to the applicant or the network is intended to supply the applicants business; 2) a limited number of connections to the network; 3) the network is intended to supply electricity to a number of cooperating connections to ensure a reliable, durable, adequate and environmental functioning energy management; 4) the network is subject to specific quality requirements. This ministerial exemption is mandated to the Energiekamer. These private networks are used i.e. for industrial areas, airports and large real estate projects.

Setting the tariffs

The Dutch E-Act describes that all network operators have to set their tariffs as specified by the Energiekamer. Articles 23.1 and 24.1 state that network operators are obliged to connect consumers and transport electricity against these specified tariffs. Paragraphs 5 and 6 of the E-Act (1998) define the way that these tariffs are set as well as section of this report. The obligation to set tariffs does not apply to distribution networks without a network operator, thus an exempted network. The rationale is that networks that have been given an exemption according to Article 15.1 and 15.2 of the E-Act are not commercial and only provide electricity to a small number of people including themselves. There is no rationale for network owners to set tariffs that are too high. These tariffs are still subject to normal ex-post competition regulation by the NMa.

Allowing new connections (access to thirds)

Access to the distribution network by new connections is regulated in the EU Directive by Article 32. Without discrimination all consumers that requests a connections needs to be connected unless the network operator can give a clear reasoning based on objective, economical and technical arguments that there is not enough capacity left on the network. There was one exception in the Second Energy Directive; the direct lines but in the Third Energy Directive another option is introduced; the closed distribution network. Direct lines are still considered to be an exception, but closed distribution networks are not as private as their name suggests.

Direct lines are mentioned in Article 34 of the Third Energy Directive. Member states have the option to award networks the status of a direct line when electricity generators provide electricity to consumers on their own territory. Direct lines are not considered to be public networks and are therefore not subject to regulation as such. The Dutch regulatory framework does not include a concept like ‘direct lines’ but the exemptions in Article 15.1 and 15.2 do have some characteristics in common like the self provision of electricity.

Closed distribution networks are described in Article 28 and consideration (30) of the Third Energy Directive. Member states are allowed to create a closed distribution network when a network that transports electricity is located in a geographically separated area. This network has to belong to a commercial or industrial location, a residential area is not allowed. The directive specifies two rationales to close a network; 1) generation or transportation and consumption are integrated because of technical or safety reasons; 2) the network primarily distributes electricity to owner/operator of the network. Closed networks can be exempted from the tariff setting regulation. These networks could be considered as private networks if they did not have the same obligation as normal distribution networks that they obliged to connect all consumers requesting a connection. Furthermore, they have to comply with all regulation related to the quality of the network.

Appendix B – exemptions to appoint a DNO

The list below contains all exemptions to appoint a network operator granted by the Minister of Economic Affairs based on Article 15.2a, Article 15.2b and Article 15.2d of the Electricity Act 1998. Exemptions have been granted based on advice by the Energiekamer (former DTe).

Companies after 2000

Stallingsbedrijf Glastuinbouw Nederland Beheer B.V.
Energie Cluster Luttelgeest Netwerk B.V.
Houwen onroerend goed B.V. Stargrowers vof
Nuon Energie und Service GmbH voor het net op Industriepark Molenberg
Nuon Energie und Service GmbH voor het net op Industriepark Noord te Sittard
Energie Combinatie Wieringermeer
Schiphol Nederland B.V.
Ontheffingsaanvraag NWO
Prominent Groeneweg 2 OG BV
Windnet B.V. afwijzend besluit
De Kleef B.V.
GTI Infra B.V.
Center Parcs Europe N.V
Coöperatief Parkmanagement Ecofactorij
HB Energy BV
Energiecombinatie Wieringermeer
aviTwente B.V.
Dukker
Natural Organic Products
Van Benthum Recycling Central BV
GTi Energy Solutions BV
Hoogheemraadschap Amstel, Gooi en Vecht
Stichting Beheer Cluster Bergschenhoek
Martens Kunstoffen BV

Company	Place
B.V. Academisch Ziekenhuis Maastricht	MAASTRICHT
Academisch Ziekenhuis Groningen	GRONINGEN
Agri Centrum Eelde	EELDE
Air Products Nederland B.V. (locatie Europoort)	ROTTERDAM
Air Products (locatie Pernis)	ROTTERDAM
Akzo Nobel Nederland B.V.	ARNHEM
Aluminium Delfzijl B.V.	DELFZIJL
Autoliv Automotive Safety Products	AMSTERDAM
Bavaria N.V.	LIESHOUT
Philips Components B.V.	ZWOLLE
Beheermaatschappij Poeldijk	POELDIJK
B.V. Bloemenveiling Aalsmeer	AALSMEER

Bloemenveiling Flora	RIJNSBURG
Bloemenveiling Holland B.A.	NAALDWIJK
Degussa Electronic Materials B.V.	UDEN
Dordrecht Energy Supply Company (DESCO) B.V.	DORDRECHT
Dow Benelux N.V.	TERNEUZEN
DSM Minera	MAARSSEN
DSM Resins International	HOEK VAN HOLLAND
DSM Services, Utility Support Group	GELEEN
DSM Special Products Rotterdam	ROZENBURG
Elf Atochem Agri/Rotterdam B.V.	VONDELINGENPLAAT/Rt
Enecal Energy v.o.f.	ROTTERDAM
Esso Nederland B.V.	BREDA
EUROGEN	ROZENBURG
Europe Combined Terminals B.V. (ECT)	ROTTERDAM
Exxon Chemical Holland Inc.	ROZENBURG
Gevudo Afvalverwerking	DORDRECHT
Gist-Brocades B.V.	DELFT
Givaudan Roure B.V.	BARNEVELD
Hoogovens Staal B.V.	IJMUIDEN
Hydro Agri Rotterdam	VLAARDINGEN
Hydro Agri Sluiskil B.V.	SLUISKIL
ICI Holland B.V.	ROZENBURG
Kappa Attica B.V.	OUDE PEKELA
Ziekenhuis MCL, locatie Zuid	LEEUWARDEN
Nederlands Omroepproduktie Bedrijf N.V.	HILVERSUM
Nedstaal B.V.	ALBLASSERDAM
Nerefco B.V. locatie Pernis	ROZENBURG
Netherlands Car B.V.	SITTARD
Overspecht B.V.	OOSTERHOUT
Philips Components B.V. Roermond	ROERMOND
Philips Components Sittard	SITTARD
Philips Research	EINDHOVEN
Philips Vastgoed Beheer en Diensten	EINDHOVEN
Plukon Poultry	WEZEP
Polynorm Holland B.V.	BUNSCHOTEN
Refaja Ziekenhuis	STADSKANAAL
Roompot Recreatie B.V.	KAMPERLAND
SCA Packaging De Hoop B.V.	EERBEEK
Amsterdam Airport Schiphol	SCHIPHOL
Sensus Operations C.V.	ROOSENDAAL
Shell Nederland Raffinaderij B.V./Chemie B.V.	HOOGVLIET
Solvay Pharmaceuticals B.V. Amsterdam	WEESP
Solvay Pharmaceuticals B.V. Weesp	WEESP
St. Antonius Ziekenhuis	NIEUWEGEIN
Technische Universiteit Eindhoven	EINDHOVEN

United Biscuits Netherlands	ZAANDAM
Universiteit Utrecht De Uithof	UTRECHT
Vrije Universiteit Amsterdam	AMSTERDAM
Wavin Nederland B.V.	HARDENBERG
White Cap Nederland B.V.	DOESBURG
AVEBE b.a. (locatie Foxhol)	VEENDAM
AVEBE b.a. (locatie Gasselternijveen)	VEENDAM
AVEBE b.a. (locatie Ter Apelkanaal)	VEENDAM
Berghuizer Papierfabriek N.V.	WAPENVELD
Dobbestroom vof	VEENDAM
Hunzestroom vof	VEENDAM
Kwekerij Mostert Nieuwerkerk B.V.	NIEUWERKERK a/d IJSSEL
Schoonmansmolen Centrale Eerbeek VOF	EERBEEK
Eerste Nederlandse Cement Industrie (ENCI)	MAASTRICHT
Maasvlakte Olie Terminal cv Maasvlakte Univest	APELDOORN

Appendix C – 'Kruisjeslijst'

BIJLAGE 2: overzicht van taken en activiteiten na afsplitsing

	HOOFDTAAK **Activiteiten van de netbeheerder**	**de huidige situatie bij netbeheerders: zelf/ uitbesteed**
1	**AANLEG NETTEN EN AANSLUITINGEN**	
1.1	**Planning netten**	
1.1.1	Ramen van vraag en aanbod	uitbesteed
1.1.2	Maken van capaciteitsprognose	uitbesteed
1.1.3	Vaststellen van de verwachte capaciteitsbehoefte	uitbesteed
1.1.4	Opstellen strategische netplanning/ capaciteitsplanning	uitbesteed
1.1.5	Besluitvorming over strategische netplanning/ capaciteitsplanning	zelf
1.1.6	Financiering van de investeringen	uitbesteed
1.2	**Ontwerpen netten**	
1.2.1	Optimaliseren van netten	uitbesteed
1.2.2	Uitvoeren van netstudies	uitbesteed
1.2.3	Research & Development netten	uitbesteed
1.2.4	Berekenen capaciteit van de netten	uitbesteed
1.2.5	Vaststellen ontwerpen netten	uitbesteed
1.2.6	Opstellen en vaststellen specificaties van de netten	uitbesteed
1.2.7	Opstellen en vaststellen van de ligging van de netten	uitbesteed
1.2.8	Planning van middelen netten	uitbesteed
1.3	**Aanleggen netten**	
1.3.1	Besluitvorming over de aanleg netten	zelf
1.3.2	Aankopen van materialen netten	uitbesteed
1.3.3	Inmeten en aanleggen van netten	uitbesteed
1.3.4	Kwaliteitscontrole aangelegde netten	uitbesteed
1.3.5	Controle toeleveranciers uitbesteding operationele taken	uitbesteed
1.3.6	Goedkeuren oplevering netten	uitbesteed
1.3.7	In bedrijf nemen van netten	uitbesteed
1.3.8	Beschrijven van de wijzigingen netten	uitbesteed
1.3.9	Vastleggen en doorgeven van kabel en leiding informatie aan KLIC	uitbesteed
1.4	**Maken aansluitingen**	
1.4.1	Behandelen verzoek aanvraag tot aansluiting	uitbesteed
1.4.2	Besluitvorming aanleg aansluiting	zelf
1.4.3	Aankoop materialen aansluiting	uitbesteed
1.4.4	Aanleggen van aansluiting	uitbesteed
1.4.5	Aansluiten afnemers (fysiek)	uitbesteed
1.4.6	Goedkeuren oplevering aansluiting	uitbesteed
1.5	**Overige infrastructuren**	
1.5.1	Aanleg, beheer of onderhoud van warmtenetten	uitbesteed
1.5.5	Aanleg, beheer of onderhoud van koudenetten	uitbesteed
1.5.3	Aanleg, beheer of onderhoud van waternetten	uitbesteed
2	**TECHNISCHE BEDRIJFSVOERING**	
2.1	**Beschikbaarheid netten**	
2.1.1	Verantw. voor het in werking hebben en houden van netten	uitbesteed
2.1.2	Werkzaamheden voor het in werking hebben en houden van netten	uitbesteed
2.1.3	Opstellen en vaststellen kwaliteitsplanning voor transport	uitbesteed
2.2	**Oplossen van storingen (E: 16-1-a jo. E 16-5)**	

2.2.1	Registeren van storingen (landelijk meldpunt)	uitbesteed
2.2.2	Aansturing oplossen van storingen	uitbesteed
2.2.3	Storingen fysiek verhelpen (storingsdienst)	uitbesteed
2.2.4	Financiele afwikkeling van storingen	uitbesteed
2.2.5	Analyseren van storingen	uitbesteed
2.2.6	Storingsrapportage aan DTe	uitbesteed
2.3	**Technische dispatch**	
2.3.1	Monitoren van de netten (waaronder de belasting in de netten)	uitbesteed
2.3.2	Regelen en schakelen in de netten (Elektriciteit)	uitbesteed
2.3.3	Regelen druk en spanning in de netten (Gas)	uitbesteed
2.3.4	Schakelen in regelkamer	uitbesteed
2.4	**Inkoop energie en vermogen**	
2.4.1	Inkoop regelend vermogen	uitbesteed
2.4.2	Inkoop blindlastvermogen	uitbesteed
2.4.3	Inkoop voor compensatie netverliezen	uitbesteed
2.4.4	Inkoop voor opheffen transportbeperkingen	uitbesteed
2.5	**Inspectie en veiligheid**	
2.5.1	Waarborgen veiligheid en betrouwbaarheid netten	uitbesteed
2.5.2	Uitvoeren van inspecties aan netten	uitbesteed
2.5.3	Lekzoeken netten (Gas)	uitbesteed
2.5.4	Uitvoeren van inspecties van de installaties afnemers	uitbesteed
2.5.5	Vaststellen rapportages over inspectie en veiligheid	uitbesteed
3	**ONDERHOUD EN VERVANGING (E: 16-1-a jo. E 16-5)**	
3.1	**Preventief onderhoud**	
3.1.1	Formuleren preventief onderhoudsbeleid	uitbesteed
3.1.2	Opstellen en vaststellen onderhoudsplanning netten	uitbesteed
3.1.3	Research & Development onderhoud netten	uitbesteed
3.1.4	Besluitvorming over uitvoeren onderhoud netten	zelf
3.1.5	Inplanning van de ingreep in de netten	uitbesteed
3.1.6	Aankoop materialen onderhoud netten	uitbesteed
3.1.7	Uitvoeren van het fysieke onderhoud netten	uitbesteed
3.2	**Reparatie en vervanging**	
3.2.1	Formuleren onderhoudsbeleid t.a.v. reparatie en vervanging	uitbesteed
3.2.2	Opstellen en vaststellen reparatie- / vervangingsplanning netten	uitbesteed
3.2.3	Bepalen van de ingreep netten	uitbesteed
3.2.4	Inplanning van de ingreep in de netten	uitbesteed
3.2.5	Aankoop materialen netten	uitbesteed
3.2.6	Uitvoeren van de fysieke reparatie of vervanging netten	uitbesteed
4	**METERING**	
4.1	**Data collectie**	
4.1.1	Uitlezen van meter bij kleinverbruikers	uitbesteed
4.1.2	Uitlezen van meter bij grootverbruikers	uitbesteed
4.1.3	Meten hoeveelheid opgewekte energie (enerQ)	uitbesteed
4.1.4	Opvragen van meetgegevens bij meetbedrijven (datacollectie)	uitbesteed
4.2	**Data handling**	
4.2.1	Valideren van meetgegevens kleinverbruikers	uitbesteed
4.2.2	Valideren van meetgegevens grootverbruikers	uitbesteed
4.2.3	Opstellen en vaststellen protocol gegevensverwerking	uitbesteed
4.2.4	Certificeren vertrouwelijkheidsprotocol (gegevensverwerkingsproces)	uitbesteed
4.3	**Uitwisselen van meetgegevens**	

4.3.1	Verstrekken van meetgegevens aan kleinverbruikers	uitbesteed
4.3.2	Verstrekken van meetgegevens aan grootverbruikers	uitbesteed
4.3.3	Verstrekken van meetgegevens aan leveranciers	uitbesteed
4.3.4	Verstrekken van meetgegevens aan netbeheerders	uitbesteed
4.3.5	Verstrekken van meetgegevens aan PV-partijen	uitbesteed
4.3.6	Verstrekken van meetgegevens aan Landelijk netbeheerder	uitbesteed
4.3.7	Verstrekken van meetgegevens aan groenproducenten	uitbesteed
4.4	**Meetinrichtingen**	
4.4.1	Verhuren van meters aan kleinverbruikers	uitbesteed
4.4.2	Verhuren van meters aan grootverbruikers	uitbesteed
4.4.3	IJken van meters	uitbesteed
4.4.4	Reviseren van meters	uitbesteed
5	**ECONOMISCHE BEDRIJFSVOERING**	
5.1	**Tarieven en voorwaarden**	
5.1.1	Overleg representatieve organisaties	uitbesteed
5.1.2	Aansluit en transportvoorwaarden Elektriciteit	uitbesteed
5.1.3	Aansluit en transportvoorwaarden Gas (KVB)	uitbesteed
5.1.4	Indicatieve tarieven en voorwaarden gas (GVB)	uitbesteed
5.2	**Administratieve processen**	
5.2.1	Voeren afzonderlijke administratie (boekhouding)	uitbesteed
5.2.2	Controle op en verantwoording over administratie	uitbesteed
5.2.3	Voeren van verbruiksadministratie	uitbesteed
5.2.4	Opstellen en bijhouden verbruiksprofielen	uitbesteed
5.2.5	Voeren van PV administratie	uitbesteed
5.2.6	Voeren van debiteurenadministratie	uitbesteed
5.2.7	Bijhouden van het aansluitingenregister	uitbesteed
5.2.8	Afhandelen van switchverzoeken	uitbesteed
5.3	**Offertes en contractsonderhandelingen**	
5.3.1	Opstellen, uitbrengen en onderhandelen van offerte aansluiting	uitbesteed
5.3.2	Opstellen, uitbrengen en onderhandelen van offerte transport	uitbesteed
5.4	**Facturering**	
5.4.1	Factureren aan en incasso bij aan grootverbruikers	uitbesteed
5.4.2	Factureren aan en incasso bij kleinverbruikers	uitbesteed
5.4.3	Factureren onder het leveranciersmodel (aanleveren factuurregels)	uitbesteed
5.5	**Voorlichting aan afnemers**	
5.5.1	Afhandelen klantcontacten / callcenter	uitbesteed
5.5.2	PR, Voorlichting aan afnemers (o.a. veiligheid)	uitbesteed
5.6	**Contractmanagement**	
5.6.1	Voorbereiden outsourcing operationele taken	uitbesteed
5.6.2	Aanbesteding outsourcing operationele taken	uitbesteed
5.6.3	Selectie toeleveranciers outsourcing operationele taken	uitbesteed
5.6.4	Besluitvorming over outsourcing operationele taken	uitbesteed
5.6.5	Controle en acceptatie van de door toeleveranciers uitgevoerde taken	uitbesteed
6	**INRICHTING BEDRIJFSORGANISATIE**	
6.1	**Organisatie**	
6.1.1	Jaarverslag	uitbesteed
6.1.2	Verklaring artikel 18.3	uitbesteed
6.2	**Human resource management**	
6.2.1	Human resource management	uitbesteed

6.2.2	Insourcing (werving en selectie)	uitbesteed

6.3 **ICT**

6.3.1	Juridisch en economisch eigendom van software voor NB applicaties	uitbesteed
6.3.2	Juridisch en economisch eigendom van hardware voor NB applicaties	uitbesteed
6.3.3	Data en applicaties netbeheer	uitbesteed

Appendix D – Complete recommendations list

H7 – Regulatory comparison NL and UK

Recommendation 1: implement more/new regulation in Codes and Decrees instead of the Electricity Act

Recommendation 2: reduce the time lag to include investments in the RAB

Recommendation 3: adjust the allowed revenue during the regulatory period

Recommendation 4: increase the use of cost projections to estimate investment levels (long term)

H8 – Incentive instruments: old and new in NL

Recommendation 1: the Energiekamer should keep on reviewing the ORD and 'substantial investment' instrument to respond swiftly to changes if necessary

Recommendation 2a: the additional revenue mechanisms of Germany and the UK can provide useful insights to improve the ORD instrument

Recommendation 2b: the Tariff Code and therefore the 'substantial investment' incentive can be redesigned after every regulatory period by joint decision of all stakeholders,

Recommendation 2c: the distribution losses incentive can be changed to include distributed generation at lower voltage levels, as well as improve allocation of benefits to DNO's investing in technologies that reduce losses (implementation as a zero sum instrument)

Recommendation 3a: investigate the possibility of technology differentiation in the supply factor of the composite output as to improve it

Recommendation 3b: a reinstatement of a redesigned generator tariff for small-scale generators would increase cost-benefit allocation between DNO's and provide options for locational pricing as to stimulate optimal unit placement

H9 – Incentive instruments: stimulate innovation

Recommendation 1: transferability of the UK IFI is possible within the 'substantial investment' instrument by changing the Tariff Code

Recommendation 2a: transferability of the UK LCN Fund is possible within the 'substantial investment' instrument by changing the Tariff Code (for first and second tier projects)

Recommendation 2b: transferability of the UK LCN Fund is possible if DNO's would cooperate for large-scale flagship projects that facilitate a renewable electricity supply (second tier projects)

Recommendation 3: remuneration for investments in the large-scale deployment stage is possible, either by direct reimbursement, by changing the 'substantial investment' instrument or by introducing zero-sum instruments

H10 – Incentive instruments: creation of competition

Recommendation 1: a connection competition incentive would have a little chance of success in the Netherlands

Recommendation 2: competition between technologies has little scope in the Netherlands

Recommendation 2a: the scope for competition between technologies could change as a result of progress in energy storage technologies that reduce demand and supply load differences

Recommendation 3: competition within a technology is partially possible and is based around a win-win situation between the DNO and a private network (result is that competition would no longer be the correct term)

Recommendation 3a: facilities based competition for electricity is economically not viable in the Netherlands

Recommendation 3c: competition in services in not possible in the Netherlands but an increase of DNO services provides opportunities

Recommendation 3b: use of unbundled network elements creates possibilities to

- better allocation of costs and benefits which can be beneficial to all involved stakeholders
- by carte blanche regulation the private networks and DNO's could learn a great deal about balancing demand and supply load changes
- the DNO would be responsible to balance a group of balanced small private networks making balancing easier

Recommendation 4: IDNO's do not have (large) future prospects in the Netherlands

Recommendation 5: increased stakeholder collaboration could pro-actively provide solutions by introducing demand-side management and innovative business cases

Recommendation 6: DNO's could extend their lines of services within the possibilities of the E-Act to include services with added value to both the DNO and consumer