DISPOWER

The Changing Role of Energy Suppliers and Distribution System Operators in the Deployment of Distributed Generation in Liberalised Electricity Markets

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JUNE 2005 ECN-C--05-048

Acknowledgement

This report is the result of a study provided within Work Package 3 (Socio-economic studies) of the DISPOWER project. The European Commission under the 5th Framework Programme supports this research project (Contract No. ENK5-CT-2001-00522). The study is conducted by ECN Policy Studies and is registered under project number 7.7397.

The authors thank Mrs Maroeska Boots for her comments as a co-reader of this report. For any questions regarding this report, please contact Mr. Michiel van Werven, vanwerven@ecn.nl, telephone +31.224.568258.

Abstract

The penetration of distributed generation (DG) is increasing in most electricity markets and it is expected that this development will continue in the near future. The main research question to be answered in this report is how distribution system operators (DSOs) and energy suppliers can adapt to the growth and concurrently can contribute to the competition strength of DG in a regulated and competitive electricity market. DSOs and energy suppliers have to change their business focus in order to keep their business lucrative. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can overcome the threats that arise from the increasing penetration of DG, incentive regulation, regulated connection charges, and unbundling. Apart from the need for a changing attitude of the DSOs, regulation needs to evolve such that it allows DSOs to have access to a wider range of options and incentives available in choosing the most efficient ways to run their businesses. For energy suppliers, the development of new business strategies and new revenue drivers is a more 'natural' process than for DSOs. At least in theory, the dynamic working of this competitive market should give incentives to energy suppliers to improve margins, respond to market challenges, continuously develop new revenue drivers, and to display a certain degree of innovation. The increase of electricity supply from DG is an opportunity for energy suppliers to extend and improve its business. A new business concept related to the growing penetration of DG is, for example, the creation of virtual power plants.

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The penetration of distributed generation (DG) is increasing in most electricity markets and it is expected that this development will continue in the near future. Generally, three policy goals can be distinguished that drive the growth of DG: the reduction of greenhouse gas emissions (the Kyoto Protocol), the use of renewable energy resources (the European RES Directive), and the energy efficiency improvement (the European CHP Directive). The main research question to be answered in this report is how distribution system operators (DSOs) and energy suppliers can adapt to the growth and concurrently can contribute to the competition strength of DG in a regulated and competitive electricity market.

Distributed generation can bring several advantages to the electricity network, including enhanced system reliability, emissions reductions through both increases in energy efficiency and the displacement of coal generated electricity, avoided transmission line losses and costs, congestion relief in the transmission system, and avoided infrastructure investments. The development of small-scale DG facilities near a load can postpone necessary investments in additional distribution and transmission capacity. Moreover, certain types of DG also have the ability to offer certain network ancillary services to the system operator, such as reactive power support and voltage control, which improve power quality.

But the increasing share of distributed generation influences the arrangement of the power system and, in combination with regulatory issues, may negatively affect the business of DSOs. Because DG units generally are located closer to demand than central generation, increasing DG penetration may result in decreasing revenues for DSOs, as less transport is needed to deliver the produced electricity to the customer. Next to decreasing revenues, the increasing penetration of DG may lead to increasing costs. DG facilities are mostly connected to the distribution network at low voltage levels; sites that were originally not meant to connect power generation facilities. This new situation can create several problems for the distribution networks in terms of stability and power quality. The more DG is connected to a particular distribution network, the greater the challenge.

Therefore, DSOs have to change their business focus in order to keep their business lucrative. Transportation of electricity must not be the only revenue source. There are other activities that create value, and that, at the same time, make DSOs less vulnerable and dependent on one revenue source. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can overcome the decreasing transport revenues.

Next to these technical issues, regulation is in place, due to the natural monopoly character, that can negatively affect the business of DSOs. The profit DSOs can make is caped by regulatory enactments. To simulate competition (and to stimulate economic efficiency) in the regulated distribution market, artificial efficiency incentives can be introduced. These efficiency incentives encourage DSOs to look for efficiency gains in order to improve profits. Incentive regulation can be aimed at prices (price cap regulation) or at rates of return. From the point of view of a DSO, economic incentive regulation can be seen as a threat since it may reduce the DSO's revenues. The impact of incentive regulation can be detrimental in the way that it stimulates doing the same things more efficiently but does not encourage DSOs to look for better alternatives. The regulation has left DSOs to focus almost entirely on cutting cost and leaves them little flexibility to create value and revenues through innovative investment, operations and services. Price caps and benchmarking, while contributing to the regulator's objectives, tend to act in an anti-innovative manner.

DG has several values that can be advantageous or disadvantageous to DSOs, but the current regulatory framework does not have an incentive for the DSO to incorporate these values in its business model. Following the SUSTELNET results, regulation needs to evolve such that it allows DSOs to have access to a wider range of options and incentives available in choosing the most efficient ways to run their businesses. Electricity systems are changing rapidly. New technologies are developing and it is unclear how networks may develop. It is vital that economic regulation does not determine technological outcome. Thus, apart from the need for a changing attitude of the DSOs, regulation needs to be able to work with uncertainty and be flexible to change as well.

Besides the regulated efficiency incentives that are often seen as a threat by DSOs, there are other threats to the current business model of DSOs. They are, for example, not allowed to own production capacity, even though it is used as substitute for line losses, for network reinforcements or extensions, or for ancillary services. This unbundling forms a hard boundary condition that forbids the DSO to extend its business in this way. Furthermore, the use of shallow connection charges can be unfavourable for DSOs. Especially if, in a specific region, there is already a lot of DG connected to the distribution network, (deep) connection costs can become very high. If the regulation prescribes the use of shallow connection charges, DSOs can only partially recoup these connection costs from the DG operators.

Currently, most DSOs are trying to gain experience with regulation and the growing penetration of DG, focusing on reducing uncertainty but behaving rather defensively. Some developments are being experienced as threats to the DSO's business model, whereas they should rather be seen as a challenge, or at least as fixed boundary conditions that should not be fought against. There is a need for a turn in the thinking of DSOs. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can bent the negative attitude into a cooperative and innovative strategy trying to use the developments, formerly seen as threats, in their advantage. In order to facilitate the integration of DG, DSOs should make a transition to 'active' management of their networks. An 'active' DSO provides market access to DG by acting as a market facilitator and it provides several network and ancillary services through intelligent management of the network. This includes the incorporation of advanced information exchange between generation and consumption, the provision of ancillary services at the distributed level, management of the network to provide network reliability and controllability, and improve customer benefits and cost-effectiveness. Currently such services are partly provided at the centralised level by TSOs. The transition from passive to active network management may be accompanied by developing new services for the electricity market, creating new revenue drivers for the DSO. Examples of new activities are the offering of extra reliability, the use and distribution of system information, providing local balancing services, and the storage of electricity.

For energy suppliers, the development of new business strategies and new revenue drivers is a more 'natural' process than for DSOs. Unlike DSOs, suppliers act in a market that is exposed to competition and that is not restricted by regulation. At least in theory, the dynamic working of this competitive market forces market players to continuously develop new revenue drivers and to display a certain degree of innovation. It gives incentives to improve margins and respond to market challenges. Only market rules (e.g. balancing market, power exchange) may be experienced as boundary conditions to the energy supplier's business. The increase of electricity supply from DG is an opportunity for energy suppliers to extend and improve its business. Whether an energy supplier is interested may depend on its market position. Historical or new ties to large power generation could create a conflict of interest. However, if an energy supplier is neglecting an interesting opportunity, it may be sure that in a competitive market a rival or new entrant will start to develop the opportunity. A new business concept for energy suppliers related to the growing penetration of DG is, for example, the operation of a large number of small electricity generators as if it is a large power plant. This concept is referred to as a virtual power plant.

1. Introduction

1.1 The DISPOWER project

The cluster of Distributed Generation (DG) research projects[1] within the EU Fifth Framework Research Programme aims to tackle technical, socio-economic and institutional barriers DG is facing in the present situation. One of these projects is the DISPOWER project that, undertaken by 38 different partners from utilities, power industry, service companies, research centres and universities from 11 European Member States, intends to support the transition of nowadays electricity supply towards a more decentralised and market oriented supply structure. New concepts, strategies and tools will be developed and implemented in order to improve the production and distribution of electricity and heat and supporting the opening of new market opportunities in a growing electricity market. For maintaining a reliable and cost effective electricity supply, new efforts have to be undertaken for the management of electricity networks, integration of renewable energy sources (RES) and other decentralised units in the distribution networks.[2, 3]

The aim of the project is the preparation of a new distributed generation structure in the power supply of European interconnected (regional, local) and island grids. Planning such fundamental structural changes, a global approach that takes into account grid control methodologies, stability aspects, power quality and safety is indispensable. On this basis elaborated in WP 1 and WP 2, planning, training and operation tools will be developed in WP 4 and WP 9. Two laboratory DG grids will be set-up in WP 6 for grid stability and control and in WP 8 for power quality issues. A cost effective introduction of the DG technology makes it necessary to apply and further develop new information and communication technologies (ICT) especially concerning energy management and electricity trading (WP 5). The developed tools will be applied by several utilities of different regional and local grids in Europe to demonstrate the RE technology implementation (WP 7 and WP 10). Finally, socio-economic issues regarding the impact of DG technology to consumers will be investigated in WP 3 and an overall assessment of DG in local supply systems will be carried out in WP 11.

The integration of DG into current electricity supply networks includes many socio-economical and institutional issues that can pose a barrier to this integration and to the further growth of DG potential. These issues are studied in Work Package 3 of the project. This Work Package involves four tasks (activities) aiming at the following issues:

3.1 Inventory of technical solutions and practices - Demand side.
3.2 Inventory of technical solutions and practices - Supply side.
3.3 Analysis of consumer responses to new communication technologies.
3.4 Competition strength of DG and RES in a liberalised market and the role of ICT and innovative distribution networks.

This report deals with Task 3.4, but it is slightly adjusted because the insight in DG and the electricity market has grown since the formulation of the tasks in 2001. The next section will concentrate on the objective of this research in further detail.

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1 See for more information on these projects http://www.clusterintegration.org/.

2 For convenience, from now on DG and RES are not mentioned separately each time. When speaking about DG, small-scale RES units are included (see Section 2.2 for a definition of DG). Only if attention is specifically focused on renewable electricity, for example in the case of support schemes aimed at sustainable energy, the report explicitly mentions RES.

3 See for more information: www.dispower.org.

1.2 Motive and objective of this report

The motive of this research arises out of the growing market penetration of distributed generation. Akkermans and Gordijn catchy state in their BusMod report: "*Every enterprise in the power industry and utility sector has to carefully rethink its business model, now that the rapid developments in distributed technologies and European wide market liberalisation have a joint and increasingly strong impact*." (Akkermans and Gordijn, 2004) The main objective that forms the basis for this DISPOWER research is to indicate how the role of different actors in the liberalised electricity market can and/or should change in order to adapt and concurrently contribute to the growing penetration of distributed generation. One of the specific objectives of Work Package 3 is to investigate the effect of DG on the operations and economic optimisations of incumbent and new utilities in different liberalised market structures. The main focus will be on distribution system operators (DSOs[4]), which are essential for the *network access* of distributed generation, and on energy suppliers, which are a relevant actor for the *market access* of DG. Both were part of the former (incumbent) integrated utilities. As the responsible agent for managing the electricity and information exchange between generation and consumption at the distribution level and being the interface with the transmission level, DSOs have a key role in providing access to the (distribution) network and in providing network services to DG. It is therefore that much of this report's attention goes out to analysing the potential role of DSOs in the changing electricity market. In this research it is analysed how DSOs and energy suppliers can alter their business focus to fluently adapt to the changing electricity market with its increasing penetration of distributed generation and concurrently contribute to the competition strength of DG. The rapid developments in distributed technologies open up new business opportunities in the liberalised market environment. The main research question to be answered in this report is as follows:

> *How can distribution system operators and energy suppliers adapt to the growth and concurrently contribute to the competition strength of distributed generation in a regulated and competitive electricity market?*

To be able to give an answer to this research question, the following subquestions are identified:

1. What is the implication of liberalisation for the structure and regulatory framework of the electricity market? Answering this subquestion reveals different reasons for introducing competition and shows where regulation is still needed.
2. What is distributed generation and why is its share in electricity generation increasing? DG is a very broad concept and a clearly defined definition of DG creates clarity and leaves little room for uncertainty about what is meant by it in this report. Moreover, this subquestion contributes to the insight in the importance of DG.
3. How does the electricity market structure look like? Answering this subquestion gives insight in the different interactions between the relevant actors that participate in the electricity market. Furthermore, it makes clear how DG fits into this picture and what its impact is on the electricity network.
4. What are the business activities and revenue and cost drivers for distribution system operators and energy suppliers and what is their business focus? Discussing this subquestion reveals the current activities that these actors are into. Understanding of the current activities is important in the process of adapting the business focus to a new situation in which distributed generation takes a more prominent role.
5. What are (regulatory) threats for DSOs to fully integrate distributed generation into their business focus? Going through this subquestion makes clear that there is not yet a level playing field for DG in the power generation market and that explicit action has to be undertaken by different stakeholders to fully integrate DG into their business focus and make it a mature element of the electricity market.

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[4] For the operator of the distribution network (150 kV and lower) both the terms Distribution Network Operator (DNO) and Distribution System Operator (DSO) are used. Directive 2003/54/EC defines the DSO as operator of the distribution network. The term DSO will be used in this report.

6. Which new activities for energy suppliers and DSOs can be developed to support the increase of distributed generation in the electricity market and, concurrently, which opportunities arise out of this growth of DG? In which way should the business model for these actors change along?[5] Researching this last subquestion provides an important part of the answer to the main research question.

1.3 Reading guide

Each chapter in this report will focus on one or two above-mentioned subquestions. Chapter 0 starts with discussing the introduction of competition and the need for unbundling and regulation. Subsequently it attempts to characterise DG. In this way Subquestions 1 and 2 are addressed. Chapter 3 focuses on Subquestion 3: the electricity market structure. It shows schematic pictures of the electricity system structure and the relevant (economic) interactions between the involved actors. On the basis of this schematic reproduction, it discusses the benefits of integrating business activities. Chapter 4 focuses on the business activities of DSOs and energy suppliers in the current market (Subquestion 4) and Chapter 5 pays attention to Subquestion 5: existing (regulatory) barriers for DSOs to integrate DG into their business focus. It also describes three behavioural strategies of DSOs that are adapting to the increasing penetration of DG. Chapter 6, concentrating on Subquestion 6, discusses new opportunities arising from the growing amount of DG as well as new revenue drivers and adjusted business models that can support DG. Conclusions arising from the research are included in the Executive Summary of this report.

[5] A business model (also called a business design) is the mechanism by which a business intends to generate revenue and profits.

2. Liberalisation and Distributed Generation

2.1 Introduction of competition and the need for regulation

Before the introduction of competition, the electricity market's greatest bottleneck was the lack of incentive for economic efficiency. Because the integral costs (investments and operation costs) of the network infrastructure and power generation facilities, profitable or not, could easily be passed on to the consumers (the 'cost-plus principle'), the electricity sector, which was unhampered by any form of competition, was hardly cost-efficient. In 1992 the European Commission proposed an Electricity Directive that had the objective to liberalise the electricity sector in Europe.[6] Liberalisation was thought to lead to lower electricity prices, which should help to strengthen the competitiveness of Europe. Liberalisation is a way to introduce (more) market competition, which eventually results in more cost efficient and customer oriented companies that better cater to the needs and wishes of consumers, i.e. better quality and service at relatively lower prices. Four general motives for introducing competition can be distinguished (Van Hulst, 1996 en Theeuwes and Velthuijsen, 1998):
1. Remove welfare losses which originate from monopoloid price-setting.
2. Promote allocative efficiency (marginal costs determine prices), dynamic efficiency (innovation), and cost efficiency (production at the lowest possible cost).
3. Strengthen international competitiveness.
4. Improve the working of public regulation.

Liberalising the electricity market has a lot of potential advantages, but when free competition cannot protect the interests of consumers, introduction of economic regulation is necessary to monitor and control the activities of companies. If introduction of competition is not desirable or possible in certain elements of the electricity sector (e.g. in case of natural monopolies), economic regulation is required, especially to prevent abuse of dominant or monopolistic behaviour. The sector is considered to be a combination of different activities. Activities like production, supply, trade, sales, and metering, are competitive activities. However, transport of electricity via the transmission and distribution networks is a natural monopoly because the entry barrier for a competing network is extremely high. The (natural) monopoly activities must be unbundled from the other activities in order to prevent cross subsidisation and discrimination.

Because of its natural monopoly, regulation of the network infrastructure is necessary to protect consumers and to guarantee access to the grid (network access). Access to the grid on the basis of fair and non-discriminatory rules is important in the opening electricity market, especially for new entrants. Experience learns that this objective can be easily realised if the owners of the transmission and distribution grids (which in practice are mostly part of vertical integrated companies) have no bond with other industrial interests, like production and supply of electricity (Commission of EC, 2000). If the grid owners do have other interests, e.g. in production or supply activities, they might abuse their monopolistic power to favour these interests and to raise entry barriers on the grid. Insufficient vertical unbundling between transport and production or supply creates possibilities for cross subsidisation. Revenues obtained from the grid are then used to strengthen the competitiveness of the production or supply activities. Trade interests and the working of the electricity grids must therefore be unbundled to make it possible to create a level playing field (see Appendix A), to guarantee free access to the grid, and to avoid distortion of competition, discrimination and cross subsidisation.

[6] Directive 96/92/EC.

In the European Electricity Directive of 2003, a specific article refers to the unbundling of DSOs.[7] This article states: "*Where the distribution system operator is part of a vertically integrated undertaking, it shall be independent at least in terms of its legal form, organisation and decision making from other activities not relating to distribution. These rules shall not create an obligation to separate the ownership of assets of the distribution system operator from the vertically integrated undertaking.*" As the last sentence implies, the new directive does not require complete (ownership) unbundling of DSOs. Legal unbundling suffices. The former Directive 96/92/EC stipulated unbundling of management activities only.[8]

Next to the protection of the interests of consumers, there where free competition fails to do so, regulation can provide guarantees for deployment of sustainable energy supply. Liberalisation should, in theory, create the right conditions for any generator to sell electricity on the free market, including electricity generated by small-scale units (distributed generation) and from renewable energy sources (RES). However, the electricity supply system was not designed for taking up supply in the distribution grids or to deal with intermittent power generation. Electricity from DG and RES is often more costly, and therefore, following different EU Directives[9], Member States (MS) have implemented support mechanisms to stimulate production and consumption of renewable electricity. In practice, however, current electricity network regulation often does not consider regulation of distribution networks to ensure effective participation of RES and DG in liberalised electricity markets. Instead, governments in EU MS use support schemes to ensure that DG and RES are deployed and environmental benefits are achieved. A level playing field in the power generation market does not (yet) exist.

To meet future sustainability targets, it is expected that the share of DG (including RES) in electricity supply will increase significantly.[10] If this occurs, DG must become a mature power generation source. This requires technological adaptations of the electricity system, but within current electricity regulation frameworks, incentives to change the design and operation of distribution networks are often lacking. The existing regulatory framework, including grid connection, access to wholesale markets and balancing arrangements, usually favours centralised generation. Therefore, supporting changes in economic regulation are required as well. Equal chances for centralised and distributed generation are a prerequisite for the realisation of a level playing field.[11] A sustainable electricity system that is economically efficient only results from electricity network regulation that provides generators and DSOs with correct economic signals. In other words, costs and benefits induced by DG should be recognised, allocated, and valued properly. DG incurs certain costs, but also certain benefits to the electricity network and society as a whole. Existing regulation, however, does often not enable a proper allocation of these costs and benefits and therefore hinders (economically and technically) optimal integration of DG. In most EU Member States DG is not or insufficiently rewarded for its benefits to the electricity system and is in some cases strongly dependent on non-market based support schemes (Connor and Mitchell, 2002a). Support schemes should, however, not be used to compensate the often complex barriers to incorporate DG within economic regulation, as this could keep DG from becoming a mature power generation source. Electricity regulation that is 'neutral' towards central generation and distributed generation will help to create a level playing field.

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7 Directive 2003/54/EC, Article 15.

8 Directive 96/92/EC, Article 14: '*Integrated electricity undertakings shall, in their internal accounting, keep separate accounts for their generation, transmission and distribution activities (…) with a view to avoiding discrimination, cross-subsidization and distortion of competition.*'

9 The first and new Electricity Directive: Directive 96/92/EC and Directive 2003/54/EC respectively; and the RES Directive: Directive 2001/77/EC.

10 Besides the targets set in the Renewables and CHP Directives, another main driver for the increase of the level of DG capacity in the medium-term is the development of new small-scale generation technologies.

11 For an elaboration on the level playing field concept, see Appendix A.

In conclusion, it is important to realise that because of the constantly changing environment in which DG operates, regulation should be dynamic as well. Electricity systems are changing rapidly. New technologies are developing and it is unclear how networks may develop. The liberalising electricity sector is constantly moving and regulation should play a supporting and leading role in the dynamic development to a level playing field for DG. It is vital that economic regulation does not determine technological outcome. Thus, regulation needs to account for uncertainty and be flexible to changes (Connor and Mitchell, 2002a). This report concentrates on the different relations between the actors in the electricity sector (DSOs, TSO, energy suppliers, DG operators, large power producers, and consumers) and studies the possible contribution of energy suppliers and DSOs to the growth of DG in the liberalised electricity market. But first, Section 2.2 describes the characteristics of DG.

2.2 Distributed Generation and its drivers

2.2.1 Different definitions

Although distributed generation has gained major importance, no general definition of what DG is has been agreed upon. There is no consensus on a precise definition as the concept encompasses many technologies and many applications in different environments. At one end, DG could include only small-scale, environmentally friendly technologies, such as photovoltaics (PV), fuel cells, micro-turbines, or small wind turbines, that are installed on and designed primarily to serve a single end-user's site. At the other end, DG could encompass any generation built near to a consumers' load regardless of size or energy source. The latter definition could include large co-generation facilities capable of exporting hundreds of megawatts of energy to the grid (NRECA, 2000). A CIGRE[12] working group defined DG as all generation units with a maximum capacity of 50 to 100 MW, that are usually connected to the distribution network and that are neither centrally planned nor dispatched (CIRED, 1999, p.4). Clearly, this latter part of their definition implies that DG units are beyond the control of the transmission grid operator. Definitions in most literature sources assume that distributed generation units are connected to the distribution network. This is also the case for the definition used by IEA (2002), which sees DG as units producing power on a customer site or within local distribution utilities, and supplying power directly to the local distribution network. IEA, however, makes no reference to the generation capacity level as opposed to most other definitions.

Although there are many different definitions of DG, it is generally agreed that DG contains electric generation that takes place at or near the point of use rather than at a central station power plant (Bluestein, 2000). Some other more or less commonly agreed features that characterise DG are the following (Jenkins, et al., 2000):

- DG is not centrally planned[13] and is usually operated by Independent Power Producers (IPP[14]) or consumers.
- DG is not centrally dispatched.
- DG is normally smaller than 50 MW.
- DG is usually connected to the distribution network.[15]

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12 CIGRE is the International Council on Large Electricity Systems (Conseil International des Grands Réseaux Électriques).

13 In liberalised markets central planning does not exist anymore.

14 An IPP is a producer who does not carry out electricity transmission or distribution functions in the territory covered by the system where it is established (Directive 96/92/EC).

15 The distribution system is taken to be those networks to which customers are connected directly and which are typically of voltages from 230/400 V up to 110 kV.

The different definitions suggest that at least the small-scale generation units connected to the distribution grid are to be considered as part of distributed generation. Moreover, generation units installed close to the load or at the customer side of the meter are also commonly identified as distributed generation. This latter criterion partially overlaps with the first, as most of the generation units on customer sites are also connected to the distribution grid. However, it also includes somewhat larger generation units, installed on customer sites, but connected to the transmission grid. In this report, distributed generation is defined as *an electric power generation source that is connected directly to the distribution network or on the customer side of the meter*. This corresponds with the general definition of DG in the Electricity Directive (2003/54/EC): *'distributed generation' means generation plants connected to the distribution system*.

2.2.2 Distinction between DG, CHP, and RES

Cogeneration (or Combined Heat and Power production - CHP) and renewable energy sources (RES) are often considered as DG. However, as is shown in Table 2.1, only a part of CHP and RES can be considered as DG. Renewable energy sources such as large hydropower plants and offshore wind parks with capacities of 100 MW and more that feed electricity into the transmission grid, cannot be considered as distributed generation. Within the SUSTELNET project an attempt has been made to divide categories of RES and CHP in large scale and distributed generation.

Table 2.1 *Characterisation of Distributed Generation*

	Combined Heat and Power (CHP)	Renewable Energy Sources (RES)
Large-scale generation	• Large district heating* • Large industrial CHP*	• Large hydro** • Off-shore wind • Co-firing biomass in coal power plants • Geothermal energy
Distributed Generation (DG)	• Medium district heating • Medium industrial CHP • Commercial CHP • Micro CHP	• Medium and small hydro • On-shore wind • Tidal energy • Biomass and waste incineration/gasification • Solar energy (PV)

* Typically > 50 MW_e — Source: Ten Donkelaar & Scheepers, 2004
** Typically > 10 MW_e

2.2.3 Drivers for the increase of DG

Generally, three policy goals can be distinguished that drive the growth of DG:

1. Reduction of greenhouse gas emissions
2. Use of renewable energy resources
3. Energy efficiency improvement.

In 1997 the Kyoto Protocol was accomplished in which different industrialised countries agreed to decrease the emissions of GHG (greenhouse gasses) between 2008 and 2012 with five percent on average compared to 1990. To this end, the EU has compelled itself to a reduction of GHG emissions of eight percent (compared to 1990, between 2008 and 2012). In order to meet this Kyoto commitment, different measures are taken. Important measures are electricity generation from renewable sources and the use of the high-energy-efficient cogeneration of heat and power.

Member States have established indicative goals for electricity generation from RES. A large part of this consists of DG. To meet this objective, there are two European directives to stimulate the production of renewable energy and CHP: the RES Directive and the CHP Directive respectively.

The European RES Directive (particularly Article 7) states that MS must guarantee the transmission and distribution of renewable electricity. The article gives MS the opportunity to give priority to producers of renewable electricity, e.g. with access to the network. Furthermore, the costs of connecting producers of renewable electricity to the network, may be completely or partly borne by the DSO.

The objective of the European CHP Directive is to establish a transparent common framework in order to promote and facilitate the installation of cogeneration plants where demand for useful heat exists or is anticipated.[16] Relevant issues are:
- Transport and distribution tariffs should not be to the detriment of electricity from CHP.
- Network access must be made easier for electricity that is generated in CHP-units.
- MS should reduce the regulatory and non-regulatory barriers to an increase in cogeneration.
- MS should ensure that the rules are objective, transparent and non-discriminatory.

To realise the indicative ambitions concerning the use of renewable electricity and CHP, MS have implemented national regulation to stimulate RES and DG. This includes various forms of subsidies.

2.2.4 Impact of DG on the electricity market

Strategically sited DG resources can complement the existing electricity infrastructure, relieve network congestion, provide ancillary services and improve reliability. Furthermore, the modularity of DG can offer enhanced flexibility in electricity system planning through the possibility to defer lumpy investments in centralised generation, as well as transmission and distribution upgrades. On the other hand, the integration of DG with intermittent loads, such as wind energy and in some cases combined heat and power[17], may pose additional challenges to system balancing. Additionally, an increased level of DG requires a transition from centralised control and system management by few actors to a control system that allows and co-ordinates decentralised decision making by many actors (Sambeek and Scheepers, 2004). Section 5.2 will discuss the impact of DG on the electricity market in more detail.

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16 http://europa.eu.int/scadplus/leg/en/lvb/l27021.htm.

17 The intermittent character of CHP units follows from their dependency on heat demand.

3. Electricity Market Structure

This chapter will focus on Subquestion 3 (Section 1.2), which aims at describing the electricity market structure. It will give insight in the different interactions between the relevant actors that participate in the electricity market and it makes clear how DG fits into this picture.

3.1 Model of the electricity system

Figure 3.1 through Figure 3.3 present a model of the electricity system and give an overview of the economic transactions. In this report, the financial flows that result from the electricity trade is referred to as the 'commodity transaction', to distinguish it from transactions related to the physical electricity flows. The figures show a theoretical view of the most important actors when they are completely unbundled. This means that all activities in the electricity market (production, transmission, distribution, and supply) are undertaken by different parties. Not only the grid is unbundled from production and supply, but production and supply are mutually separated as well. In this way the different costs and benefits of each activity can easier be identified. In integrated companies, revenue and cost streams between the different activity-based departments are not always explicitly known.[18] The figures include all stakeholders at the distribution and transmission level: the DG operator, the DSO, a separate energy supplier, the large power producer connected to the transmission network, the transmission system operator (TSO), and the final consumer. The remainder of this section will elaborate on the (numbered) transactions in the figures.

In the figures, the physical power streams have been separated from the commodity trade. Following De Vries (2004), the term *electricity system* is used to indicate the combination of the systems that produce, transport and deliver power and provide related services. It includes the actors that trade the commodity or provide trade-related services such as electricity exchanges and brokerage services. In the figures, the electricity system is divided into a physical subsystem, centred around the production, transmission, and distribution of electricity, and a commodity subsystem, in which the commodity is traded. The two subsystems are related but they are not linked one on one. A generator with a constant output may have fluctuating revenues as a result of variations in market price. Both subsystems are constrained by regulations, such as safety limits, construction permits, operating licenses and emission permits for the physical subsystem, and competition law and market rules for the commodity subsystem. It is important to note that in the figures, for simplicity, different actors of the same type (like different DSOs) are aggregated into one presented actor.

In the liberalised electricity market, several relevant parties can be distinguished:[19]

- The *producer* is responsible for generating electricity (large power producers, as well as DG-operators that produce electricity with small scale distributed generation).
- The *transmission system operator* (TSO) is responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long term ability of the system to meet reasonable demands for the transmission of electricity. In this context *transmission* stands for the transport of electricity on the extra high-voltage and high-voltage interconnected system with a view to its delivery to final customers or to distributors, but not including supply[20].

[18] Section 3.2 deals with the implications of integrating different activities.
[19] These parties and their definitions are based on Article 2 of Directive 2003/54/EC.
[20] Extra high-voltage is defined as a voltage level equal to or larger than 220 kV. High voltage is defined as a voltage level smaller than 220 kV but bigger than or equal to 35 kV (Website IPA Energy Consulting).

The TSO is also responsible for providing system services in his control area[21]. System services consist of balancing services (i.e. compensating the difference in the demand and supply, see also Section 3.1.2), reserve capacity (i.e. compensating shortfall in power generating capacity), power quality (e.g. frequency control), reactive power supply and black start. For some of the system services TSOs cooperate with TSOs in other EU MS[22].

- The *distribution system operator* (DSO) is responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area, the connections to the transmission grid and for ensuring the long term ability of the system to meet reasonable demands for the distribution of electricity. In this context *distribution* means the transport of electricity on high-voltage, medium voltage and low voltage distribution systems with a view to its delivery to customers, but not including supply. The DSO is also responsible for system services, e.g. power quality.
- The *supplier* is responsible for the sale of electricity to customers (retail). Producer and supplier can be the same entity but this is not always the case. A supplier can also be a *wholesale customer* or *independent trader* who purchases electricity with the purpose to resell it in the system.
- The *final customer* purchases electricity for its own use and is free to purchase electricity from the supplier of its choice.

3.1.1 The electricity system

Physical subsystem

The physical subsystem consists of the hardware that physically produces and transports electricity to customers, as well as the equipment that uses the electricity. The structure of the physical subsystem is determined by the nature of the components that make up the electricity supply system: the generators (large power producers and DG operators), the transmission network (TSO), the distribution networks (DSOs) and the loads (consumers) (De Vries, 2004). The physical subsystem is depicted in the lower part of Figure 3.1. The large power producers generate electricity that is fed into the transmission grid. Relation 1 represents the (regulated) agreement between the large power producer and the TSO. In compensation of a connection charge (and sometimes also a use of system charge) paid by the power producer, the TSO transports the produced electricity to the DSOs (2), who distribute it to the final consumer. Relation 5 represents the payment of the connection and use of system charges by the consumer to the DSO for the delivery of the electricity and system services. Figure 3.1 shows that electricity generated by DG operators is directly fed into the distribution network based on a (regulated) agreement between the DSO and the DG operators (3). The DG operator pays a connection charge and sometimes also a use of system charge to the DSO for electricity transport and for system services. Most of this electricity is then distributed to the consumer by the DSOs (5), but because of the growing amount of DG capacity, a local situation can occur in which supply exceeds demand. In that case the surplus of electricity is fed upwards into the transmission grid (4), after which the TSO transports it to other distribution networks (2). A last relevant physical stream concerns the auto-production of DG electricity (6). This is the direct consumption of electricity produced on-site by a consumer, skipping the commodity purchase and sale process through the energy supplier. This is in fact a form of integration (Section 3.2).

[21] A control area is a concept that usually coincides with the territory of a country and is operated by a single TSO. In this report, control areas are sometimes referred to as ‘countries’. This may in fact be incorrect: e.g. Germany exists of four control areas, and consequently have as many TSOs.

[22] For example by means of the UCTE.

Commodity subsystem
In contrast with the physical power streams, the economic transactions related to the commodity flow are merely administrative and depicted in the upper part of Figure 3.1.[23] Its goal is an efficient allocation of costs and benefits, within the constraints imposed by the physical system. The commodity subsystem is defined as the actors that are involved in the production, trade or consumption of electricity, in supporting activities or their regulation and their mutual relations (De Vries, 2004). The commodity subsystem controls the physical subsystem, but is constrained by it at as well. Large power producers (7) and some very large DG operators (8) offer the commodity on the wholesale market, where the commodity is traded between different actors. Very large electricity consumers can buy the commodity directly on the wholesale market (13). Next to those consumers, energy suppliers buy commodity in the wholesale market (9) on the basis of wholesale contracts to serve smaller consumers. The trade on the wholesale market provides a payment for the produced electricity. Besides the wholesale market, the energy supplier extracts the commodity directly via (small) DG operators (10). The energy supplier subsequently delivers the commodity from the wholesale market and the DG operators to the consumers (12) who pay for it. Because energy suppliers are often 'long' (which means they have contracted more commodity than they plan to offer to consumers) there is a commodity stream backwards to the wholesale market (11).[24] Therefore, the energy supplier is a third party that offers commodity to the wholesale market.

In the situation that the energy supplier has accurately forecasted the actual amount of electricity that his consumers use, the received payment for the commodity (12) perfectly corresponds to the amount of delivered electricity (5). But deviations from forecasted use or planned generation often occur, and, due to the failing of the mechanism to balance supply and demand on the short-term, they create the need for an additional short-term balancing mechanism.

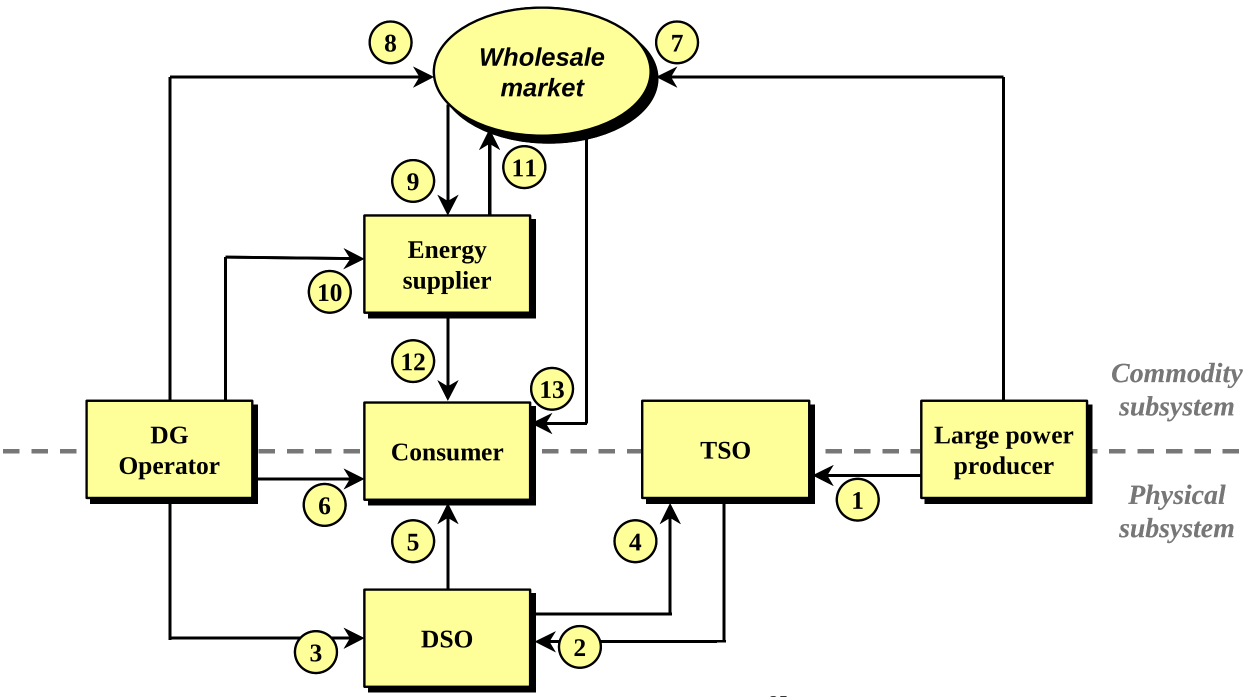

Figure 3.1 *Overview of transactions within the electricity market*[25]

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[23] The auto-production of DG electricity (6), which skips the commodity purchase and sale process via the energy supplier, has no counterpart in the commodity subsystem.

[24] To be sure to have enough commodity available for consumers, energy suppliers often contract more commodity beforehand than they think they will need at actual delivery. As from a day before actual delivery (when energy suppliers have a sound insight in the commodity demand for the next day), they offer their surplus commodity to the wholesale market.

[25] The figure is partly based on Ten Donkelaar and Scheepers (2004).

3.1.2 The electricity system including the balancing market

System operators and contractors have to estimate demand in order to make sure that sufficient supply is available on short (seconds and minutes), medium (hours), and long timescales (days). Because the electricity system is liberalised, the market itself is responsible for matching supply and demand on the long term.[26] As stated before, the electricity supply (output from all generators including import) has to be controlled to be very close to demand. This has to be maintained on the timescale of seconds. Maintaining the short and medium term balance is the responsibility of the system operator, which for this purpose uses forecasts of electricity production and demand that are submitted by market players (energy programs[27]). Deviations between electricity demand and production on the actual moment of execution of the energy programs become visible to the TSO as an exchange of electrical power with neighbouring control areas, different from the agreed international exchange programs (involuntary or unintentional exchange[28]). In this way the TSO has insight in the actual balance of the total system. The TSO monitors and adjusts the collective actions of the full complement of market players at any moment, automatically compensating the imbalance, if any, of the full complement of deviations from forecasts by adjusting generating capacity up and down. If actual demand and supply deviate from the amounts that were contracted by market players, the TSO uses a balancing mechanism to balance the system by producing additional electricity (upward adjustment of production units), making use of demand response (both in case of a shortage) or by adjusting production units downwards (in case of a surplus). For this balancing purpose, TSOs can bilaterally contract balancing power from large power producers (e.g. by annual or monthly contracts). The costs for this balancing can be socialised by means of the system tariffs of the TSO. In that case, all market players pay for the balancing costs. But it is also possible that the TSO uses the forecasts (energy programs) to determine which players are not complying with their forecasts at actual delivery and, consequently, who has to pay for restoring the balance. In that case, the balancing costs are allocated specifically to the players that cause the imbalance. To stimulate market players to make their forecasts of electricity production and demand as accurate as possible and to act in accordance with these energy programs, the price for this balancing power must be above the market price for electricity. This incentive can be artificially introduced by imposing a balancing fine. However, a major drawback of the described balancing mechanism is that the exact balancing price is not univocal[29]. Furthermore, because balancing power is only contracted once a year or once a month the system is not very efficient, as the TSO has contracted balancing power beforehand while during actual deployment there may be cheaper options available.

A more elegant and efficient way of balancing the electricity system is the establishment of a separate balancing market, apart from the wholesale and retail market. In many European control areas the ongoing liberalisation of the energy market has led to the establishment of these separate balancing markets.

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26 Maintenance planning of generating capacity is an example of this long-term responsibility. The very long-term investment in generating capacity is another element of this responsibility which is left to the market. However, it is to be seen if these investments will be sufficient to be able to meet the growing demand on the long term. Currently, generating margins are decreasing. However, although important, the question of security or adequacy of supply is not a part of this report.

27 Each party connected to the electricity grid, generators as well as consumers, is responsible for the supply and demand of electricity according to a beforehand made program. In this report, an energy program is referred to as the deliveries of electrical energy agreed between market players, as reported to the TSO. The responsibility for this program can be transferred between parties (small consumers pass their responsibility on to energy suppliers).

28 An unintentional deviation is the difference between the sum of scheduled electricity exchanges in a given control area and the electricity which has actually been exchanged within a given time interval. Unintentional deviations will be corrected by means of a compensation programme for the supply of electricity to (or the importing of electricity from) the remainder of the system during the following week, in accordance with fixed rules.

29 This is particular the case when the incentives for parties to reduce imbalances is only based on fixed fines.

This market is controlled by the TSO, who is the single buyer on this market. Access to the supply side of the balancing market is mainly limited to the large power producers, but DG operators (in particular large CHP-units) and energy suppliers also have access.[30] Figure 3.2 shows the impact of the balancing market. The transactions that are less common in existing electricity market are shown with dotted lines. As soon as a situation of shortage arises, the TSO corrects this by buying the lowest priced commodity offer in the balancing market (16). Most offers come from the large power producers (14), but sometimes DG operators offer electricity as well (15, CHP units), just as energy suppliers (18). The TSO charges the energy supplier(s) that caused the imbalance (17) on basis of the (relatively high) price that it has paid on the balancing market. In case of a surplus of produced electricity, the TSO accepts and receives the highest bid in the balancing market for adjusting generating units downwards.[31] Also in this case the energy supplier(s) pay the TSO so-called imbalance charges. Handling these imbalance charges is arranged in the energy contracts between all market players, but mostly energy suppliers are responsible for the demand of their contracted consumers and contracted DG-operators. Therefore, the energy supplier has to pay the balancing costs in case there is a deviation of the forecasted use of its consumers or forecasted generation of its contracted DG operators.[32] In case a large power producer does not comply with its contracts, e.g. there is a malfunctioning of a generating facility, it has to pay for the balancing costs itself, as large power producers are responsible for their own energy program. As stated before, to stimulate market players to make their forecasts of electricity production and demand as accurate as possible and to act in accordance with these energy programs, the price for balancing power (imbalance charges) must be above the market price for electricity. Because balancing power is typically provided by units with high marginal costs, this is in practice always automatically the case.

[30] The offers of energy suppliers in the balancing market consist of demand response by their consumers (curtailment or shift of electricity use).

[31] Normally, producers have to pay the TSO (a relatively low price) for adjusting generating units downwards during a surplus in the total system. But it is possible that a negative price for electricity develops, in which case the producer receives money for producing less electricity (adjusting generating units downwards).

[32] An energy supplier takes over the ‘energy program responsibility’ of consumers. This means the responsibility of customers (who are not protected customers or licence holders) to draw up, or have drawn up, energy programs relating to the production, transmission and consumption of electricity, to announce them to the grid administrators and to act in accordance with these energy programs.

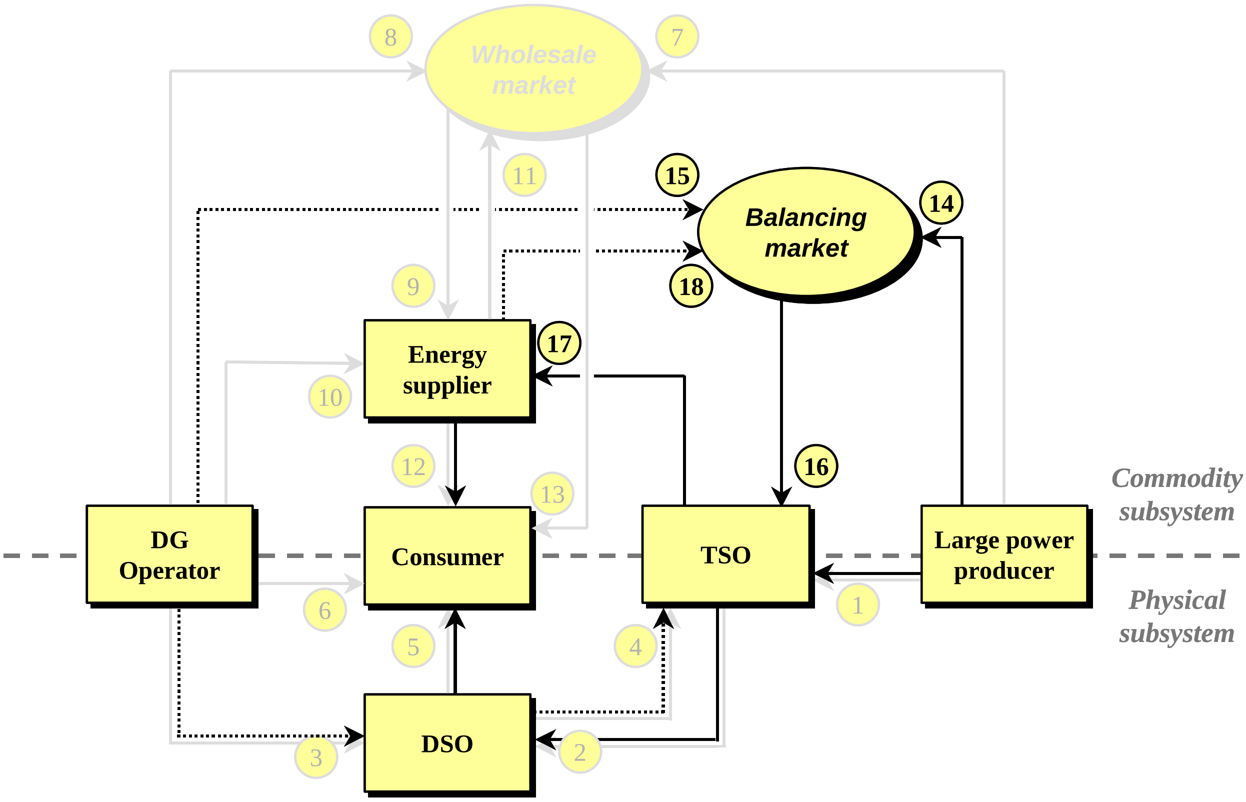

Figure 3.2 *Overview of transactions within the electricity market, including the balancing market*

In conventional electricity systems, (contracted) imports and exports are not used in balancing supply and demand on the short term. Imports are traded on daily, monthly and yearly basis. However, if the imbalance deviates outside the specified standards and the balancing market cannot restore the balance between demand and supply, more drastic measures are required. Most TSOs have an agreement with neighbouring control areas that they will supply electricity in the event of an imminent overload or underload. This situation cannot last for more than 15 minutes, according to rules of UCTE.

3.1.3 The electricity system including the market for ancillary services

Next to the balancing mechanism (and the establishment of a separate balancing market), ancillary services are another relevant issue. Because these services have very different characteristics (as will be discussed later on in this section), it is not a matter of creating a separate ancillary services market. However, in Figure 3.3 the ancillary services are depicted as a separate market. It must not be taken too literal, but it is done to give a well-ordered idea of the place of these services within the electricity system. Figure 3.3 shows the impact of the ancillary services market.

According to the Electricity Directive (2003/54/EC), ancillary services are all services necessary for the operation of a transmission or distribution system. It comprises compensation for energy losses, frequency control (automated, local fast control and coordinated slow control), voltage and flow control (reactive power, active power, and regulation devices), and restoration of supply (black start, temporary island operation). These services are provided by generators (19 and 20) and the system operators (21, 22 and 23) and are required to provide system reliability and power quality (Bopp, 2004). As stated before, there is not one separate market for all ancillary services. An important distinction has to be made between distribution networks and the transmission network.

In general, DG operators can offer (local) ancillary services to the DSO and large power producers (and some large DG operators) can also offer ancillary services to the transmission network (TSO). There often exist local needs of the DSO (e.g. for voltage support or reactive power) that only can be fulfilled locally. Reinforcing or extending the local distribution network can overcome these local needs[33], but deploying DG units in the right way can also be an option to fulfil this local need for specific ancillary services. In this way, DG can be an alternative for investment in network reinforcements. Thus, some ancillary services can be offered by DG operators directly to the DSO (in Figure 3.3 depicted by Relation 20 and 23 through an imaginary ancillary services market). Other ancillary services can also (or only) be offered by large power producers (19). These services are directly needed for the operation of the transmission system (21), e.g. frequency control, or can be useful for the distribution system (22). Table 3.1 gives an overview of which party is able to offer specific ancillary services in the distribution network.

Table 3.1 *Possible suppliers of ancillary services on a distribution level*

Ancillary service	Large power producers[34]	DG operators
Compensation for power losses	+	+
Frequency control	+	–[35]
Voltage support (active power)	–	+
Reactive power	–	+
Black start	+	+
Reserve	+	+

As the majority of existing DG has been installed for electricity supply purposes, very few generators are equipped with the infrastructure necessary to provide ancillary services. But future opportunities for DG to provide ancillary services will increase as DG penetrations and availabilities increase. However, Mutale and Stbrac (2005) suggest that the value of the most feasible ancillary services will be relatively low. Consequently, such services will represent incremental revenue opportunities for DG. Niche opportunities will emerge for DG to provide ancillary services, usually in circumstances where constraints restrict network development, e.g. environmental, planning, and terrain related constraints (Mutale and Stbrac, 2005).

[33] By reinforcing or extending the distribution network, it becomes capable of ‘importing’ ancillary services from the TSO (transmission network). In the past, when DG was a less relevant part of total electricity production, local needs for ancillary services were indeed fulfilled by reinforcing the distribution network.

[34] A minus sign in this column means that the large power producer (or TSO) could, in theory, supply the concerned ancillary service (via Relation 19, 21 and 22 in Figure 3.3), but that the DSO then has to invest considerably in network reinforcements or extensions.

[35] In theory, DG operators can supply the service ‘frequency control’, but it depends on the type of DG and the amount of DG capacity in the concerned distribution network. Currently, most DG operators are not equipped to supply this service (distribution connected CCGT plants already provide this service to TSOs) (Mutale and Strbac, 2005).

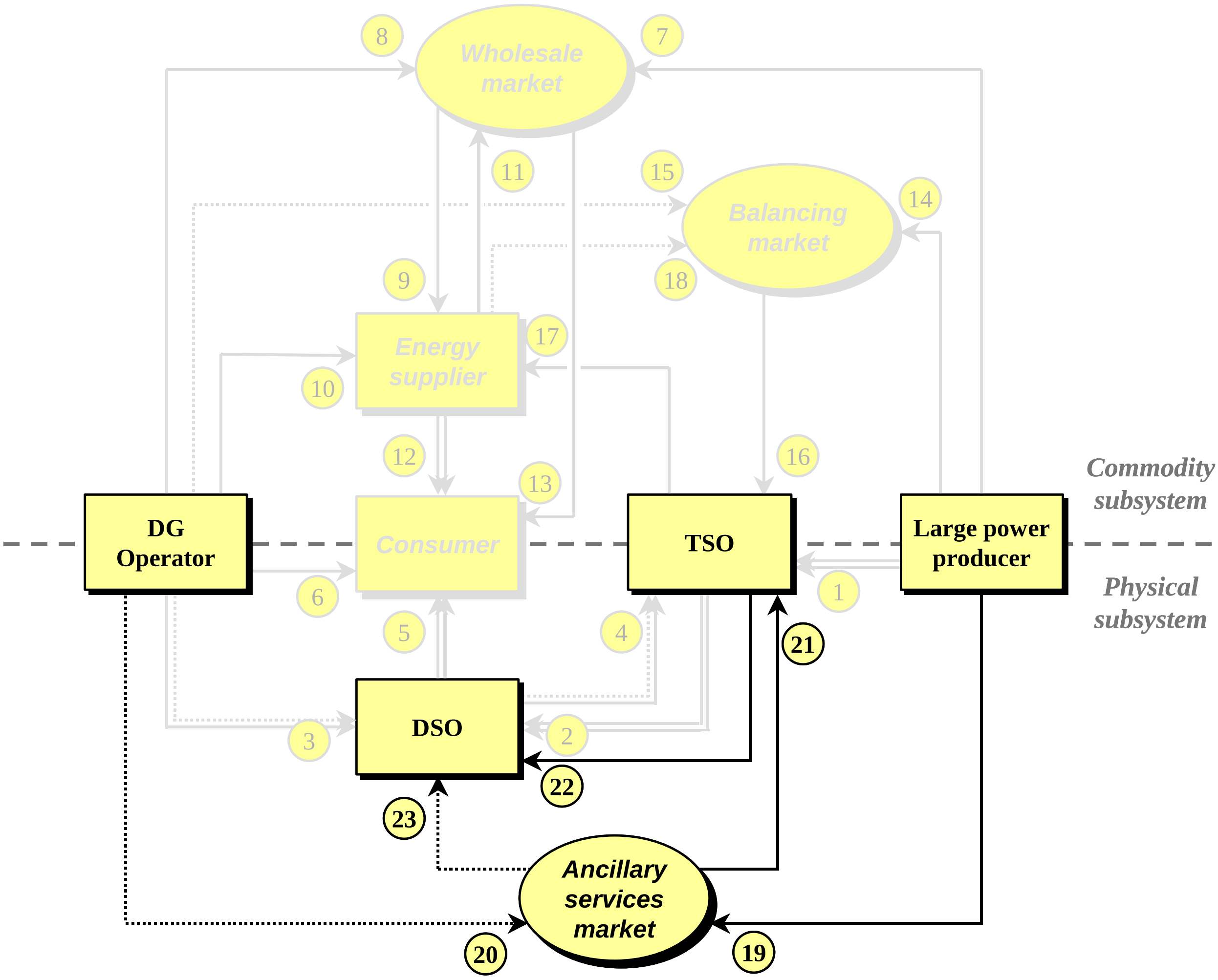

Figure 3.3 *Overview of transactions within the electricity market, including the balancing and the ancillary services market*

In some markets separate metering companies exist. In this analysis it is presumed that this activity is part of the DSO, the actor responsible for the physical power streams. The DSO provides metering data to the energy supplier.

3.2 Vertical integration

In the previous section, the activities in the electricity system (generation, transport and system services, supply, consumption) were all performed by different companies, completely unbundled from each other. In practice, however, activities are often integrated. The degree to which a firm owns its upstream suppliers and its downstream buyers is referred to as vertical integration.[36] Firms have an interest in vertical integration, which can be explained by the value chain theory (see Appendix B). Companies have an interest in vertical integration because of lower transactions costs, improvement of coordination, and reduction of risks.

Vertical integration means matching on upstream and downstream components of the value chain in order to provide an internal hedge. Expansion of activities downstream is referred to as *forward integration*, and expansion upstream is referred to as *backward integration*.

36 Vertical integration means integration within one product column in contrast with horizontal integration, where similar activities (e.g. retail supply) for different products are integrated.

As a result of vertical integration, performance can be improved through synergies within a vertical scope, and market fluctuations at individual steps along the value chain can be balanced more flexible. Objectives and goals that can be achieved by vertical integration are (Hendrickson, 2003):

- strengthen the balance sheet and improve overall financial performance,
- acquire specific assets that build on or reinforce core strengths and activities, and provide opportunity to increase size and presence in selected markets to reduce operating costs,
- optimise the 'spark spread': the difference between fuel costs and the price at which electricity is sold,
- balance the portfolio to reduce the volatility of operating earnings.

Essentially, the ultimate objectives of any prospective merger and acquisition are improved portfolio balance, earnings predictability, and risk hedging by improving scale and locking in margins between value chain segments.

In the coming subsections a number of integration possibilities are briefly discussed. As already mentioned in Section 2.1, transport and distribution (the network) must be legally unbundled from generation and supply. Consequently, in electricity markets integration of production and distribution is not allowed, nor is the integration of supply and distribution. Nevertheless some integration possibilities for network operators will be explored.

3.2.1 Energy supplier - Large power producer

By integrating a large power producer, an energy supplier reduces its dependency on the wholesale market. Owning production units offers long-term certainty about future availability of electricity, independent of the market situation in future times. The energy supplier can hedge itself against price risks. For the short term as well, the integration of a power producer has advantages. Especially in case of small domestic consumers, demand can be very volatile, enlarging the price risks of energy suppliers. A supplier with own production facilities is better capable of following demand in the short term.[37] It makes the supplier less dependent on the wholesale and balancing market. Furthermore, suppliers are able to neutralise variable supply sources, like wind power, preventing the exposure to high balancing costs resulting from the sometimes very expensive balancing market.

For the power producer, the integration with the energy supplier is also interesting. Vertical integration can make sense as a means of protecting upstream investments by acquiring a captive customer base. In this way large power producers can secure their output to avoid the risk of not having customers. Besides, the direct contact with final consumers, through supply and trade activities, is very useful in taking right investment and production decisions. The mix of instruments to achieve optimal returns (type of fuel, type of production units, type of products, type of contracts) becomes more extensive because of the integration of production and supply activities.

3.2.2 Energy supplier - DG operator

For the integration of DG operators with an energy supplier, roughly the same reasons apply as discussed in the previous subsection. The energy supplier can better adapt to short-term changes in demand, and it offers long-term certainty about electricity availability. The energy supplier becomes less dependent on the wholesale market. Difference with integrating a large power producer is the much smaller scale and the sometimes intermittent character of DG, which do not make the given reasons invalid, but certainly less applicable.

[37] If the consumers of the supplier are large users of electricity, risks will be less, because their electricity demand is relatively flat and deviations from general use patterns will usually be smaller.

A specific reason for energy suppliers to integrate CHP has to do with the fact that CHP-units are usually built at the site of the customer to fulfil a heat demand. Even if an energy supplier does not integrate these units into its business, the consumer will build and operate the CHP-unit (because of its heat demand), but skips the commodity purchase and sale process through the energy supplier. The energy supplier consequently looses a customer. For that reason it is wiser to integrate the CHP unit (or make a joint venture), thereby maintaining contact with the end user and keeping open the possibility to make a profit. Point of attention is the fact that CHP-units (and DG units in general) may conflict internally with large-scale production capacity (if the supplier is vertically integrated with a large power producer as well).

Another motive for energy suppliers to integrate DG into their business model is of regulatory nature. Currently there are lots of rules and subsidies that favour DG (because of environmental benefits), making it an attractive and competitive option of producing electricity. But in the long run, striving for a level playing field for DG, this regulatory motive will become less relevant. However, the demand for ‘green’ energy will remain a driver for energy suppliers to integrate DG, propagating a green reputation.

For the DG operator, integration with an energy supplier means the assurance that produced electricity is bought by the energy supplier. Furthermore, its balancing costs decrease significantly. Especially for intermittent sources, that is of great value for a DG operator. For an energy supplier with a considerable amount of integrated generating capacity, the intermittency of a single unit does not make a great difference, while for a DG operator it does.

3.2.3 Consumer - DG operator

The operation of a DG facility by a consumer means the direct consumption of electricity produced on-site by a consumer, skipping the commodity purchase and sale process through the energy supplier (auto-production of DG electricity). The consumer can also save network costs; this, however, depends on the ability to cover all or only part of the electricity consumption by the DG facility. In practice, consumers operate a CHP unit, a wind turbine or PV-panels.

3.2.4 DSO - TSO

Integration of the TSO with DSOs can especially be useful if DG penetration is very high. A lot of DG means a lot of coordination needs between the TSO and DSOs. Integration can diminish coordination problems and costs.

3.2.5 DSO - DG operator

As indicated in Section 3.1.3, DG can contribute to the needs of DSOs. For DSOs, DG can be an alternative for network reinforcements and DG can provide local ancillary services. Although many DG is not really integrated in the electricity system, some DSOs have recognised the potential of DG. However, they are now hindered by the unbundling clause in the new electricity legislation. DSOs are not allowed to invest in and operate DG units, i.e. integrate DG into the DSO business. New configurations are necessary to incorporate DG into the network planning and operations of the distribution networks. If DSOs are able to provide local signals to DG operators in their planning, the DG units may be located at the optimal sites (see also Scheepers, 2004). DSOs and DG operators should make contracts for ancillary services (see Mutale and Strbac, 2005[38]).

[38] The referred report considers the opportunities for DG to contribute to existing TSO ancillary services and investigates the potential for DG to contribute to new DSO services that could develop in the short to medium term. See also Section 3.1.3.

3.2.6 DSO - energy supplier

Before the electricity market was liberalised, the businesses of DSOs and energy suppliers were integrated. A major advantage was the relative simple transactions with consumers and also with DG-operators. Energy supply and network issues could be also be relatively ease optimised. This was not always in the interest of individual consumers and DG-suppliers. As is explained in Section 2.1 the introduction of competition in the electricity market and the regulation of the natural monopoly of the electricity grid required an unbundling of both businesses. The drawback is a more complicated exchange of information between the DSO and energy supplier, e.g. on metering data.

4. Business models of the DSO and the Energy Supplier

To be able to understand the impact of the increasing amount of DG on the businesses of DSOs and energy suppliers, in this chapter the current revenues and expenditures of DSOs and energy suppliers are studied through the use of business models. A business model (also called a business design) is the mechanism by which a business intends to generate revenue and profits.

4.1 Business model of the DSO in the current market

In the Electricity Directive (2003/54/EC), a distribution system operator is defined as:

"(…) *a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long term ability of the system to meet reasonable demands for the distribution of electricity*".

The cost and revenue streams of a DSO are illustrated in Figure 4.1. The main revenues of a DSO are in the form of network charges:

- Use of System (UoS) charges (per unit kWh and/or kW) received from consumers and (in some countries) from power producers (i.e. DG).
- Connection charges from consumers and DG operators.

Connection charges for DG can be based on shallow or deep costs or a mixture of both. Shallow cost charging means that the DG operator only pays for the connection line to the nearest point of connection to the network. Deep costs charging means that the DG operator has to pay the costs for the connection line and for the reinforcements that are necessary for the uptake of the electricity in the network (see also Section 5.4).

The main costs of a DSO exist of:

- Capital expenditures - investments in the network, extension of the grid, reinforcement of existing lines and transformers or investments in other supporting devices.
- Operational expenditures - these include (1) maintenance of the network, (2) use of system (UoS) charges paid to the TSO, (3) electricity to cover energy losses, and (4) ancillary services such as reactive power management and voltage control. Up until now, ancillary services are mainly purchased from the TSO, sometimes included in the TSO's UoS charges, but they may also be purchased from DG operators that are able to provide these services (mainly DG units with controllable production).[39]

The network tariff structure is often based on the cascade principle: consumers pay for the costs of the network level to which they are connected to and the costs of all higher network levels proportionally to the use of these network levels. Therefore, the DSO pays the TSO for the use of the transmission network, based on the power flows towards the distribution network (e.g. the maximum load).

[39] For example: since January 1, 2004, DSOs in the Netherlands have the possibility to purchase ancillary services from third parties, which may be DG producers. See also Section 3.1.3.

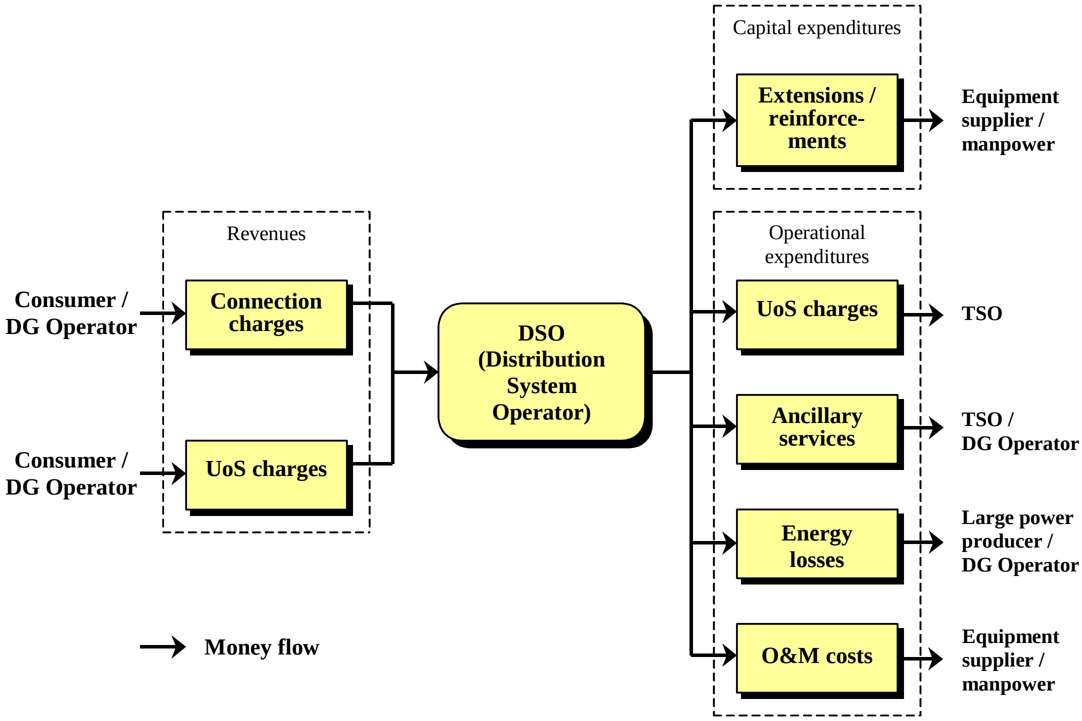

Figure 4.1 *Business model for the DSO*

Note that the current revenues for the DSO are subject to economic regulation and are not market based. The tariffs they are allowed to charge are based on operational and capital expenditures and regulated profitability (see Section 5.3).

4.2 Business model of the energy supplier in the current market

The energy supplier purchases electricity from producers on the wholesale market and sells it to consumers. As the Electricity Directive states: "*supply means the sale, including resale, of electricity to customers*". Figure 4.2 illustrates the costs and revenues of an energy supplier.

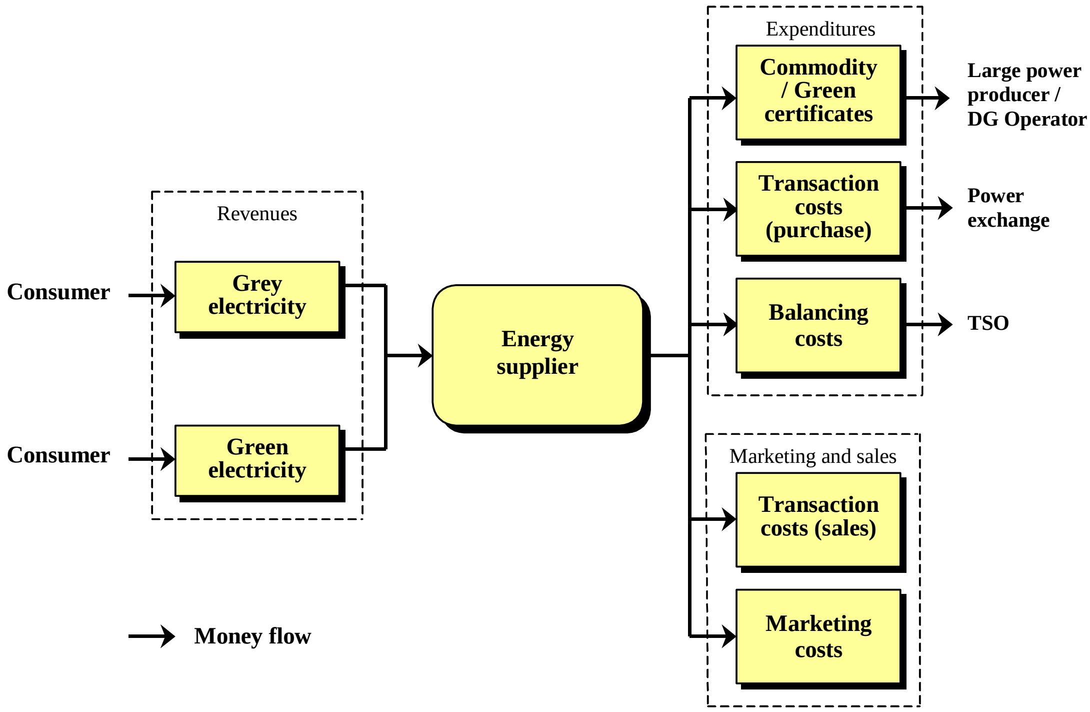

Figure 4.2 *Business model for the Energy Supplier*

As the figure shows, the main revenue stream of the electricity supplier concerns the sales of electricity against retail price, after electricity is purchased at a wholesale price directly from large power producers and DG operators or from the wholesale power market. Energy suppliers may try to increase their income by offering the customers other energy (and non-energy) related services and products. These products can exist of energy advisory services, sale of different technologies, etc. The revenues generated by these services are not presented in the figure, as they are not within the scope of this research. The main costs for the energy supplier, apart from the purchase of electricity from power producers, consist of the balancing costs charged by the TSO. Other costs concern the transaction costs for purchase and sale of electricity, including costs for access to the power exchange.

Other factors influencing the costs and revenues of the electricity supplier are the following:

- In energy markets the energy supplier may be part of a company also owning production capacity (vertical integration; see Section 3.2.1). This means that the energy supplier can optimise power production with supply activities and vice versa.
- The type of power source the supplier purchases is also of influence to the costs. When purchasing from intermittent sources (with fluctuating power output) the energy supplier may face increasing balancing costs to comply with its energy program (agreed supply and demand)[40].
- Green electricity, purchasing green certificates and selling green power.

[40] Energy suppliers that manage the energy program responsibility for (intermittent) DG producers will ask a contribution from the DG producer in the balancing costs. This may be in the form of an adapted (lower) wholesale price of electricity, or a certain payment, depending on the contract between the energy supplier and the DG operator.

5. Threats to current business model of the DSO

5.1 Introduction

Current market developments, in combination with regulatory measures, may affect the business of DSOs. As is discussed in the previous chapter, the revenues of a DSO result from regulated connection charges paid by consumers and DG operators and regulated use of system (UoS) charges paid by consumers (and in some countries by DG operators as well). These revenues result from the transport of electricity over the network that is owned and managed by the DSO. However, the increasing amount of DG could reduce this source of income. Because DG units generally are located closer to demand than central generation, less transport is needed to deliver the produced electricity to the customer. Revenues may even totally vanish for the direct consumption of electricity produced on-site by a consumer (when DG is used for auto-production), in particular if small consumers start generating electricity, because charges are based on kWh for them.[41] Next to decreasing revenues in the business model of DSOs, the increasing penetration of DG into the electricity system may lead to increasing costs. The distribution networks were originally not meant to connect power generation facilities (DG). As a result of the increasing penetration of DG into the distributed network, the DSO faces potential technical challenges, which may require engineering and design changes to the system, and a more holistic approach to system management. Section 5.2 will elaborate on this potentially threatening impact of the increasing penetration of DG. Section 5.3 will discuss the impact of regulatory incentives on the network business. Section 5.4 will deal with the problem of connection charges that may only partially cover the total costs of connecting DG to the network, and Section 5.5 discusses the boundaries that unbundling imposes to the DSOs. Section 5.6 describes possible behavioural strategies of DSOs to deal with the discussed threats, and Section 5.7 summarises the conclusions of Chapter 5.

5.2 The increasing penetration of DG

The increasing share of distributed generation influences the arrangement of the power system.[42] Because of the growing amount of DG feeding electricity into the downstream network, the original utilisation of the distribution network changes. In the past, the distribution network was mainly used to pass on electricity to the consumers (consumption of electricity), but nowadays the distribution network is more and more also used to feed in electricity (production). Sometimes, production even exceeds local demand[43], which implies that electricity has to be fed in the opposite direction into the (transmission) grid. DG facilities are mostly connected to the distribution network at low voltage levels. But these sites were originally not meant to connect power generation facilities. This new situation can create several problems for the distribution networks in terms of stability and power quality. Especially when large amounts of DG are connected at locations with little local load, this will increase the burden on the distribution lines. If DG supply exceeds the local electricity demand, network capacities have to be increased, in order to transport the electricity to other demand areas via higher voltage grids.

The majority of new DG and renewable energy plants being connected to the distribution network in Europe at present is powered by wind or in the form of CHP. A major problem with these units is that they are operated independently of (local) electricity demand.

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[41] An opposite process, which can veil this development, is the growing demand for electricity. Furthermore, not all DG leads to less transport. For example wind power in rural areas (with low demand) can result in increasing transports.

[42] This section is based on Ten Donkelaar and Scheepers (2004).

[43] A good example is the case of wind energy in rural areas.

The intermittency of wind energy increases the burden on distribution lines. And although CHP units can, in principle, be centrally dispatched, they tend to be operated in response to the requirements of the heat load or the electrical load of the host installation rather than the needs of the public electricity demand. Therefore, the distribution network must be capable of functioning in the extreme situation that there is no local DG production while demand is peaking as well as in the reverse situation when there is full DG production but little (local) electricity demand. The more DG is connected to a particular distribution network, the greater the challenge. The emergence of micro power units or other small-scale DG[44], which may be located in dwellings or small businesses, and connected to the distribution network via the metering system, could take the trend for lower voltage connection even a step further. The network constraints of DG can be solved to a certain extend when the capacity of the (distribution) network is reinforced. However, from an economic point of view this is not always attractive as it may concern large, long-term investments. Given the increased use of technologies such as fuel cells, micro-CHP, wind turbines, and PV cells, ways to effectively integrate them into the electricity networks have to be found, preventing considerable impacts and costs of (distribution) network upgrades.

However, apart from a number of constraints, distributed generation can also bring several advantages to the electricity network. For example, DG can reduce transmission and distribution losses by reducing the electricity flow from the transmission system through the transformers and conductors to the distribution system.[45] This largely depends, however, on the location of a specific DG facility. If a small, distributed generator is located close to a large load, then the network losses will be reduced as both real and reactive power can be supplied to the load from the adjacent generator. Conversely, if a large distributed generator is located far away from network loads, then it is likely to increase losses on the distribution system. Another possible network benefit is distribution capacity cost deferral. The development of small-scale DG facilities near a load can postpone necessary investments in additional distribution and transmission capacity. Network operators can benefit from new DG facilities as they can reduce their investment costs in upgrading or extending the distribution network. Moreover, certain types of DG also have the ability to offer certain network ancillary services to the network operator, such as reactive power support and voltage control, which improve power quality.

Several technical experts have addressed the issue of growing DG levels in existing distribution networks (e.g. Nielsen, 2002; Strbac and Jenkins, 2001). They argue that if the penetration level of distributed generation continues to grow while the distribution grid remains unchanged, a chain of technical conflicts may develop, unless such issues as operation, control, and stability of distribution networks with DG installations are properly addressed. There are several aspects that need to be fully understood in order to obtain maximum benefits from both DG and the power grid, mainly:

- The distribution network and DG are interacting and actively affecting each other.
- No generic conclusion can be drawn regarding the influence of DG on the grid, as various power sources have quite different characteristics. Instead, individual cases have to be treated separately.
- Both DG and the grid should be studied as one integrated, flexible, dynamic and complex structure, for to a great extend they do have a major impact on operation, control, and stability of each other.

[44] The most common categories of small-scale DG are micro CHP, photovoltaic, micro-wind, micro-hydro and fuel cells. See, for the case of domestic CHP in the UK, Forrest and Wallace (2003).

[45] This is a development with an opposite result compared to the one discussed in Section 5.1: Less transport results in less revenues.

5.3 Regulatory incentives

As is already stated in Section 2.1, regulation of the grid is necessary to protect consumers and to guarantee access to the grid, because transport is a natural monopoly.[46] If the grid owners do have interests in other elements of the electricity system, e.g. in production and/or supply activities, they might abuse their monopolistic power to favour these interests and to raise entry barriers on the grid. Trade interests and the working of the electricity grids must be completely unbundled to make it possible to create a level playing field, to guarantee access to the grid, and to avoid distortion of competition, discrimination and cross subsidisation.

In the production and supply sectors of the electricity market, the market itself engenders competition (if the market works well enough). But transport is a natural monopoly where competition, as an incentive to become more efficient, is lacking. To simulate competition (and to stimulate economic efficiency) in a market with the character of a natural monopoly, artificial efficiency incentives can be introduced.[47] These efficiency incentives encourage companies to look for efficiency gains in order to improve profits.

Incentive regulation can be aimed at prices (price cap regulation) or at rates of return.[48] With rate of return regulation, prices are determined in such a way that the regulated DSO can just earn its costs including a return on invested capital that is in conformance with the market. Does the rate of return afterwards appear to be higher than the determined amount, prices will be lowered. If the return appears to be lower than is allowed, the DSO can be compensated, e.g. by a price increase. A shortcoming of rate of return regulation is the lack of an incentive to improve the economic efficiency. Cost changes will, after all, be transferred to consumers and will not lead to changes in profits.

Price cap regulation in its pure form neglects the internal cost structure and assets valuation of DSOs completely, and aims at the simply perceptible tariffs. These tariffs can be corrected each year for the inflation (RPI, the retail price index), but must yearly decrease in real terms with a fixed percentage x. This x is the efficiency improvement that is considered to be achievable by the DSO. The x must be determined in advance for a period of several years. If the companies spend less than they are allowed, they are able to make a higher return during the price control period. Conversely, if companies spend more they make a lower return. This is very demanding and intrusive regulation. The regulator can never really know as much as the regulated company, yet has the final say in the setting of allowable spending. The knowledge asymmetry between DSOs and regulators is solved by use of a benchmark or a yardstick approach. The regulator can benchmark the cost development of regulated DSOs and use the best performing DSO(s) as indicator of the efficiency frontier. The regulator uses this indicator for establishing the efficiency improvement factor x. In a benchmarking system it is important that DSOs are mutually resembling or that they are compensated for possible differences (Weyman-Jones, 1995). With yardstick competition, the criterion for efficiency is the average cost development of all other DSOs. The yardstick approach acknowledges structural differences between DSOs that, for example, arise from geographical differences.

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46 Regulation is not the focus of this report, but it has to be mentioned, because in the evolution of the electricity system it seems not to be an external driver but an external brake. In many countries, regulation has fixed the existing structure of the power industry as if that is the only possible structure. And it has done so in such a manner that innovations are very strongly disincentivised (Van Overbeeke and Roberts, 2002). The opposite is needed if DG is to become a mature power source.

47 This section is based on earlier research, mainly performed in the SUSTELNET program, e.g. Connor and Mitchell (2002a) and NYFER (2001).

48 In their original form, the two regulation models differ quite much. Newbery (1999) summarises the distinction concisely: '*Rate-of-return regulation evolved (…) in the United States to provide procedural fairness in the allocation of rents accruing to franchise monopoly investor-owned utilities, but it has been criticized for its inefficiency. Price regulation was designed in the United Kingdom to create an efficient system of regulation (…) but it has been criticized for its lack of fairness.*'

In both the benchmark and yardstick approach the efficiency objective is not determined by the regulator, but, just as in a market environment, by the DSOs themselves. At the same time, the efficiency incentive is maximal: the objective for a DSO is independent of its own cost development and all additional cost savings are for its own account. Companies that do better than the sector's average will receive extra benefits. Conversely, DSOs that do worse than average will see their revenues reduced. Shortcoming is that the system is vulnerable for collective manipulation of the observed performance of DSOs. From the point of view of a DSO economic incentive regulation can be seen as a threat since it can reduce the DSO's revenue. Measuring economic efficiency development and adjusting the efficiency factor each couple of years implies that extra returns companies can achieve by performing better than the sector's average will, after a while, be passed on to the consumers. The impacts can be detrimental in the way that they, broadly, incentivise doing the same things more efficiently but not stimulate DSOs to look for better alternatives. This is anti-innovative and unhelpful to distributed generation as it hinders a structural change of planning and management of the networks, which is very much about doing new things and dealing with new technologies and concepts (Connor and Mitchell, 2002a).

If only economic efficiency regulation applies, it may have a negative effect on the (technical) performance of DSOs because cost reduction leads to additional profits. DSOs have an incentive to invest little and to cut back operational costs of maintenance and personnel, as long as loss of power quality and reliability does not harm consumers too much. The effect of economic efficiency regulation appears to be the locking of DSOs into focusing on trying to do the same things, but with greater efficiency and reduced costs, which results in a reduction of innovation potential. DSOs are encouraged to minimise capital costs, which is the same as avoiding network investments, and that raises the problem of the quality of the system. Firms under this regulatory framework are discouraged to invest.

In order to ensure that the efficiency improvements are not made at the expense of the reliability of the network, quality regulation can be included.[49] Performance based regulation (PBR) is a way to combine the benefits of benchmarking whilst combating the detrimental approach to innovation of RPI-*x* and benchmarking (Connor and Mitchell, 2002a). Under this system, tariffs will also be determined based on the DSO's performance. If the DSO performs better, it is rewarded by being allowed to charge higher tariffs, but when performance is poor, the DSO will be penalised by lowering its tariffs.[50] The regulator can, for example, make a distinction between three dimensions of quality: reliability, power quality, and commercial quality. Reliability relates to the degree to which buyers can be supplied without interruption. Power quality is a term that refers to keeping the voltage between certain limits and avoiding disturbance of the ideal sinusoidal curve of alternating currents. The DSO also maintains a commercial relationship with its customer. This relates to the contact that takes place between a network company and a consumer.

5.4 Connection charges for DG

Revenues for DSOs comprise connection charges and use of system (UoS) charges. UoS charges are regulated as discussed in the previous section and are related to transporting the electricity through the network. Connection charges are regulated as well (they are not market based) and incorporate a charge with respect to capital assets. From the perspective of the DSO, a new power plant will affect the cost of operating and maintaining the network. This cost can, either partially or wholly, be paid for in the connection charge or in the use of system charge. Policies for connection charging for DG can be split into two groups: those with deep connection charges and those with shallow connection charges. Deep connection charges comprise all the costs to the network resulting from the power plant connecting.

[49] Based on Wals et al. (2003) and Wals and Hendriks (2004).
[50] The regulator decides the weight of the performance incentive relative to economic efficiency.

Shallow connection charges only comprise the costs of connecting to the nearest point and none of the costs that occur within the network. Especially if, in a specific region, there is already a lot of DG attached to the distribution network, (deep) connection costs can become very high. The network has to be reinforced considerably to be able to handle the corresponding electricity flows. If the regulation prescribes the use of shallow connection charges, DSOs can only partially recoup these connection costs from the DG operators. The DSOs may experience difficulties to pass on the uncovered reinforcement costs to consumers because of the efficiency incentive regulation. Therefore, in these circumstances DSOs will consider DG as a threat to the network business.

5.5 Unbundling

DG can contribute to reducing network costs, if located at the right place (near local demand). In the short term DG can only reduce operational expenditures, e.g. line loss reduction. In the longer term DG may contribute to a further reduction of operational expenditures (e.g. DSOs purchasing ancillary services from DG locally) and also reducing capital expenditures (e.g. avoiding reinforcements). However, DSOs are not allowed to own production capacity, even though it is used as substitute for line losses, for network reinforcements or extensions, or for ancillary services. In this way, unbundling forms a hard boundary condition that forbids the DSO to extend its business model in the described way. This could be overcome by the DSO by giving (financial) incentives to urge DG operators to settle in the right place and/or to control the DG units in response of needs of the electricity system. Economic benefits are then shared between the DSO and DG operators. However the contracts with DG operators do not solve network problems in the same way as network reinforcements. The lifetime of DG units is shorter than that of the network. Furthermore, the DG operator may suddenly decide to stop operations, e.g. for economic reasons.[51]

5.6 Behavioural strategies of DSOs

Depending on the experience that has been gained in the electricity market, the introduction of competition and the accompanying regulation has led to different behavioural strategies of actors in the electricity market. Roughly, there can be distinguished three theoretical stages in the adaptation process of DSOs. First, the new market structure and regulation lead to a *stabilisation strategy*. The introduced regulation is new to the whole electricity sector and every actor has to gain experience with the specific consequences of it. Stabilisation means reducing uncertainty, and that is the first aimed objective. It is not before the sector has insight in the new structure and, in the scope of the subject, becomes aware of the unstoppable and rapid development of DG, that DSOs enter a next stage: a *defensive strategy*. In this stage it is clear for the DSO what (negative) consequences different developments and regulation can have on its business. The DSO is going to work against the regulator and against potentially negative developments, like the growing amount of DG. DSOs incorporate the regulation into their business in the best possible way, thereby minimising the exposure to it, but offering resistance to the regulation process wherever regulation leads to diminishing profits. They are obstructive to every change that influences their business model. This strategy is of course very negative for the development of DG. The last (and obviously most desirable) stage is the *entrepreneurial strategy*. In this phase, the strategy changes from fighting against the regulator to thinking along with it, in order to influence the results in a positive way instead of contesting them. It is an active strategy in which the DSO puts forward alternatives for regulation, instead of defensively fighting it. DSOs cooperate with regulators in the development of new regulatory strategies and they develop new activities that can diversify their business model.

[51] Gas fired CHP is vulnerable to rising gas prices, whereas, the economy of RES depends very much on the continuation of support schemes.

For the greater part, DSOs currently act corresponding to the stabilisation and defensive strategy. Some developments are being experienced as threats to the DSO's business model, whereas they should rather be seen as a challenge, or at least as a fixed boundary condition that should not be fought against. As already mentioned in the previous chapter, a business model is the mechanism by which a business intends to generate revenues and profits. The 'threats', which can be of regulatory as well as of institutional nature, potentially harm the revenues or increase the costs of a DSO. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can bent this negative attitude into a cooperative and innovative strategy (the entrepreneurial strategy stage) trying to use the developments, formerly seen as threats, in their advantage.[52] This will be elaborated in Chapter 6.

5.7 Conclusions

To avoid undue extraction of monopoly rents, regulation has focused on separating network management from generation and consumption interests and on improving the economic efficiency of network management through revenue and price controls. The regulatory framework provides an incentive to DSOs to become more efficient, resulting in lower future network tariffs, i.e. reducing the future revenues and expenditures of DSOs. This regulation has left DSOs to focus almost entirely on cutting cost and leaves them little flexibility to create value and revenues through innovative investment, operations and services. Price caps and benchmarking, while contribution to the regulator's objectives, tend to act in an anti-innovative manner. DG may have several values that can be advantageous or disadvantageous to DSOs, but the current regulatory framework does not have an incentive for the DSO to incorporate these values in its business model (Van Sambeek and Scheepers, 2004). Furthermore, the use of shallow connection charges can be very unfavourable for DSOs if reinforcement costs cannot be passed on to consumers.

Currently, most DSOs are trying to gain experience with regulation, focusing on reducing uncertainty and behaving rather defensively. Some developments are being experienced as threats to the DSO's business model, whereas they should rather be seen as a challenge, or at least as fixed boundary conditions that should not be fought against. There is a need for a turn in the thinking of DSOs. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can bent the negative attitude into a cooperative and innovative strategy (the entrepreneurial strategy stage) trying to use the developments, formerly seen as threats, in their advantage. This will be the subject of the next chapter. In order to facilitate the integration of DG, DSOs should make a transition to 'active' management of their networks.

However, regulation is important, as it can restrict the DSO's freedom of action. Following the SUSTELNET results, it should be noted that regulation needs to evolve such that it allows DSOs to have access to a wider range of options and incentives available in choosing the most efficient ways to run their businesses. Electricity systems are changing rapidly. New technologies are developing; it is unclear how networks may develop. It is vital that economic regulation does not determine technological outcome. Thus, apart from the need for a changing attitude of the DSOs, regulation needs to be able to work with uncertainty and be flexible to change as well (Connor and Mitchell, 2002b).

Due to the natural monopoly character, the profit DSOs can make is caped by regulatory enactments. There often is an economic efficiency incentive to simulate competition, but that reduces the margin even more.

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52 The development of new business activities is subject of Chapter 6.

The regulatory framework provides an incentive to DSOs to become more efficient, resulting in lower future network tariffs, i.e. reducing the future revenues and expenditures of DSOs. The business size of DSOs threatens to shrink. Therefore, DSOs have to change their business focus in order to keep their business lucrative. Transportation of electricity must not be the only revenue source. There are other activities that create value, and that, at the same time, make DSOs less vulnerable and dependent of one revenue source. By developing new business activities, thereby diversifying the business model, and by changing networks into active networks, DSOs can overcome the decreasing transport revenues. But regulation is important, as it can restrict the DSOs' freedom of action.

6. New Business models of the Energy Supplier and the DSO

6.1 Introduction

The increasing penetration of DG creates new business opportunities in the competitive market environment for energy suppliers and forces the DSOs to reconsider their approach to network design and management. If the future electricity system is to accommodate the expected growth of DG, a DSO needs to change from a design standpoint as well as from a management and commercial perspective. In countries with a large share of DG connected to the distribution network, such as Denmark and the Netherlands, it is already recognised that distribution networks can no longer be treated as passive appendages to the transmission network, but that the whole network must be operated as a closely integrated unit. DSOs should become 'active'. Section 6.3 will discuss the implication of this notion and the opportunities that may arise of it. But the following section will first describe the situation for energy suppliers.

6.2 New revenue drivers for the Energy Supplier

For energy suppliers, the development of new business strategies and new revenue drivers is a more 'natural' process than for DSOs. Unlike DSOs, suppliers act in a market that is exposed to competition and that is not restricted by regulation. At least in theory, the dynamic working of this competitive market forces market players to continuously develop new revenue drivers and to display a certain degree of innovation. It gives incentives to improve margins and respond to market challenges. Only market rules (e.g. balancing market, power exchange) may be experienced as boundary conditions to the energy supplier's business. The increase of electricity supply from DG is an opportunity for energy suppliers to extend and improve its business. Whether an energy supplier is interested may depend on its market position. Historical or new ties to large power generation could create a conflict of interest. However, if an energy supplier is neglecting an interesting opportunity, it may be sure that in a competitive market a rival or new entrant will start to develop the opportunity.

A new business concept for energy suppliers related to the growing penetration of DG is, for example, the operation of a large number of small electricity generators as if it is a large power plant. This concept is referred to as a virtual power plant.

In the Virtual Power Plant concept (VPP), the energy supplier may act as an aggregator of small electricity producers. The VPP uses the billing system of the energy supplier to aggregate the electrical output of e.g. hundreds of small, high efficiency, distributed generators located behind the retail electricity meter in commercial buildings. In this way they appear to the outside as one Virtual Power Plant, rather than as hundreds of individual appliances. A problem that DG faces is the resistance of the DSO (which has legitimate safety, lost revenue, and power quality issues, as discussed in Section 5.2). A possible solution is, therefore, to develop an approach that integrates DG and Demand Side Management (DSM) that provides profit for the supplier, a turnkey application for the host, and economic returns for the DSO. By aggregating the electrical output of many individual DG installations, the production of these facilities, owned by one developer (the supplier), can be treated as one generator. DG offers a range of possible benefits[53] that, in the case of individual DG installations, may be too small to justify the transaction costs required to capture them.

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[53] Including enhanced system reliability, emissions reductions through both increases in energy efficiency and the displacement of coal generated electricity, avoided transmission line losses and costs, congestion relief in the transmission system, and avoided infrastructure investments; see also Section 5.2.

Aggregation of the DG premiums from hundreds of generators can potentially create a viable, tradable commodity when placed in the hands of an energy supplier. VPPs provide a new revenue opportunity (DG aggregation and settlements services) that permits the supplier to increase it's net income even as the supplier's purchases from the wholesale electricity market decline due to increases in energy efficiency and the deployment of DG. The heart of the VPP is the capability to meter the output of the small generators (in a time sensitive fashion), aggregate these outputs, and perform the necessary financial settlements. In this process, cooperation of DSOs is essential.

6.3 New business opportunities for the DSO

In conventional electricity systems, distribution networks are designed to facilitate a unidirectional power flow from high voltage transformers to the final consumer. The network morphology has a radial or loop design, which results in little redundancy and thus potentially higher sensitivity for system faults (compared to the transmission networks that have high redundancy and thus higher reliability[54]). Typically there are only very limited metering or control devices that allow influencing the use of the networks or the flow of energy. Because of this lack of active control mechanisms, these systems are sometimes attributed as 'passive networks' (Künneke, 2003; Beddoes and Collinson, 2001). An 'active' DSO provides market access to DG by acting as a market facilitator and it provides several network and ancillary services through intelligent management of the network. This includes the incorporation of advanced information exchange between generation and consumption, the provision of ancillary services at the distributed level, management of the network to provide network reliability and controllability, and improve customer benefits and cost-effectiveness. Currently such services are partly provided at the centralised level by TSOs (Van Sambeek and Scheepers, 2004). According to Akkermans and Gordijn (2004), with active management of distribution networks, the amount of DG that can be connected to existing distribution networks can be increased by a factor of three to five without requiring network reinforcement.

In the active networks vision, the principles of network management differ from the classical view of networks, being only one-way lanes for electricity transport from high-voltage to low-voltage grids. Two fundamental messages mark the transition from the present to the future system. First, the network is not, and must not be considered as a power supply system anymore. The network is a highway system that provides connectivity between points of supply and consumption. Secondly, an active network interacts with its customers. The 'infinite network' as customers used to know it, no longer exists. The network interacts with its customers and is affected by whatever loads and generators are doing (Van Overbeeke and Roberts, 2002).

The transition from passive to active network management may be accompanied by developing new services for the electricity market, creating new revenue drivers for the DSO. Figure 6.1 illustrates adaptations of the business model of DSOs with some examples of new activities (Donkelaar and Scheepers, 2004):

- *Additional reliability*. Not all consumers will have the same reliability requirements for the electricity network. DSOs can offer additional reliability to consumers with high requirements (e.g. companies in the ICT sector).

[54] Transmission networks connect generation devices, balance load differences, enable a bi-directional flow of energy, safeguard the overall system stability and power quality, and allow for various monitoring and control activities. In Europe, transmission networks have a morphology as meshed design, which adds additional redundancy to the system and thus improves its reliability.

- *System information*. With active network management, a DSO will have detailed information on the status of network components, generators connected to the network, and flows through the network. This information can be shared with DG operators and energy suppliers who can operate their DG units and electricity demand (i.e. demand response) in a more efficient manner. DG operators or energy suppliers will pay for this information, but this may be reversed in case the DSO profits.
- *Local balancing services*. To avoid network congestions, local balancing can reduce transportation of electricity to higher voltage levels. Local balancing can also be used to enhance (local) demand response in case of relatively large uncontrollable DG supply. Based on their ICT systems for active network management and automatic meter reading, DSOs can develop these services. The beneficiaries (energy supplier, TSO) will compensate the DSO for this.
- *Storage*. Electricity storage can help to reduce load fluctuations, but can also be attractive for price arbitrage over time. DSOs can operate a storage facility and offer storage to energy suppliers or DG-operators.

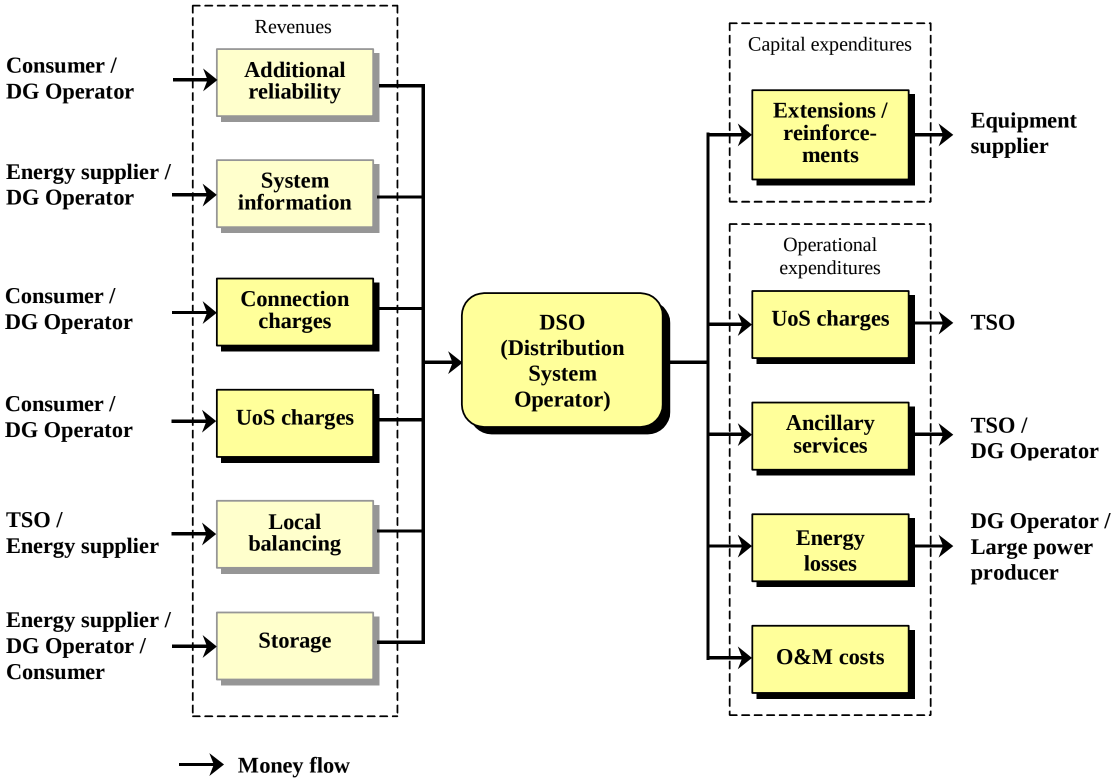

Figure 6.1 *Adapted business model for the DSO*

6.4 Will DSOs change their business?

Because DSOs are operating in a regulated environment instead of in a competitive market, the thesis that competition leads to innovation does not hold for DSOs. For this reason, the development of new business strategies is much harder for DSOs than it is for energy suppliers. There is little incentive coming from the regulated market itself; regulation may even have a contradictory effect, as is discussed in Chapter 5. Paradoxically, it is regulation that should simulate a competitive market environment. It should provide incentives to DSOs to change their passive behaviour into an active and entrepreneurial attitude. Regulation should at the least not be a hindering factor in this process. Next to inadequate regulation that slow down innovation, another barrier to the development of active DSOs can be an insufficient unbundling of the DSO with its parent company.

Legal unbundling may not be drastic enough to let the DSOs act completely independent, thereby inhibiting them to become active entrepreneurs. Ownership unbundling must then be considered as a logical and necessary step in reaching the desired situation. If above-mentioned reasons prevent DSOs from changing their business strategy into an active one, it might even be necessary to start a transition to active network management performed by the (central or local) government. This would imply a backward step in the liberalisation process, but might be unavoidable for the growing penetration of DG to be smoothly integrated into the electricity network, in case the DSOs experience insufficient incentives to change their passive attitude into active behaviour. But this must be seen as a last remedy. Coercion by the regulator is not the best way to get DSO co-operation in the development of DG. If DG has good potential, there should be enough gravy to buy the enthusiastic participation of DSOs.

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Appendix A The level playing field concept

A.1 Definition of a level playing field

As with the definition of DG, it is difficult to provide an exact definition of a level playing field as well. The Longman Dictionary of Contemporary English (1995 edition) provides the following definition: "*A situation in which different companies, countries, etc. can all compete fairly with each other because no one has special advantages*." In line with this definition, there is an unlevel playing field if some firms have special advantages. Despite the definition, economists, lobbyists and policymakers seem to interpret the concept 'level playing field' in conflicting ways. The definition in the dictionary lacks precision about what is meant by 'fairly' and 'special advantages'. Economic literature does not provide a more precise definition either. According to Aalbers et al. (1999), there is a level playing field if all parties pay for the costs that are caused by themselves. The thought behind this is that in a free market, actors must have equal (starting) chances. The market itself determines who remains active and who has to leave the market. If market parties indeed only pay for the costs they cause themselves, this will, in term, additionally lead to minimisation of social costs (Aalbers et al., 1999).

The remainder of this section tries to specify the concept 'level playing field', based on Appelman et al. (2003). Appelman et al. distinguish two common specifications of the concept level playing field:

- Rules-based level playing field: the rules are the same for all firms. The word 'rules' refers to all types of government policy, such as legislation, taxes, and subsidies. There is a rules-based level playing field if rules are symmetric: equal non-discriminating rules apply to all (different) firms in a market. That is: two firms in equal circumstances are treated equally.
- Outcome-based level playing field: all firms have the same expected profit. Firms have an outcome-based level playing field if they have equal characteristics (for example in cost efficiency and strategic options) and the rules are symmetric. In case firms are heterogeneous, the government can create an outcome-based level playing field by compensating the disadvantaged firm (for instance with subsidies).

Appelman et al. conclude that a rules-based level playing field is desirable, although there are reasons to deviate from this assumption. Starting point for analysing a level playing field issue is that a rules-based level playing field generally enhances welfare. The idea is that the government creates equal conditions for all firms and that market forces do the rest. The government does not need to benefit disadvantaged firms, for example with subsidies, in cases that competition leads to an optimal allocation of resources.

A second conclusion of Appelman et al. is that it is never desirable to pursue a fully outcome-based level playing field, but that it may be desirable to level the playing field to a certain extent in the case of market failure. In case of market failure it is preferable to use symmetric rules (equal for all firms), instead of asymmetric rules (favouring some firms).

A.2 The absence of a level playing field for DG

Concentrating on DG, there is general agreement that a level playing field entails markets and regulation that provide neutral incentives to centralised versus distributed generation (Scheepers and Wals, 2003). All parties must have equal competition conditions. The principle to pay for the costs you cause (mentioned in the previous section) requires that all the values of DG are recognised and that appropriate mechanisms are set up to put a monetary value to these values.

Furthermore, incentives should be provided to network operators, energy suppliers, and generators to exploit these values in the best possible way. Despite the economic benefits that are often attributed to DG, these benefits have not formed a significant driver for the increase of DG. This can be explained by the fact that in general there is no level playing field between centralised and distributed generation, because the economic values of DG are often hardly recognised in markets and regulation. A complication in establishing a level playing field is that the values of DG are often ambiguous (they can be positive or negative) and difficult to measure and to monitarise.

It is recognised that the provision of non-discriminatory incentives and proper valuation of benefits and cost associated with distributed and centralised generation alone may not result in a level playing field in the long run (Van Sambeek and Scheepers, 2004, p.8). This is because existing path dependencies in the electricity infrastructure may create a certain degree of bias towards centralised generation. For example, the DSOs may not be equipped to integrate DG or the transmission and distribution network may not be suitable to absorb a large amount of DG. As Van Sambeek and Scheepers state, it may therefore be granted to temporarily tilt the playing field slightly in favour of DG to overcome such path dependencies in order to create a level playing field in the longer run. A level playing field should, therefore, balance long-term and short-term benefits and costs of the electricity infrastructure.

Appendix B The value chain theory

One of the widely used techniques to examine what a firm does is the value chain theory, which was introduced by Michael Porter in his 1985 best seller: *Competitive Advantage: Creating and Sustaining Superior Performance*.[55] The focus of the value chain analysis is a *firm*. The primary goal of using the value chain analysis of a firm is to examine its competitive advantage in terms of cost leadership, differentiation, and focus. The term 'value chain' refers to the full-scale production chain from the input of, for example, raw materials, labour, or capital, to the output of the final product or service of the firm. The chain is called 'value chain' because each link in the chain adds some value to the original inputs. Through modelling a firm's value chain, it is possible to examine the value of what the company does as it completes a series of functions within its production cycle.

The basic concept in Porter's value chain analysis of a firm is a *value activity*. The effective execution of individual activities within a firm's value chain determines how cost-effectively the firm performs with respect to its rivals. Porter argues that an organisation can gain competitive advantage over its rivals by performing key internal activities in the value chain at a lower cost and superior quality compared to its competitors. Value activities are defined as technologically and physically distinct activities. The value chain approach identifies two major activity types - primary and secondary (see Figure B.1). Primary activities include production, marketing, logistics and after-sales functions. Secondary activities are identified as support processes to primary activities. These include firm infrastructure, human resource management, technology development, and procurement. Every primary activity embodies purchased inputs (procurement), human resources, and technologies. Firm infrastructure, implying general management, legal work, and accounting, supports the entire value chain. The value chain is a collection of value activities and a margin. The margin is the difference between the value the firm creates by selling its product or service and the costs of performing the firm's value activities. The margin is an indicator of the profitability of the firm.

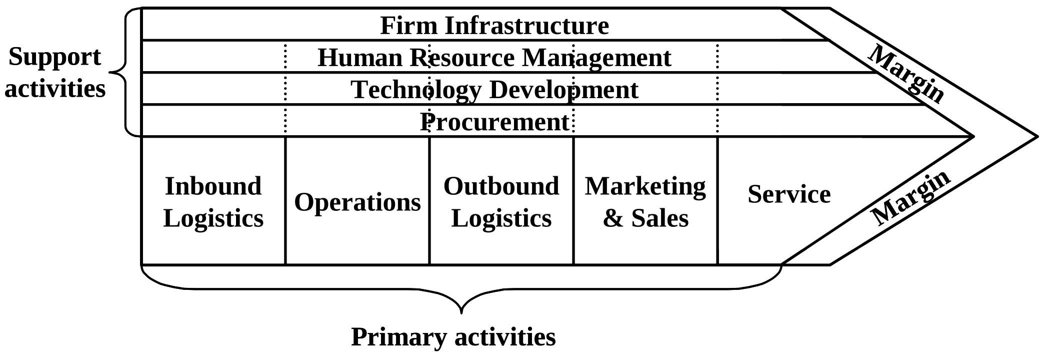

Figure B.1 *The Generic Value Chain, based on Porter (1985)*

B.1 The value system

The interdependent activities within a value chain are connected with linkages. A linkage reflects how the performance of some activity influences the effectiveness or cost produced by another activity. Linkages can exist both between activities performed within one value chain and between activities performed in value chains of different firms. The value chains of different firms and the linkages between their activities compose the *value system*.

55 This section is partly based on Brodsky et al. (2002), pp.12-14 and Porter (1985).

The simple value system, presented in Figure B.2, consists of value chains of suppliers, channels, buyers, and the firm. The value system is a tool to analyse how a company positions itself relatively to other companies. The goal of the value system is to make explicit the role of a company in the overall activity of providing the product to customers. The value system makes explicit who are the suppliers and what are the channels of the given company. It allows understanding if all the companies involved in the sale process are truly collaborating or if they have conflicts of interests.

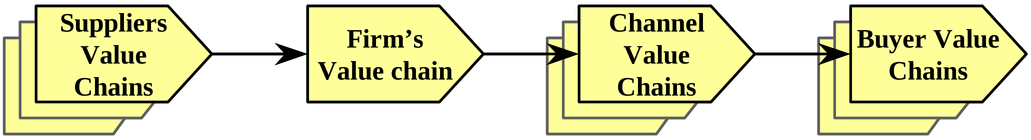

Figure B.2 *The Value System, according to Porter (1985)*

B.2 The value chain of the electricity sector

The above-mentioned theory about firm's value chains can also be applied to a higher level: the level of an industry sector. The same theory holds, but now it applies not to the separate value activities within a specific firm, but to the different successive activities within a sector (often each performed by a specific actor). For the electricity sector, a simplified representation of this higher-level value chain is given in Figure B.3.

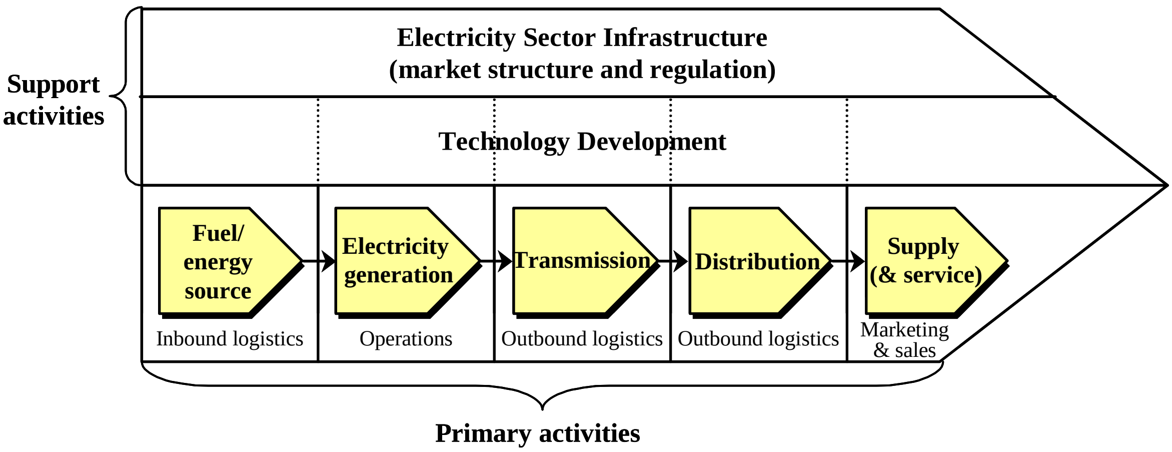

Figure B.3 *A simplified representation of the value chain of the electricity sector*

This simple electricity value chain is relatively straightforward as it only includes one-way transport of electricity from the power producer through the transmission and distribution network to consumers (the primary activities). The real situation of how electricity is produced, bought, sold, and used, including liberalisation, is far more complex than the figure shows. The increasing share of distributed generation creates opposite electricity flows through the network, large consumers can get their electricity directly from the transmission network (skipping the distribution network), because of competition and deregulation a whole new area of energy services has sprung up around electricity consumption, etc. Like so many industries, the electricity sector is no longer characterised by a linear value chain - from generation, transmission, and distribution to the final customer. Instead, value chains become networked value constellations (Akkermans and Gordijn, 2004, p.4). The delivery of the final product (electricity) to the end customer entails a mix of related products and services, which will mobilise different actors that have to act together in order to provide a market offering, each managing their own value chain.

The industry wide synchronised interactions of those local value chains create an extended value chain (on the industry or sector level).

The most important secondary activities (or support processes) in the electricity sector identified in this report and shown in Figure B.3 are the infrastructure and technology development. On the sector level, infrastructure relates to the electricity market structure (Section 3.1) and relevant regulation (which will be the subject of Chapter 5). Technology development is, in this report, related to the increasing share of distributed generation and the technical solutions and approaches that are developed for the integration of DG in electricity distribution systems.[56]

B.3 Strategic choices

In a perfect market a firm will not really benefit from the integration with suppliers upwards or buyers downward in the value chain. Although transaction costs will be reduced by vertical integration, the firm will lose flexibility in purchasing the best primary products from suppliers at the lowest costs and gaining the highest revenues form sales at the best prices. However, in real markets the coordination through perfect markets can be disturbed in many ways, which can threaten the margin of the firm. Therefore, the firm has an interest in a better coordination of the value chain. Vertical integration with suppliers and buyers at both sides of the firm's activity in the value chain will result in lower transaction costs and reduction of risks, but also the possibility to optimise the supply and demand and transferring the competition with rivals to other market levels.

Porter shows that also a different strategy may be attractive: specialisation. Firms can try to become excellent in their business and optimise the margin within their part of the value chain. It will strongly depend on the market characteristics, which of the strategies is preferred.

[56] This is the subject of Task 3.2 in WP 3 (see Chapter 1), which is discussed in Ten Donkelaar and Scheepers (2004).