S U S T E L N E T

Policy and Regulatory Roadmaps for the Integration of Distributed Generation and the Development of Sustainable Electricity Networks

New Approach in Electricity Network Regulation

An issue on Effective Integration of Distributed Generation in Electricity Supply Systems

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Abstract

By analysing the technical, socio-economic and institutional dynamics of the European electricity system and markets, the SUSTELNET project identifies the underlying patterns that provide the boundary conditions and levers for policy development to reach long term targets for electricity from renewable energy sources (RES) and greenhouse gas emission reduction (2020-2030 time frame). This report presents results of this analytical phase of the SUSTELNET project. Furthermore, preliminary results of the current work in progress are presented. Principles and criteria for a regulatory framework for sustainable electricity systems are discussed, as well as the development of medium to long-term transition strategies/roadmaps for network regulation and market transformation to facilitate the integration of RES and decentralised electricity generation into electricity supply systems.

PREFACE

Technological developments and EU targets for penetration of renewable energy sources (RES) and greenhouse gas (GHG) reduction are decentralising the electricity infrastructure and services. Although liberalisation and internationalisation of the European electricity market has resulted in efforts to harmonise transmission pricing and regulation, no initiative exists to consider the opening up and regulation of distribution networks to ensure effective participation of RES and distributed generation (DG) in the internal market. The SUSTELNET research project provides the analytical background and organisational foundation for a regulatory process that satisfies this need.

Within the SUSTELNET research project, a consortium of 11 research organisations analysed the technical, socio-economic and institutional dynamics of the European electricity system and markets. This has increased the understanding of the structure of the current European electricity sector and its socio-economic and institutional environment. The underlying patterns thus identified have provided the boundary conditions and levers for policy development to reach long term RES and GHG targets (2020-2030 time frame). Consequently, it was analysed what regulatory actions are needed on the short-to-medium term to reach the existing medium-term goals for 2010 as well as likely scenarios for longer-term goals.

Regulatory Road Maps

The main objective of the SUSTELNET project was to develop regulatory road maps for the transition to an electricity market and network structure that creates a level playing field for centralised and decentralised generation and network development. Furthermore, the regulatory road maps will facilitate the integration of RES, within the framework of the liberalisation of the EU electricity market.

Participatory Process

To deliver a fully operational road map, a participatory regulatory process was initiated throughout this project. This process brought together electricity regulators and policy makers, distribution and supply companies, as well as representatives from other relevant institutions. This ensured a good connection with current industry, regulatory and policy practice, created involvement of the relevant actors and thereby will enhance the feasibility of implementation.

Newly Associated States

The SUSTELNET project also anticipated on the enlargement of the EU by providing support to the Newly Associated States (NAS) with the preparation of a regulatory framework and thus also with the implementation of EU Directives on energy liberalisation and renewable energy in four Accession Countries (The Czech Republic, Poland, Hungary and Slovakia).

Project Structure

The SUSTELNET project was divided into two phases. During the first phase, the analytical phase, three background studies were produced:

- Long-term dynamics of electricity systems in the European Union.
- Review of the current electricity policy and regulation in the European Union and in Member States.
- Review of technical options and constraints for the integration of distributed generation in electricity networks.

In the second phase, the participatory regulatory process phase two activities took place, during which there were extensive interactions with regulators, utilities, policy makers and other relevant actors:

- Development of a normative framework: criteria for, and benchmark of distribution network regulation.
- Development of policy and regulatory road maps.

This Report

This report provides an overview of the results of the analytical phase and the preliminary results of the participatory regulatory process phase.

CONTENTS

EXECUTIVE SUMMARY

This report presents results of the analytical phase of the SUSTELNET project. In this analytical phase the technical, socio-economic and institutional dynamics of the European electricity system and markets have been analysed in order to identify the underlying patterns that provide the boundary conditions and levers for policy development to reach long term RES and GHG targets (2020-2030 time frame).

Furthermore, preliminary results of the work in progress are presented. The SUSTELNET project departs from the basis that in a liberalised market the existence of a level playing field in the regulation of the electricity system is a *sine qua non* condition to achieve an effective and efficient participation of DG. It is difficult to provide an exact definition of a level playing field. There is general agreement that a level playing field entails markets and regulation that provide neutral incentives to centralised versus distributed generation. This 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 and generators to exploit these values in the best possible way.

A long-term regulatory strategy is needed for the transition of the current regulatory framework into new regulation that creates the level playing field in electricity supply, considers the deployment of DG and creates incentives for DNOs to innovate. To operationalise the regulatory strategy, regulatory road maps can be used. A regulatory road map is a guide to the development of electricity regulation. A road map stipulates the regulatory actions that are necessary to reach a desired future state of market organisation. A road map contains a series of regulatory actions and developments. Furthermore, the road map indicates the timing of regulatory steps. The timing of these steps depends on key developments in the electricity sector and the penetration of DG in the electricity market.

This report presents results of analyses performed in the SUSTELNET project and ideas and approaches of work in progress. The project team will continue with the development of regulatory roadmaps for a number of EU MS and accession countries as well as a regulatory road map for the EU. These regulatory roadmaps will be discussed with stakeholders in national and international forum discussions.

1. INTRODUCTION

Liberalisation of energy markets and promotion of sustainable energy supply are major policy issues in Member States of the European Union. Following EU Directives (EC, 1996; 2001; 2003). Member States have implemented legislation to introduce market competition in electricity production and supply and implemented support mechanisms to stimulate production and consumption of renewable electricity[1]. As a consequence of market liberalisation, access of electricity networks is regulated, since these networks are considered to be natural monopolies. 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 and from renewable energy sources (RES), so called distributed generation (DG). In practice, however, current electricity network regulation often does not consider regulation of distribution networks to ensure effective participation of RES and DG in liberated electricity markets. Alternatively, governments in EU MS still use support schemes to ensure that DG and RES are employed and environmental benefits are achieved and so mitigating the often complex barriers to incorporate DG and RES within economic regulation.

To meet future sustainability targets, it is expected that the share of DG/RES in electricity supply will increase significantly. If this occurs, DG/RES should become a mature power generation source. This would require technological adaptations of the electricity system as well as changes in economic regulation. Within current electricity regulation frameworks, incentives to change the design and operation of distribution networks are often lacking. Furthermore, a sustainable electricity system that is economically efficient only results from electricity network regulation that provides generators and distribution network operators (DNOs) with correct economic signals. In other words, costs and benefits induced by DG/RES should be recognised, allocated and valued properly. This requires the separation of electricity system values from external values (e.g. emission reduction) as long as the latter are not internalised.

In Chapter 2, this report first gives a short introduction on DG/RES, its impact on the electricity system and the required technical and institutional transition. Subsequently, the DG/RES drivers and an introduction to possible problems raised by the liberalisation of power markets are described in Chapter 3. Chapter 4 outlines values created by DG on distribution networks, while discussing the desirability and feasibility of creating a level playing field between small and large-scale power generation. Chapter 5 investigates the rationales and principles of current and future economic regulation. The introduction of a new regulatory approach in electricity network regulation requires a transition process. The SUSTELNET project proposes the use of a ‘regulatory roadmap’ as a tool to map out the regulatory strategy. The development and use of regulatory roadmaps is explained in Chapter 6.

It should be noted that this report is based of ongoing research and preliminary results are presented.

[1] Currently these EU Directives are also implemented in accession countries.

2. DISTRIBUTED GENERATION

2.1 What is Distributed Generation?

An electricity supply system consists of power generating units, a transmission and a distribution network. Generally, power generation that is connected to the distribution network and has a capacity up to a certain limit is considered to be distributed generation (DG). However, it appears difficult to pin down DG on specific numbers because this is country specific and relates to characteristics of the centralised power system. Co-generation (or Combined Heat and Power; CHP) and renewable electricity 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.

What is considered as large-scale power generation and DG in a specific country can be determined from existing network regulation. Often distinctions are made in electricity network regulation on the basis of network level and generation capacity, for example regarding connection costs, system balancing, system reserves and auxiliary services. How these distinctions are made can implicitly create a non-level playing field between large-scale generation and DG. This is further discussed in Chapter 4.

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.
** typically > 10 MW_e.

2.2 Development of DG in centralised electricity systems

To understand the structure and use of current electricity supply systems and to lean about possibilities and the barriers to changing these systems Verbong and Van der Vleuten (Verbong et al, 2002) analysed the historic dynamics of long-term electricity supply systems. They observe that, in a long-term historical perspective, the current concern or critical problem creating a level playing field for distributed and centralised generation is remarkable. This concern seems completely opposite to the dominant critical problem in the 1950s and 1960s, which was to reduce the contribution of distributed generation to public electricity supply as much as possible, in order to achieve advantages of scale. It is no surprise therefore, that current systems have an intrinsic bias towards centralised production. Arguments for large scale power generation during the era of scale increase and expansion (see Figure 2.1) were economies of scale, production of (coal) power plants located near mining sites and integrated with hydro, investment savings on back-up units and avoiding over-capacity[2]. Due to the increasing availability of natural gas in many countries, environmental concerns and technological development (such as availability of

[2] In the first part of the 20th century Georg Klingenberg, professor at the polytechnical school of Berlin and head of the German company AEG, put forward these four arguments for large integrated electricity networks.

competitive smaller generators) scale increase and siting of power generation locations became of lesser importance. As a result, in the 1970s and 1980s electricity systems in some countries[3] started to develop from central systems in the direction of ‘hybrid systems’ hosting centralised as well as decentralised generation units in one and the same system. The possibilities (barriers, opportunities) for DG in the current socio-technical electricity supply systems are conditioned by characteristics of the system developed in the era of centralisation and by what way actors since the 1970s have been dealing with these.

In parallel to national electricity systems, a European electricity supply system has developed (see Figure 2.1). Although the European network was more and more intensively used, until the1990s national boundaries provided barriers for international co-operation in production and transmission. This completely changed with the implementation of energy market liberalisation and the creation of an international electricity market. More recently, efforts have been made to harmonise transmission pricing and to improve congestion management[4]. The impact of the development of the European grid is uncertain. On the one hand, large scale introduction of distributed generation, both co-generation and renewable energy sources, could push for balancing demand and supply of electricity on a lower system level, reducing the role of high voltage transmission grids. On the other hand increasing exchange of electricity, exploiting differences in the availability of resources, economies of scale and favourable market conditions (e.g. cheap base load from nuclear power stations during the night) could be a factor, pushing for sustaining and expanding the European network.

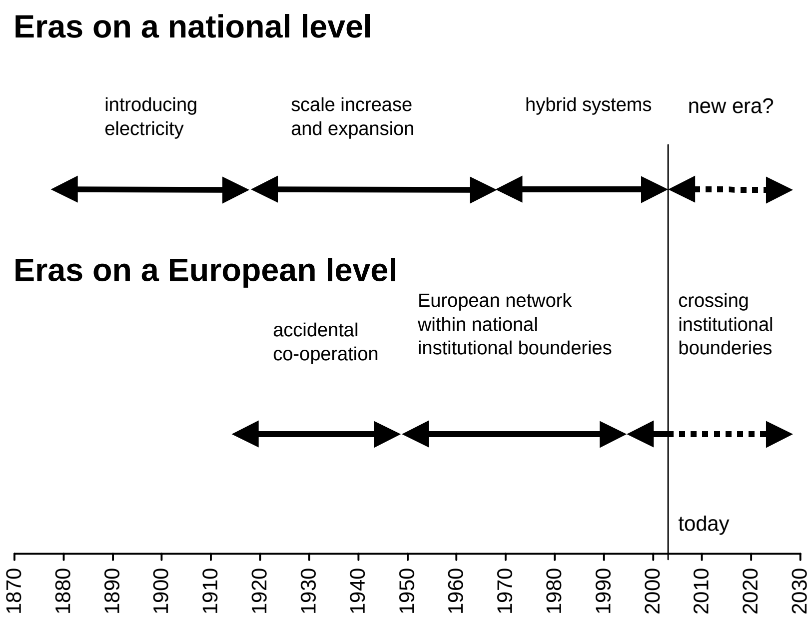

Figure 2.1 *Eras in the development of electricity supply systems*

3 There are considerable differences from country to country. A co-evolution of centralised and decentralised systems can be observed.

4 The Electricity Regulatory Forum of Florence currently addresses issues on cross border trade of electricity, in particular the tarification of cross border electricity exchanges and the allocation and management of scarce interconnection capacity.

2.3 Technical options and constraints

In some countries the level of DG in the electricity supply is already remarkably high. For instance, in the Netherlands approximately 20% and in Denmark approximately 35% of the power (on a yearly basis) is supplied by DG. These 'hybrid supply systems' were developed before the electricity markets were liberalised. The opportunities for DG were created by changes in the institutional framework.

Nielsen (2002a) reviewed technical options and constraints for the integration of distributed generation in electricity networks. The review is based, to a large extent, on a case study of large-scale DG deployment in the Western part of Denmark. In this area 1621 MW local CHP and 1900 MW of wind turbines have been introduced in a system with a minimum demand load of 1150 MW and a maximum demand load of 3800 MW (see Figure 2.2). Although, such a high DG penetration in a conventional grid is technically possible, strong international connections were necessary to balance the system. The risk of serious network failures has increased since. The mixture of production and consumption in the same local networks has made operational tasks more complicated, particularly under emergency conditions.

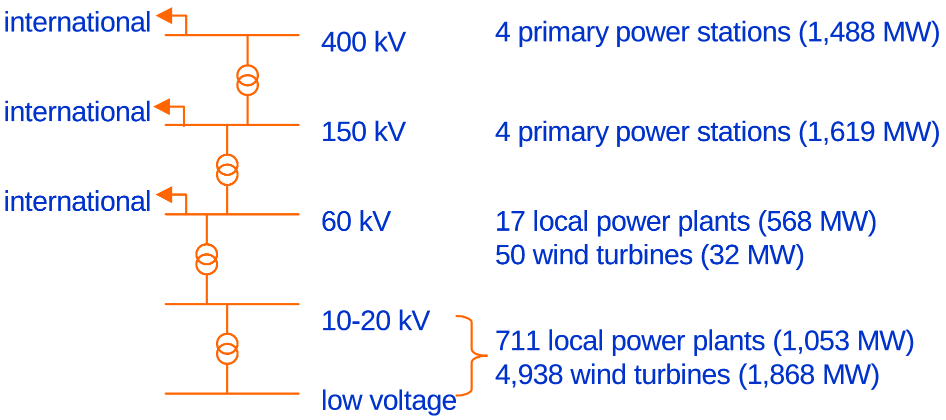

Figure 2.2 *Production capacity at each voltage level in the Western part of Denmark (Eltra)*

In present electricity systems control structures are still based on a division of networks into two parts: a distribution network connecting end-users to the electricity supply system and a transmission network connecting power plants and cross-border lines to major users and to the distribution networks. The operational co-ordination between the two networks is limited, both under normal conditions and in emergency situations. To minimise the risk of serious network failures and to be able to improve the economical optimisation of electricity networks it is important to recognise that distribution networks can no longer be considered as passive appendages to the transmission networks. The entire network must be operated as a closely integrated unit. Organising this co-operation will be a major challenge. Furthermore, a number of technical improvements have to be developed and implemented. Several ideas for redesigning electricity networks have been put forward[5], however, practical experience is still limited. In these future electricity networks the role of information and communication technologies (ICT) will certainly increase. Nielsen has also reviewed the role of ICT in network management and market operations (Nielsen, 2002b).

[5] Nielsen (2002a) illustrates this with three ideas: 'The Grid', 'Active network' and 'Micro-grids'.

3. DG PROSPECTS

3.1 Drivers for DG

Environmental policy is an important driver for DG. In 1995 the share of CHP and RES in Europe's electricity supply (the current 15 EU member states) amounted to 23% (see Figure 3.1). Because of the EU policy targets on green house gas (GHG) emission reduction and renewable energy, and the accompanying measures implemented in EU MS, CHP and RES will most likely grow to a level of approximately 40%. Figure 3.1 shows that renewable energy and CHP contribute significantly to meeting the EU Kyoto commitment. Although environmental targets on the longer term (i.e. after 2010) are not clear yet, it is very likely that these targets will become more ambitious. GHG reduction will be intensified and renewable energy will become more important in electricity supply after 2010.

Another driver for DG is security of supply. Electricity from RES and the high total efficiency of CHP will reduce the dependency on fossil fuels. Furthermore, an electricity supply system with distributed resources could, under the right technical conditions, be less vulnerable to network failures and power supply disruptions. Also innovations in electricity generation technologies (e.g. renewable technologies, micro turbines, fuel cells, etc.) will stimulate DG development. In summary, in the longer term a continuation of the increase of the CHP and RES share in electricity supply is to be expected, and as a result, the share of DG will also grow, because a significant part of new CHP and RES is DG.

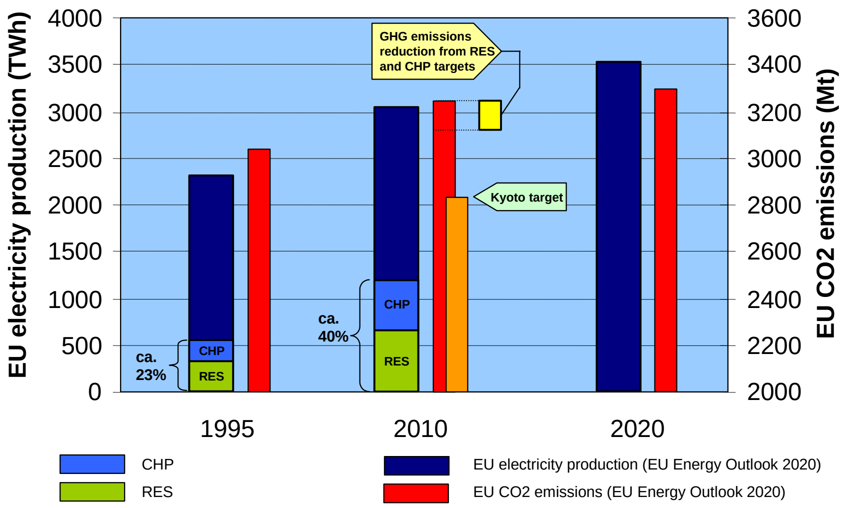

Figure 3.1 *Position of CHP and RES in the electricity supply in the European Union (EU-15)*

3.2 Electricity market liberalisation

The liberalisation of electricity markets has an impact on the development of DG. Although the opening of electricity markets should create opportunities for decentralised power generation, the participation of DG in competitive power markets could affect the profitability of DG. Based on the analysis of the electricity regulation in four EU MS, Connor and Mitchell (2002) illustrate that in a liberalised electricity market RES and DG are often not rewarded or insufficiently rewarded for their benefits to the electricity system and are in some cases strongly dependent on non-market based support schemes. It is suggested that 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. Connor and Mitchell also state that the current regulation framework tends to favour the centralised production of power and that current systems for incentivising investment by distribution companies reduce the potential options available to network operators by locking them into doing the same thing while trying to reduce associated costs. The pricing and regulation of distribution network services is, therefore, crucial to the penetration of distributed generation in the current EU electricity market. The achievement of policy goals on RES and GHG may become in danger if distribution network operators (DNOs) are not able to adapt their networks or and are unwilling to connect DG. This is not only dependent on whether DNOs are disincentivised regarding DG but on whether regulation allows them to actively discourage its uptake as well.

4. DG VALUES

4.1 Market incentives

Market incentives and disincentives towards DG are generated basically through regulatory issues and support mechanisms. While the former deals with the regulation of the electricity system - namely network regulation and market access - the latter should be introduced when the pricing system does not internalise all positive externalities created, to support technologies that are in their infant phases and to achieve a determined policy objective. Typically, regulation of current electricity systems favours centralised generation to the detriment of DG and, in many countries, support mechanisms are generally introduced to correct this. The use of support measures to correct regulation imperfections is inefficient. The SUSTELNET project departs from the basis that in a liberalised market the existence of a level playing field in the regulation of the electricity system is a *sine qua non* condition to achieve an effective and efficient participation of DG. Support mechanisms, instead, should only be used for the three aforementioned objectives: to compensate for externalities, in support of infant technologies and in the achievement of specific policy objectives. In this report only the area of economic regulatory issues is considered.

4.2 Level playing field

It is difficult to provide an exact definition of a level playing field. There is general agreement that a level playing field entails markets and regulation that provide neutral incentives to centralised versus distributed generation. This 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 and generators to exploit these values in the best possible way.

4.3 Costs and benefits

When DG connects to the distribution grid, it generates operational and capital costs that are recovered via the respective tariffs. However, a number of the benefits or costs they generate are not always taken into account. In order to achieve a level playing field, all DG values (benefits or costs) should be recognised, assigned - if possible - a monetary value and allocated between DG and DNOs. Long-term and short-term values should both be considered.

The benefits and costs of DG can generally be separated into two broad categories: those that are network-related (infrastructure) and those that are energy-related (commodity) (Leprich and Bauknecht, 2003). Within each category and subcategory there can be a range of different benefits and costs to the DNOs, the TSOs, the customers and the society as a whole. Each benefit or cost tends to be highly technology-, site- and time-specific; they do not necessarily apply equally or at all to every individual DG case.

Table 4.1 *DG costs and benefits*

	DG can create benefits to the electricity system:	DG can create costs to the electricity system:
Network related	• *Distribution capacity cost deferral:* The development of small-scale DG facilities near a load can avoid necessary investments in additional distribution and transmission capacity temporarily or forever. DNOs can benefit from these new DG facilities as it can reduce their investment costs in upgrading or extending the distribution network. The costs of distributing electricity differ from location to location, and placing DG facilities in "high-cost areas" may reduce costs for DNOs. • *Operational cost savings:* Distributed generation can reduce costs for operation and maintenance of the distribution system. Values regarding engineering costs include: - reduction of losses - voltage support - reactive power support - equipment life extension • *Congestion relief* • *Reliability improvement*: through grid relief probability of blackouts or brownouts decreases.	• *Connection costs:* The connection of the DG plant to the distribution network incurs expenses regarding connection lines and grid upgrade, depending on the location of the DG facility. Choosing the location of a DG facility close to an existing grid may reduce connection costs. • *Metering costs:* Metering of DG production presents a cost that is allocated outside the network, and can be attributed to the DG operator. The costs for a management and control system that automatically collects metering data and provides control signals to the DG plants should, however, be attributed to the DNO. • *Costs for network upgrade and extension:* network investments induced by DG plants • *Costs for additional planning efforts* • *Transaction costs:* e.g. administration costs, etc.
Energy related	• *Contributions to (peak) load reduction, to backup capacity and to balancing power* • *Flexible option values*: e.g. short lead times for DG, contribution to balancing power • *Improvement of security of supply* • *Avoidance of overcapacity*: Avoidance of overcapacities or at least reduction of reserve margins compared to more centralised systems. In traditional power systems an increasing demand of electricity was solved by installing a new "central" power plant. In today's market environment, over-dimensioning of power plants may be a risky investment. Small-scale DG plants are better equipped to respond to short-term demand changes. • *Less lumpy generation investment*	• *Reserve costs:* When installing a large capacity of intermittent DG sources (e.g. wind and PV generators) a certain backup of power needs to be available. This can be another DG source (illustrating that DG can act as reserve capacity also). DG that is 'controllable', such as CHP plants that can be operated independently from heat demand, can contribute to reserve capacity. • *Balancing costs:* There might be a need for additional balancing power because of the intermittent character of some DG sources (such as wind and PV systems). Generally, the ability to balance the distribution system depends on the way that a DG generation facility is controllable and can present a burden or a benefit to the distribution system. • *Costs for additional system services* • *Control costs:* e.g. in the case of controllable DG plants

The recognition and assignment of a monetary value can sometimes prove difficult because not all values are always individually measurable. It should be also stressed that in many cases values can be positive (benefit) or negative (cost), depending on the particular situation. Mendez, et al (2002) shows that DG can have positive or negative impacts on distribution losses, depending on the penetration level[6]. As Figure 4.1 shows, variations of losses in distribution grids due to DG have a sort of U-shaped behaviour. In general, for low DG penetration level, losses decrease but for higher penetration level losses marginally increase and can be higher than losses in the base case.

[6] Penetration level = ratio of capacity factor times total DG power installed and the peak power demanded on the feeder.

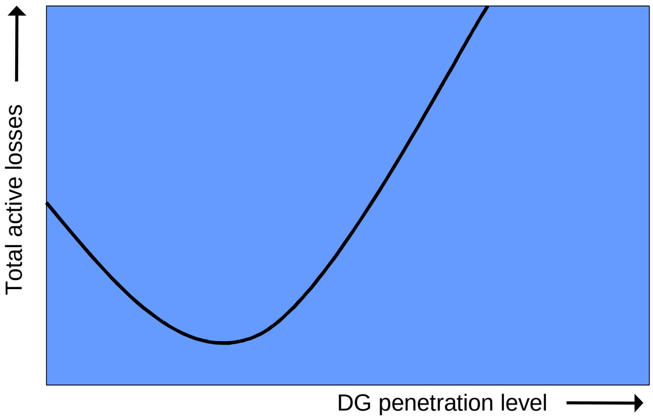

Figure 4.1 *Variation of distribution losses due to DG penetration*

Values can also be short-term or long-term, depending on the timeframe in which the benefits or costs arise for the DG or DNO. For example, avoided network losses are short-term benefits DG generates in distribution networks. On the other hand, avoided network investments (distribution capacity cost deferral) are long-term benefits. It is important to draw a distinction concerning the time frame of the DG values in order to construct a level-playing field.

5. RATIONALES AND PRINCIPLES FOR A FUTURE REGULATORY FRAMEWORK

When restructuring electricity markets, all activities - production, transmission and distribution and retail - are unbundled. While in the first and last activities competition is introduced, the second activities remain regulated due to their natural monopolistic characteristics. As market conditions cannot be created in the network sector, regulation should, on the one hand, provide incentives for DNOs to undertake efficient investments and operation of the network while complying with consumer interests of quality levels. On the other hand, regulation should also guarantee the economic viability of the business. The regulator has the power to influence the DNO through regulation incentives.

5.1 Regulatory approach

Different types of regulatory approaches exist that range from light-handed to heavy-handed regulation systems. Alongside the liberalisation of the electricity sector, the regulation of networks developed from traditional, heavy-handed rate of return (ROR) regulation to more light-handed, incentive regulation systems. The ROR regulation allows the utility to cover its operation and capital costs as well as a return on capital, without encouraging firms to reduce costs and become more efficient. Incentive regulation aims at providing DNOs with incentives for efficiency improvements while also passing them down to consumers. Incentives are given through the benchmarking of certain costs. Jamasb and Pollit (2000) provide a review of different countries, including some EU Member States that have implemented incentive regulation systems.

In order to provide a sustainable regulation, the regulatory framework should consider the values of DG. In other words, DNOs should be provided with incentives to use DG as an option for the efficient operation of the network. As Connor and Mitchell (2002) show, current distribution regulation systems in a number of MS currently do not properly consider DG. Examples of these problems include:

- Incentive regulation systems implemented prove to be anti-innovative. For example, when both operational and capital expenditures are benchmarked, DNOs are encouraged to minimise these costs. As a result, DNOs are not given incentives to undertake innovative actions which could prove to be more expensive in the short-term but more profitable in the longer-term.
- When capital expenditures are provided with a fixed rate of return, DNOs will not be encouraged to connect DG, as this type of generation can avoid network investments and therefore reduce DNOs income.
- Connection tariffs are also of high significance to DG. While tariffs based on deep connection costs[7] can prove prohibiting to DG projects, tariffs based on shallow connection costs[8] can be a burden to DNOs because the latter tariff don't cover costs generated inside the network. As a result DNOs are disincentivised towards possible connection of DG and are likely to look for ways of avoiding its connection and of avoiding investment in a network favourable to DG.

[7] Deep connection costs: generators or customers are required to pay not only for the cost of the local connection but also for the incremental investment made on the wider system to accommodate the additional generating capacity or load.

[8] Shallow connection costs: generators and customers are required to pay only for the local assets specifically required to connect them to the grid. The costs of reinforcing the system beyond the connection assets are recovered through use of system charges.

In summary, when moving to a more sustainable system, the correct incentivisation of DNOs needs to play a principal role. Regulation should provide DNOs with instruments and incentives to manage the network in an innovative way, while DG has to become an option in the managing of the network. With the increase of innovation and the use of DG, the need for a more flexible framework gains in importance.

In the SUSTELNET project, two regulatory systems are put forward that solve the first two problems mentioned above (Leprich and Bauknecht, 2003). These are:

- *Revenue-cap regulation:* In its simplest form, the amount of revenue per year that a firm can collect from its customer base is limited to a predetermined level. In particular, a revenue-per-customer-cap is argued to be the best system that does not bias against DG. A utility under this regulatory framework has a clear incentive to encourage minimizing total demand, and thus minimizing demand per customer. One way to do this is to encourage the efficient use of power. In other words, with proper adjustment, and in the right circumstances, a revenue cap might motivate both supply-side cost minimisation and demand-side efficiency maximisation without imposing too much risk or inducing perverse behaviour on the part of the utility.
- *Multi-driver cap regulation:* When multi-driver cap regulation is properly applied, it can provide powerful incentives for economic efficiency on the supply-side, decrease the incentives to increase sales and therefore bias against DG and allow the inclusion of direct costs of DG programs.

Mitchell (2002) also argues that in order to achieve a more sustainable regulatory system, the distribution regulatory framework should be based on an overall charging and incentivisation package of three equal and linked parts: shallow connection charges, use of system charges with entry and exit charges, and performance based incentives.

A shallow connection charge in conjunction with an entry charge, plus performance standards, should provide the most economic incentive for appropriate connection from the perspective of the DNO. With the entry and exit charges, the DNOs could send locational signals to generators to site, or to suppliers to reduce demand. This should reduce their overall costs of designing and operating the network, which should give them further reason for supporting DG. Furthermore, by considering long-term values of DG managed through short-term signals, it contributes to the process of building a sustainable level playing field. However, if an increased proportion of the DNO's revenues were linked to performance based regulation, the DNOs should be incentivised to connect DG but also operate their network in a holistic manner whilst meeting performance criteria at the least cost.

It is important in the analysis to recognise, 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. Path dependencies in the electricity infrastructure are likely to create a bias towards centralised generation. It may therefore be granted to temporarily tilt the playing field slightly in favour of DG initiating a transition process towards a level playing field in the longer run. Thus a level playing field should balance long term and short term benefits and costs of the electricity infrastructure.

5.2 Future of DNOs

DNOs have to radically evolve if a more sustainable system is expected to develop. DNOs in the current electricity supply industry are passive organisations whose sole objective is the provision of distribution network services, mainly transport of electricity. The operation of the system and provision of ancillary services is generally done by the Transmission System Operators. However, if the expected increase in DG has to be successfully accommodated in the electricity system, electricity networks should reconfigure into active networks, where DNOs evolve from passive organisations into more active actors. In other words, DNOs should become active and innovative entrepreneurs that should facilitate and profit from the connection of DG into the system. By doing so, and because DNOs would receive (for some part) the benefits DG creates, they would on the one hand be provided with incentives to connect DG and, on the other hand, provide the correct signals to generators and consumers in order to efficiently behave towards the network.

6. REGULATORY STRATEGIES

Just as building electricity networks is a long-term activity, changing existing distribution networks into innovative networks will also take many years. Furthermore, to create stable conditions in economic network regulation, new rules are only introduced at the start of a new regulatory period (i.e. each 3 to 5 years). Changing the regulatory framework may take more than one step and therefore also the transition period for regulation may take many years. A long-term regulatory strategy is needed for the transition of the current regulatory framework into new regulation that creates the level playing field in electricity supply, considers the deployment of DG and creates incentives for DNOs to innovate. A clear regulatory strategy could help to reduce regulatory uncertainty.

6.1 Regulatory roadmaps

To operationalise the regulatory strategy, regulatory road maps can be used[9]. A regulatory road map is a guide to the development of electricity regulation. A road map stipulates the regulatory actions that are necessary to reach a desired future state of market organisation. A road map contains a series of regulatory actions and developments. Furthermore, the road map indicates the timing of regulatory steps. The timing of these steps depends on key developments in the electricity sector and the penetration of DG in the electricity market. The level of detail in the description of the regulatory actions is higher for the short-term actions than for the long-term actions. Considering that regulation never takes place in isolation, a road map should address all stakeholders (Van Sambeek et al, 2003).

6.2 DG Scenarios

The regulatory roadmap should be based on expected future developments. However, a large number of factors can influence the development of the electricity supply sector. These factors have a different nature (technical socio-economic, institutional) and can be part of the electricity system or can be external. For instance, harmonisation in the EU is an important external factor that cannot be influenced directly by the actors in the electricity sector but can have a significant impact on the electricity regulation. The use of information and communication technologies for operation and control of electricity networks is an example of a technology development that can be influenced by the actors in the electricity sector. The uncertainty of the different factors influencing the development of the electricity system makes it difficult to determine the future state. The range of possible future developments of complex systems like the electricity sector becomes even larger if the distance from the present increases.

By using a scenario method, possible future developments can be described by a set of 'scenario descriptors'. For the electricity system more than 120 possible descriptors were identified in the SUSTELNET project. To keep the scenarios operational, a limited number of these have been selected for the basic scenario layout. By using two independent factors - harmonisation of EU regulation and energy policy (i.e. the incentives for RES and DG) - four different possible futures have been identified (Timpe and Scheepers, 2003). These four scenarios are characterised in Table 6.1.

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[9] The principle of regulatory road maps can be derived from technology road maps. Technology road maps describe possible routes of technology development and show the probable date of market introduction. Often technology road maps also indicate the intermediate steps and timing of technology development. For example: Electricity Technology Roadmap, EPRI, 1999 (http://www.epri.com/corporate/discover_epri/roadmap/index.html).

Table 6.1 *DG Scenarios*

	High RES & DG incentives	Moderate RES & DG incentives
	Scenario A DG opportunities in a fully harmonised EU market	Scenario B Difficult times for DG in a fully harmonised EU market
Stronger EU harmonisation policy	• Efficient regulation (EU Regulator) • Market concentration • Non discriminating grid access rules. • Ambitious EU-wide targets for RES & DG • Strong EU-wide support schemes (tradable certificates)	• Efficient regulation (EU Regulator) • Market concentration • Grid access rules disfavour small units • Harmonisation of RES & DG support at a low level • EU wide certification schemes (tradable certificates)
	Scenario C DG opportunities in national markets	Scenario D Difficult times for DG in national markets
Reduced EU harmonisation policy	• No harmonised regulation (national focus) • Some MS implement fair grid access • Ambitious EU-wide targets for RES & DG • Diversity of national support schemes. • Strong RES & DG support compensates for regulatory deficits	• No harmonised regulation (national focus) • No improvements in grid access • National support schemes partially reduced • No compensations for regulatory deficits

6.3 Development of regulatory roadmaps

The scenarios presented in Table 6.1 will help to map out strategies for a regulatory framework. In principle regulatory road maps can be developed for each of the four scenarios. However, having more roadmaps will not help to set out a clear regulatory strategy for changing the regulatory framework. Preferably, one scenario should be used that complies with existing and/or desirable policies, for instance Scenario A in Table 6.1 (strong EU harmonisation and high RES & DG incentives). The other scenarios can then be used to check the robustness of the roadmap for changing circumstances and to identify alternative actions in such circumstances. It should be emphasised that not only gradual development, but also sudden changes (e.g. disruptive events such an unforeseen shortage in power supply) could have a major impact on the developments of the electricity system.

Today there are large differences between EU MS and accession countries regarding electricity regulation, electricity market competition, share of DG in the electricity supply, electricity network structure, incentives for RES and DG, etcetera. Looking at the potential for RES and CHP development large differences can also be identified between countries. Therefore, the starting point as well as the future outcome of a similar scenario will be different for each specific country.

The road maps are developed in a step-wise approach. First, a starting point of the scenario for possible the future is defined. The starting point is defined and described with use of technical, socio-economical/political, institutional and regulatory descriptors. This will help to determine at which stage a country currently is. Secondly, a definition of the possible future for the electricity supply system is made. Thirdly, a story line is constructed, i.e. a description of the path along which developments could take place. For constructing the story line the scenario descriptors could be used by which already the starting point and the future state are described. Once the scenario and the background storyline are developed, the future is described and therefore, the final status of the regulatory framework in the roadmap scheme should be identified. The regulatory steps to be taken can be identified by backcasting from the final status. Next, the timing of the regulatory steps is defined and the regulatory framework for the different stages is further detailed. At this stage the roadmap should be checked for robustness (i.e. changing developments and disruptive events). The regulatory roadmap is completed with the description of actions and responsibilities for the stakeholders in the different steps of the roadmap.

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