Policy and Network Regulation for the Integration of Distribution Generation and Renewables for electricity supply

Michael ten Donkelaar & Frits van Oostvoorn
Energy research Centre of the Netherlands (ECN)
P.O. Box 1, 1755 ZG Petten
Phone: +31 224 564001, Fax: +31 224 568338, E-mail: tendonkelaar@ecn.nl

Abstract

This study has analysed the existing policy and regulation aimed at the integration of an increased share of Distributed Generation (DG) in electricity supply systems in the European Union. It illustrates the state of the art and progress in the development of support mechanisms and network regulation for large-scale integration of DG. Through a benchmark study a systematic comparison has been made of different DG support schemes and distribution network regulation in EU Member States to a predefined standard, the level playing field. This level playing field has been defined as the situation where energy markets, policy and regulation provide neutral incentives to central vs. distributed generation, which results in an economically more efficient electricity supply to the consumer. In current regulation and policy a certain discrepancy can be noticed between the actual regulation and policy support systems in a number of countries, the medium to long term targets and the ideal situation described according to the level playing field objective. Policies towards DG and RES are now mainly aimed at removing short-term barriers, increasing the production share of DG/RES, but often ignoring the more complex barriers of integrating DG/RES that is created by the economic network regulation in current electricity markets.

Introduction

The share of distributed generation (DG) and renewable energy technologies, connected directly to distribution networks, has experienced a strong growth during the last decade. Particularly in countries like Denmark, Germany, Spain and the Netherlands the share of electricity supplied to the customers by distributed generation has increased substantially. The main drivers for this development are:

- Contribution in meeting environmental goals and policy targets in the EU and individual Member States
- The expected flexibility in increasing generation capacity of smaller power sources
- Recent cost reduction in DG & renewable energy technologies

DG technologies are nowadays predominantly connected at low to medium voltage networks, at sites that were originally not meant to connect such a large number of power generation facilities. In some countries and regions this is already becoming an increasing burden on the distribution network operations in terms of grid stability and power quality.

In the framework of the 5th R&D programme, ECN has conducted several large research projects[1] for the EU to analyse these issues from a socio-economic point of view. This research included the impact of different support policies for Combined Heat and Power (CHP) & renewable energy sources (RES) and electricity network regulation related to the connection of these power sources.
The research illustrates the state of the art and progress in the development of support mechanisms and network regulation for large-scale integration of DG. Increasing shares of DG require adapting policy and regulatory frameworks to adapt to the physical network and the growing electricity markets.

[1] The results of two Fifth Framework research projects are discussed here, ENIRDG-Net and SUSTELNET.

ECN-RX--05-173

With in the SUSTELNET and ENIRDG-net research projects a systematic comparison in the form of a *benchmark study* has been made of different DG support schemes and distribution network regulation in EU Member States to a predefined standard, the *level playing field*.

The level playing field

There is a general agreement that a level playing field entails markets and regulation that provide neutral incentives to centralised versus distributed generation (Scheepers & Wals, 2003), resulting in equal competition conditions for all parties. The level playing field concept is closely connected to the principle that an actor gets paid for the costs it causes and gets rewarded for all benefits it brings to the system. In the electricity supply sector the attribution of values (benefits and costs) to DG has not yet been developed properly, especially not when compared to the situation of centralised electricity generation.

Therefore, incentives should be provided to network operators, energy suppliers and generators to exploit these values in the best possible way. This level playing field situation could then lead to the elimination of market failures and finally to an economically more efficient electricity supply to the consumer.

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 monetarise.

It is recognised that the provision of non-discriminatory incentives and proper valuation of benefits and costs associated with distributed and centralised generation alone may not result in a level playing field in the long run (Van Sambeek & Scheepers, 2004). This is because existing path dependencies in the electricity infrastructure may create a certain degree of bias towards centralised generation. For example a DSO 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 (2004) state, it may therefore be granted to temporarily tilt the level 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.

DG policy and regulation

An optimal DG integration policy should in the long-term reach a level playing field, leading to the elimination of market failures. Under the current situation where centralised generation has often a preferential situation above distributed generation, the development of the level playing field is both dependent on support mechanisms for certain types of DG and the network regulatory framework in place. The role of both support schemes and network regulation has been analysed in this research.

Support schemes such as feed-in tariffs can facilitate specific DG sources to penetrate into the energy market and in this way overcome a number of barriers, such as the upfront investment, access to the energy market and the connection to the network. When DG sources reach a certain level or market share, they might start influencing the physical power flows and the commodity flows on the energy markets. This can then on one hand result in increasing costs for the transmission and distribution of power and on the other hand in distortions of the energy markets. To prevent any of these distortions and the creation of inefficiencies and higher electricity supply prices, the support schemes should be adapted when DG reaches a significant level of power capacity and may influence the electricity infrastructure.

The barriers that have prevented DG from entering the market in the first place have been overcome with the introduction of support schemes. To prevent that the balance in the energy market will be too much in favour of DG, support schemes have to be eventually adapted. A level playing field situation does not necessarily exclude the existence of support schemes. Nevertheless, they only have to exist for very specific reasons, such as (Leprich and Bauknecht, 2004):

- Fostering the dissemination of new non-mature DG technologies (specific temporary support for certain types of technology)
- Internalisation of environmental externalities in power production. DG sources not using fossil fuels have enormous environmental benefits over fossil-fuel based centralised generation. As externalities to the environment and to society cannot always be monetarised, long-term support to cover these externalities may be justified.
- Overcoming specific energy market failures such as access to markets, networks etc. These failures are usually temporary and so the support schemes overcoming these failures should also be introduced for a limited period.

To summarise, DG access to the energy market can distinguish three different stages as shown in Table 1: a protected niche situation, wholesale market access and a level playing field situation.

Table 1: Market access for DG

Market presence	Market participation	Description
Low	Protected niche	DG develops outside the regular energy market. Penetration levels are low and priority access and obligatory purchase schemes such as feed-in tariffs are the most efficient way to integrate DG.
Medium	Wholesale market	Penetration levels of DG are growing and DG can sell its energy on the wholesale market. Market conform pricing mechanisms are required, such as green certificates or premium tariffs based on the environmental benefits of DG.
High	Level playing field	Penetration levels of DG are high and dispatch problems can occur. DG should start playing a role in balancing the electricity system and contributing to power quality.

When market access of DG is growing, network regulation aimed at DG will play an increasing role. For example, this regulation has to ensure non-discriminatory access to the power grid, transparent setting of connection costs and access to the wholesale and balancing markets.

The *network regulatory framework* adopted in a certain country may have as much influence as support schemes in the way distributed generation is integrated into the electricity network. The following elements are of key importance.

- *The system of network connection charges* paid by generators (including DG) and consumers for connection to the power network. Network connection charges can be either shallow, deep[2] or be of a combined system. To optimise the connection charging system for the inclusion of DG, it should be designed in such a way that costs and benefits of the DG connection can be optimally allocated to the right market actor and its

[2] When shallow connection charges are applied, the DG operator pays for the connection only and grid reinforcement costs are covered by the DSO. When deep connection costs are applied, the DG operator pays for grid connection and grid reinforcement.

services. For that purpose, network connection charges could be shallow but include a locational signal to more optimally allocate costs & benefits of new grid connections.

- *Use of System (UoS) charges* provide an important source of revenues for the DSO for operating the electricity network. The way they are composed and by whom they are set will influence the integration of DG. UoS charges are usually composed by an electricity (kWh) and capacity (kW) component and are paid by consumers and/or producers. DG producers may pay a certain part of UoS charges as to cover part of their costs they bring to the network. Of importance is also that the UoS charges are set by an independent party that has no bias against further development of DG.
- *Allocation of ancillary services and other system benefits*. In some countries, power generators (including DG) can receive compensation for certain system and network services. This leads to a more equal position of DG in the electricity market, a fairer allocation of network costs and benefits and in a number of cases an additional revenue stream for DG operators.
- The regulatory framework aimed at DSO activities. Managing the electricity network is a monopoly activity and as such this activity has to be regulated. Regulation can be purely based on cost-efficiency of network management or also include performance-based criteria. In case of this performance regulation, DG can be taken into account when DSOs plan extensions and upgrades of their network.
- Last but not least, the *unbundling of DSO activities*. The EU has set requirements for the unbundling process, but DSOs with less than 100,000 connections are exempted. This might cause a competitive advantage for incumbent electricity companies in some, mainly rural areas.

If applied properly, DG support mechanisms and the network regulatory framework can complement each other in creating a correct allocation of benefits of DG and thereby stimulate the convergence towards an optimal and efficient integration of DG/RES in energy supply.

Benchmarking methodology

The benchmarking methodology applied in the SUSTELNET project provided for a first systematic comparison of distribution network regulation. The ENIRDG-net project took the benchmarking exercise a bit further by comparing support mechanisms for DG in the different countries and assessing their impact on network functionality. Making use of a benchmarking exercise provides the opportunity to lay down a broader vision on needed regulatory framework changes for integrating DG more effectively in the electricity network in the medium and long term.

The evaluation method used for DG policy and regulation is based on three ‘normative valuation grids’, one for each different stage of market presence of DG, namely low, intermediate and high share of DG (in %). These three levels of DG share are distinguished from each other by the impact of network regulation on the creation of a level playing field, which may differ with the current or increased shares of DG. For example, the DG capacity in Germany increases rapidly, but the regulatory framework for DG lags behind this development.

A real benchmark requires knowledge on the best (relative) or most optimal (normative) regulation. Regulation can for example be benchmarked against the requirements of the European Directives (normative). In the SUSTELNET project (FP5) the regulatory framework of several EU Member States was benchmarked on the basis of an adequate regulatory framework (best practices) defined in the SUSTELNET project. These best practices include (Leprich and Bauknecht, 2004):

- The creation of an economic level playing field, meaning that costs and benefits for both centralised and distributed generation are treated equally. This also means that benefits and costs created by DG are properly valued in the current regulatory system[3].
- The position of the DSO and its transformation into a more active service provider. A DSO should not only limit itself to maximising the transport of electricity but actively aim at improving distribution services and the quality of electricity supply.
- Setting connection charges in such a way that it benefits both the DSO and DG operator. A charging system for DG, including connection charges and specific UoS charges, should be able to value costs and benefits of DG to the network.
- Setting UoS charges in such a way that:
    - Recovery of costs associated with network management is ensured.
    - Sales maximisation is neutralised so that DSOs are motivated to do more than distribute as much electricity as possible
    - Grid reinforcement costs are covered through connection and Use of System charges.

These predetermined best practices have led to the development of a questionnaire covering the five following issues (Boccard, 2004):

- A - Network regulation - Legal framework for DG operation and generation, what type of regulation is in place for DG in relation to authorisation procedures and access to markets
- B - Network regulation - Financial relationship between DG operators and DSOs, what is the position of DG operators in relation to the DSO regarding connection charges and charges for using the distribution network
- C - Network regulation - Legal framework for DSOs, what is the status of unbundling and what incentive mechanisms are in place
- D - Market access - what is the share of DG in electricity production
- E - Market access - how does DG participate in the electricity market

In section A, B and C the benchmarking study identifies the main potentials for regulatory improvement in each of the EU Member States (MS). In section D and E an additional analysis of the DG support schemes is carried out to see whether present schemes conflict with short and medium term goals of a level playing field for DG. This review tries to explain the relatively high DG share in some countries, although the regulatory framework (according to the benchmark study) is in fact still 'hostile' to this development.

Benchmarking results

The ENIRDG-net benchmark study analysed the policy and regulatory framework for DG in seven European countries, namely Austria, Belgium, Finland, France, Ireland, Spain and Sweden. These results were compared to the results for nine other countries carried out in the framework of the SUSTELNET project, being Denmark, Germany, Italy, the Netherlands, United Kingdom, the Czech Republic, Hungary, Poland and Slovakia.

The benchmark study has lead to the following findings regarding the use of *support schemes* (ten Donkelaar & van Oostvoorn, 2005):

- Support mechanisms in the different member states are only rarely adapted to the position of DG in the market. For example, feed-in tariffs exist in countries that already have a relatively high DG share (Denmark, Germany, Spain). Other countries have recently introduced market-based mechanisms, such as green/CHP - certificates, although DG share remains low (e.g. Belgium, United Kingdom).

[3] An example is the valuation of prevented network losses when DG is located closely to the demand and electricity does not have to be transported over the transmission grid and only partly over the distribution grid.

- The effectiveness of feed-in tariffs can be illustrated by DG penetration levels in Denmark, Germany and Spain. All these countries have reached a relatively high level of DG penetration, in particular regarding wind power. But these high levels of intermittent wind power sources have also posed a challenge to appropriate network management.
- Protecting DG in a niche-market when its share is already relatively high may not be cost-effective for the power system in the long-term. A number of countries recognised the need to make their support schemes more cost-effective at higher DG levels:
  - Spain has made a first step in transforming the support system by giving DG operators the choice to choose between fixed feed-in tariffs or a fixed premium on top of the market price. Denmark has also recently transformed its fixed feed-in tariff system to price premiums.
  - Belgium is gradually moving from feed-in tariffs to a green/CHP- certificate system, recognising the need of a market based approach. In Sweden, only a temporary feed-in system exists for wind power, recognising the need for a temporary 'tilting' of the level playing field in favour of certain types of DG.
  - The Netherlands has introduced a 'hybrid' support system for RES with a combination of feed-in tariffs and green certificates. Although the long-term objective is to create a market-based system, these measures have not yet been sufficient in properly promoting new DG capacity in the Netherlands.
- Access to the energy market largely depends on the development of energy liberalisation. Countries such as the Netherlands and the UK have already full access to wholesale and balancing market in place. In other countries market access lags behind and DG is dependent on priority dispatch and obligatory purchase (e.g. Italy).

The analysis of the *network regulatory framework* led to the following findings (ten Donkelaar & van Oostvoorn, 2005):

- Both shallow and deep connection charging are commonly applied in EU Member States even as 'combined systems' where the additional grid reinforcements are shared between DG operators and DSOs. In some countries, such as Austria and Finland, the DSO has the possibility to choose between shallow and deep charging, based on the available capacity of the grid. This makes it possible to allocate grid costs to the proper party (the DG operator wishing to connect). It requires, however, supervision from a regulator to ensure that deep connection charges are merely being applied for covering costs related to that particular connection.
- Consumers generally pay UoS charges, although in some countries producers also pay a share of it. DG operators are generally exempted from paying UoS charges for the transmission network or exempted from paying UoS charges at all.
- In countries with shallow connection charges there are little incentives for DSOs to connect DG into the network. The most straightforward incentive is an obligation, as applied in most EU Member States, but this might not automatically lead to efficient network investments.
- With a system of deep connection charges, such as in the UK, DSOs should not have a problem with connecting DG. However, when DSOs are only benchmarked on the basis of cost efficiency, meaning that UoS is charged on the basis of kWh transported, the integration of DG brings no additional benefits to the DSOs.
- A performance based regulation system as recently introduced in the Netherlands and the UK may be an incentive for more efficient network investments and the integration of DG.

As it was difficult to compare the scores of the different EU Member States in the benchmark study without explaining the specific country situation this review is limited to a qualitative analysis. However, when critically reviewing the results, one sees a number of clear paradoxes (Boccard, 2004):

- An example is the situation in Denmark. The Danish regulatory regime was (successfully) used to achieve the policy objective of achieving a higher level of DG in the power system. However, the benchmarking study shows that Denmark has failed to adjust its regulatory regime to a situation where DG is a major market player, and where DG should be included in the market on terms that induce efficiency.
- A comparable situation has occurred in Germany where strong support for DG (especially wind energy) did not go hand in hand with improving network regulation. Network regulation remained relatively ‘hostile’ to DG as a transparent system of calculating connection costs was missing.
- Conversely, countries with medium or low levels of DG presence fare rather well, e.g. France, UK for the reason that criteria used for low levels of DG are less stringent than for high levels. France scores rather well with market access, although the level of DG is still low. This might be caused by the fact that the type of support mechanisms in place in France is, according to the methodology, suitable for a niche-market situation.

As a general result new Member States outperform older EU Member States since their relative recent implementation of electricity law has closely followed the EU directives. Item C to the questionnaire showed that the *legal framework for the DSO* in all Member States seems not to incentivise the DSO in such a way that it would favour DG. Developments in the last two years in the Netherlands and the UK show, however, that performance based regulation of DSOs and incentives for certain investments gain importance.

The benchmarking exercise above provided a first methodological approach for benchmarking DG network regulation. It has been almost impossible to compare network regulation with support schemes and both outcomes have therefore been presented separately.

Policy recommendations

Based on the results of the SUSTELNET and ENIRDG-net projects a number of recommendations have been made for policy makers to consider when integrating DG into electricity networks:

- To reach a level playing field between DG and centralised power generation, existing support schemes will have to be gradually modified when the DG share in electricity supply is growing. When DG starts to influence physical power flows and energy markets, DG cannot be considered as a protected niche market anymore. This will ensure a cost-effective approach in network management in the medium and long-term.
- With regards to the regulatory framework, a general pre-condition is non-discriminatory network access for DG. This includes access to the wholesale electricity market in the short-term and access to newly developed markets for ancillary services (balancing, securing power quality, etc.) in the longer-term.
- The benefits and cost of distributed generation to the electricity system are directly related to the geographical point of connection. It is therefore considered fair that these costs and benefits are somehow reflected in the UoS charges and electricity pricing to the distributed generator. Although not always charged to DG, UoS charges could be a powerful tool in allocation of costs and benefits DG brings to the network.
- When DG/RES levels increase it will become important that DSOs develop active network management aimed at integrating DG to the network. This active network management entails investment in innovations to improve network management, in particular in the field of ICT applications. This requires in particular a change in the regulatory framework related to DSOs, meaning that not only cost-efficient management of networks should be rewarded, but also their willingness to invest in network performance and innovations.

- In view of the required innovations in network management, both EU and national policies should also seek to stimulate the exchange of knowledge in the field of DSO incentivisation and innovation in distribution networks EU-wide.

Conclusions and final remarks

So far it has not been possible to draw any general conclusions from the benchmarking exercise of SUSTELNET and ENIRDG-net. Scores found when comparing network regulation in different countries do not speak for themselves and can therefore not be interpreted exactly. This is mainly caused by the fact that the successful deployment of DG in some EU Member States was caused by a mix of factors, the regulatory environment and the energy and environmental policy environment. A good example is the 'Danish paradox', a high level of DG in the Danish power system but no regulatory framework that is adapted to this situation and is still treating DG as being part of a protected niche-market.

Another issue that influences the integration of DG is the role of intermittent resources. Controllable and non-controllable DG sources create different values to the distribution network. This has not been taken into account, as it was difficult to give a certain weight to intermittent/non-intermittent resources. Nevertheless, the benchmarking exercise provided a first methodological approach for benchmarking DG network regulation. It is still a methodology in development and it has already been applied in follow-up studies.

The field of electricity network regulation is experiencing important developments during the last years, caused by the growth of DG capacity and the completion of the liberalisation of electricity markets in all EU Member States. The benchmark study in this field is continuing in a follow-up project of SUSTELNET, DG-GRID. In this project the benchmark methodology is applied to study the regulatory environment for several different types of DG technologies. This way the regulatory barriers that concrete types of technologies are experiencing can be illustrated and it will also cover the difference between controllable and non-controllable DG sources with regards to the regulatory environment. This research will have to provide the possibility to give concrete advice to policy makers in the field of electricity network regulation.

Literature

- Boccard, N.: *A Benchmarking of 9 European Member States policies towards Distributed Generation.* Final report for the SUSTELNET project, http://www.sustelnet.net/docs/wp4_benchmarking.pdf. (2004).
- Donkelaar, M. ten, Oostvoorn, F. van: Recommendations for Institutional Policy and Network Regulatory Frameworks towards Distributed Generation in EU Member States, ECN-C--05-005, ECN, Petten (2005).
- Leprich, U., Bauknecht, D.: *Development of benchmark criteria, guidelines and rationales for distribution network functionality and regulation.* Final report for the SUSTELNET project, http://www.sustelnet.net/docs/wp4_development.pdf.(2004).
- Sambeek, E.J.W. van, Scheepers, M.J.J.: Regulation of distributed generation - A European Policy Paper on the Integration of Distributed Generation in the Internal Electricity Market, ECN-C--04-070, ECN, Petten (2004).
- Scheepers, M.J.J., Wals, A.F.: New Approach in Electricity Network Regulation. An Issue on Effective Integration of Distributed Generation in Electricity Supply Systems, ECN-C--03-107, ECN, Petten, (2003).