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Guidelines for improvement on the short term of electricity distribution network regulation for enhancing the share of DG

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Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Gomez, T., Rivier, J., Frias, P., Ropenus, S., Welle, A. V. D., & Bauknecht, D. (2007). Guidelines for improvement on the short term of electricity distribution network regulation for enhancing the share of DG. Petten: Energy Research Centre of the Netherlands (ECN). (DG GRID report; No. D12/13).

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Enhancement of sustainable electricity supply through improvements of the regulatory framework of distribution networks for distributed generation

Guidelines for improvement on the short term of electricity distribution network regulation for enhancing the share of DG

Work Package 4, Report D12/D13

June 15, 2007

Final Report

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Intelligent Energy  **Europe**

Research project supported by the European Commission,
Directorate-General for Energy and Transport,
under the Energy Intelligent Europe (EIE)

Acknowledgement

This research project is supported by the European Commission, Directorate-General for Energy and Transport, under the Energy Intelligent Europe (EIE) 2003-2006 Programme. Contract no. EIE/04/015/S07.38553

We thank our DG-GRID colleagues, in particular Klaus Skytte, Philipp Spaeth, Uwe Leiprich, Seppo Karkkainen, Benoit Esnault, Jaap Jansen, Jeroen de Joode, and Martin Scheepers, for inputs to this report.

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Summary

This report provides some general recommendations and guidelines for improving network regulation in the short-term to enhance the share of distributed generation (DG) in EU-15. These recommendations are mainly based on the research carried out under previous work packages of the DG-GRID project.

General recommendations are formulated at the EU level. However, the specific implementation of most of these recommendations corresponds to national regulators. For this reason national questionnaires have been developed and completed to collect the current situation and expected developments on each of the particular regulatory topic in each DG-GRID participating country.

Recommendations are organized mainly around two main issues

- How DSO regulation should be changed for enhancing the share of DG; and
- What economic signals should be given to DG to achieve its active integration in distribution networks.

Regarding **DSO unbundling** according to the provision stipulated in the European Directive 2003/54/EC, the main recommendations are as follows.

The effectiveness of the unbundling provision of the EU Directive is highly dependent on their actual enforcement by the Member States. A lack of unbundling at the distribution level may negatively impact the access conditions for new DG operators trying to penetrate the market. This can cause severe problems for new DG operators when DSOs display anticompetitive behavior by favoring their own DG units or DG sites owned by their previously affiliated companies.

***RI:** It is recommended to adopt measures for achieving a higher level of national compliance with the requirements of both legal and functional unbundling and for obtaining more transparency on the actual state of unbundling (not only in law, but also in fact) in the individual MS. This could be done via a semi-annual benchmarking conducted by the national regulatory authority or another independent body as a supplement to the yearly evaluation in the EU Benchmarking Report. In addition, a separate report dealing solely with the progress in unbundling could be published yearly to shed light on major shortcomings and to identify best practices in the MS.*

If measures to enhance the implementation of legal and functional unbundling at the national level are not deemed sufficient in the long term to achieve non-discriminatory network access and transparency, a decision with regard to tighter unbundling provisions has to be taken at the EU level. The unbundling requirements then chosen must apply to all operators and to all national markets in order to avoid inconsistencies between the national dimension of regulatory competences and the EU dimension of a

single energy market (European Commission, Directorate-General for Energy and Transport, 2007).

R2: Regarding the exemption clause contemplated in the Directive 2003/54/EC on unbundling for DSOs with less than 100,000 connections, it is recommended to leave it to the discretion of the Member States, provided that transparent procedures for planning, operation and accounting are in place. It is vital that the regulator adopts the necessary measures and procedures to ensure egalitarian conditions to network access where vertical integration of small DSOs is granted. What these measures should consist of is a country-specific issue dependent on the existence of entry barriers, network charging methodology and national regulatory framework (e.g., network regulation and support mechanisms/prioritized access) in place.

One aspect which should be highlighted in this respect is the kind of connection charging philosophy. In the absence of transparency, a deep charging method may provide vertically integrated DSOs with more incentives and scope for discrimination than a shallow charging approach.

The second regulatory topic is related with **DSO revenues and incentives to integrate DG**. Recommendations are formulated to improve network planning taking into account DG, to design regulatory arrangements for compensating DSO extra costs due to DG, and to improve DSO performance in quality of service taking into account DG.

Article 14/7 2003/54/EC Electricity directive stipulates that DG should be considered by DSOs when planning the development of the distribution network optimising the need for upgrading or replacing network capacity.

R3: *Some recommendations to implement in practice the Article 14/7 mandate are the following ones.*

- *Incentive regulation based on price or revenue caps rather than rate of return regulation puts more pressure on DSOs for network efficient investment.*
- *Under incentive regulation, allocation of allowed investment budgets for the next regulatory period for individual DSOs is recommended. DSOs will be allowed to keep efficiency gains, for more than one regulatory period, due to efficient integration of DG, as incremental profits.*
- *It is recommended to implement use-of-system charges for DG and/or support mechanisms applied to DG, differentiated by time of use and voltage levels, together with economic incentives to DG for providing ancillary services to help DSOs to operate the network, for instance, providing voltage control and reactive power support, with a more active management of the network by DSOs. That will lead to a better optimization of the use of existing facilities, minimizing the requirement for new installations.*
- *The revision of planning and security criteria used by DSOs in order to include the potential benefit of DG deferring or reducing network investments is recommended. Engineering Recommendation P2/6 in UK can be an example to follow¹.*

DSOs with high levels of DG penetration, defined as the energy generated by DG locally with respect to the local energy consumption, for instance higher than 15-20%, should be compensated for incremental CAPEX & OPEX due to DG, mainly because network investment and energy losses costs. There are several options to achieve this objective. In UK, a revenue increment per each kW of connected DG has been included in the DSOs remuneration. In addition, if a DG connection scheme qualifies as a Registered Power Zone (RPZ), the revenue increment is increased for the first five years of operation. DG-GRID project has investigated DSO revenue drivers based on the feed-in capacity and the energy delivered by DG modulated according the DG penetration levels. Other options such as allowance for these extra costs in the Regulated Asset Base are more appropriate for rate of return regimes.

R4: *It is recommended that the specific regulatory mechanism to compensate DSOs for incremental CAPEX & OPEX due to DG, should be designed taking into account the particular DSO regulatory framework in each country.*

Among these extra costs are incremental energy losses.

¹“Engineering Recommendation P2/6. Security of Supply”, Energy Networks Association, July 2006.

R5: DSOs with distribution areas with high DG penetration/concentration levels could be compensated for incremental energy losses. For instance, a DSO revenue driver, in €/kWh, associated with DG production (kWh) located in those areas can be implemented. This compensation would mainly come from those generators connected in those areas that would be charged with a fee (€/kWh) proportional to the value of the incremental losses they produce in the network. On the other hand, it is recommended to implement use-of-system charges for DG and/or support mechanisms applied to DG, differentiated by voltage levels, to take into account that DG connected in lower voltage networks can reduce losses at higher voltage levels.

DSOs have to meet quality of service targets in terms of i) duration and frequency of supply interruptions, and ii) voltage quality keeping voltage disturbances within certain limits. The potential advantages of having DG as a new control source should become a DSO opportunity instead of a threat.

R6: DG can help to improve reliability indices working in islanding mode in case of network outages. DG can provide ancillary services such as voltage control, frequency reserve, or black start to improve voltage quality. To achieve this aim, it is recommended to implement

- performance based regulation for quality of service targets that provides explicit incentives to DSOs for improving quality of service levels.
- incentives for DSO innovation programs that promote a deep transformation from passive to active management increasing DG participation in network control and DG contribution in case of network disturbances.
- incentives to DG for providing ancillary services to help DSOs to operate the network, for instance, providing voltage control and reactive power support, frequency reserve, islanding operation, etc. to improve quality of service levels.

R7: *Incentives to promote DSO innovation for efficient integration of DG should be incorporated into network regulation. Some of the instruments to implement them can be:*

- *R&D investments can be included in the Regulated Asset Base as a separate item with higher rates of return or with a partial pass-through. An example is the Innovation Funding Incentive (IFI) in UK. A DSO is allowed to spend up to 0.5% of its revenue on eligible IFI projects.*
- *Selection of performance indicators that can be improved through network innovation. Several countries have implemented performance regulation to improve quality of supply.*
- *Regulators may work with DSOs formulating and testing new regulatory instruments, and developing new regulatory scenarios with a shared vision, in order to explore deeper and long-term network transformations.*

The selection of the most appropriate instruments in each country would take into account the type of DSO incentive regulation in place and the national regulatory framework.

Finally, regarding the third regulatory topic, recommendations about the **economic signals to be given to DG for its efficient integration** are proposed. The support mechanisms are critically reviewed. DG connection charges and use-of-system charges should be efficiently designed. Ancillary services and other network services provided by DG are identified and mechanisms for efficient provision are proposed.

R8: *DG (RES/CHP) support mechanisms, especially with high DG shares, should be made compatible with energy market prices and network UoS tariffs that promote efficient DG operation and network location. Regarding DG operation to achieve efficient market integration it is recommended:*

- *RES-E and CHP market stimulation systems should be smartened to better reflect the social value of the MWh injected in the system. In case of high DG penetration, avoid fixed production payment mechanisms, such as constant feed-in tariffs or feed-in subsidies as a general rule.*
- *Implement feed-in tariffs with time discrimination or feed-in premiums on top of market prices that promote efficient DG operation, i.e. higher production at peak hours, and storage and controllability capabilities in medium and large size DG installations.*

Connection charges are paid just once when DG require network access. Use-of-system (UoS) charges are periodically paid by network users, usually end consumers, and, in

some MS, also DG. UoS charges should, as far as possible, (i) reflect the cost incurred to provide the network user with the network transport and system service, and (ii) ensure full recovery of the DSO's total acknowledged revenues.

R9. *To create a level playing field for DG integration, DG connection charges, paid just once when the connection is required, should be regulated, based on simple rules mainly recognizing shallow costs, i.e. the direct costs of connection. Calculation rules should be transparent and standardized by national regulation. Other costs for network reinforcements and upgrades due to DG connections should be socialised among the network users and paid through the Use of System (UoS) charges.*

R10: *It is recommended that DG pay or receive UoS charges. DG use of system charges should be cost reflective (positive or negative).*

- *DG UoS charges should be differentiated by time of use and voltage levels. DG connections at lower voltage levels and DG production at load peak hours should be incentivized.*
- *Differentiated DG support mechanisms, such as feed-in tariffs by voltage levels can be used to achieve the same effect that differentiated DG UoS charges.*
- *DG UoS charges calculation methods should be in line with the other elements of the national regulatory framework: DG connection charges, DG support mechanisms, DG network services, etc.*

DG can contribute significantly to TSO/DSO ancillary and network services.

R11: *DG through aggregators can participate in balancing and reserve markets. DG can provide voltage support and compensate energy losses as required by DSOs. In the future, with higher levels of network automation and DG controllability, DG would help to solve congestion management, and to improve quality islanding. Commercial arrangements between TSO/DSO and DG to recognize such contribution can be*

- *Regulated payments to DG, for instance acknowledged in the UoS charges*
- *Bilateral contracts between DG and DSO*
- *DG participation in markets: i) energy balancing and reserve markets; and ii) network related markets, such as local balancing, reactive power, congestion management, or energy losses compensation.*

1 Objectives

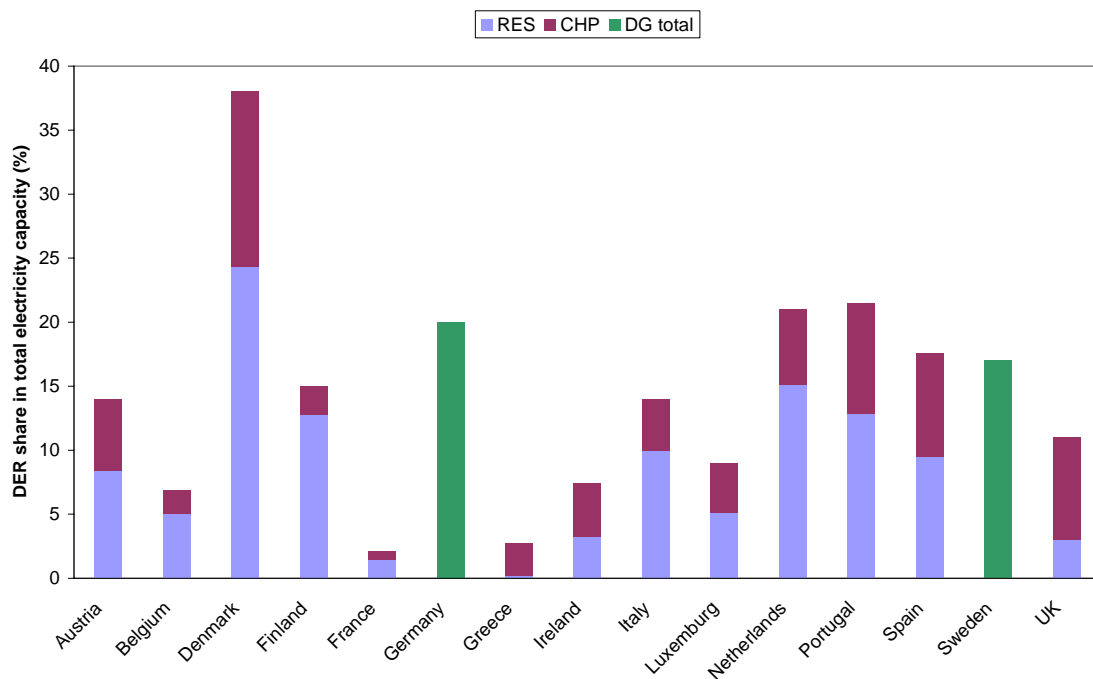
This report provides some general recommendations and guidelines for improving network regulation in the short-term to enhance the share of distributed generation (DG). These recommendations are mainly based on the research carried out under previous work packages of the DG-GRID project.

The DG-GRID project is structured in four work packages (WP). WP1 reviews the regulation of DG in the old EU-15 Member States and also determines the main barriers for DG integration. In WP2 new network concepts are identified, and an analysis of the consequences of using innovative network concepts (defined for large penetration of DG) in the current networks is carried out. WP3 analyses the role of network operators, how DG influence in their economic balance, and what improvements in DSO regulation should be assessed. Finally, WP4 collects all the information of the previous WPs, and gives general and specific guidelines to increase the proper penetration of DG. The following presents a resume of the main findings and conclusions of the different WPs.

Work package 1

In WP1 a review of the current regulation of networks with respect to distributed generation in the EU-15 MS and a comparison among the different systems have been carried out. A start-point for this analysis is to determine the current situation of DG penetration in power systems as shown in Figure 1. Current situation shows that ten countries have a DG share over total capacity above 10%, and half of them are over 20%.

Figure 1 DG share of total generation capacity



WP1 has also identified the major regulatory barriers for connection of DG (see Table 1) where the most important are the lack of incentives for the DSO, connection charges, procedural barriers and access to energy and balancing markets.

Table 1 Presence of the main barriers in EU-15

Barrier	AU	BE	DK	FI	FR	DE	GR	IRL	IT	LUX	NL	P	ES	SE	UK
Connection charges	✓	✓		✓		✓	✓	✓			✓			✓	✓
Physical/technical network constraints	✓				✓		✓	✓					✓	✓	✓
Procedural barriers Network	✓				✓	✓	✓		✓		✓	✓	✓		
Lack of unbundling		✓				✓	✓			✓					
Lack of incentive for proactive DSO role	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓		✓
Power market entry barriers	✓	✓		✓			✓				✓	✓		✓	✓
Procedural barriers Market							✓	✓					✓		
Lack of benefit for DG	✓	✓					✓			✓					

The main findings of WP1 analysis has been summarized in two deliverables, D1 “Regulatory Review and International Comparison of EU-15 Member States” and D2 “Assessment and Recommendations Overcoming in Short-Term Grid System Regulatory and other Barriers to Distributed Generation”.

Work package 2

In WP2 medium- to long-term changes into the grid structure and how these need to be promoted and accompanied by regulatory innovations in order to integrate higher levels of DG are investigated. First, a review of innovative network concepts has been carried out, identifying different alternatives for the future distribution network. Among these new concepts stand active networks, virtual power plants, power cells, intelligent networks, and microgrids. To introduce these new concepts into distribution networks radical shift in DSOs control philosophy will be required, changing from traditional central control to a distributed control paradigm based on active network management.

Under this new paradigm, innovation will be a key issue for delivery of efficient integration of DG and demand response into operation and development of power systems. To achieve this change in DSOs operation paradigm, WP2 has designed a three-step regulatory improvement framework: innovating regulation, regulating innovation and long-term transformation.

First, innovation in regulation is needed to minimize the difference of economic interests between DG and DSOs which is the result of the current incentive structure. For this purpose two regulatory innovations are proposed for DSOs remuneration: (i) benchmarking including quality, and (ii) the implementation of article 14/7 of the 2003

EU electricity directive which requires DSOs to consider DG as an alternative to network expansion.

In order to introduce innovation in current DSO regulatory schemes, some positive incentives for DSOs to connect DG are needed. Under this topic three regulatory alternatives have been analyzed such as: including innovation costs in the regulatory asset base, a separate treatment of innovation costs, and extending regulatory periods.

Finally, medium and long-term promotion of R&D and innovation needs specific regulatory mechanisms. WP2 has worked on two instruments to deal with the uncertainty for future system transformation: (i) developing long-term visions through scenarios and (ii) experimentation with regulatory instruments in “Regulatory innovation zones”.

The main findings of WP2 have been summarized in two reports, D4 “Review of Innovative Network Concepts” and, D5 “Regulating Innovation & Innovating Regulation”.

Work package 3

In WP3 costs and benefits associated with DG integration in distribution networks are identified and evaluated. First, the impact of DG on network losses, voltage profile, fault level / short circuit power and investment schemes is assessed. The evaluation has been carried out considering different DG technologies such as PV, CHP and small hydro. The impact of two different operating regimes namely passive and active network management has also been investigated. The results cover UK and Finnish cases based on generic distribution network models of rural and urban networks.

The general conclusions of the analysis are:

-Reinforcement costs will increase as the DG penetration level increases. DG contribute to energy losses reduction when the penetration is low, but increases losses for high DG penetration.

-Under traditional passive network operation philosophy, a large amount of investment is needed to upgrade current network assets in order to accommodate new DG. Active management can clearly reduce these upgrade costs, as it has been demonstrated for the UK and Finnish rural networks. Different results are obtained for Finnish urban networks, where active management increases investment costs compared with passive management. However, active network management should not only be justified with cost reduction, but also with improving the controllability and operation of the distribution and transmission networks with high penetration of DG.

-The effect of intermittent and non-intermittent generation depends on the balance between generation and load. Micro CHP has a good effect on losses reduction as its generation is coincident with the peak load, both in the UK and Finnish cases. On the other hand, PV maximum output occurs in summer while maximum load is in winter – in Finland as well as in the UK. Finally hydropower only impacts on rural networks.

A more detailed analysis can be found in two reports D7 “Method for Monetisation of Cost and Benefits of DG Options”, and D8 “Costs and Benefits of DG Connections to Grid System”.

A second topic in WP3 is the analysis of DSO business models in order to evaluate the impact of DG connection and network integration on DSO costs, revenues, and profits. A first analysis is made on report D9 “Evolving network regulation to efficiently accommodate distributed generation”. This report identifies the cost impacts of the provision of access of increasing volume of DG to their networks by DSOs and the contractual relationships between the DSO and DG operators. In addition, the roles of DG and DSOs in the provision of ancillary services are analyzed.

A second analysis on this topic from a more quantitative perspective was conducted. It was observed, that the combination of a special allowance and a direct revenue driver is the most successful regulatory arrangement in compensating the negative DG impact on DSO costs. Under this option DSOs will be able to recover their costs and at the same time are stimulated to connect existent and new types of DG. In order to implement these criteria, some policy actions are proposed:

- Current regulation of DSOs should recognize the impact of DG on DSO performance.
- Implement a DSO regulatory formula where the impact of DG on both operating expenditures and capital expenditures would be taken into account.
- Initially it may be needed some ‘overcompensation’ of possible negative DG impact on DSOs in order to provide them an explicit incentive to facilitate and accommodate new DG connections in their distribution networks.
- Compensatory regulation for DG penetration is intertwined with the developments in the field of ancillary services provision by DG. On the one hand, DSOs might need to be compensated for the negative impact following the penetration for DG. On the other hand, if DSOs benefit from the provision of ancillary services enabled by DG penetration, the DSO should compensate the DG operators.

A deeper analysis on DSOs business models can be found in the report D10 “Business models for DSOs under alternative regulatory regimes”.

Work package 4

This report synthesizes the work in WP4, giving guidelines and recommendations as a result of the research conducted in DG-GRID. The report is organized around two main issues

- First, how DSO regulation should be changed for enhancing the share of DG; and
- Second, what economic signals should be given to DG to achieve its active integration in distribution networks.

For each recommendation a general description of the problem and the current situation is provided. Main drawbacks and barriers for DG integration are identified. Finally,

guidelines to improve the current situation with the corresponding recommendations are proposed identifying the entity responsible for their development and implementation.

The aim of these recommendations is twofold. First it would be desirable to formulate general recommendations valid at EU level. Second, specific treatment at national level including discussion and proposals on how to implement such recommendations will be provided for the countries involved in DG-GRID. To achieve this later objective a specific questionnaire has been designed to collect the corresponding information including the opinion of national regulators.

2 DSO regulation

Several topics are discussed regarding DSO regulation and DG integration. The issues where recommendations are proposed are:

- DSO Unbundling
- DSO revenues and incentives to integrate DG
- DSO incentives for innovation

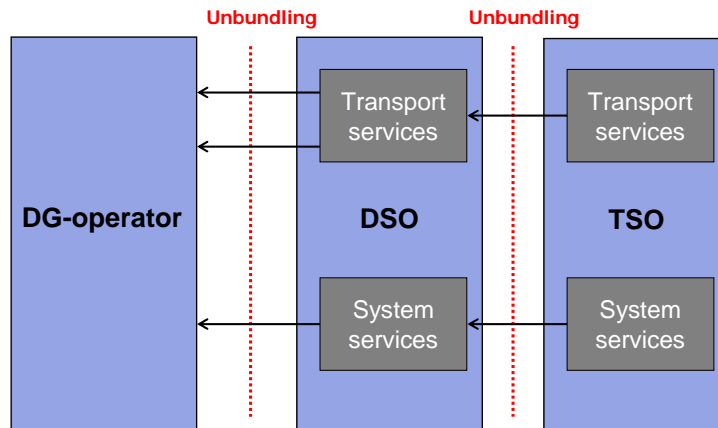
2.1 DSO Unbundling

Traditionally, generation, transmission and distribution of electricity have been carried out by vertically integrated monopolies. Liberalisation of the electricity industry requires the adoption of unbundling, i.e., the “separation of the various components of production, distribution and service in order to introduce greater elements of competition to these segments of an industry”².

Of particular relevance for Distributed Generation (DG) are the unbundling requirements for Distribution System Operators (DSOs). Those are stipulated in Directive 2003/54/EC, Art. 15 (1): “where the distribution system operator is part of a vertically integrated undertaking, it shall be independent in terms of its legal form, organisation and decision making from other activities not relating to distribution”. In addition to **legal unbundling**, certain criteria of **functional unbundling** have to be met. The latter have been established to guarantee the DSO’s independence with regard to its organisation and decision making, such as effective decision-making rights independent from the integrated undertaking with respect to assets to operate, maintain and develop the network. The provisions of functional unbundling are laid down in Article 15 (2) of the same Directive.

² http://ec.europa.eu/comm/competition/general_info/u_en.html

Figure 2 Unbundling of the DSO (Source: adapted from DG Grid Report D 1, p. 12)



The unbundling requirements at the distribution level differ from those at the transmission level in two important respects: first, legal unbundling of the DSO may be postponed until the date of full market opening, **1 July 2007** (Dir. 2003/54/EC, Art. 30 (2)). Second, Art. 15 lays down the possibility for an exemption: Member States may decide to exempt integrated electricity undertakings serving less than 100,000 customers, or serving small isolated systems, from the unbundling provisions. This **exemption** is not limited in time.

2.1.1 National compliance on DSO unbundling

The effectiveness of the unbundling provisions of the EU Directive is highly dependent on their actual enforcement by the Member States. A lack of unbundling at the distribution level may negatively impact the access conditions for new DG operators trying to penetrate the market (especially independent power producers). Since networks are operated as natural monopolies, fair and non-discriminatory network access is an essential condition for the development of competition in the generation segment. There is asymmetry of information as DSOs have access to market sensitive information, e.g., through the collection of metering data and the managing of exchange of information. Aggravation of network access may occur in different ways: e.g., transmission and distribution system operators may claim a lack of capacity, charge excessive transport fees, delay access by long negotiations, litigation and manipulation of price (Wälde, 2001). Furthermore, a lack of unbundling coupled with a lack of transparency bears the risk of cross-subsidies between the competitive segment and the regulated network activity. For instance, an incumbent can use his distribution assets as collateral for his more risky commercial activities as the latter activities deliver higher revenues than regulated network activities (higher risk asks for higher return), while new suppliers do not have such kind of collaterals generating a stable income stream. All these factors can cause severe problems for new DG operators when DSOs display anticompetitive behavior by favoring their own DG units or DG sites owned by their previously affiliated companies.

Table 2 depicts the current state of DSO unbundling in selected Member States and the existence of national plans for the implementation of more effective ways of DSO unbundling.

Table 2 Implementation of Unbundling

Country	Type of unbundling implemented	Plans to implement more effective ways of DSO unbundling
Austria	Legal	No
Denmark	Legal	No
Finland	Legal (if amount of electricity distributed in 0.4 kV level > 200GWh/year)	No
France	Management	Not in short-term, but envisaged improvement of accounting transparency.
Germany	Legal	No
Italy	Accounting mandatory Legal facultative for large DSOs	Review process with aim of introducing functional unbundling. Proposals concern the timeliness of moving towards ownership unbundling of some activities. Proposal to develop simplified approach to accounting unbundling.
Netherlands	Legal One small DSO ownership unbundled	Functional unbundling by 1 st July 2008. Discussions of ownership unbundling (see below).
Spain	Legal	Draft of new regulation to transpose Directive 2003/54/EC nationally, especially to adopt functional unbundling.
UK	Legal	Effective unbundling priority area; if independent network operation cannot be ensured under existing framework, the UK would support ownership unbundling.

Table 2 illustrates that legal unbundling of DSOs is the prevalent form of unbundling adopted. However, this statement has to be read with caution as there may be discrepancies between the minimum unbundling stipulated by national law and its actual en-

forcement. E.g., in Greece legal unbundling has been formally established, but the single national grid operator is still strongly bound to the national utility PPC (Skytte et al., 2005). As the process of unbundling of DSOs is currently still in transition (until July 2007), no final evaluation can be made at this point in time; however, it is important to remove shortcomings that are already apparent.

Table 3 Ownership of DG by DSOs

Country	Can DSOs own DG under specific circumstances?
Austria	Yes.
Denmark	No, but exemption for small DSOs.
Finland	In general no. Only if amount of electricity distributed in 0.4 kV level < 200GWh/year in past 3 years, then financial unbundling required.
France	Yes, but accounting unbundling.
Germany	Yes, but accounting unbundling.
Italy	Yes
Netherlands	No
Spain	No, but exemption for small DSOs.
UK	No, but private distribution networks/independent DNOs may own DG.

No specific problems related to DSO unbundling and network integration of DG were to be found in Denmark, Germany, Finland and the UK.

In Austria, some past incidents have been reported by independent power producers in which insufficiently unbundled daughter companies of DSOs received preferential treatment in the development for sites of wind projects.

In France, access to distribution systems is sometimes considered as insufficiently transparent. It is, however, difficult to consider that unbundling plays a role in that. In fact, obstacles are often due to the reluctance of DSOs to facilitate the access to their system for “cultural reasons”, i.e., a culture of centralized power generation, and also for “technical reasons” (due to the difficulties associated to DG development).

In Italy, the main problem related to unbundling is the lack of transparency. The AEEG is therefore revising the unbundling requirements to reach a so-called “functional unbundling”.

In the Netherlands, from a practical point of view, the major issue is cross-subsidization of commercial activities by network companies of integrated incumbents as well as the extraction of capital from DSOs that is used for commercial activities instead for replacement investments and innovation.

In Spain, there have been network access conflicts, which were reported by DG owners resulting from discriminatory treatment by the DSOs, as well as technical problems such as overloads or voltages out of margin.

R1: *It is recommended to adopt measures for achieving a higher level of national compliance with the requirements of both legal and functional unbundling and for obtaining more transparency on the actual state of unbundling (not only in law, but also in fact) in the individual MS. This could be done via a semi-annual benchmarking conducted by the national regulatory authority or another independent body as a supplement to the yearly evaluation in the EU Benchmarking Report. In addition, a separate report dealing solely with the progress in unbundling could be published yearly to shed light on major shortcomings and to identify best practices in the MS. If measures to enhance the implementation of legal and functional unbundling at the national level are not deemed sufficient in the long term to achieve non-discriminatory network access and transparency, a decision with regard to tighter unbundling provisions has to be taken at the EU level (Section 2.1.2). The unbundling requirements then chosen must apply to all operators and to all national markets in order to avoid inconsistencies between the national dimension of regulatory competences and the EU dimension of a single energy market (European Commission, Directorate-General for Energy and Transport, 2007).*

Regulation level: National MS Regulators and possibly EU.

2.1.2 Discussion of Ownership Unbundling and Independent System Operators

The way in which unbundling has been introduced did not prove to be effective in guaranteeing non-discriminatory network access. This is why the EU has launched the discussion on two alternative solutions: ownership unbundling or the establishment of an independent system operator (ISO). In its Memo “The Internal Energy Market: Foundation of the EU Energy Policy” from January 2007, the European Commission identifies as a key measure:

“new rules to avoid discrimination, for instance so that a company owning both power generation and distribution network does not hinder the access of other companies to the market. Two unbundling options could redress the problem. The most radical is called “ownership unbundling”, by which vertically integrated companies would be split between their different activities. Another possibility would be the creation of independent system operators, by which system operation would be separated from the ownership of assets”

(European Commission, Directorate-General for Energy and Transport, 2007).

At the national level, a discussion to go further than the provisions of legal unbundling stipulated by Directive 2003/54/EC has been carried out in the Netherlands: ownership unbundling was proposed by the Minister of Economic Affairs which has submitted the law of independent network management to the Lower House. The Lower House agreed in majority with ownership unbundling. However, last year the vision of the parliament with respect to ownership unbundling has radically changed; the Upper House has made the decision that DSOs are not obliged to unbundling, unless the European Union decides to do so or if utilities undertake actions that risk to give foreign entities undue control over their networks or if utilities exercise undue market power, e.g., through tacitly impeding level-playing-field access by third parties.³ In fact, the Upper House overruled the Lower House, which earlier in majority agreed on ownership unbundling. However, there is still a lot of vagueness concerning the precise nature of the situations that would result in enforced unbundling.

2.1.3 Exemption clause on DSO unbundling

In addition to problems related to the implementation of unbundling in law and in fact, there is the case of the optional exemption clause where unbundling does not have to be adopted at all. The overall effect of this exemption clause depends on the number of DSOs with less than 100,000 connections, how many per cent of the connections fall into this category in the individual MS and if those DSOs own generation connected to their networks. Especially small-scale DG is often connected to the low voltage net and deployed in rural areas where there are many DSOs with less than 100,000 connections (Skytte, Ropenus et al. 2005, p. 81).

³ Kamerstuk 2006-2007, Eerste Kamer (Upper House), 30 212, H.

Table 4 DSOs with less than 100,000 connections

Country	Number of DSOs	Number of DSOs with less than 100,000 connections	% of connections that fall into this category	Do these small DSOs own generation connected to their networks?
Austria	138	119	12%	Yes
Denmark	120	112	43%	No
Finland	91	85	51%	Yes, but accounting separation
France	166	160	5%	Yes
Germany	950	900	n.a.	Yes
Italy	170	n.a.	n.a.	Yes
Netherlands	10	5	3%	No
Spain	308	303	3%	Yes
UK	18	3	1%	Yes

As the situation is very different from country to country, the effect of small DSO unbundling requirements on DG development varies – also dependent on whether the existence of integrated small DSOs constitutes a barrier for DG integration or not. Therefore, before giving a general recommendation at the EU level on this issue, it is important to collect information of the particular situation in each country involved in DG-GRID. Pros and cons of requiring legal unbundling for small DSOs regarding DG connection and development should be identified in each particular case. In the following, the advantages and disadvantages of requiring also unbundling of these small DSOs regarding effective DG integration are given on a country-by-country basis.

In Austria, the detrimental impact on DG integration due to the existence of small integrated DSOs is negligible. Unbundling would hit severely very small DSOs that have very little staff so they cannot provide separation without prohibitive increases in personnel costs. There are no current plans to introduce legal and functional unbundling for these DSOs. Even to force the medium-sized DSOs between 10.000 and 100.000 connections to unbundle would probably not foster DG employment since some of these integrated DSO invest innovatively in DG – presumably *because* they integrate generation and distribution.

In Denmark, there are no problems for DG integration related to the existence of integrated small DSOs.

In Finland, it is difficult to assess whether there are specific DG integration problems arising from small DSOs' integration as all DSOs have an obligation to connect network power generating installations. Unbundling would provide the advantage of having less diffusion of confidential information to other suppliers or traders. However, unbundling would entail the disadvantage of extra personnel and systems costs for small companies which can result in higher DG connection and operation costs. There are no plans to require legal and functional unbundling for small DSOs.

In France, DSO integration does not appear to be an obstacle to the further developing of DG. Small DSOs have the same obligations as EDF to open their network to DG under certain technical conditions. They have to implement cost accounting and separate production and distribution. As DG integration is a legal obligation for DSOs, there is no apparent reason to move towards more unbundling. Deepening the unbundling requirements could even reduce the effectiveness of distribution network management by reducing the coordination with DG owned by local distributors. In fact, there is no possible competition between different DG operators.

Also, in Germany there are no specific problems for DG integration related to the existence of integrated small DSOs. Although there are theoretical arguments for full DSO unbundling to promote DG, it is doubtful that DSO unbundling in Germany would help in practice and there are no current plans to do so. Regulation of network tariffs and clear rules are certainly more important.

In Italy, no specific problems related to small DSO integration could be identified either. The establishment of functional unbundling for all the network operators is under way.

In the Netherlands, there are also no specific obstacles to DG development stemming from the integration of small DSOs. The advantages of unbundling consist in having a more independent DSO that sets that the interests of the DSOs at the forefront instead of the interests of the utility as a whole. Furthermore, it would be beneficial as to the achievement of a level playing field (no competitive advantages of integrated utilities); and supervision and administrative costs of the regulator would be lower if there was one system applicable to all DSOs instead of two systems to different DSOs. One of the major drawbacks associated with unbundling is a loss of efficiency due to a loss of economies of scope. DSOs are already obliged by law to complete functional unbundling in 2008. The law does not make any difference between large and small DSOs at this point. In the Netherlands there is made a distinction between a so-called 'fat' network administrator as will be the case in 2008 compared to a 'lean' DSO as is now the case. A 'fat' network administrator has its own decision making rights, has the economic ownership of the network and the disposal of own financing sources (the network). Also, legal limits have been set for contracting out tasks to other parties.

In Spain, some conflicts of DG access to small DSO networks have been reported; however, the importance of these small DSOs is only marginal so that the regulator does not consider this subject as a priority. There is no political willingness for additional unbun-

dling requirements at the regional level, where these companies have a long tradition, nor at the national level.

No specific problems related to small DSO integration were found in the UK.

In theory, there is a trade-off between the introduction of unbundling to guarantee fair access conditions and the additional burden put on small DSOs in terms of costs and complexity of system integration. However, in practice the exemption clause does not constitute a major barrier with regard to network access in the above mentioned Member States. Rather, the exemption clause is of great importance for those Member States with a high number of small DSOs. First, the adoption of unbundling would entail high transaction costs particularly for small DSOs. Second, vertical integration of small DSOs may enhance their ability and incentive to innovate when integrating more small DG units into their networks. Solutions they develop to integrate their own DG sites can be applied when connecting DG units of new independent producers. Therefore, the impact of the exemption clause has to be assessed rather on a country by country basis than on the European level, taking into account the structure of the distribution sector and the regulatory framework in the individual Member States.

R2: *It is recommended to leave the exemption clause for small DSOs to the discretion of the Member States, provided that transparent procedures for planning, operation and accounting are in place. It is vital that the regulator adopts the necessary measures and procedures to ensure egalitarian conditions to network access where vertical integration of small DSOs is granted. What these measures should consist of is a country-specific issue dependent on the existence of entry barriers, network charging methodology and national regulatory framework (e.g., network regulation and support mechanisms/prioritized access) in place.*

One aspect which should be highlighted in this respect is the kind of connection charging philosophy. In the absence of transparency, a deep charging method may provide vertically integrated DSOs with more incentives and scope for discrimination than a shallow charging approach. Connection charges are discussed more thoroughly in Section 3.2.

2.2 DSO revenues and incentives to integrate DG

Under unbundling, DSOs are a regulated *wire* business. In most countries of Europe, DSOs revenues are determined by incentive regulation. Price caps or revenue caps set the tariffs for a period of several years (three to five). This is a regulatory incentive that leads DSOs to reduce costs and investments, while regulators should control that these reductions do not adversely affect the quality of service.

In general, the integration of DG in distribution networks means an important challenge for DSOs. DG integration not only impacts on short-term DSO costs but also involves new DSO risk uncertainty regarding system reliability, security, and network planning.

Therefore, it is important to accurately analyse the effects of a DG extension on the DSOs' interests within every step of the incentive regulation mechanism and to develop approaches

- to systematically take into account additional costs for DSOs,
- to at least neutralise the negative incentives on the allowed revenues of the DSOs resulting from a volume reduction in the case of auto-generation or independent area networks.

In DG-GRID several quantitative analyses have been carried out where DSO incremental costs as a function of DG penetration levels have been assessed. Incremental network reinforcement costs, energy losses, active network management costs, and other operational costs have been identified and evaluated. In addition, a multi-year simulation of DSO revenues, under current incentive regulation, shows that if DSOs are not compensated for these incremental costs, DSO profits will decrease as DG penetration levels increase, therefore increasing the DSO reluctance to connect DG.

Figures 3 and 4 represent how the traditional DSO management model should be modified to take into account an effective integration of DG.

Under the traditional DSO management model, demand increase and new demand supplies are the main driver for system development and reinforcement. Planning and operational criteria are based on passive management, i.e. new installations are planned and operated under the “fit and forget” principle. Allowed capital expenditures (CAPEX) and operational expenditures (OPEX) are remunerated through a price cap or revenue cap formula. Incentives (penalties) for improving (not achieving specific targets) quality of service indicators or/and network energy losses are also included in the DSO annual remuneration. A more detailed view of how distribution regulation is implemented in the European countries participating in the DG-GRID project is presented in the following subsections.

To achieve an efficient DG network integration, the traditional DSO management model must migrate to a more complex model where additional costs and benefits from DG should be incorporated. New DG connections and DG operation is a new driver for system development and operation. DSOs have to provide network services to any network user including demands and generators. In this new management model with high DG penetration levels, network active management (AM) for maximizing the use of existing assets while maintaining the required quality of service standards will become a critical issue. AM actions include: (i) power flow management by DG to avoid line overloading, (ii) voltage control, (iii) power quality management, (iv) demand side management, and (v) fault level control by specific devices. Active management will deeply impact on current DSO operation and planning practices, and, consequently, on DSO CAPEX and OPEX. AM in distribution networks will potentially reduce network reinforcements, although it may increase OPEX as the network is operated more intensively. Additionally, AM will increase also investments in communication and control equipment. To obtain the benefits derived from AM, specific services and contracts between

DG and DSO should be designed, such as dispatch generation contracts and contracts for interruptible loads.

On the other hand, DSOs obtain their allowed revenues through use-of-system charges paid by network users, demands and in some countries distributed generators. In addition, new connections should pay connections charges associated with the required investments to connect the user to the distribution network. There are two main approaches for connection charges, deep or shallow charges. Shallow connection charges only comprise the costs of connecting to the nearest point of the distribution network, while deep charges include in addition to the connection installation all the required network reinforcements inside the distribution network. Deep charges provide a strong locational signal. However they represent a financial barrier to new network users, specially for distributed generation. For efficient integration of DG shallow connection charges are recommended, while all the network reinforcements required inside the distribution network should be recovered through use-of-system charges. That assumption was thoroughly justified in SUSTELNET⁴, a previous European project, and it will be adopted as an assumption in the rest of this document.

⁴ M.J.J. Scheepers, 'Policy and Regulatory Roadmaps for the Integration of Distributed Generation and the Development of Sustainable Electricity Networks', Final Report of the SUSTELNET project, ECN Report ECN-C-04-034, 2004, NL.

Figure 3 The traditional DSO management model

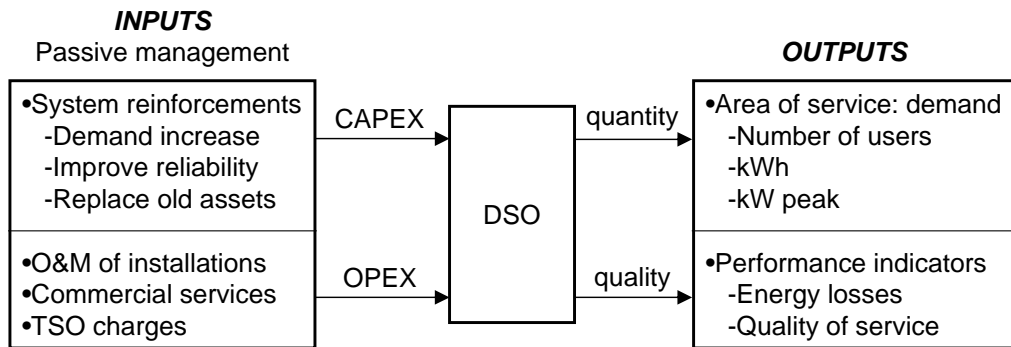
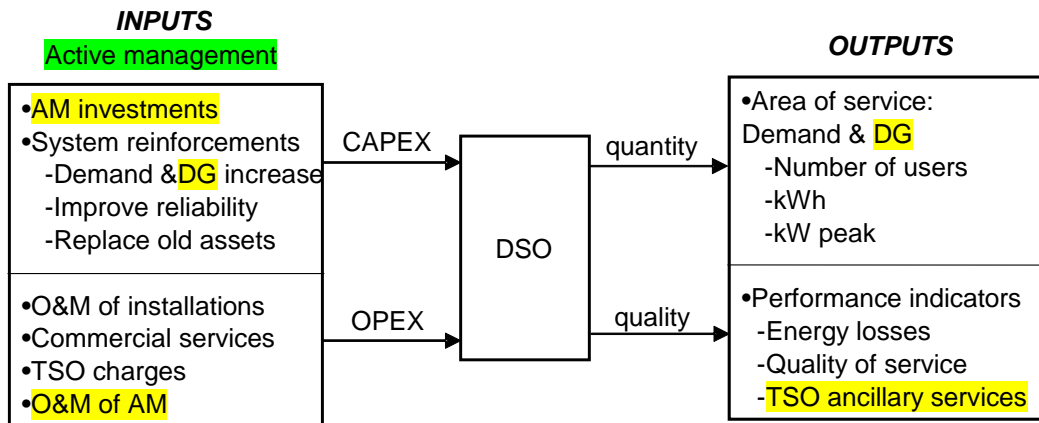


Figure 4 The new DSO management model with effective integration of DG



In the following, different aspects of DSO regulation that impact on the DSO business model and related to network investments, incremental OPEX and CAPEX, and DSO performance on energy losses and quality of service are analyzed. Recommendations to improve DG integration in distribution networks are formulated.

2.2.1 Network planning taking into account DG

Article 14/7 of the EU electricity directive requires DSOs to consider DG as an alternative to network expansion. Although it is very important for the further development of DG that its potential to replace network investments becomes realised, there is no concept yet as to how this provision can be implemented and backed up by appropriate regulatory mechanisms and incentives for unbundled network operators. That it is even more challenging if DSOs are effectively unbundled and therefore they can not own DG.

According to the questionnaires that have been completed among the DG-GRID participating countries, in four of the nine European countries, i.e. Finland, France, Germany, and Italy, distribution investments are remunerated based on a cost of service or rate of return regulation. That means that DSOs report network investments to the regulator, allowed investments are remunerated to a pre-specified rate of return. Therefore, this type of regulation does not provide specific incentives to DSOs for efficient network expansions taken advantages of the potential DG benefits.

In Finland, network investments are remunerated at standard costs calculating the replacement value of the network asset. Basically efficiency requirements are related to OPEX. It is foreseen that in the next regulatory period (2008-2011), efficiency input-output models will be implemented.

In France, every year DSOs report investment programs to the regulator. Allowed investments are remunerated at a fixed rate of return. The main problem for the regulator to control efficient investment is the lack of transparency and the quality of the information.

In Germany, DSO investments are considered when calculating DSO revenues. However there is not mechanism to promote efficient investment. Incentive regulation will start in 2009. The problem to allocate investment budgets, for instance, is that in Germany are more than 700 DSOs.

In Italy, despite a RPI-X price cap has been implemented for OPEX, DSO network investments are explicitly remunerated at a fixed rate of return. An incentive framework aimed at improving energy efficiency has been also implemented with energy efficiency certificates and quota obligations. DSOs can propose projects and investments to reach the targets.

On the other hand, five countries, Denmark, Netherlands, Spain, Austria and the UK, have implemented incentive regulation, that, in theory, will promote CAPEX and OPEX reductions while keeping quality of supply standards.

In Denmark, the regulator can increase the cap level if, due to DG connections, it is estimated that is needed. However, there are no explicit mechanisms to induce DSOs for efficient investments taking into account DG.

In Netherlands, caps apply to TOTEX the sum of CAPEX and OPEX. Therefore, efficient investment is implicitly considered as improvement in quality of supply is rewarded. In addition, yardstick competition is implemented. Therefore DSOs always look for firm-specific investments that provide them comparative advantages. DG is not considered as a measure to lower network costs.

In Spain, a revenue cap applies for OPEX together with CAPEX. This scheme has not been updated for 8 years. DSOs have been strongly addressed to minimize network investments. On the other hand, DG deep connection charges, has led to DSOs to charge DG with network extensions not totally justified. A new proposal for DSO regu-

lation that considers incremental DSO revenues associated to efficient network expansions is under discussion.

In UK, every five years the DSO price control is reviewed. Under price control there is an implicit mechanism for efficient investment. In addition, the Engineering Recommendation P2/6 acknowledges the DG contribution to network security. However, there is not strong evidence that DSOs have relied on DG to reduce their network investments. Moreover, the Innovation Funding Incentive (IFI) and the Registered Power Zones (RPZ) are two mechanism implemented by the regulator in the period 2005-2010 to encourage DSOs to invest efficiently and economically.

As a summary, incentive regulation based on price or revenue caps, provides an implicit incentive to DSOs to reduce network investments. The problem here can be the opposite. How to compensate DSOs if, due to connections of DG, network reinforcements are needed? See next section on incremental CAPEX due to DG.

The following table summarizes the main findings regarding network expansion taking into account DG.

Finland and Germany have plans to migrate also to incentive regulation. Therefore, incentive regulation is becoming the most used mechanism in Europe to remunerate DSOs. Under incentive regulation, the question is how to allocate specific incentives to DSOs for DG integration that in the long-term will reduce the need for network expansions. Under this mechanism, a possible scheme to promote efficient investment can be formulated as follows. The regulator will allocate investment budgets for each individual DSO for the next regulatory period. This scheme leaves all system optimising decisions completely up to DSOs. At the end of the regulatory period, the DSO should inform to the regulator on the network investment actually implemented. Efficiency gains on investments due to DG, for instance, investment in active network management that integrates DG in order to postpone network reinforcements, will be recognized to the DSO as an allowed profit in that period. This scheme, by the contrary, can be expensive in terms of regulatory control. Technical experts on behalf of the regulator should assess the efficiency of implemented actions. However it put pressure on both, regulator and DSO, in order to take into account efficient integration of DG when allocating investment budgets.

From an operational point of view, to achieve network efficiency due to DG, it is required to implement locational signals that promote the DG contribution to the peak demand, i.e. the location of DG close to the demand and their production in local peak hours. Use of system charges for DG and/or support mechanisms applied to DG, differentiated by time of use and voltage levels is a way of implementing these locational signals. For instance, support mechanisms for DG based on renewable or CHP, such as feed-in tariffs or feed-in premiums, should incentive DG production at peak hours rather than at valley hours. Moreover, use of system charges and/or support mechanisms should recognize network benefits to DG connected in lower voltage networks rather than those in higher voltage networks. In addition, DG should be economically compen-

sated for providing ancillary services to help DSOs to operate the network, for instance, providing voltage control and reactive power support, especially in rural networks. All of these signals together with a more active management of the network by DSOs will lead to a better optimization of the use of existing facilities, minimizing the requirement for new installations. Section 3 of this report provides guidelines for the implementation of these actions.

Table 5 Incentives to DSO for efficient network expansion

Type of regulation for investment	Countries	Incentives for efficient network expansion	Guidelines
Rate of return	Finland, France, Germany, Italy	NO	Migrate to incentive regulation.
Incentive regulation: price or revenue caps	Denmark, Netherlands, Spain, Austria	YES. Investments dropped significantly for various reasons.	Implement explicit mechanisms to take into account DG.
Incentive regulation plus ad-hoc explicit mechanisms	UK	YES. Engineering Recommendation P2/6 acknowledges DG contribution for system expansion. IFI and RPZ mechanisms.	Evaluate and refine already implemented mechanisms.

Finally, another type of actions in order to take into account the potential benefit of DG by deferring network investments is to update planning and security criteria used by DSOs. In some countries, as in UK, planning criteria that should be met by DSOs have been reviewed in order to take into account DG as an alternative to network expansion. The Engineering Recommendation P2/6 acknowledges the DG contribution to network security. This technical recommendation mandates DSOs to evaluate the contribution of the DG to the peak demand, depending on the technology and the number of DG units, when calculating network reinforcements. For instance, the required transformer installed capacity in a distribution substation could be reduced depending on the amount of DG connected in the distribution network supplied by that substation.

R3. *Article 14/7 2003/54/EC Electricity directive stipulates that DG should be considered by DSOs when planning the development of the distribution network optimising the*

need for upgrading or replacing network capacity. Some recommendations to implement in practice such mandate are the following ones.

- *Incentive regulation based on price or revenue caps rather than rate of return regulation puts more pressure on DSOs for network efficient investment.*
- *Under incentive regulation, allocation of allowed investment budgets for the next regulatory period for individual DSOs is recommended. DSOs will be allowed to keep efficiency gains, for more than one regulatory period, due to efficient integration of DG, as incremental profits.*
- *It is recommended to implement use-of-system charges for DG and/or support mechanisms applied to DG, differentiated by time of use and voltage levels, together with economic incentives to DG for providing ancillary services to help DSOs to operate the network, for instance, providing voltage control and reactive power support, with a more active management of the network by DSOs. That will lead to a better optimization of the use of existing facilities, minimizing the requirement for new installations.*
- *The revision of planning and security criteria used by DSOs in order to include the potential benefit of DG deferring or reducing network investments is recommended. Engineering Recommendation P2/6 in UK can be an example to follow⁵.*

Regulation level: National MS Regulators.

2.2.2 Incremental OPEX + CAPEX due to DG

Under the DG-GRID project a deep investigation on technical and economic impacts of DG penetration on distribution networks has been carried out. This analysis identified some relevant factors that affect the magnitude and direction of such impact. Among them, the level of DG penetration in the network, defined as the energy generated by DG locally with respect to the total energy consumption, and the concentration of DG capacity, defined by the physical location of DG units inside each voltage network level, were the most relevant. The conclusions of these analyses show that DSOs generally do not benefit for DG, except for cases where DG penetration is low (below 23% in the study cases) and for low concentration of these units in the network. Benefits in these situations are mainly due to energy losses reduction. Higher penetration levels result in a negative impact on DSO benefits, and the more concentrated the presence of DG in the distribution network, the more negative the impact. Incremental network investments and energy losses increases are the reason for this observed behaviour.

⁵ “Engineering Recommendation P2/6. Security of Supply”, Energy Networks Association, July 2006.

In order to neutralise the negative impacts of high DG penetration levels on DSO incremental costs, to adopt some kind of regulatory compensation mechanism is strongly recommended.

The DG-GRID questionnaires were used to analyze how DSO regulation in European countries acknowledges for incremental DSO costs, in our case due to DG. DG-GRID participating countries have been classified according the type of regulation they use to remunerate CAPEX and OPEX. First, France and Germany use rate of return or cost of service regulation for both. Then, Finland and Italy use rate of return for CAPEX and incentive regulation for OPEX. Finally, Denmark, Netherlands, Spain, Austria and the UK use incentive regulation for both, CAPEX and OPEX.

In France, CAPEX and OPEX are remunerated based on a cost of service regulation. DSOs have an incentive to reduce annually OPEX by 3%. Under this regime DSOs can obtain compensations for over-costs due to DG.

In Germany, OPEX and CAPEX are explicitly recognized. However, there are no explicit provisions for extra costs due to DG. There are plans to introduce incentive regulation in 2009. DG has been listed as a potential cost driver to be considered in the DSO efficiency analysis.

In Finland, DSOs should reduce OPEX by 1.3% per year (period 2005-2007), CAPEX are remunerated by applying a rate of return to the Replacement Value of the Network calculated at specific standard costs. Network reinforcements due to DG are taken into account in the calculation of CAPEX, in addition the possible change of network volume is also noticed in OPEX.

In Italy, a RPI-X formula is applied to OPEX, CAPEX are remunerated at a rate of return. Incremental DSO costs due to the connection of DG are taken into account when DSO revenues are calculated.

In Denmark a revenue cap applies for total DSO costs. The incremental effect of DG connections on DSO costs is not considered. The individual DSOs average tariffs are more or less fixed to the level they had in January 2004.

In Netherlands, the allowed DSO revenues are calculated by a benchmark analysis applied to total costs TOTEX. In addition yardstick competition in terms of relative efficiency among DSOs has been implemented. In the previous analysis, DG connections are not taken into account. If DG is larger than 10 MVA deep connection charges are applied, therefore the DG operator pays the necessary reinforcement costs.

In Spain, a revenue cap formula applies to both OPEX and CAPEX. Therefore DSO revenues do not change due to DG connections. Because deep connection charges are applied, DG operators pay for network reinforcements. It is proposed a new revenue cap formula that takes into account annual incremental revenues due to new demands and new DG connections. The use of a reference network model is proposed to calculate these incremental revenues.

In UK, a revenue increment per each kW of connected DG has been added to the price cap formula. In addition, if a DG connection scheme qualifies as a Registered Power Zone (RPZ), the revenue increment is increased for the first five years of operation by £3/kW. RPZs are intended to encourage DSOs to develop and demonstrate new, more cost effective ways of connecting and operating generation that will deliver specific benefits to new distributed generators and broader benefits to consumers generally.

In the following table, the current situation and some guidelines regarding the treatment of incremental OPEX and CAPEX due to DG are summarized.

Table 6 Treatment of incremental OPEX & CAPEX due to DG

Type of regulation	Countries	Incremental OPEX & CAPEX due to DG	Guidelines
Rate of return or cost of service for both OPEX & CAPEX	France, Germany	YES, however there are not explicit treatment of them	Migrate to incentive regulation.
Rate of return for CAPEX. RPI-X for OPEX	Finland, Italy	Incremental CAPEX are explicitly included. There is not explicit treatment for incremental OPEX.	Include specific treatment of incremental OPEX.
Incentive regulation: price or revenue caps	Denmark, Netherlands, Austria, Spain	NO. Incremental OPEX and CAPEX are not considered.	Implement explicit mechanisms to take into account incremental costs due to DG.
Incentive regulation plus ad-hoc explicit mechanisms	UK	YES. Incremental revenues associated to DG connections, and IFI and RPZ mechanisms.	Evaluate and refine already implemented mechanisms.

The current situation in the different EU countries regarding the treatment of incremental costs due to DG is quite similar in all of them, with the exception of UK. It is clear that under incentive regulation based on price or revenue caps, if the level of DG penetration is increasing, a specific treatment of these incremental costs is required. We can find two different practical experiences. In the countries where rate of return regulation is still in force, the incremental CAPEX are included in the Rate Asset Base (RAB). On the other hand, in countries with incentive regulation, only UK includes a specific revenue driver to consider such kind of incremental costs.

In the DG-GRID project, several regulatory options to compensate DSOs for incremental costs due to DG have been investigated:

- Allowance for DG in the Regulated Asset Base (RAB): In each price control process at the beginning of each regulatory period, a estimation on how the regulated asset base should be modified to include all the incremental CAPEX associated with new DG connections is calculated. At the end of the regulatory period the initial estimations will be reviewed according with real DG connections. This approach might not be the most effective and efficient one. In assessing ‘estimations’, the questions on how bears the risk of under- or overestimation of required network costs is important. Incorporation in CAPEX and OPEX estimates might be too complicated.
- DSO benchmarking considering DG as a cost driver: In each price control process, it is quite frequent that regulators carry out a benchmarking procedure that evaluates the efficiency of each individual DSOs apart from their cost bases. The results of the benchmarking procedure correct either the start value of the use-of-system tariffs and/or the tariffs during the regulatory period (“X-factor”). Due to the aforementioned impact of DG on DSO costs, it is clear that DG should be explicitly considered during the benchmarking process. One investigated possibility is to include DG as another DSO cost driver. For instance, for OPEX the number of DG plants can be considered, while for CAPEX the DG feed-in capacity in peak load hours it is recommended. In addition, it has been proposed to define a performance indicator for DSOs associated with DG efficiency; for instance, the DG contribution to the peak load substituting centralized generation capacity to supply the load. Regarding this last item, the issue is how DSOs can modify the production of controllable DG units, and what kind of active actions should be implemented for that (see DG support mechanisms and DG use-of-system charges in section 3 of this report. Time dependant premiums on top of the electricity price and time-variable generator use-of-system charges can stimulate efficient feed-in of DG).
- Tariff adjustment factor: Since it seems nearly impossible for a DSO to foresee the DG development in his network territory for a 3 to 5 year period, another regulatory option is to include secondly a possibility to recover the costs associated with DG ex post. This could mean an ex post recovery on a yearly basis or after the whole regulatory period. Formally this could be done through a balancing account that is included in the regulation formula through a Z-factor.
- Allowance for a DSO revenue driver: the regulator may include in the DSO revenue formula, a DG-related increment revenue associated with DG connected capacity and production on a yearly basis. This revenue driver should be calibrated to broadly reflect “average DSO” DG-attributable incremental costs, not allowed for by other incentives. For instance,

$$TAR_t = TAR_{t-1}(1 + CPI - X) + \text{€}A/kW_{DG} + \text{€}B/MWh_{DG}$$

Where:

TAR_t : is the DSO total allowed revenue in year t

CPI : is the consumer price index in year t

X : is the efficiency factor set by the regulator according to a benchmarking analysis

A : is an incremental DSO allowed revenue for each new kW of installed DG capacity connected to its network in year t

B : is an incremental DSO allowed revenue for each additional MWh produced by DG installations connected to its network in year t

In the DG-GRID project some numerical analysis has been carried out to investigate different formulations of the revenue drivers under revenue cap regulation. It should be noted that the main difference between the tariff adjustment approach and the revenue driver one, is that under the first approach incremental costs are evaluated in each case and passed through ex post; while in the second case, standard costs are recognized ex ante for DG, no matter of particular situations.

Finally, it is recommended that the specific regulatory compensation scheme should be designed taking into account the regulatory framework for distribution regulation in the country. Again, special importance has the regime for connection charges. Incremental investment costs are totally paid by DG under deep connection charges. Therefore that is not an incremental cost for DSOs. Therefore, it is important to keep in mind that all the previous analysis and the following recommendations assume shallow connection charges for DG.

R4. *DSOs with high levels of DG penetration, defined as the energy generated by DG locally with respect to the local energy consumption, for instance higher than 15-20%, should be compensated for incremental CAPEX & OPEX due to DG, mainly because network investment and energy losses costs. There are several options to achieve this objective. In UK, a revenue increment per each kW of connected DG has been included in the DSOs remuneration. In addition, if a DG connection scheme qualifies as a Registered Power Zone (RPZ), the revenue increment is increased for the first five years of operation. DG-GRID project has investigated DSO revenue drivers based on the feed-in capacity and the energy delivered by DG modulated according the DG penetration levels. Other options such as allowance for these extra costs in the Regulated Asset Base are more appropriate for rate of return regimes. It is recommended that the specific regulatory compensation mechanism should be designed taking into account the particular DSO regulatory framework in each country.*

Regulation level: National MS regulators.

2.2.3 DSO performance on energy losses

As it has been evaluated in the DG-GRID project, energy losses in distribution networks are affected by DG. For low DG penetration levels usually DG would reduce network energy losses with respect the reference situation with no DG. On the other hand, high DG penetration levels would increase energy losses.

The real economic impact of losses variations due to DG on DSO profits depends on how losses costs are considered in each particular DSO regulation.

Among the European countries considered in the DG-GRID questionnaire, we can distinguish three different cases according the way losses energy reduction by DSOs is incentivized.

There is a first group of countries where energy losses costs are not considered as a controllable OPEX. In Austria, Finland, and Germany, DSOs are compensated for their actual losses, and they do not have incentives to reduce them. Therefore, the impact of DG on losses does not affect DSO profits.

There is a second group of countries where DSOs has to compensate energy losses in their networks by buying that energy in the market. Losses costs are considered as controllable OPEX. DSOs make more profits it they reduce losses in their networks. Therefore, DSOs have an incentive to reduce losses. If the impact of DG in losses is not compensated to the DSO, as it happens today, the economical consequences of higher or lower losses due to DG are totally assumed by DSOs. That is the case of DSOs in France, Italy, and Netherlands.

In France, a predetermined level of losses is included in the provisions for the tariffs. Targets for reduction in non-technical losses ranging from 0.5% to 1.5%, depending on the concerned territory, have been considered.

In Italy, DSOs have obligation quotas on energy to be saved. Therefore one way of achieving energy efficiency is by reducing network losses. On the other hand, DSOs have to compensate DG operators (except PV below 20 kW) for avoided transmission costs, i.e. the costs of purchasing electricity from the high voltage transmission network.

In Netherlands, DSOs have to compensate energy losses by contracting energy from their own utility (if supplier and DSO belong to the same holding) or from other generators like DG. Therefore, DSOs have an incentive to reduce losses. Since 2006, DG operators are credited for reducing energy losses on high voltage transmission levels through the feed-in of energy in lower voltage levels. The TSO determines the yearly amount devoted to these credits.

Finally, there is a third group of countries, under incentive regulation, where DSOs have incentives to reduce losses below specific targets. If the impact of DG in losses is not considered by the regulator when calculating those targets, as it happens today, the economical consequences of this impact are totally assumed by the DSOs. These countries are Denmark, Spain, and UK.

In Denmark, DSOs have incentive to reduce losses according to the cost caps, i.e. revenue-cap regulation.

In Spain, DSOs buy at the energy pool price the difference between actual energy losses in their networks and standard energy losses set by the regulator.

In UK, each DSO has an incentive to decrease energy losses below a specific target. This target is calculated as an average of the DSO losses in previous years.

There is a proposal in UK to take into account the impact of DG on DSO losses. An explicit adjustment to the level of reported DSO losses may be made to reflect the impact of DG with a Loss Adjustment Factor (LAF) below 0.997. This adjustment will be the aggregate product of the difference between the site-specific LAF and 0.997, multiplied by the export volume of the generator.

The following table summarizes the previous information and presents some guidelines for the future.

Table 7 Impact of DG on DSO losses reduction incentives

Incentives for losses reduction	Countries	Impact of DG on losses reduction incentives	Guidelines
DSOs are compensated for actual energy losses. They do not have incentives	Austria, Finland, Germany	Not considered.	Migrate to implement incentives
DSOs have to compensate energy losses by buying them in the market. Losses cost is a controllable OPEX.	France, Italy, Netherlands	The impact of DG on DSO losses cost has not been considered. DG is compensated for avoiding losses only in the transmission network (Italy, Netherlands).	Compensate DSO for incremental losses due to DG. If due to DG, losses decrease, DSO can credit DG for such benefit.
DSOs have incentives to reduce losses below specific targets.	Denmark, Spain, UK	The impact of DG on losses targets has not been considered.	Include specific impact of DG on DSO losses targets. An example: proposal in UK.

With higher DG penetration or concentration levels on distribution networks, the impact of DG in network losses will be more important. To take this effect into account is a key issue for a better integration of DG. If this impact is not considered in the computation

of DSO losses costs or targets, as it happens today, the economical consequences of higher or lower losses due to DG will continue being assumed by the DSOs. To share the potential benefits or costs among DSOs and DG is important to design specific mechanisms that take into account this effect.

For high DG penetration/concentration levels, an increase of revenues should be allocated to compensate DSOs. For instance, in network areas with high DG penetration, a revenue driver to compensate the DSO in €/kWh associated with DG production (kWh) would be allocated. This compensation mainly will come from those generators connected in those areas that would be charged with a fee (€/kWh) proportional to the value of the incremental losses they produce in the network, providing the correct locational signals.

On the other hand, DG connected in lower voltage networks can be credited for losses reductions at higher voltage levels, that is the case of Italy and Netherlands. Again, this locational signal can be sent as a reduction of the use-of-system charges paid by DG, or by increasing the DG support as feed-in tariffs or premiums in lower voltage levels. Section 3 of this report provides guidelines for the implementation of these actions.

R5. *DSOs with distribution areas with high DG penetration/concentration levels could be compensated for incremental energy losses. For instance, a DSO revenue driver, in €/kWh, associated with DG production (kWh) located in those areas can be implemented. This compensation would mainly come from those generators connected in those areas that would be charged with a fee (€/kWh) proportional to the value of the incremental losses they produce in the network.*

On the other hand, it is recommended to implement use-of-system charges for DG and/or support mechanisms applied to DG, differentiated by voltage levels, to take into account that DG connected in lower voltage networks can reduce losses at higher voltage levels.

Regulation level: National MS regulators.

2.2.4 DSO performance on quality of service

Quality of service in distribution networks consists mainly of two topics: i) Continuity of supply associated with the frequency and duration of supply interruptions, and ii) voltage or power quality associated with voltage disturbances such as voltage changes, flicker, harmonics, voltage dips, etc.

Continuity of supply is strongly related with DSO network investments and operational and maintenance expenses. Under incentive regulation, setting quality of service targets to DSOs has become a key issue to ensure adequate performance with efficient pricing. Otherwise, DSOs can increase their profits by reducing investments leading to a progressive degradation of the quality of service.

Half of the countries included in the DG-GRID WP4 questionnaire have already implemented performance-based regulation to encourage DSOs to keep adequate quality of service levels. This performance based regulation is focused on the measurement and control of zonal reliability indices, SAIDI⁶ and SAIFI⁷. If DSOs achieve better actual values than those set as quality targets they will increase profits, otherwise profits will be reduced.

How does DG affect to the quality of service provided by DSOs? This is still an open question.

The capacity of DG to supply loads in islanding mode is a possibility that would increase the continuity of supply provided by DSOs, however this is nowadays far from real DSO practices. How DG can be used to increase the continuity of supply provided by DSOs is a subject that needs further research and innovation efforts.

In the following the country situation regarding this issue is reviewed.

In Austria, continuity of supply indices, SAIDI and SAIFI are monitored, however there are no explicit incentives or penalties to DSO for meeting specific targets. DSOs can negotiate with DG for reactive power provision.

In Denmark, no specific DSO regulation in terms of improving quality of service levels has been implemented yet.

In Finland, DSOs are penalized if the interruption time of a single outage is longer than 12 hours. In spite of that, there are plans to include in the next regulatory period (2008-2011) performance regulation based on the value of the non-distributed energy to the customers.

In France and Germany, there are not specific incentives/penalties related to quality of service targets. DG is mainly seen by DSOs as a potential source of quality problems. There are plans to implement a new performance based regulation for quality, however DG is not considered as a specific source for improvement.

In Italy, performance regulation is based on a combination of technical standards and economic incentives. DG is not explicitly considered as a source of improvement.

In Netherlands, incentives and penalties related to meet quality of service targets have been implemented. Total allowed DSO price increases depend on a quality indicator (Q-factor). DSOs see DG units rather as a threat to their business than as an opportunity to diversify.

In Spain, DSOs have to meet specific quality targets in terms of frequency and duration of supply interruptions. DG is not currently considered as a control element that can improve quality of service levels.

⁶ SAIDI stands for System Average Interruption Duration Index.

⁷ SAIFI stands for System Average Interruption Frequency Index.

In UK, penalties and rewards have been implemented for DSOs associated with continuity of supply indices. The most extended opinion is that DG neither improves nor reduces the continuity of supply figures. A radical change in the design of protection systems in distribution networks is required in order to DG can help improving quality of service indicators.

The following table summarizes the current situation and guidelines regarding DSO quality of service performance and the role of DG.

Table 8 Impact of DG on DSO quality of service obligations and incentives

Incentives/penalties to meet quality of service targets	Countries	Contribution of DG to quality of service levels	Guidelines
DSOs have not incentives/penalties	Austria, Denmark, Finland, France, Germany	Neutral. Most of DSOs see DG as a potential problem rather as a control source.	Implement incentives for quality of service improvements.
Performance based regulation for quality of service	Italy, Netherlands, Spain, UK	Neutral. Most of DSOs see DG as a potential problem rather as a control source.	Implement specific innovation actions to integrate DG as a control source for improving quality of service levels.

Concerning voltage quality, the European standard EN – 50.160⁸ establishes the voltage characteristics that should be met by DSOs when supplying electricity to users connected to distribution networks.

As a conclusion, most of the countries have already or have plans to implement performance based regulation for quality of service levels. Currently, DG is seen by most of DSOs as a potential source of problems rather than a help for network management and quality improvement. That is mainly due to the lack of observability and controllability of these sources, together with their frequent disconnections in case of network disturbances. However, if DG penetration levels increase as it is foreseen, the potential advantages of having DG as a new control source should become a DSO opportunity instead of a threat. DG can help to improve reliability indices working in islanding mode in case of network outages. DG can provide ancillary services such as voltage

⁸ European Committee for Electrotechnical Standardisation (CENELEC), 'Voltage characteristics of electricity supplied by public distribution systems, European Norm EN 50160', November 1994.

control, frequency reserve, or black start to improve voltage quality. However, to achieve this aim, a deep DSO transformation from passive to active management is needed. Regulators should include incentives for specific innovation actions taken by DSOs in this direction. See also recommendation 7 in next section

Finally, quality of service targets currently required to DSOs to be met for consumers in their connection points should be extended for distributed generators connected to distribution networks. Distributed generators and electricity consumers should be both considered network users with the same rights and requirements in terms of quality of service levels.

R6. *DSOs have to meet quality of service targets in terms of i) duration and frequency of supply interruptions, and ii) voltage quality keeping voltage disturbances within certain limits. The potential advantages of having DG as a new control source should become a DSO opportunity instead of a threat. DG can help to improve reliability indices working in islanding mode in case of network outages. DG can provide ancillary services such as voltage control, frequency reserve, or black start to improve voltage quality. To achieve this aim, it is recommended to implement*

- *performance based regulation for quality of service targets that provides explicit incentives to DSOs for improving quality of service levels*
- *incentives for DSO innovation programs that promote a deep transformation from passive to active management increasing DG participation in network control and DG contribution in case of network disturbances.*
- *incentives to DG for providing ancillary services to help DSOs to operate the network, for instance, providing voltage control and reactive power support, frequency reserve, islanding operation, etc. to improve quality of service levels.*

Regulation level: National MS regulators.

2.3 DSO incentives for innovation

The EU-15 survey carried out in the WP1 of DG-GRID has shown that current regulation of DSOs lack of mechanisms to promote network innovation. DG integration poses on DSOs new challenges on network planning, operation, and control to be cost effective. DSO regulated business are risk adverse to make investments on new technologies that are not enough mature. Even more, incentive regulation mostly promotes cost and investment reductions. Therefore, network regulation should provide additional tailor-made instruments for DSOs to get involved in R&D and take the risk to try out new approaches for network innovations to accommodate a rising share of DG.

The country questionnaires completed in DG-GRID WP4 concluded that most of the DG-GRID countries, but UK, has not implemented explicit incentives for DSO innova-

tion yet. Some of them think that current DSO regulation towards economic efficiency and quality of service improvements will bring, in an indirect way, innovation. Few countries have incorporated innovative designs in the support mechanisms for DG or in the DG use-of-system charges to achieve a more effective integration of DG.

The country situation on this issue is as follows.

In Austria no explicit incentives for innovation have been implemented. The controllability of DG should increase as a requirement for better integration. An idea could be to allow DSOs dispatch DG, e.g. biomass plants, during 10% of the year, compensating DG-IPP by raising their feed-in tariff in a specific percentage.

In Denmark, current incentive regulation provides incentives to DSOs to be more effective. The benchmark analysis conducted by the regulator aims to determine the potential for a more effective way of running the DSOs.

In Finland, according to the plan during the next regulatory period, DSOs would have incentives to improve quality of service. This will bring opportunities for innovation. DG use of system charges are differentiated typically from two to four time zones.

In France, the obligation to connect DG together with incentive based regulation for quality should be, in the opinion of the regulator, the main driver for DSO innovation. Controllable and hydro DG get a premium for the *guaranteed generation capacity* they offer to the system in winter periods.

In Germany, there are not incentives for DSO innovation, neither innovative price signals for DG integration.

In Italy, innovation is associated with the obligations imposed to DSOs to improve energy efficiency and to connect DG within sort delays. DG is compensated by DSOs for avoided costs of purchasing electricity to TSO. This compensation or DG credits are differentiated in four time zones (peak, two intermediates, and base load).

In Netherlands, there is a DSO platform for research with limited results until now. In opinion of the regulator, innovation is part of the regular DSO business. Time-dependent premiums and tariffs seem to be a good solution. However, the DSO administrative burden with the cost of communication infrastructures would increase significantly.

In Spain, there are not specific incentives for DSO innovation. DG larger than 5 MW can participate in the electricity market receiving market price signals plus a constant premium.

In UK, there are two different mechanisms to promote DSO innovation. The Innovation Funding Incentive (IFI) for projects focused on the technical development of distribution networks. The Registered Power Zones (RPZ) to develop more effective ways of connecting and operating DG. Currently DG pay use of system charges, but these charges do not give signals considering the potential benefit from DG on network losses or flow reduction.

The following table summarizes the current situation and provides some guidelines to improve it regarding DSO innovation and DG integration.

Table 9 Incentives for DSO innovation

Incentives for DSO innovation	Countries	Guidelines
No incentives	Austria, Finland, France, Germany, Spain	Implement incentives for improving DSO performance.
Implicit incentives associated to performance based regulation	Denmark, Italy, Netherlands	Critical review of current situation. Performance based regulation is bringing DSO innovation?
Explicit incentives	UK	Validate and tune current innovation schemes.

As a conclusion, the main open question today is if performance based-regulation is bringing innovation by it-self or not? The UK is the only country that has included explicit incentives to DSO innovation, the rest of the countries have not really thought about it. Our recommendation is to complement performance-based regulation with explicit incentives for DSO innovation..

In the DG-GRID project two different and complementary approaches for network innovation have been investigated. First, some recommendations on short-term regulatory measures that can be implemented in combination with current DSO incentive regulation were made. Second, a long-term regulatory vision on how deeper network transformations will favour migration from a centralized to a decentralized network paradigm was envisaged.

2.3.1 Network innovations to integrate DG

There are several regulatory mechanisms to promote innovation in line with incentive regulation. In DG-GRID WP2 the following ones were analyzed.

- Input incentives: R&D investment and costs can be included in the RAB as a separate item with higher rates of return or with a partial pass-through that reduces the risk perceived by DSOs. In addition, the regulatory period to pass-through associated gains of efficiency derived from such innovations to customers, should be extended.

An example of a partial pass-through approach is the Innovation Funding Incentive (IFI) in UK. IFI projects can embrace any aspect of distribution system asset management from design through to construction, commissioning, operation, maintenance and decommissioning. A DSO is allowed to spend up to 0.5% of its Combined Distribution Network Revenue on eligible IFI projects.

- Output incentives: the regulator selects one or several performance indicators that can be significantly improved through network innovation. In general, DSOs may obtain incentives if they improve the quality of supply and reduce energy losses. In order to foster DG integration through innovation, specific performance indicators with associated economic incentives if DSOs reach specific targets, should be selected. One of these indicators could be the number of DG connections already integrated in the network with respect the total number of applications submitted to the DSO.

An example of this type of incentives for innovation is the Registered Power Zones (RPZ) in UK. RPZs are focused specifically on the connection of generation to distribution systems. RPZs are intended to encourage DSOs to develop and demonstrate new, more cost effective ways of connecting and operating generation that will deliver specific benefits to new distributed generators and broader benefits to consumers generally. If the regulator accepts a specific proposal as RPZ, the incentive element of the DG Incentive is increased for the first five years of operation by £3/kW (€ 4.5/kW).

On the other hand, input or output instruments as the ones previously described require evaluation by external experts in the small electricity sector world that can become a critical aspect for the success of this kind of instrument.

Another important driver for DSO innovation could be the design of more market-conform instruments like time-variable feed-in premiums on top of the energy price that make more system valuable generation at peak and valley hours; or time-variable use-of-system tariffs for generators connected to distribution networks that improve efficiency in network utilization and help to postpone network investments (see DG support mechanisms and DG use-of-system charges in section 3 of this report). Regarding innovative designs of price signals to integrate DG is interesting to mention the previously commented experiences of DG market integration in Spain, DG use-of-system charges with time discrimination in Finland, and DG credits in France and Italy.

2.3.2 Long-term network transformation

A large scale penetration of DG into the distribution networks will impose significant challenges to the network operation and development. DG penetration is changing the distribution paradigm from a central control philosophy to a distributed control. This makes it necessary to rethink network regulation as a whole, rather than merely solving specific regulatory problems. In order to promote a long-term transformation of the

network, the regulatory process needs to be complemented by instruments that go beyond one regulatory period, enable the regulatory process to deal with future structural changes and future uncertainty and provide coordination mechanisms for the stakeholders involved (network and plant operators, technology developers etc.)

In the DG-GRID project, two instruments that could help deal with the uncertainty of future system transformation have been analyzed:

- Developing long-term visions through regulatory scenarios, and
- Experimentation with new regulatory instruments.

R7. *Incentives to promote DSO innovation for efficient integration of DG should be incorporated into network regulation. Some of the instruments to implement them can be:*

- *R&D investments can be included in the Regulated Asset Base as a separate item with higher rates of return or with a partial pass-through. An example is the Innovation Funding Incentive (IFI) in UK. A DSO is allowed to spend up to 0.5% of its revenue on eligible IFI projects.*
- *Selection of performance indicators that can be improved through network innovation. Several countries have implemented performance regulation to improve quality of supply.*
- *Regulators may work with DSOs formulating and testing new regulatory instruments, and developing new regulatory scenarios with a shared vision, in order to explore deeper and long-term network transformations.*

The selection of the most appropriate instruments in each country would take into account the type of DSO incentive regulation in place and the national regulatory framework.

Regulation level: National MS Regulators.

3 Enhancing DG network integration

In this section, guidelines and recommendations are provided regarding what efficient economic signals should be given to DG units in order to achieve their effective network integration. First, it is analyzed if current DG support mechanisms provide an economic incentive to DG in order to operate minimizing incremental costs to the system. Second, efficient designs of DG connection charges and use-of system charges are recommended. Finally, different ancillary and other network services that can be supplied by DG are reviewed and some recommendations for efficient procurement are presented.

3.1 DG support mechanisms

A lot of DG technologies have not reached a mature state of development yet to compete against electricity produced from conventional thermal technologies or nuclear power. The EU adopted Directive 2001/77/EC and Directive 2004/8/EC on support schemes for electricity generated from renewable energy sources (RES-E) and from combined heat and power (CHP), respectively. Member States may adopt support mechanisms at the national level to promote RES-E and CHP, thereby taking account of national circumstances. The support mechanisms differ between the Member States and for the different technologies even within a Member State. This allows the Member States to consider their fuel mix, generation potential, and the stage of market development of the individual technologies. E.g., Denmark applies a price premium for onshore wind power, a feed-in tariff for solid biomass and biogas, and an annual subsidy or prioritised production for small-scale CHP based on natural gas and waste.

There are two main kinds of support schemes: market-based policies where the quantity is set by the regulator, such as renewable quota obligation, and price-based mechanisms, such as feed-in tariffs and price premiums on top of the spot price of electricity.

The most frequently applied support scheme in the EU-15 is the feed-in tariff (Skytte, Ropenus et al. 2005, p. 86), which has proven very effective for the deployment of wind energy⁹.

Feed-in tariffs provide a lot of investment certainty and high ecological effectiveness and are therefore well suited to promote immature technologies. However, with an increasing share of DG, feed-in tariffs may become problematic as the production quantity is set according to the tariff level and independent of the actual demand for power (Skytte, Ropenus et al. 2005, p. 84). When technologies become more mature, a move towards more market-based policies (price premium, tradable green certificate market) may improve economic efficiency and enhance compatibility with liberalisation. Trad-

⁹ For a thorough evaluation of the effectiveness of support mechanisms, see COM(2005) 627 final. With regard to the DG Grid project, not all RES-E is DG, e.g., a large offshore wind farm or large hydro-power units would not fall under the definition of DG.

able green certificate markets further economic efficiency, but also expose DG operators to a higher risk inherent to the volatility of the spot and the certificate price. This may lead to an exclusion of technologies that have not reached the necessary level of maturity yet.

At the same time, if deployed effectively, DG may exhibit characteristics of a public good, such as low negative environmental externalities compared to conventional thermal generation, the avoidance/deferral of network expansions, the contribution to local security of supply, reliability and reserve capacity. These public values are not included in the market price and may legitimatise support for DG. The question is how to strike the balance between economic efficiency (including market compatibility) and the provision of sufficient support to promote DG.

According to the requirements of Directive 2001/77/EC, Art.4, at the end of 2005, the Commission released a Communication on the support of electricity from renewable energy sources (COM(2005) 627 final). Therein, it concludes that competing national schemes could be regarded as healthy at least over a transitional period and envisages a co-ordinated approach to support schemes for RES-E based on cooperation between countries and optimisation of the impact of national schemes. This also allows for sub-harmonisation of Member States with systems with a sufficient degree of similarity (cf. *ibid*, p. 16).

In line with the Communication of the Commission (COM(2005) 627 final), national support mechanisms will be maintained at least during the transitional period and they will be fine-tuned at the national level. With higher shares of DG, support mechanisms should be adapted to become more compatible with market price signals in order to achieve a higher level of DG market integration.

In electricity markets, conventional generators receive two main price signals: energy hourly prices and network use-of-system (UoS) charges. Energy prices reflect the opportunity cost of the hourly generated energy. It is clear that the operation of controllable generators should be linked to this signal. Generation production is most system valuable at higher price hours. On the other hand, use-of-system charges paid by generators reflect the network incremental costs that generators are responsible for. These costs are usually differentiated by time of use and network location. However in some countries such as France, Germany, and Spain, generators do not pay use-of-system charges.

As conventional generation, to promote efficiency in the system, DG should be exposed to the same kind of economic signals, independent of the selected support mechanism. For instance, if DG only receives as incomes a flat feed-in tariff without time or location differentiation components, the economic efficiency signals regarding DG operation and location in the system are lost.

One step further, support mechanisms like the feed-in premium system can be designed in order to maximize the social value of generation production. The current practice is that an eligible wind generator gets his premium on top of the commodity price irre-

spective of the point in time he feeds in his production. The social value of this production is very time-variable though. At system peak demand, his contribution will in the margin substitute inefficient, highly polluting (including GHG emissions) peaking power technologies. Also depending on the way wind power facilities are operated its capacity credit can increase and it can replace/postpone more investment in fossil-fuel or nuclear based technologies. Moreover, T&D losses can be reduced. However, wind power feed-in at rated capacity on a quiet early Sunday morning can pose quite some operational challenges to TSOs/DSOs. For example, base-load coal technology plants might be forced to ramp down at reduced energy efficiency and concurrent negative environmental impacts. With current feed-in premium regulations for eligible generators, no generator is incentivised to give any attention to improving the social value of his feed-in by timing. If the premium were negligible when the electricity price would be low, it might become interesting for him to provide certain ancillary services such as possibly (conditional) secondary frequency response (at a certain modest compensation).

Most of the DG-GRID countries have implemented feed-in tariffs or premiums as the major support mechanism to promote DG based on RES or CHP.

The current situation by country is as follows.

In Austria feed-in tariffs are differentiated by DG technologies and size, not by voltage levels, nor by time of use. Within the framework of the green electricity scheme, DG generally enjoys 'priority dispatch'.

In Denmark, price premium is the selected support mechanism.

In Finland, support for investment (up to 40%) and exemption from taxes of generated electricity are the main support mechanisms.

In France, feed-in tariffs are differentiated by DG technology, size and time of use for some hydro and controllable DG. Feed-in tariffs and purchase obligations are disconnected from market prices. Some specific contracts consider the possibility of dispatching the DG plant, and/or additional remuneration for guaranteed capacity in winter.

In Germany, feed-in tariffs for renewable are differentiated by technology and vintage. For other DG, implicit differentiation by network area/level due to the payment to DG of avoided network costs has been implemented. This gives incentives to generate during network peak hours, provided the DSO supplies the necessary information. For CHP, the support is a premium plus the market price. There are not clear procedures to control DG outputs in case of network constraints.

In Italy, a RES-E quota obligation system has been implemented. Only photovoltaic small plants are remunerated through feed-in tariffs. They receive higher remuneration at peak hours.

In Netherlands, feed-in premiums are differentiated by technologies and in some instances by size but not by time-of-use. This support scheme has been suspended since August 2006 for new applicants.

In Spain, DG can select between two options: i) constant feed-in tariffs, or ii) fixed premium on top of the market price plus an incentive. These differ by technology and size. However there is not differentiation by network voltages or time-of-use. 56% of total DG is under the premium option, that includes 96% of the total wind installed capacity. DG under the premium option has the same obligations as conventional generators regarding daily production programs and energy unbalances. Aggregation of small generators is allowed to minimize program unbalances.

In UK, a quota system has been implemented. Next regulation will include the possibility of aggregators to act fully on behalf of small generators.

The following table summarizes the current situation and provides some comments and guidelines to improve DG integration regarding actual support mechanisms.

Table 10 Compatibility between DG support mechanisms and DG efficient market and network integration

DG support mechanism	Countries	Comments & Guidelines
Feed-in tariffs	Austria, France, Germany, Spain	This is adequate only for renewable small generators.
Feed-in tariffs with time of use and/or voltage level differentiation	France, Germany	This is adequate for renewable and controllable medium and small generators
Feed-in premiums	Denmark, Netherlands, Spain	This is adequate to achieve DG market integration. It is recommended to include network signals through DG use-of-system charges or DG credits differentiated by voltage levels or areas.
Quota	Italy, UK	DG market and network integration is not affected by the support mechanism.
Incentives for investment and taxes exemption	Finland	DG market and network integration is not affected by the support mechanism.

As a conclusion, feed-in tariffs and, a least extent, feed-in premiums, should be made more compatible with market prices and efficient network use-of-system charges in order to maximize the system value of DG production. Given the quite high premium levels offered to certain DER generators, the latter will be very reluctant to agree to restrictions on their mode of operation because of network considerations. Generally,

DER-based generators benefiting from high premiums will be rather unresponsive to market and grid conditions

Different alternatives can be adopted to improve current practices, for instance:

- Constant feed-in tariffs should be avoided as a general rule. They can be justified in terms of learning curves and risk reduction. They have their role to play as an effective instrument to develop new technologies without controllability . capacity. For instance, they can be justified for small renewable generators, such as PV or wind, where it is assumed no operation control would be implemented.
- Feed-in tariffs with time of use discrimination that promote energy production at peak hours and do not provide incentives for production at valley hours are more appropriate for medium size and controllable DG where storage and controllability capabilities can be more easily justified.
- Feed-in premiums on top of market price is a better signal for DG market integration. In addition it has been proposed to make feed-in premiums time dependent. For instance, a premium dependent on the average power price of a relevant day-ahead market for short time intervals e.g. 15 minutes.
- Finally, support mechanisms decoupled from market signals, such as quotas or incentives to investments, are very appropriate for a good market integration, because in each hour the DG incomes are mainly determined by its market participation as conventional generators.

R8. *DG (RES/CHP) support mechanisms, especially with high DG shares, should be made compatible with energy market prices and network UoS tariffs that promote efficient DG operation and network location. Regarding DG operation to achieve efficient market integration it is recommended:*

- *RES-E and CHP market stimulation systems should be smartened to better reflect the social value of the MWh injected in the system. In case of high DG penetration, avoid fixed production payment mechanisms, such as constant feed-in tariffs or feed-in subsidies as a general rule.*
- *Implement feed-in tariffs with time discrimination or feed-in premiums on top of market prices that promote efficient DG operation, i.e. higher production at peak hours, and storage and controllability capabilities in medium and large size DG installations.*

Regulation level: National MS Governments/Regulators

3.2 Connection charges

Fair and non-discriminatory network access is one of the main requirements for an increase in distributed generation. New network users have to pay a charge to obtain a connection to the existing network. Three different kinds of *connection charges* can be distinguished: shallow, deep and shallowish charges. Shallow connection charges encompass only the direct costs of connecting the DG producer to the nearest point in the distribution network. Additional costs for network reinforcements and upgrades are socialized among the grid users and paid through the use-of-system charges. By contrast, deep connection charges imply that all the costs for network reinforcements both at the transmission and distribution level have to be borne by the DG producer. Shallowish or mixed connection charges constitute a hybrid of the two former approaches: they include direct connection costs and costs for reinforcements at the distribution level, but only the proportional use of that.

The connection charging approach can be of great relevance for DG producers trying to penetrate the market. There is a trade-off between providing incentives for the optimal and cost-reflective siting of new generation capacity (deep connection charges) and facilitating entry for small-sized DG operators (shallow connection charges) for whom these charges may otherwise present substantial capital costs.

DG usually should have priority access to the network for reasons of investment security, low transaction costs and the acknowledgement of DG system benefits. Shallow connection charges seem to be the best economic signal for DG integration in order to i) keep the barriers to entry as low as possible, ii) keep the calculation simple and transparent, and iii) lower transaction costs to DG promoters. However, shallow connection charges may seem less attractive for DSOs, especially if there is not a clear mechanism to recover network reinforcements associated to DG connections. In this case, costs for possible network reinforcements and upgrades should be socialised among the network users and paid through the Use of System (UoS) charges¹⁰. This recommendation was also supported as a conclusion in the previous European project SUSTELNET¹¹.

In order to promote DG integration with transparent and simple rules, avoiding negotiations with DSOs, shallow connection charges paid just once when the connection is required, are recommended. Other network reinforcements to accommodate DG should be covered by DSOs and collected through use of system tariffs. In addition, for higher DG penetration/concentration levels, DSO should be able to give a location signal to DG developers through an adequate design of UoS charges, see recommendation **R10**.

¹⁰ Use of system (UoS) charges are intended to recover network transport and system services. They are periodically paid by network users as capacity and/or energy charges.

¹¹ M.J.J. Scheepers, 'Policy and Regulatory Roadmaps for the Integration of Distributed Generation and the Development of Sustainable Electricity Networks', Final Report of the SUSTELNET project, ECN Report ECN-C-04-034, 2004, NL.

Most of the DG-GRID countries apply DG shallow connection charges. However, some of them still maintain deep connection charges.

The current situation per country is as follows.

In Austria, shallow charges plus, in some regions, lump sums are applied. The latter being partly subject to negotiation between DSO and DG. In opinion of the regulator, the connection charging rules are clear. Few conflicts have been evident to the public.

In Denmark, negotiated shallow charges are applied by DSOs. Published tariffs should be notified to the regulator.

In Finland, connection charges are determined and applied by DSOs. Differences on charges can be high depending on size and location of DG. Since January 2008, DG will pay shallow costs. DG will pay only the network that is used for its connection to the network. All the customers will pay possible network reinforcement.

In France, DG only pays for the connection line and/or transformer upgrading. The rest of reinforcements are included in the tariff for public grid use.

In Germany, DSOs apply non regulated shallow charges to DG. They will be regulated in the future.

In Italy, the network upgrading costs are shared among the DSO and the DG by negotiation. Any general upgrading must be charged to the DSO. Small generators do not pay network investment, but they are charged a predetermined amount by DSOs as a management cost.

In Netherlands, for DG below 10 MVA connection charges are shallow, regulated and averaged. On the other hand, DG larger than 10 MVA pay deep and negotiated with the DSO connection charges. Wind farm project developers typically have to negotiate hard and over long periods before reaching a final agreement with DSOs on connection charges.

In Spain, connection charges are deep. Rules and negotiations are not transparent. Some conflict cases among DG and DSOs have been reported.

In UK, shallowish charges are applied. It is a kind of hybrid between shallow and deep charges. The generator covers the direct connection installations (shallow) and only the proportional use of new reinforcements in the existing network. Some argue that still this method constitutes a barrier for DG network access.

Table 11 Connection charges for DG

Connection charges for DG	Countries	Structure of connection charges	Guidelines
Deep charges	Finland, Netherlands (>10 MVA), Spain	Negotiated between DSO and DG	Implement shallow charging.
Shallowish charges	UK	Negotiated between DSO and DG	Evolve to regulated charges.
Shallow charges	Austria, Denmark, Finland (in 2008), France, Germany, Italy, Netherlands (<10 MVA)	Mostly negotiated between DSO and DG. Regulated for small generators in Italy, and Netherlands	Evolve to regulated charges.

Most of the countries apply negotiated shallow charges for the connection of DG. There is still a lack of transparency in the calculation methods for connection charges (see ELEP report on connection charges, <http://www.elep.net/>). The two main recommendations are i) for those countries that still apply DG deep connection charges migrate to shallow connection charges, and ii) for those countries that apply DG negotiated shallow connection charges evolve to simple and transparent rules to calculate regulated shallow charges.

R9. *To create a level playing field for DG integration, DG connection charges, paid just once when the connection is required, should be regulated, based on simple rules mainly recognizing shallow costs, i.e. the direct costs of connection. Calculation rules should be transparent and standardized by national regulation. Other costs for network reinforcements and upgrades due to DG connections should be socialised among the network users and paid through the Use of System (UoS) charges.*

Regulation level: National MS Regulators.

3.3 Use of system charges

DSO allowed revenues are recovered through use-of-system (UoS) charges paid by network users, usually end consumers, and, in some MS, generators connected to the distribution network. UoS charges should, as far as possible, (i) reflect the cost incurred to provide the network user with the network transport and system service, and (ii) en-

sure full recovery of the DSO's total acknowledged revenues. UoS charges for end users typically include a component proportional to the energy demand, in euros/kWh, and a component proportional to the peak demand, in euros/kW-year. They are usually differentiated by network voltage levels and time of use: peak, flat, and valley hours.

As DG penetration levels increase, regulators should implement network locational and time of use charges that promote efficient connection and operation of DG units.

When implementing UoS charges, locational differentiation can take into account network voltage levels. In a more sophisticated scheme, they can be differentiated by DG penetration and concentration levels for rural and urban networks. Regarding differentiation for network voltage levels, it is clear that the connection of DG to lower voltage levels would bring more benefits to the system in terms of losses and delaying system reinforcements than the connection to higher voltage levels. As an example, in the Czech Republic, in addition to the feed-in tariffs, a compensation system for DG (RES/CHP) based on bonus per injected kWh has been implemented. The bonus is higher for DG connections at low voltage networks, and gradually decreases for connections to medium and high voltage networks. These bonuses can be understood as negative UoS charges for DG. This is an example of how the support mechanism can be used to achieve the same effect as a cost reflective design of a DG UoS charge.

Time of use differentiation should promote higher production at local peak demand hours in order to match locally generation and demand. Time-variable UoS charges could encourage more focus on bringing down network utilization and losses at peak load times, i.e. when the network is used most intensively and therefore would have a tendency to increase line losses (line losses are proportional to the square of the load).

According to DG-GRID WP4 questionnaire, most of the countries have implemented UoS charges for DG. Among the countries with UoS charging, some use a uniform charging, while others differentiate between voltage levels, DG size, time of use and location.

In the following the country situation regarding this issue is reviewed.

In Austria and Denmark there are UoS charging mechanisms. UoS charges in Austria are used to compensate for secondary balancing on a kWh dispatched basis.

In Finland, DSOs determine the UoS charges freely, with a cap of 0.7€/MWh. The UoS charges are including usually constant component [€/month], energy dependent component [€/MWh], and power based component [€/kW, €/kvar], input energy to network and in some DSO's also consumption of own production are charged. Charges are dependent on voltage level [≤ 1 kV, 6-70 kV and ≥ 110 kV] and DG sizes. The energy rates differ depending on the time of day and/or the time of year. The charges are defined by DSOs and there are large variations between DSOs.

In France, Germany and Spain there are no UoS charging mechanisms for DG. In Spain Conventional and distributed generators do not pay UoS charges by law, only demands pay UoS charges. There is no prevision to change this rule in the short term.

In Italy, UoS charges are combined with the losses reduction remuneration for DG. These charges are set for small DG in 120€/year (mainly management cost) plus 0.5% of the value of energy with a cap on the whole year payment.

In The Netherlands, DG-operators are obliged to pay uniform UoS charges for system services according to the amount of net energy taken from the network. These charges cover reserve requirements, black-out arrangements and costs related with the maintenance of system stability, among others.

In UK, UoS charges are defined for EHV customers and negotiated with the DSO. These charges include transport services and metering, and depend on the location of the DG power plant.

The following table summarizes the current situation and guidelines regarding UoS charges for DG.

Table 12 UoS charges for DG

UoS charges for DG	Countries	Structure of UoS charges	Guidelines
DG operators have no UoS charges	France, Germany, Spain	Not considered	Implement UoS charging mechanisms.
DG operators have uniform UoS charges	Austria, Denmark, Italy, The Netherlands	No distinction	Structure UoS charges, according to voltage levels, DG size, and power plant location.
DG operators have specific UoS charges	Finland, UK	Voltage level, DG size, time of use.	Evaluate the efficiency of this cost mechanism.

As a conclusion, most of the countries have already UoS charging mechanism, although most of them have the uniform charging option. In general, there are no plans to modify this situation. UoS charging mechanisms are very important to reflect the cost of the service, including a differentiation of the voltage level, location, and time of use. To improve economic signals sent to the DG-operators regarding their contribution to the system cost, specific UoS charges should be designed and implemented.

R10. *To promote a more efficient integration of DG, it is recommended that DG pay or receive UoS charges. DG use of system charges should be cost reflective (positive or negative). To achieve that some recommendations are:*

- *DG UoS charges should be differentiated by time of use and voltage levels. DG connections at lower voltage levels and DG production at load peak hours should be incentivized.*
- *Differentiated DG support mechanisms, such as feed-in tariffs by voltage levels can be used to achieve the same effect that differentiated DG UoS charges.*
- *DG UoS charges calculation methods should be in line with the other elements of the national regulatory framework: DG connection charges, DG support mechanisms, DG network services, etc.*

Regulation level: National MS Regulators.

3.4 DG ancillary and other network services

DG units can provide DSO ancillary services and other network services that can lead to a more economic efficient system. For instance, a more flexible operation of controllable DG according to network price signals can save investment or delay network reinforcement and network automation facilities. In addition, if islanded operation is implemented, DG can reduce the impact of network outages on customer supply interruptions, improving quality of service indicators. Moreover, controllable DG under local control or following system operation orders can provide local voltage support or flow control when needed by the DSO.

To achieve these advantages from DG, what is needed is an important change in the relationships between DG and DSOs. For instance, DSOs should be entitled to enter into agreements with DG to regulate under certain transparent conditions the active power feed-in at agreed financial compensations. That should be also acknowledged by DSO regulation that should allow DSOs to make an optimal choice between reinforcing the network, high CAPEX, and active network management (lower CAPEX and higher OPEX). Moreover, DSOs should be able to purchase ancillary services from DG, such as voltage and reactive support, energy losses, or congestion management.

Different levels of participation in the provision of Ancillary Services (AS) can be found among the countries included in the DG-GRID WP4 questionnaire. Reactive power control and energy balancing are the AS usually procured by DG.

In the following the country situation regarding this issue is reviewed.

In Austria, DG is not allowed to receive incentives from the AS. Anyway, certain contributions of DG - e.g. seasonally split power factors - are usually negotiated and can be expected to make it more likely that DSOs embrace the connection of DG and hence ease integration procedures.

In Denmark, DG is allowed to participate into AS but in practice there is no real contribution.

In Finland, there is no concern about AS provided by DG. At TSO level the minimum requirement for the most ancillary services is 10 MW.

DG participation into the AS in France is not mandatory, but there are clear incentives to provide them. DG “dispatchable”, mainly based on small diesel units, can participate both in reactive power control and in short-term balancing services (used for peak shaving). Cogeneration units can also sign contracts with DSOs. The DG operator then commits itself to make its full production capacity available for the system between the last day of October, November, December, January or February (the choice of the day is set up by contract) and the 1st of April. The buyer (the DSO) sends everyday a fax stating whether the plant will be asked to produce or not the day after. The remuneration of the producers includes: i) a fixed component based on the actual availability of the plant; ii) a component based on natural gas prices; iii) a remuneration for the energy injected into the system during the “call periods”, i.e. when asked by the DSO; iv) a remuneration for the energy injected at the initiative of the producer; and v) a bonus for energy efficiency.

In Germany, pooled DG units can participate into the balancing market. There are auctions for balancing power where one can apply with a minimum amount of 30 MW; there is an IPP who pools decentralised power plants and markets them to the balancing market.

In Italy, there is not specific compensation for DG participating into AS, small units are not supposed to contribute to balancing and reserve services, although DG units are incentivized to produce energy during peak hours.

In Netherlands, DG units of above 5MW and connected to more than 1kV voltage networks can provide AS. DG can participate into both balancing markets (through market aggregators) and reactive power control. However, in practice there is no real contribution of DG to reactive power control.

In Spain, DG can participate in different AS. DG units have incentives to keep power factors within specific margins or penalties if they go out of required margins. DG under feed-in premiums can participate in ancillary services markets run by the TSO, balancing and reserves, as other conventional generators. Prediction of the day-ahead energy production is mandatory for DG larger than 10 MW, and deviations over a settled range are penalized.

In UK, DG can arrange with the DSO AS procurement. In practice, aggregated small DG can provide reserves. Bilateral Agreements are likely to continue to be used in any developing ancillary service market in the short to medium term, and if further studies are to be carried out at this stage, the focus should be on developing commercial frameworks/agreements.

The following table summarizes the current situation and guidelines regarding DG participation in AS.

Table 13 DG participation in the procurement of AS

DG participation in AS	Countries	Services	Guidelines
There is no contribution of DG to AS	Austria, Denmark, Finland, Italy	None	Include DG into AS.
Participation of DG into AS	France, Germany, Netherlands, Spain, UK	Reactive power control, balancing market and reserves	Improve the contribution of DG to AS.

In most of the countries, there is still very low contribution of DG into the AS. The main contribution acknowledged to DG is to keep power factors within certain ranges, and, through aggregators, to participate in the balancing market or providing reserves. Furthermore they can contribute to network optimisation, e.g. contribution to congestion management, and contribution to (network) capacity reserve, in order to save or delay network reinforcement and upgrade. They can improve quality of service through islanding. Active network management by DSOs is a crucial transformation that is required in order to implement in practice such possibilities.

To achieve this aim, several approaches for commercial arrangements can be thought, for instance, bilateral contracts between DSOs and DGs; payments from the TSOs/DSOs, acknowledged in the UoS charges; and/or network related markets. The economic signals from the TSOs/DSOs to DGs to contribute to the provision of ancillary and other network services should heavily rely on the incentives they get themselves from the existing network regulation scheme.

The design of network related markets such as local balancing, reactive power or energy losses compensation should take into account facilitate market access to every dg, especially if they are controllable. Market prices would be the correct signal for DG participation in these markets.

R11. *DG can contribute significantly to TSO/DSO ancillary and network services. DG through aggregators can participate in balancing and reserve markets. DG can provide voltage support and compensate energy losses as required by DSOs. In the future, with higher levels of network automation and DG controllability, DG would help to solve congestion management, and to improve quality islanding. Commercial arrangements between TSO/DSO and DG to recognize such contribution can be*

- *Regulated payments to DG, for instance acknowledged in the UoS charges*
- *Bilateral contracts between DG and DSO*

- *DG participation in markets: i) energy balancing and reserve markets; and ii) network related markets, such as local balancing, reactive power, congestion management, or energy losses compensation.*

Regulation level: National MS Regulators.

4 References

4.1 General references

Bauknecht, Dierk; Leprich, Uwe; Späth, Philipp; Skytte, Klaus; Esnault, Benoît (2006): “Regulating Innovation and Innovating Regulation”, draft report D5 in the DG Grid projects. 2006.

Commission of the European Communities: Communication from the Commission. The support of electricity from renewable energy sources. COM(2005) 627 final.

European Commission, Directorate-General for Energy and Transport (2007): The Internal Energy Market: Foundation of the EU Energy Policy. MEMO, January 2007.

Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. OJ L 52/50-60.

Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC. OJ L 176/57-78.

Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market. OJ L 283/33-40.

Skytte, Klaus; Ropenus, Stephanie et al. (2005): “Regulatory Review and International Comparison of EU-15 Member States”, report D1 in the DG Grid projects. 2005. Available online at <http://www.dg-grid.org>

Scheepers, M.J.J. 'Policy and Regulatory Roadmaps for the Integration of Distributed Generation and the Development of Sustainable Electricity Networks', Final Report of the SUSTELNET project, ECN Report ECN-C-04-034, 2004, NL.

Wälde, Thomas W. (2001): “Access to Energy Networks: A Precondition for Cross-Border Energy and Energy Services Trade”. A discussion paper for 23-25 July UNCTAD experts meeting on energy services.

In addition, the following references have been used by DG-GRID partners answering the national questionnaires.

4.2 Country questionnaire references

4.2.1 Austria

See the regulator's site: www.e-control.at

4.2.2 Denmark

<http://www.energitilsynet.dk/english/>

http://ec.europa.eu/energy/electricity/publications/doc/2006_03_08_final_common_report.pdf

http://ec.europa.eu/energy/electricity/publications/doc/2006_03_08_annexes.pdf

<http://www.elforsk.dk/>

<http://www.energinet.dk>

You might also find a lot of information at Annual Energy Statistics (Danish Energy Agency):

<http://www.ens.dk/sw16508.asp>

Look at the reports: Energy in Denmark and Energy Statistics 2005 and download the excel og ppt files Graphs or Figures

4.2.3 Finland

<http://www.energiemarkkinavirasto.fi/index2.asp?languageid=826&start=1>

4.2.4 France

Websites:

The French regulator's website: www.cre.fr

The website of the Direction of Energy and Raw Materials, French Ministry of Industry: <http://www.industrie.gouv.fr/energie>

Documents of reference:

Annual report of the French Energy Regulatory Commission - CRE 2006 (http://www.cre.fr/uk_documents/rapporta.jsp#)

CRE, 2005, "Règles tarifaires pour l'utilisation des réseaux publics d'électricité" (Pricing rules for the use of public electricity networks), in French, and its "exposé des motifs" (explanatory statement, with an English version available)

Document (in French) from the Ministry of Industry: “Modèle de contrat d’achat d’énergie cogénération : avenant mode dispatchable » (Model of purchase contract for cogeneration : complement concerning « dispatchable mode »)

Some information directly came from the French regulator and from EDF.

4.2.5 Germany

The homepage of the German regulator (www.bundesnetzagentur.de) is probably the best source; unfortunately nearly all documents are in German

A good source is of course DG Tren with the benchmarking reports.

4.2.6 Italy

Websites

- Italian regulator, Autorita per l’Energia Elettrica e il Gas (AEEG), www.autoritaenergia.it
- Italian TSO : www.terna.it

Documents of reference

- Annual report of the AEEG, 2006 (English version and Italian version for details)
- Annual report for the European Commission, AEEG, 31/07/2006

The information collected also directly came from the Italian regulator.

4.2.7 Netherlands

4.2.8 Spain

- Spanish Energy Regulator, <http://www.cne.es/>
- Spanish Ministry of Economic Affairs. Special Regimen Section.
<http://www.mityc.es/Electricidad/Seccion/ProductoresEspecial/Productores/>
- Spanish Wind Energy Association, <http://www.aeeolica.org/>
- Renewable Energy news in Spain, <http://www.energias-renovables.com/>

4.2.9 UK

- “Engineering Recommendation P2/6. Security of Supply”, Energy Networks Association, July 2006.
- DTI, Research On International Distributed Generation Practice (Phase Two). 2004
- DTI, UK Response to the Commission Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy. June 2006
- Ofgem, Electricity Distribution Price Control Review. Regulatory Impact Assessment for Registered Power Zones and the Innovation Funding Incentive. 2004
- Ofgem, Electricity Distribution Price Control Review Final proposals, November 2004
- <http://www.ofgem.gov.uk/ofgem/shared/template2.jsp?id=1274>
- <http://www.ofgem.gov.uk/ofgem/shared/template2.jsp?id=9989>
- Ofgem, Electricity Distribution Cost Review 2005-2006, January 2007
- Ofgem, Open Letter Consultation on the Innovation Funding Incentive and Registered Power Zone Schemes for Distribution Network Operators. February 2007
- Ofgem, Renewables Obligation: Annual report 2005-06. 28 February 2007
- Ofgem, Distributed Energy, A Call for Evidence for the Review of Barriers and Incentives to Distributed Electricity Generation, Including Combined Heat and Power. November 2006
- <http://www.ofgem.gov.uk/ofgem/microsites/microtemplate1.jsp?toplevel=/microsites/edist&assortment=/microsites/edist/edist06>
- Ofgem, Structure of electricity distribution charges, Consultation on the longer term charging framework. May 2005
- DTI, Ancillary Service Provision from Distributed Generation. 2004