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Current state of and recommendations for improvement of the network regulations for large-scale integration of DER into the European electricity market

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Preface and Acknowledgement

This is Part A of the final report D1.3 of SOLID-DER project concerning a detailed study of the "Current state of and recommendations for improvement of the network regulations for large-scale integration of DER into the European electricity market. This study in phase 2 of the project follows from the discussions and questions often posed during the National Seminar in new MS in phase 1 organised. Furthermore in follow up of the WP1 Phase 1 report (M ten Donkelaar et al, 2006) on Current barriers and issues regarding more DER integration in Europe with a focus on new Member states" a study was undertaken in Phase 2 on "The existing Support Schemes in all EU countries and the pros and cons of the different support schemes. For the result of this WP1 study in Phase 2 see Report D1.3-Part B. Finally for meeting another overall objective of the SOLID-DER project we present also a summarising report D1.3-Part C, on the development, progress of in integration of DER and the issues tackled so far and issues still pending to be solved by further RTD in the future. This SOLID-DER WP1 study includes also recent findings from other related RTD projects on Socio-economic issues and present some final recommendations for RTD.

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Project website: **www.solid-der.org**

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Summary

This report is part A of Deliverable 1.3 of WP1 of the SOLID-DER project, concerning the Socio-economic issues of integration of DER in the electricity supply system. Project co-financed by the European Commission[1] and carried out by 17 partners under the coordination of ECN. Report

Report D1.3-Part A "Current state of and recommendations for improvement of the network regulations for large-scale integration of DER into the European electricity market" presents a complete overview of the key issues concerning changes required in network regulation under a European scenario with large penetration of DER. Even though the role of Transmission System Operators (TSOs) and transmission networks is deemed increasingly important for enabling more DER in the system, distribution networks and Distribution System Operators (DSOs) will be especially affected by growing levels of DER.

This report reviews the current regulation of distribution networks in the European Union Member States (MS), with an emphasis on new MS. The focus is placed on those aspects that might hinder the future integration of DER. Several regulatory issues have been identified. Recommendations to improve the current situation are proposed for each separate topic considered, taking into account the position of both DER and DSOs in the electricity system. Regarding economic signals sent to DER, connection charges and cost reflective use-of-system charges together with incentives to provide ancillary services are deemed the key aspects. Concerning DSOs regulation, unbundling from generation and supply according to the European Electricity Directive, incentives for optimal planning and network operation considering DER, including energy losses, quality of service and incremental DER-related costs, and innovation schemes to migrate to active networks are the most relevant topics. Finally, the interaction between demand response mechanisms and DSOs is analyzed.

1 The SOLID-DER project is supported by the European Commission through the 6th Framework Programme. The sole responsibility for the content of this deliverable lies with the authors. It does not represent the opinion of the Community. The European Commission is not responsible for any use that may be made of the information contained therein.

1. Introduction

The EU Energy Policy aims at enhancing environmental sustainability and increasing security of energy supply whilst securing overall economic competitiveness and welfare of Europe. Promotion of the use of Renewable Energy Sources (RES) and energy efficiency, including Combined Heat and Power (CHP) contributes highly to these goals. Therefore the approval of the Renewable Electricity Directive (2001/77/EC) marked a milestone in the promotion of these technologies. It stated a target of 22% of RES over total electricity consumption in the EU. Additionally, an Energy Efficiency Directive (2006/32/EC) and a Cogeneration Directive (2004/8/EC) were passed in order to promote these measures. However, much more ambitious targets have been recently agreed upon for the 2008 Climate Action and Renewable Energy Package. More precisely, a 20% share of RES in primary energy consumption (detailed on a country per country basis in Figure 1) and a 20% improvement in energy efficiency as compared to a baseline scenario are planned to be required at EU level for the year 2020.

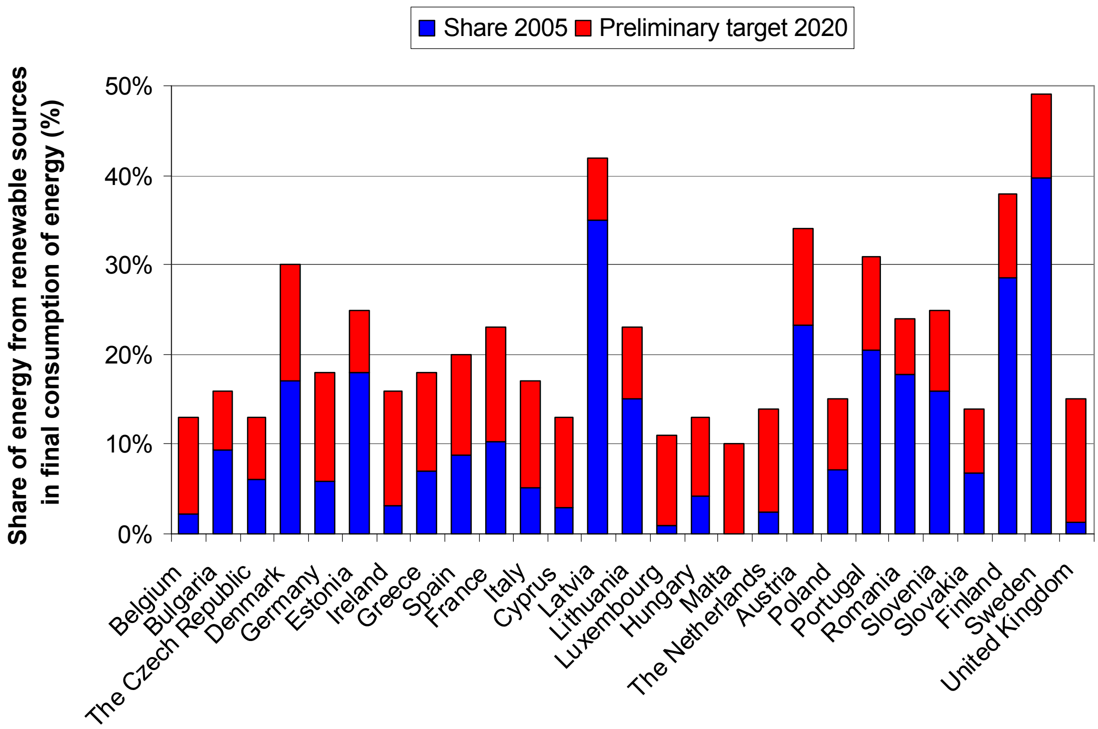

Figure 1: Share of energy from renewable sources in final consumption of energy in 2005 and preliminary EC target for 2020 (source EC, COM 2008 (19) final)

Undoubtedly, the electricity sector is essential for the achievement of these goals. RES and CHP technologies are not mature enough to compete with conventional generation yet, hence the implementation of different support mechanisms has been deemed necessary. The main instruments for the promotion of these technologies are feed-in tariffs (FITs), either as a fixed value or as a premium added to the market price, quota obligations with tradable green certificates, tenders and fiscal incentives. An extensive analysis of the support schemes for RES and CHP can be found in the other SOLID-DER project report D1.3-Part B.

The characteristics of the new RES and CHP generation technologies vary considerably from those of conventional generation concerning, for instance, ownership, location (geographically and characteristics of the network at connection point), size and controllability of production. Therefore, as a result of the promotion policies, the presence of small-scale generation facilities, known as Distributed Energy Resources (DER), in electricity grids is steadily increasing. Demand response is generally considered as an additional DER and will be addressed in this report; albeit the focus of this report is found mainly on the generation side. During the last decade the new energy sources, on the ensuing referred to as DER, have been described in different ways: decentralised generation, embedded generation, dispersed generation or distributed generation. No final definition of DER exists, although they are usually considered as installations that feed energy into (mostly) distribution networks with a rated capacity (generally) lower than 50MW. Figure 2 shows the shares of DER in electricity production at the end of 2004 in EU-25.

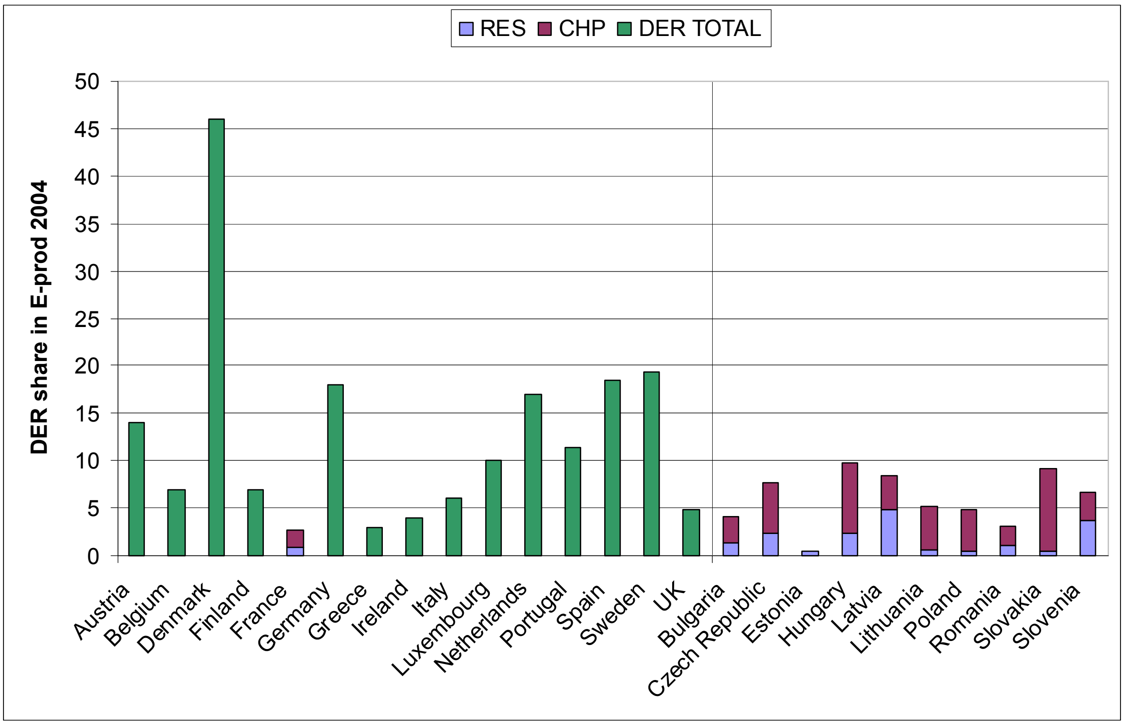

Figure 2: DER shares in EU-25 over total electricity production at the end of 2004

The share of DER in electricity production differs considerably along the different countries. EU-15 Member States (MS) have, as an average, higher shares of DER than new MS, where these percentages do not exceed 10% in any case. Nonetheless, it is true that some exceptions exist, being the most remarkable those of France or Greece. On the contrary, DER accounted for nearly 20% of total electricity production in Germany, Spain or Sweden. Denmark is the European country with the highest DER share (above 45%). Note that low DER shares in new MS do not necessary imply low RES and CHP participation in electricity production. Most new MS have CHP shares similar to those of EU-15 countries and some have even higher RES shares in electricity production. However, high RES shares in electricity in new MS mainly consist of large hydro plants whereas the percentage of small-scale CHP is generally very low. For example, RES and CHP accounted for nearly 69% of Latvian total electricity production in 2004. Despite this fact, the corresponding DER share amounts to only 8.4%. The previous percentages will necessary increase during the next years in order to achieve the aforementioned targets.

Growing presence of DER will have profound effects on several elements of the electricity system, such as transmission and distribution networks, system balancing, etc. Impacts at distribution level will be treated in this report, whereas SOLID-DER report D1.3-PartC discusses also the effects of DER production on the system as a whole.

Since their connection takes place at distribution networks, this process is bound to produce significant effects on distribution networks, which are operated by Distribution System Operators (DSOs). These networks have been traditionally designed and operated considering energy injections from the transmission level and supplying it to final consumers. Therefore, the role of DSOs was a rather passive one. However, the large-scale connection of DER in distribution networks will presumably bring many changes to the distribution activity. Therefore, the role of DSOs and the distribution regulation needs to be adapted in order to facilitate the integration of DER. Moreover, DER could become in the future active elements in the operation and planning of distribution networks. Additionally, they could participate in ancillary services provision either managed by DSOs or TSOs.

The report from phase I of SOLID-DER project WP1 (2006), with a focus on new MS, already showed that numerous barriers for even a take-off of DER integration still exist fin many new MS and some EU-15 countries. What is more, network regulatory barriers were reported to be some of the most relevant ones. A survey of the current regulation of electricity distribution was carried out among SOLID-DER countries. The project partners filled in detailed questionnaires about specific regulatory aspects of distribution and comments on practical experiences. Additionally, the situation in the UK will be frequently described as a best-practice example since its distribution regulation is deemed the most advanced when dealing with DER. Data for the UK have been obtained from the DG-GRID project and OFGEM[2] documents. This report builds on earlier work carried out under several projects such as SUSTELNET[3] or DG-GRID[4] and studies both EU-15 and new MS.

Herein the regulatory implications that high levels of penetration of DER might have at distribution level are analysed and the current situation of several EU countries described, paying special attention to new EU MS. Several regulatory recommendations are proposed to facilitate an effective and efficient large-scale penetration of DER in distribution networks. Section 2 focuses on the economic incentives DSOs may send to

[2] Office of Gas and Electricity Markets: http://www.ofgem.gov.uk/Pages/OfgemHome.aspx

[3] http://www.ecn.nl/en/ps/research-programme/energy-supply/sustelnet/

[4] http://www.ecn.nl/en/ps/research-programme/energy-supply/dg-grid/

DER, whereas DSO regulation is addressed along section 3. Finally, conclusions and thorough regulatory recommendations are provided in section 4.

2. Network related economic signals received by DER

As it was previously stated, DER in the EU mainly consist of RES and CHP generators that receive some kind of support mechanism. These additional payments are deemed necessary so as to overcome the technological gap that still exists between DER and conventional generation. However, short term efficiency signals for DER behaviour may not be adequately sent through these instruments. Therefore, providing DER with additional behaviour related economic signals, such as those already perceived by consumers or conventional generators may constitute a key issue in the integration of large levels of DER in electricity grids.

2.1 DER network charges

Networks charges allow DSOs to recover the costs resulting from the presence of DER in distribution grids. Two different kinds of network charges can be identified: connection charges and use-of-system (UoS) charges. A correct design of UoS charges and connection charges is a key issue to ensure fair and non-discriminatory network access. Therefore, this is one of the main requirements for an increase in the share of DER at European level.

2.1.1 Connection charges

Connection charges are paid just once when DER require network access to compensate for the costs of connection. Two different kinds of connection charges can be distinguished: shallow and deep charges. In some cases shallowish connection charges are used, being these an intermediate approach between deep and shallow charges. The connection charging approach can be of great relevance for DER producers trying to penetrate the market. There is a trade-off between providing incentives for the optimal and cost-reflective siting of new generation (deep connection charges) and facilitating entry for small-sized DER operators (shallow connection charges) for whom these charges may otherwise be a major barrier. Shallow connection charges encourage the entry of DER producers, however, may seem less attractive for DSOs. The latter may recover the arising additional costs for network reinforcements through other means such as UoS charges.

Most EU-15 member states (MS) have implemented shallow connection charges. Among the EU-15 MS participating in the SOLID-DER project only Spain and The Netherlands (for capacities over 10MW) still use deep connection charges.

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

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

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

In Denmark, shallow charges are set and published by DSOs. The charges are transparent.

In Germany, DSOs apply non regulated shallow charges to DER and are sometimes used to discriminate DER. They will be regulated in the future.

In UK, shallowish charges are applied. It is an intermediate approach between shallow and deep connection charges. Generators pay for the direct connection installations plus a proportion of the upstream reinforcement costs proportional computed on the basis of the use of any new infrastructure by the generator. Some argue that still this method constitutes a time-consuming and costly barrier for DG network access.

On the contrary, several new MS taking part in SOLID-DER project still apply deep connection charges. The situation per country is as follows.

In the Czech Republic, DER must pay for all costs of their connection to the grid. There are rules to determine which costs are eligible for a DER to pay.

In Slovakia, DSOs and TSO determine transparent rules for the calculation of these charges which are later approved by the regulatory office. Promoters can calculate these fees from the technical information provided by the system operator. DER have to pay for the overall costs of their connection to the network and all the necessary upgrades.

In Romania, DER pay deep connection charges as any other generator, although E-RES may obtain facilities for connection as State Aid. The methodology to calculate these charges is set by the regulatory authority, but some generators have complained about their being too high. There is a proposal under study to split connection costs between network owners and DER.

In Lithuania, deep connection charges are normally applied although sometimes shallowish methodology is used. According to the regulator, rules are relatively simple and transparent.

In Slovenia, connection charges are shallow but a DSO can refuse to connect any user if the necessary investments are too high, situation in which no transparent rules are applied. Negotiation between DSO and DER owners can delay projects.

In Bulgaria, DER only pay for direct connection costs within the boundaries of the plants according to the rules established by the regulator, but the DSO may not build the connection. Furthermore, some DER promoters have used political power to blackmail DSOs to build connections for their facilities.

In Poland, RES plants under 5 MW and CHP over 1 MW have to pay only half the actual costs of their connection to the grid.

In Hungary, DER owners (only RES, for CHP there is no discount; and even for RES this discount counts as a subsidy which is taken into account in granting a shorter feed-in tariff supported time in their licence) pay 50-70% of shallow connection costs although the lack of transparent rules leads to negotiation between DER and DSOs and conflicts due to discrimination have arisen, especially as DSO related DER is sometimes granted connection at better terms than as an independent DER.

Connection charges for DER	Countries	Structure of connection charges	Guidelines
Deep charges	Czech Republic, Slovakia, Romania, Lithuania[1], Spain, The Netherlands (>10MVA)	Generally, even though rules for calculation are set, charges are subjected to DSOs or TSOs intervention	Implement shallow charges
Shallow charges	Austria[2], Germany, Slovenia, Bulgaria, Poland, Hungary	Costs to be paid by DER are especified but its amount is usually calculated by DSOs	Evolve to regulated charges
	The Netherlands (<10MVA), Denmark	Regulated and published charges	Evaluate current scheme
Shallowish	UK	Negotiation between DSOs and DG takes place	Evolve to regulated charges

1-Shallowish charges are sometimes used
2-Negotiated lump sums may be added to these charge

Table 1: Connection charges for DER

There are many MS that still use deep connection charges whereas those which actually apply shallow connection charges generally have no regulated and standardized charges. The impression is that there is still much work to do, and Romania is the only country that intends to release new regulation on this matter in the short term. Consequently, no innovative recommendations may be suggested until more experience is acquired.

These recommendations can be summarized as:

i) Negotiation between DSOs and DER promoters ought to be avoided to prevent discriminatory behaviours and conflicts

ii) Those countries that apply DER deep connection charges should migrate to shallow connection charges. Locational economic signals to DER can be provided via the use-of-system tariffs or the support mechanisms

iii) Countries applying shallow connection charges should implement simple and transparent rules to determine regulated connection charges. Other costs associated with network reinforcements should be socialized between network users and recovered through the use-of-system tariffs

2.1.2 Use-of-system charges

Contrary to connection charges, UoS charges are periodically paid by network users, generally end consumers but also generators in some MS. 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 costs.

Regarding Use-of-System charges, the countries questionnaires have showed that there are still many countries where DER do not pay these charges. Furthermore, most countries which do apply UoS charges for DER have no specific fees for these generators and little differentiation is made. No significant differences were observed between EU-15 and new MS.

A country by country description is provided below.

In the Netherlands, DER-operators are obliged to pay uniform UoS charges for system services according to the net amount of energy taken from the network. These charges cover reserve requirements, black-out arrangements and costs related with the maintenance of system stability, among others. Therefore, DER pay only for their own consumption and not for the energy produced.

In Austria there are UoS charging mechanisms. UoS charges in Austria are used to compensate for secondary balancing on a kWh dispatched basis for those generators bigger than 1MW.

In UK, DER pay UoS charges that include transport and metering services. UoS charges consist of an energy term, i.e. per kWh, and a power term, i.e. per kW. Locational discrimination only applies for EHV customers, but not for lower voltage ones.

In Denmark, Germany and Spain there are no UoS charging mechanisms for DER. In Spain generators do not pay UoS charges by law, only demands pay UoS charges. In Denmark, conventional generators pay low and fixed charges. None of these countries expect to change this rule in the short term.

In Romania, every network user has to pay UoS charges. Distribution tariffs are regulated and are differentiated in three voltage levels and eight distribution companies. Transmission tariffs, which are also regulated, are differentiated on 6 generating areas (G) and 8 consumption areas (L).

In Slovakia, UoS fees are identical for all users of the system and include the costs related to transmission, distribution, system operation, and other system costs. Fee for transmission and distribution is related to connected capacity (kW), and the amount of transmitted energy (kWh).The fees for balancing services and system costs are related only to transmitted energy (kWh). A new special act for RES and CHP is under preparation, which might establish different economic conditions.

Czech Republic, Slovenia, Bulgaria, Poland, Lithuania and Hungary do not have UoS charges for DER either.

UoS charges for DER	Countries	Structure of UoS charges	Guidelines
No	Czech Republic, Slovenia, Bulgaria, Poland, Lithuania, Hungary Denmark, Germany and Spain, The Netherlands	N/A	Implement UoS charging mechanisms.
Yes	Slovakia Austria, UK	Uniform charges	Structure UoS charges, according to voltage levels, DER size, time of use and power plant location.
	Romania	Distribution: voltage levels and DSO Transmission: generation or consumption area	Implement time of use and DER size differentiation Evaluate the efficiency of this cost mechanism.

Table 2: Use of system charges for DER

It can be concluded that DER do not have to pay UoS charges in many countries participating in the SOLID-DER project. In addition, most countries where there are UoS charging mechanisms have only implemented a uniform rate, which makes no differentiation per location, time of use, etc. Regulatory changes are not expected in the near future with the only exception of Slovakia, where a new economic environment for RES and CHP is being prepared.

Given the situation described above, the following guidelines can be provided:

i) Economic signals sent to DER operators should be improved by means of efficient UoS charges that take into account their impact on the network. Efficient UoS charges ought to include differentiation per location (voltage level, urban/rural area) and time of use; in order to better reflect the actual costs (and benefits) for the system. Of course, the design of these tariffs is not trivial.

ii) The cost causality criterion implies that DER UoS charges can be either positive or negative, since they may achieve cost savings through losses reduction, investments deferral, voltage control, etc. For instance, a generator could be paid when producing at local peak demand time since losses will be decreased and voltage kept under margins. Otherwise, the DSO operating that area would receive some windfall profit for this whereas the generator originating the benefit would not perceive it.

iii) UoS tariffs must be consistent with the whole regulatory framework of each MS. For instance, in some countries the corresponding Electricity Act states that generators do not pay these charges. Moreover, their amount and structure should take into account other elements such as support mechanisms (avoid double paying), connection charges (in case of shallow charges, it is necessary to recover socialized costs), DER network services…

2.2 DER participation in ancillary services: reserves and network services

DER units are able to provide different ancillary services and other network services that can lead to a more secure and economic efficient operation of the distribution network. For instance, a more flexible operation of controllable DER according to network price signals can save investment or defer network reinforcements. In addition, DER can reduce the impact of network outages on customer supply interruptions if islanding operation is implemented in distribution network. Moreover, DER under local control or following system operation orders can provide voltage support or flow control when needed by the DSO. Therefore, the quality of service indicators of the corresponding DSO are improved.

In order to get profit from the operation advantages of DER, a deep transformation of the current relationships between DER and DSOs should be carried out. For instance, DSOs should be entitled to enter into agreements with DER to regulate under certain transparent conditions the active power feed-in at agreed financial compensations. That should be also acknowledged by DSO regulation that would allow DSOs to make an optimal choice between reinforcing the network (high CAPEX) and active network management (lower CAPEX but higher OPEX). In addition, DSOs should be able to purchase ancillary services from DER, such as voltage and reactive support, energy losses, or congestion management.

According to the questionnaires analyzed under the SOLID-DER project different levels of participation in the provision of Ancillary Services (AS) can be found among the MS. Some countries allow DER to participate into the reactive power control and energy balancing.

The situation in each country regarding this issue is as follows.

In Czech Republic, every generator above 30MW must take part in voltage and reactive power regulation. In addition, the procurement of secondary and tertiary reserve is usually provided by large units, above 15MW. Currently, the contribution of DER to the system AS is technically limited, and no experience has been reported.

In Slovakia, DER participate in different AS, such as black start reserves, some services of secondary regulation as well as the coverage of peaks in the power system. In addition, DSOs and TSOs can make attractive contracts with DER to procure these AS.

In Romania, DER are both obligated and incentivized to participate in the AS, including reserves and voltage control. Moreover, islanding operation is implemented for emergency situations, when DER can actively contribute.

In Slovenia, DER are allowed (but not obliged) to provide AS. Sources over 10MW are legally required to provide AS of voltage and frequency regulation if the TSO requests so, and compensated for it. However, AS are provided by large hydro power plants connected to the transmission network, with no contribution from DER.

In Bulgaria, rules for the participation of DER into the AS are currently under development. However, current experience of DER, usually based on old asynchronous generation, is a source of problems in the operation of the network due to their inability to provide voltage and frequency control, produce reactive power or perform black start.

In Poland, there are no regulations that allow DER to contribute to the AS of the power system. The participation in the balancing service is only provided by large power plants.

In Lithuania, DER is allowed to provide AS. Power plants over 5MW are required to participate in the services to ensure the stable operation of the power system. In addition, power plants can be obliged to make contracts with TSOs and DSOs to provide AS. However, current experience shows that the contribution of DER is still very low.

In Austria, DER do not provide AS nor get paid for it. Anyway, certain contributions of DER - e.g. seasonally split power factors - are usually negotiated and can be expected to make it more likely that DSOs embrace the connection of DER and hence ease integration procedures.

In Denmark, DER is allowed to participate into AS but in practice there is no real contribution. DER can receive incentives from the DSO to participate in certain AS. Some pilot projects are currently evaluating the contribution of DER into the islanding operation.

In Germany, pooled DER 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 a Virtual Power Plant (VPP) which pools the power supply of a number of decentralised power plants for participation in the balancing market.

In Netherlands, DER units of above 5MW and connected to more than 1kV voltage networks can provide AS. DER can participate into both balancing markets (through market aggregators) and reactive power control. Although DER can receive attractive remunerations from the TSO to participate in these services, the real contribution of DER is still very low. Currently there are some VPPs that can improve the participation of DER into the AS.

In Spain, DER can participate in different AS. DER units have incentives to keep power factors within specific margins or penalties if they go out of required margins. Different reference power factors are defined for peak, intermediate and off-peak periods. Controllable DER under feed-in premiums can also participate in the ancillary services markets run by the TSO, such as balancing and reserves, as other conventional generators do. The minimum capacity to access these markets is 10MW, which can be achieved through aggregation. Prediction of day-ahead energy production is mandatory for DER larger than 10 MW, and deviations over a settled range are penalized.

In UK, DER can arrange with the DSO AS procurement. In practice, aggregated small DER 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 DER participation in AS.

DER participation in ancillary services	Countries	Services	Guidelines
There is no contribution of DER to AS	Lithuania, Poland, Bulgaria, Slovenia, Czech Republic	None	Include DG into ancillary services
	Austria, Denmark		
Participation of DER into AS	Romania, Slovakia	Reactive power control, balancing market and reserves	Improve the contribution of DG to ancillary services
	Germany, Netherlands, Spain, UK		

Table 3: DER participation in the procurement of ancillary services

In most countries, there is still a non-existent or very low contribution of DER to the provision of AS. In several MS, this is true in spite of being legally entitled to do so, as in Czech Republic, Slovenia, Lithuania, Austria and Denmark.

The main contribution acknowledged to DER is to contribute to voltage control or, by proxy, to keep power factor between certain limits. In some countries DER can participate in the balancing market or provide reserves, mainly under aggregators. The capability of DER to 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 is hardly recognized. Finally, DER can improve quality of service by its contribution to the operation in islanding mode. In order to implement in practice such possibilities it is required that DSOs introduce active network management in their distribution networks. For the time being, islanding is not allowed in mot countries. The few countries that have implemented islanding operation either impose specific conditions, as it is the case in Czech Republic and Slovenia, or do it only in case of emergency, as in Romania. In Denmark exclusively pilot projects perform islanding operation.

Despite the fact that this report focuses on distribution networks, the TSO perspective cannot be ignored when dealing with AS. System balancing may constitute a great barrier for a large-scale deployment of DER and RES due to security concerns. Actually, it is normally TSOs that are in charge of managing the reserves and balancing markets. Nevertheless, some AS and network related services have a local dimension and could be controlled by DSOs. The design of network related markets such as local balancing, reactive power or energy losses compensation should facilitate market access to every DER, especially if they are controllable. Market prices would be the correct signal for DER participation in AS provision.

Several approaches for commercial arrangements can be thought. For instance, bilateral contracts between DSOs and DER; payments from the TSOs/DSOs, acknowledged in the UoS charges; and/or network related markets. The economic signals from the TSOs/DSOs to DER 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.

To summarize, DER can positively contribute to the operation of the networks, through different ancillary services. DER can provide voltage support and compensate energy losses as required by DSOs. In addition, DER through aggregators can participate in balancing and reserve markets. DSO quality of service can also be improved by defining the islanding operation with the participation of DER. Finally, the contribution of DER should be recognized and compensated by commercial arrangements between TSO/DSO and DER.

3. Interactions between DER and DSO regulation

The introductory section of this report argued that DER shares in EU MS will presumably grow over the coming years. Moreover, despite the fact that new MS hardly reach a 10% share of DER in electricity production, some of the EU-15 countries already show considerable figures. When electricity supply from RES and CHP surpasses a particular level, it can no longer be ignored by DSOs in network planning and operation. In the same way, the regulatory framework of electricity distribution should be adapted to the new situation too. Therefore, the recommendations provided in this section are more relevant for those countries with higher DER penetration levels.

3.1 Network planning taking into account DER

Article 14/7 of the EU Directive 2003/54/EC[5] requires DSOs to consider DER, together with energy efficiency measures and demand side management (DSM), as an alternative to network expansion. Although the potential of DER to replace network investments is a key issue for their further development, there is no clear concept yet as to how this guideline can be implemented and backed up by appropriate regulatory mechanisms. This it is even more challenging in an environment where DSOs are effectively unbundled and therefore they can not own generation assets.

The distribution activity costs can be divided into two separate categories: operating costs or operational expenditures (OPEX) and investments or capital expenditures (CAPEX). Traditionally, distribution network investments were remunerated under a cost of service or rate of return regulation. This means that DSOs report their expenditures to the regulator, and the allowed investments were remunerated at a pre-specific rate of return. Therefore, under this regulation, DSOs have no incentives to efficient network expansion that could exploit potential DER benefits. Nowadays, more and more MS are implementing incentive regulation that, theoretically, fosters DSOs costs reduction while keeping quality of supply and security standards.

The former type of remuneration is being abandoned, in fact, from all the SOLID-DER partners, only one uses cost of service regulation.

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 individual investment budgets is that in Germany are more than 700 DSOs.

On the other hand, the rest of the participating countries use some kind of incentive regulation.

In Spain, a revenue cap applies for OPEX together with CAPEX. This scheme has not been updated for 8 years and DSOs have been strongly addressed towards minimizing network investments. Besides, DER deep connection charges have leaded DSOs to

[5] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:176:0037:0055:EN:PDF

charge DER with network extensions not totally justified. A new proposal for DSO regulation that considers incremental DSO revenues associated to efficient network expansions has been recently approved, starting in 2009. The costs would be calculated according to a reference model that takes into account growth in demand and new DER connections. A price control will take place every four years.

In Netherlands, a price cap applies to TOTEX the sum of CAPEX and OPEX, preventing a cost shift from OPEX to CAPEX (which is usually less stringent regulated). Efficient investment is considered since both TOTEX (including CAPEX) are benchmarked and improvement in quality of supply is rewarded. In addition, yardstick competition is implemented. Therefore DSOs have an incentive to look for firm-specific investments that provide them comparative advantages. DER are not considered as a measure to lower network costs.

In Denmark, the regulator can increase the cap level if, due to DER connections, it is estimated that is needed, but there are not explicit mechanisms. No cases are known where DER was considered to postpone network investments, but most connections will take place in less populated areas where this is a less important option.

In Austria, incentive regulation has been implemented too.

In the Czech Republic, a revenue cap in a five-year period is used to remunerate network investments. There is an incentive to reduce losses. DSOs regard DER as an added burden to their activity.

In Slovenia, incentive regulation is in force under a price cap formula. There are incentives to reduce losses and increase quality of supply, but no explicit incentives to integrate DER.

In Slovakia, investments are included in the calculation of the DSOs’ allowed revenues. At the end of every regulatory period, investments are assessed by the regulator and a correction can be made regarding its fulfilment.

In Romania, DSOs are remunerated according to a price cap regulation reviewed every five years. Performance standards such as quality of supply, continuity and quality of service are considered in the calculations.

In Bulgaria, a revenue cap mechanisms is used that includes performance indicators on quality of service.

In Lithuania, there are only two DSOs with a very similar market share. Therefore, benchmarking to evaluate investment efficiency is simple. A price cap is applied to individual investments plans proposed by the DSOs and coordinated with the regulator.

In Poland, DSOs are remunerated via a revenue cap formula. They are forced by law to prepare investment plans for at least three years ahead that must take into account future changes in demand, generation and network expansion or interconnection. If this plan is approved, DSOs may keep benefits from efficiency gains until the next regulatory period. Polish DSOs are starting now to include DER into their investment plans.

In Hungary, a price cap formula is applied on four-year periods. At the beginning of each period, the cost of capital for the next regulatory period is calculated according to an expected rate of return on assets. The X-factor can be set annually within a specific range. For 120kV networks, DSOs have to prepare and execute an investment plan every two years to be approved by the regulator.

Type of regulation for investment	**Countries**	**Incentives for efficient network expansion**	**Explicit incentives to network integration of DER**	**Guidelines**
Cost of service	Germany	No	No	Implement incentive regulation[1]
Incentive regulation: Price or revenue cap	Bulgaria, Czech Republic, Lithuania, Poland, Romania, Slovakia, Slovenia , Hungary Austria, Denmark, Spain, The Netherlands	Yes. Mostly quality of service and losses reduction	No	Implement explicit mechanisms to take into account DER
Incentive regulation: Price or revenue cap	UK	Yes	Yes	Evaluate and fine-tune existing mechanisms

1-Planned for 2009

Table 4: Incentives to DSOs for efficient network planning

As it was previously said, incentive regulation based on price or revenue caps provides an implicit incentive to DSOs to reduce network investments while keeping quality of service levels. However, it has been observed that in some countries this has led to underinvestment. The only incentives DSOs generally receive to invest efficiently are those associated with energy losses and quality of service. To comply with the regulation regarding these issues, DSOs need to invest in network assets, in theory, until the economic incentives or penalties they receive equal the marginal investment needed.

Most countries have implemented incentive based regulation, although explicit incentives for network integration of DER are not generally utilised. Furthermore, there are few plans to achieve this kind of mechanisms in the near future.

Another problem that arises too is the opposite, i.e. how to compensate DSOs if, due to connections of DER, network reinforcements are needed. This will be addressed in section 3.2 on incremental CAPEX due to DER.

An initiative to implement measures towards efficient network investment is that of the UK. An implicit mechanism for efficient investment is provided by price control mechanism. In addition, the Engineering Recommendation P2/6[6] acknowledges the contribution of DER to network security. This technical recommendation mandates DSOs to evaluate the contribution of the DER to the peak demand, depending on the technology and the number of DER units, when calculating network reinforcements. For

[6] "Engineering Recommendation P2/6. Security of Supply", Energy Networks Association, July 2006

instance, the required transformer installed capacity in a distribution substation could be reduced depending on the amount of DER connected in the distribution network supplied by that substation. However, there is not strong evidence that DSOs have relied on DER 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 explicitly encourage DSOs to invest efficiently and economically.

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 carried out. Efficiency gains on investments due to DER, for instance, investment in active network management that integrates DER 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 DER when allocating investment budgets.

Several signals can be used, together with a more active management of the network, which will lead to a better optimization of the use of existing facilities, minimizing the requirement for new installations. In order to achieve higher efficiency in network operation due to DER, it is required to implement locational signals that promote the DER contribution to the peak demand, i.e. the location of DER close to the demand and their production in local peak hours. Use of system charges for DER and/or support mechanisms applied to DER, differentiated by time of use and voltage levels is a way of implementing these locational signals. For instance, support mechanisms for DER based on renewable or CHP, should promote DER production at peak hours rather than at valley hours. Moreover, use of system charges and/or support mechanisms should also recognize network benefits to DER connected in lower voltage networks rather than those in higher voltage networks. In addition, DER should be economically compensated for providing ancillary services that help DSOs operate the network, for instance, providing voltage control and reactive power support, especially in rural grids.

Finally, another type of actions in order to take into account the potential benefit of DER by deferring network investments is to update planning and security criteria used by DSOs.

3.2 Compensating DSOs for incremental costs due to the connection and operation of DER

The connection and operation of DER affects the costs of the distribution activity. The most relevant factors to determine the impact of DER on DSOs costs are the level of DER penetration in the network, defined as the energy generated by DER locally with respect to the total energy consumption, and the concentration of DER capacity, defined by the physical location of DER units inside each voltage network level. DSOs generally do not benefit for DER, except for cases where DER penetration is low, i.e. below 20%, 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. This negative impact is the more remarkable the more concentrated the presence of DER in the distribution network. Incremental network investments and energy losses increases are the reason for this phenomenon.

It was studied how participating countries acknowledge for DSO incremental costs due to the connection of DER in their regulatory framework. Most countries use incentive based regulation to remunerate OPEX and CAPEX to DSOs, although few of them explicitly considered DER as a costs driver.

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

In Denmark a revenue cap applies for all costs. Incremental OPEX are adjustable depending on market price, cost indexation and volume. CAPEX was included in the original calculation of network capital. New investments must be approved. Since 2008 there are efficiency improvement targets for each DSO including a quality parameter.

In Austria, DSOs are remunerated according to an incentive based regulation. DER are not considered in the calculation procedure.

In Spain, a revenue cap formula applies to both OPEX and CAPEX. Therefore DSO revenues do not change due to DER connections. Because deep connection charges are applied, DER 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 DER connections. The use of a reference network model is proposed to calculate these incremental revenues.

In The 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. If DER is larger than 10 MVA deep connection charges are applied, therefore the DER operator pays the necessary reinforcement costs. If DER is under 10 MVA, it is supposed that DSOs are able to pay all incremental capital costs for network reinforcement out of the depreciation of their network assets and incremental operational costs are nil. An additional provision in the tariffs can be allowed in the case that large investments are required. In case this judgement is unfair, it may be that not all reinforcement costs are paid by the network tariffs. Until now, no additional tariff provision has been allowed to any DSO.

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 Slovenia, a price cap methodology is in force for OPEX and CAPEX. A benchmarking is also used to determine DSOs eligible costs, but incremental costs due to DER are not taken into account.

In Romania, DSOs are remunerated according to a price cap regulation. Since DER investments are scarce, DER incremental costs are not significant.

In Poland, DSOs are remunerated via a revenue cap formula plus a benchmarking is carried out to compare OPEX. There are no specific regulatory mechanisms to compensate DSOs for their incremental costs due to DER.

In Slovakia, DSOs make price proposals that the regulator uses to set the allowed revenues, after assessing DSOs costs. DSO incremental CAPEX shall be included in the deep connection charges. It is mandatory to purchase energy from RES and CHP to cover all system losses at a regulated price. A new policy is being prepared that will increase the control over expenditures and eligible costs in regulated activities.

In Lithuania, a price cap is applied to individual investments plans and to OPEX. Any investment costs not satisfied by the connection charges is included and remunerated in the CAPEX. There is no explicit mechanism to recognize incremental OPEX.

In Bulgaria, revenue cap regulation applies. The information provided by DSOs is subjected to a running surveillance and regulatory review. Shallow charges for DER exist, thus connection costs are included in the CAPEX and remunerated as such. Incremental losses caused by DER (positive or negative) are not explicitly considered, but they might be included when calculating the recognized energy losses.

In the Czech Republic, a revenue cap in a five-year period is used to remunerate both OPEX and CAPEX. Incremental costs are included in the tariffs and account for 0.3% of total electricity costs. These costs are passed through to prices for end consumers by dividing total extra costs divided by total estimated consumption at the distribution system. A correction can be made by the regulator at the end of the regulatory period considering time value of money. Regional differentiation is implemented.

In Hungary, investment and operation incremental DER-related costs are checked and recognised in the next regulatory period. A compensation fund allows for some kind of inter-DSO payments to level their costs and profitability.

Type of regulation	Countries	Incremental OPEX and CAPEX due to DER	Guidelines
Cost of Service	Germany	YES No specific mechanisms	Migrate to incentive regulation
Incentive regulation: Price or revenue cap	Slovenia, Poland, Romania, Slovakia Denmark, Austria, Spain, The Netherlands (>10MVA)	NO Incremental CAPEX and OPEX are not considered	Implement explicit mechanissms to take into account incremental costs due to DER
Incentive regulation plus incremental CAPEX	Lithuania, Bulgaria The Netherlands (<10MVA)	Only CAPEX Investments necessary to connect DER not covered by connection charges are remunerated as any other CAPEX	Include specific treatment of incremental OPEX
Incentive regulation plus explicit mechanisms for OPEX and CAPEX	Hungary, Czech Republic Denmark, UK	YES Incremental costs are remunerated after approval of the regulatoty authority In the UK, a regulated incremental revenue driver and other incentives are in place	Implement mechanisms that consider DER performance and give incentives for the connection of more DER

Table 5: Treatment of incremental OPEX and CAPEX due to DER

As a conclusion, it can be said that few steps have been taken to include incremental costs originated from the connection of DER. In Germany, where cost of service regulation is still in force, incremental CAPEX are included in the RAB. Most countries under incentive regulation have no specific treatment for the incremental costs of connecting DER to the system other than CAPEX directly caused by the connection of DER if shallow or shallowish connection charges are implemented. Only in the Czech Republic OPEX and CAPEX are both taken into consideration, where total extra costs are divided by total energy consumption in the distribution system and added to the prices of electricity to final consumers.

It is recommended that countries where cost of service is still in force migrate to incentive based regulation. On the other hand, countries with incentive regulation should implement specific mechanisms to take into account incremental costs due to DER when calculating DSO's allowed revenues. In the Czech Republic, incremental costs are included in the computation of electricity tariffs but it is not specified how this is taken into account in the DSO remuneration formula.

Mechanisms that explicitly consider incremental costs due to DER in the DSOs revenues and foster efficient DER connection and generation should be implemented. There are several options to do this:

– Incremental costs could be included in the asset base at the beginning of the regulatory period. Nonetheless, it is difficult to estimate incremental CAPEX and OPEX in advance and most probably a correction would have to be made in the beginning of the next period.

- Consider DER as an additional cost driver in the benchmarking procedure to assess the efficiency of each DSO. For instance, DER capacity connected to the network or DER production at peak hours can be considered as efficiency measures in the benchmarking.
- Recover DER-related incremental costs ex-post, eliminating the need to foresee them, on a yearly basis or at the end of the regulatory period. To do this it will suffice to include an adjustment factor in the DSO remuneration formula.
- Include a DER-related incremental revenue factor in the remuneration formula. There could be a capacity based term (as in the UK) and an energy based term, related with incremental CAPEX and OPEX respectively. The main difference with the previous alternative is that in this case DSOs do not receive actual incremental costs but a standard cost determined ex-ante, equal for every company.

The last approach is considered as the most effective one to mitigate negative impact of DER connection. Its implementation under a revenue cap regulation would be as follows:

$$R_t = R_{t-1} \cdot (1 + I - X) + \sum_i \gamma^1{}_i \cdot kW_i^{DER} + \sum_i \gamma^2{}_i \cdot kWh_i^{DER} \qquad (1)$$

Where:

R_t is the total allowed revenues in year t

I is the inflation rate

X is the efficiency factor

γ^1 and γ^2 are the DSO revenue increment associated with the connection of DER capacity and the injection of DER energy respectively

The previous formula should be computed separately for each DSO. Due to the fact that DER impacts greatly depend on penetration and concentration levels, the coefficients γ^1 and γ^2 should be adjusted for each area of distribution and changed over time as the situation concerning DER changes.

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 DER under deep connection charges. Therefore that is not an incremental cost for DSOs.

3.3 Impact of DER on energy losses and on DSO performance

Technical energy losses, i.e. those produced as a consequence of the increase in temperature of network elements as a result of the electricity circulating through them, in distribution networks are affected by DER. In fact, this may be the main cost driver for incremental DSO OPEX originated from the connection of DER. For low DER penetration levels usually DER would reduce network energy losses with respect to the reference situation with no DER, thanks to the fact that generation is nearer to the load and electricity circulates through a shorter part of the network. On the other hand, high DER penetration levels would increase energy losses when local generation exceeds local demand and power flows reverse. This effect normally depends on the period of the day, and might be controlled on the generation side by means of time dependant use of system charges.

In some EU countries, in each regulatory period, regulators set the target for energy losses to each DSO. If real energy losses are higher than the target, then DSOs incur in an economic loss, otherwise, they earn a profit. On the other hand, in other EU countries, DSOs have to compensate energy losses on his grid by contracting more energy from the TSO or DER. In this latter approach, the economic incentive for DSOs to reduce losses is also clear. DSOs will earn the difference between the amount of actual losses they have to buy and the amount of losses regulator allows to pass-through to the tariff.

Four different methodologies to treat energy losses have been encountered in the SOLID-DER project. Most countries have implemented some way to promote DSO to reduce losses, although generally DER are not considered within these methodologies. Furthermore, DER operators are impervious to the effect they cause on energy losses.

The first group of countries is that where energy losses costs are not considered as controllable OPEX. DSOs are remunerated their actual losses, hence where they do not perceive any kind of incentive to reduce losses in their networks. This is the situation in Austria and Germany.

Secondly, in some countries allowable losses have an upper limit. DSOs only have incentives to reduce them below that level, because they will not get any economic compensation beyond that point. Lithuania and Slovenia are among these countries.

In Lithuania, upper limits for losses are set. If losses exceed normative values, the additional costs of network operators will be reimbursed from the profit.

In Slovenia, the cost of losses is included in the network charge. The reimbursed cost of losses is limited and the limit is set by the Energy Agency.

Another possibility is the case of The Netherlands, where losses are regarded as controllable costs. Dutch DSOs have to compensate energy losses by contracting that energy from their own utility or any other generator, including DER. Therefore, DSOs have incentives to reduce their losses as they would have to purchase less energy. Additionally, since yardstick competition is implemented, DSOs would earn a larger profit should they reduce losses in comparison with other DSOs. A recent change in regulation has cancelled payments to DER for avoided losses at transmission level, which used to be an efficient economic signal for DER to reduce losses.

Finally, DSOs in the remaining countries have incentives to reduce losses below some pre-determined levels. However, the impact of DER is not considered to calculate these targets, the economical effects will be completely assumed by DSOs, who will probably conceive DER as an added difficulty to their activity. Spain, Denmark, Czech Republic, Slovakia, Romania, Lithuania, Slovenia, Bulgaria and Poland are within this group. The target level of losses is generally computed considering historical values, corresponding either to that of each utility or obtained from a benchmark of several of them. In addition, some countries use network reference models that design the optimal network to supply a specific area given the actual network and considering geographic inputs, technical constraints, and planning principles.

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

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

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. Since the last price control in 2005, the impact of DG on DSO losses is considered to some extent[7]. 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.

In the Czech Republic, a compensation for reduced network losses for each MWh produced on distribution level exists. Moreover, DER receive a certain payment for their energy, which is higher at lower voltage levels.

In Slovakia, DSOs have to buy losses from RES or national coal at regulated prices. If actual losses are lower than regulated ones, respective costs spend on them are cut down, thus making profit from the difference.

In Romania, some level of losses is recognized in the price cap formula. Therefore DSOs have incentives to reduce them.

In Bulgaria, for each regulatory period targets for energy losses to each DSO are set. At the end of the regulatory period the Regulator sets new, normally lower, targets. In case energy losses decrease promptly in the beginning of the regulatory period the profit left to DSO until the end of the regulatory period.

In Poland, a linear regression model is applied to verify justified level of grid losses. Regulated revenues cover model costs, any difference in reality is assumed by DSOs. Consequently, DSOs may earn more money if they reduce their losses. The longer the regulatory period, the more incentives they have to behave more efficiently.

In Hungary, the regulator recognizes a certain level of distribution losses. Thus, if the network losses decrease, the DSO profit will increase. On the other hand, DER are not rewarded nor penalized in any means if they reduce or raise network losses.

[7] OFGEM, “Electricity Distribution Price Control Review: Final proposals”. November 2004 265/04

Incentives for losses reduction	Countries	Impact of DER on losses reduction incentives	Guidelines
DSOs are compensated for actual losses. No incentives to reduce them	Austria, Germany	Not considered	Implement some kind of incentive for losses reduction
An upper limit on compensated losses is established. DSOs have no incentives to reduce losses further	Lithuania, Slovenia	Not considered	Give incentives to DSOs for reducing losses beyond the limit value Take into account the influence of DER over energy losses
DSOs have to compensate energy losses by buying them in the market Losses are regarded as a controllable cost	The Netherlands	DER effect on losses is not considered	Compensate DSOs for incremental losses due to DER Reward DER for losses reductions
DSOs have incentives to reduce losses below specific regulated targets	Czech Republic, Slovakia, Romania, Lithuania, Slovenia, Bulgaria, Poland, Hungary Spain, Denmark	The impact of DER on losses targets have not been considered In the Czech Republic, energy payments to DER are higher at lower voltage levels, which compensates for avoided losses at higher voltage levels	Include the impact of DER on energy losses to compute the losses targets Reward DER for losses reductions
DSOs have incentives to reduce losses below specific regulated targets	UK	A loss adjustment factor may take into account the impact of DER on energy losses	Evaluate current mechanisms Reward DER for losses reductions

Table 6: Impact of DER on losses reduction incentives

DER penetration is bound to increase in the next few years; therefore their impact on energy losses will become more significant. It has been observed that despite most countries provide DSOs with incentives to reduce losses in their networks, none of them take into consideration the influence of DER over this issue, thus DER are not rewarded for energy losses reduction. What is more, DER are generally regarded as an obstacle to the distribution activity rather than as an element to support the network operation.

It is essential that DSOs perceive economic signals to operate more efficiently, i. e. lower energy losses among other things. Moreover, in those countries where these incentives exist but DER are not considered, this situation ought to be modified. In the UK, a proposal was made to tackle this problem. This mechanism suggested modifying the level of DSO reported losses according to a site-specific Loss Adjustment Factor (LAF) and the export volume of the generators. It is clear that specific mechanisms to share potential benefits among DSOs and DER should be designed, especially with higher shares of DER.

A consideration on the level of allowed losses ought to be made. Along this section, the word “target” has been used when referring to energy losses, which by the way is the term sometimes used in regulatory documents. However, a more appropriate word would be reference value. Equation (1) shows the formula to calculate the incremental (or reducing) revenues associated with the energy losses. Symmetry in the formula is supposed, i.e. the incentive equals the penalty.

$$\mathrm{Re}\,venue_{Losses} = Incentive \cdot (Losses_{\mathrm{Re}\,ference} - Losses_{Actual}) \qquad (2)$$

The reference value should not be set at the desired level of losses, or "target losses", but at a value consistent with the allowed revenues. If a DSO does not invest enough to achieve a level of energy losses in accordance with its allowed revenues, it would be forced to return that money via the penalty for not complying with the energy losses reference value. On the contrary, if further reductions of energy losses are accomplished, the DSO will receive an incremental revenue to compensate for the extra costs. DSOs would, in theory, keep reducing energy losses as long as the extra expenditures that are required for this are compensated by the incentive (or penalty) provided. Moreover, this remains true regardless of the reference value that has been set. Setting a reference value not consistent with the allowed revenues would only imply a transfer of rents between customers and DSOs, but the economic signal for losses reduction corresponds to the incentive of penalty per kWh of losses alone.

The development of DER in the distribution network should be taken into account in this process. For a high DER penetration/concentration level, which is not the case yet in most countries, an increase of revenues should be allocated to compensate DSOs. For instance, in network areas with high DER penetration, a revenue driver to compensate the DSO in €/kWh associated with DER 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, DER connected in lower voltage networks can be credited for losses reductions at higher voltage levels. Again, this locational signal can be sent as a reduction of the use-of-system charges paid by DER, or by increasing the DER support mechanisms as feed-in tariffs or feed-in premiums in lower voltage levels.

3.4 DSO performance on quality of service taking into account DER

Quality of service in distribution networks consists of two aspects: commercial services and technical quality. Commercial quality refers to metering, billing and customer services. Note that even under an unbundled environment DSOs have clients to attend, although in this case these clients might be retailing companies. On the other hand, technical quality comprises: 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.

Concerning voltage quality, the European standard EN – 50.160 establishes the voltage characteristics that should be met by DSOs when supplying electricity to users connected to distribution networks. The connection of DER may produce problems related with harmonics injection, flicker, etc. On the other hand, continuity of supply is strongly related with DSO network investments and operational and maintenance expenses. Due to the regulatory implications of this issue, the emphasis will be placed on continuity of supply. 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, especially when the regulation does not provide incentives for efficient investments, leading to a progressive degradation of the quality of service.

It is still uncertain how DER will affect DSOs quality of service. DER can become an opportunity instead of a threat by helping to improve reliability indices working in islanding mode in case of network outages. DER can also provide ancillary services such as voltage control, frequency reserve, or black start to improve voltage quality. However this is nowadays far from real DSO practices. How DER can be used to increase quality of service is a subject that needs further research and innovation efforts.

A deep transformation from passive to active management increasing DER participation in network control and DER contribution in case of network disturbances should be carried out. Active management (AM) of distribution networks will deeply influence current DSO operation and planning practices, and consequently on DSO CAPEX and OPEX. AM in distribution networks will potentially reduce network reinforcements and losses, and increase quality of service. On the other hand, it may increase OPEX as the network is operated more intensively and new investments in communication and control equipment would have to be made.

Several countries included in the SOLID-DER project 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, SAIDI[8] and SAIFI[9]. If DSOs achieve better actual values than those set as quality targets they will increase profits, otherwise profits will be reduced. On the contrary, there is still quite a large group of countries where DSOs have no incentives to keep adequate quality of service levels.

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 DER for reactive power provision.

In Germany, there are not specific incentives/penalties related to quality of service targets. DER 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 DER is not considered as a specific source for improvement.

In Denmark, since 2008 the revenue regulation includes effect of quality performance in 2007. Revenue caps will be adjusted by benchmarking. DER are not expected to cause great impact on quality of service.

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[8] SAIDI stands for System Average Interruption Duration Index.

[9] SAIFI stands for System Average Interruption Frequency Index.

In Spain, DSOs have to meet zonal quality targets in terms of frequency and duration of supply interruptions not only on average parameters but also on individual parameters. If individual reliability indexes are not met by the DSO, then an economic penalty is applied and paid back to the affected customers. If zonal indexes are not met, then the DSO has to present an investment plan to correct the deficiencies. DER is not currently considered as a control element that can improve quality of service levels.

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 have also the duty to pay compensation allowances to households and small firms if disruptions occur. It is assumed that large firms have other possibilities to receive compensation, for instance by the possibility of legal action. DSOs see DER units rather as a threat to their business than as an opportunity to diversify.

In Poland, standard reliability indexes were implemented in 2007. Now system operators are obliged by law to publish information on reliability expressed, in the case of DSOs by the parameters SAIDI, SAIFI and MAIFI[10]. There are neither penalties nor incentives with regard to quality of service.

In the Czech Republic, there is no specific regulation about quality of service. DER, especially from intermittent sources, is mainly seen as an additional cost factor for DSOs. Exception can be reduced network losses, since a compensation for this exists.

In Lithuania, the regulator may set requirements for quality of service and reliability. The National Control Commission for Prices and Energy is controlling how these requirements are implemented. DER as considered as a potential source of problems due to the fact that they cannot be controlled. In January 2007, a problem aroused when due to an increase in gas prices, almost all small generators (fired on gas) had disconnected without notifying network operators.

In Romania, there is a performance standard for distribution activity and the price methodology has quality related provisions. Nonetheless, there is not experience with significant shares of DER yet.

In Slovenia, DSOs must observe standard quality of service limits defined in the standard EN 50160. The price cap for the network charge also depends on the DSO continuity of supply which is assessed on the basis of SAIDI and SAIFI indexes. DER is some times seen as a new source of potential quality of service problems, especially for larger units which affect network operation.

In Bulgaria, the regulator annually sets targets for technical indicators of quality of service. The DSO revenues in a regulatory period can be adjusted according to the performance of the previous one based on those indicators. DER are considered mainly as a potential sources of difficulties, particularly where large concentration levels are present. Some difficulties with hydro power plants that use asynchronous motors

[10] MAIFI stands for Momentary Average Interruption Frequency Index

operating as generators have been encountered. The possibility of using DER for frequency regulation services is considered for the wind farms over 15 MW.

In Hungary, there were penalties for not complying with several quality of service indicators until 2007. However, since new regulation was passed it is now the regulator that imposes penalties through individual resolutions. The rules to be applied are not clear yet. At present, DER is not considered as a technical burden threatening power quality at distribution level, nonetheless, DER causes balancing problems to the TSO.

In Slovakia, DSOs are bound to keep the quality of service under valid technical standards and provisions of the contracts signed with their partners. In case of violation of agreed parameters, they are sanctioned as is stipulated in the contracts. DER, especially wind, are regarded as a kind of threat for system reliability, although there is little experience yet.

Incentive/penalties to meet quality of service requirements	**Countries**	**Contribution of DER to quality of service levels**	**Guidelines**
DSOs have no incentives or penalties	Lithuania, Poland, Czech Republic Austria, Germany	No contribution DER mainly seen as a source of problems related with quality of service	Implement incentives for quality of service improvements
Performance based regulation for quality of service	Romania, Slovenia, Bulgaria, Hungary Denmark, Spain, The Netherlands, UK	No contribution DER mainly seen as a source of problems related with quality of service	Implement specific innovation actions to integrate DER as a control source to improve quality of service
DSOs have non-regulated targets for quality of service	Slovakia	No contribution DER mainly seen as a source of problems related with quality of service	Implement specific innovation actions to integrate DER as a control source to improve quality of service

Table 7: Impact of DER on DSO quality of service requirements and incentives

There are still several countries where DSOs are not compelled to accomplish certain quality of service levels yet. What is more, DER are seen by most 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 monitoring and controllability of these sources, together with their frequent disconnections in case of network disturbances.

However, if DER penetration levels increase as it is foreseen, the potential advantages of having DER as a new control source should become a DSO opportunity instead of a threat. DER can help to improve reliability indices working in islanding mode in case of network outages as well as improving voltage quality by providing ancillary services such as voltage control, frequency reserve, or black start. Nevertheless, 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.

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.

In conclusion, DSOs should have to meet certain regulated quality of service levels in terms of duration and frequency of supply interruptions and voltage quality. DER can help to achieve that by functioning in islanding mode in case of network outage, for which it is necessary to solve security problems, or providing ancillary services such as voltage control, frequency control, or black start. The recommendations can be summarized as:

i) Implement regulation for quality of service that provides explicit incentives (and penalties) for DSOs to improve quality of service levels

ii) Promote an active management of the distribution networks and improve the controllability of DER by DSOs

iii) Provide incentives to DER for providing ancillary services and as a consequence improving quality of service levels

3.5 DSO incentives for innovation

Current regulation of DSOs lacks of mechanisms to promote network innovation. DER 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 DER.

There are several regulatory mechanisms to promote innovation in line with incentive regulation. For example:

- 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 this latter approach can be found in the Innovation Funding Incentive (IFI) implemented in the UK. This allows DSOs to expend up to 0.5% of their revenues on eligible IFI projects.
- Output incentives: Generally, DSOs may obtain incentives if they improve certain indicators such as the quality of supply and reduce energy losses. In order to foster DER integration through innovation, specific performance indicators with associated economic incentives if DSOs reach specific targets, should be selected. For instance, the number of DER connections already integrated in the network in comparison with the total number of applications.

> An example of this is the Registered Power Zones (RPZ) in UK. RPZ are specifically aimed at the connection of DER into the network by using innovative and more cost effective ways. If the regulator accepts a proposal as RPZ, the DSOs incentive to connect DER (In the UK the DSOs remuneration formula includes a term expressed as £ per kW of DER connected) is increased considerably.

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.

A large scale penetration of DER into the distribution networks will impose significant challenges to the network operation and development. DER 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.)

Two instruments can help to deal with the uncertainty of future system transformation:

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

Most of the SOLID-DER countries, have not implemented explicit incentives for DSO innovation yet. Some of them think that current DSO regulation towards economic efficiency and quality of service improvements will bring, indirectly, innovation. Few countries have incorporated innovative designs in the support mechanisms or in the use-of-system charges to achieve a more effective integration of DER.

The country situation on this issue is as follows.

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

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

In Spain, there are not specific incentives for DSO innovation. The situation is rather the opposite because DSOs claim that allowed revenues are not enough and investments have reduced.

In Denmark, the revenue cap and benchmarking is an incentive for network innovation that can reduce cost. Contribution of DER to balancing would make it more attractive to DSOs to pay for the equipment that is needed for efficient operation of distribution grid.

In Netherlands, there are not explicit incentives for innovation. On the other hand, under yardstick competition investments in innovation may provide DSOs with competitive advantages that are difficultly replicated by the rest of the DSOs. Additionally, 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 so customers should not pay twice.

In Slovakia, there is a study under preparation to explain DER influence at the network, but there are not results yet. The new Regulation Policy will be based on efficient incentives for higher utilisation of RES and investments to improve the quality of electricity supply.

In Slovenia, there are not incentives for DSO innovation, neither immediate future plans to change regulation on this topic.

In the Czech Republic, there are not specific mechanisms for innovation although an incentive-based revenue cap regulation has been introduced.

In Romania, DSOs have incentives for higher efficiency and reducing costs due to the incentive regulation. Also the quality factor in the price-cap formula is an incentive.

In Bulgaria, the regulator adopts the inherent costs of DSOs by advisability of investments. The innovations are taken into consideration when this is done for each DSO.

In Lithuania, it is possible to get the additional funds for the investments. The network operators have incentives for the highest efficiency of their investments. The regulator believes that motivate regulation could be applied.

In Poland, tariffs for gaseous fuels, electricity and heat may take into account the costs of co-financing projects and services aiming at energy efficiency which are an economically justified alternative to avoid the development of new energy sources or networks, and the development of renewable energy sources.

In Hungary, DSOs have the possibility to spend 0.3% of annual revenues on innovation instead of paying that amount in taxes. The can either research themselves or outsource the innovation activities.

Incentives for DSO innovation	**Countries**	**Guidelines**
No incentives	Slovakia, Slovenia Austria, Germany, Spain	Implement incentives aimed at improving DSO performance
Implicit incentives associated with incentive regulation	Czech Republic, Romania, Bulgaria, Lithuania Denmark, The Netherlands	Critical review of current situation to asses wheter performance based regulation is enough to bring DSO innovation
Explicit incentives	Poland, Hungary UK	Validate and tune current scheme

Table 8: Incentives for DSO innovation

It is still unknown to what extent performance based regulation can promote innovation by itself. In addition, there are some countries where even though performance based regulation is applied; DSOs clearly do not get any incentive for innovation. Among all the SOLID-DER countries, only Poland has explicitly considered innovation in the DSOs revenues

It is advisable to complement performance based regulation with explicit incentives for DSO innovation. The most advisable regulatory instrument may vary according the specific regulatory framework of each country. However, it should be evaluated somehow whether these investments are efficiently made and justifiable so that they will provide useful results in the end.

3.6 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” [11].

Of particular relevance for DER are the unbundling requirements for DSOs. Those are stipulated in Directive 2003/54/EC, Art. 15 (1); where legal unbundling is required. In addition to legal unbundling, certain criteria of functional unbundling have to be met. The latter has been established to guarantee 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.

[11] http://ec.europa.eu/comm/competition/general_info/u_en.html

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 DER operators trying to penetrate the market. 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. Asymmetry of information and barriers created by system operators should be overcome. 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, discriminating new suppliers. All these factors can cause severe problems for new DER operators when DSOs display anticompetitive behavior by favoring their own DER units or DER sites owned by their previously affiliated companies.

Country	Unbundling situation	Plans to implement more effective ways of DSO unbundling
Czech Republic	Legal	No
Slovakia	Legal	No
Romania	Unbundled	No
Lithuania	Legal	No
Slovenia	Only one public DSO, have no other function. Network owners are five, although 79.5% owned by the state	No
Bulgaria	Legal	No
Poland	Legal	No
Hungary	Legal	No
Spain	Functional	Electricity Directive 2003/54/EC was transposed implementing functional unbundling Separate DSOs network functions from commercialization to regulated customers Regulated tariffs will be eliminated for all customers, but small domestic customers, by 2009 Two main legal developments: i) define independent DSOs by electrical zones, regardless of the network ownership ii) set operational procedures for DSOs, similar to the ones used by the TSO
The Netherlands	Legal One small DSO is voluntary ownership unbundled	Functional unbundling before july 2008 Ownership unbundling before 2011
Austria	Legal	No
Germany	Legal	No
Denmark	Legal	Moving to ownership unbundling

Table 9: Implementation of unbundling

In order to asses the current implementation stage of unbundling of DSOs and try to identify problems derived by lack of unbundling as those commented before, a survey was carried out. Table 9, shows that the most common form of separating different activities is legal unbundling. However, Denmark and The Netherlands are on the way to implement ownership unbundling. Finally, in Slovenia there is only one public DSO with no other electricity related function and the companies that hold the property of the distribution network are mostly state-owned.

Generally, the SOLID-DER countries have no future plans to implement further ways of DSO unbundling than those stipulated by the EU Directive 2003/54/EC with few exceptions. There are two possible alternatives to solve discrimination in network access which are to define an independent system operator regardless of the ownership of the assets or to implement ownership unbundling[12]. The latter approach will become mandatory in The Netherlands at the beginning of 2011. On the other hand, Spain is planning to create zonal independent DSOs whose procedures would be similar to the ones of the TSO. However, a discussion at national level should be undertaken to determine the best solution for each particular case, if further unbundling measures are required.

Country	**Can DSOs own DER**
Czech Republic	No
Slovakia	No
Romania	No
Lithuania	Only DSOs with less than 100000 connections
Slovenia	No
Bulgaria	No
Poland	Only DSOs with less than 100000 connections
Hungary	No
Spain	Only DSOs with less than 100000 connections
The Netherlands	No
Austria	Only DSOs with less than 100000 connections
Germany	Yes, but accounting unbundling
Denmark	Only DSOs with less than 100000 connections

Table 10: Ownership of DER by DSOs

In most MS participating in the SOLID-DER project, DSOs are not allowed to own DER with the exception of small DSOs with less than 100000 clients connected to their grids. Only in Slovakia and Germany they can own DER, but no specific problems related to DSOs unbundling have been reported in these countries. Other states that have not found problems of this kind are Denmark, Czech Republic, Romania, Lithuania, Slovenia, Poland and Bulgaria.

[12] EU MEMO, "The Internal Energy Market: Foundation of the EU Energy Policy". European Commission, Directorate-General for Energy and Transport. January 2007

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 the Netherlands, from a practical point of view, the major issue is fear of the government for 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 DER owners resulting from discriminatory treatment by the DSOs, as well as technical problems such as overloads or voltages out of margin.

It is advisable that MS adopt measures to achieve better compliance with the requirements in legal and functional unbundling as stated in EU Directive 2003/54/EC. The monitoring of the process is a key issue to gain in transparency, which could be done by each national regulatory authority or another independent entity through periodic reports solely on the state of unbundling. Further actions ought to be undertaken if the actual provisions at EU level prove to be insufficient to avoid discriminatory network access. Should this be required, it must be applied at European level to avoid discrepancies between national regulation and the EU process towards a single electricity market. However, in the new proposal for a directive amending Directive 2003/54/EC[13], belonging to the Third Legislative Package for the energy sector, the European Commission concluded that the current legal and functional unbundling rules are sufficient and proposes not to apply ownership unbundling rules to DSOs.

3.6.1 Exemption clause on DSO unbundling

In EU Directive 2003/54/EC, Art. 15 (2) it is laid 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. The overall impact of this exemption clause depends on the number of DSOs with less than 100,000 connections, the percentage of connections that fall into this category in the individual MS and whether those DSOs own generation connected to their networks. Especially small-scale DER is often connected to low voltage networks and deployed in rural areas where DSOs with less than 100,000 connections mostly operate.

The situation concerning small DSOs varies greatly from one country to another. In theory, there is a trade-off between the implementation 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 many MS. On the contrary, the exemption clause can be of great importance for those MS with a high number of

[13] COM (2007) 528 final. Available on-line: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0528:FIN:EN:PDF

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 DER units into their networks. Solutions they develop to integrate their own DER sites can be applied when connecting DER units of new independent producers. Therefore, the impact of the exemption clause has to be assessed rather on a country by country basis than at European level, taking into account the structure of the distribution sector and the regulatory framework in the individual MS.

Country	Number of DSOs	DSOs with less than 100000 connections	Small DSOs own generation connected to their networks
Czech Republic	3	None	-
Slovakia	N/A	250 small DSOs, account for 0.5% of connections	Yes, mostly below 1MW
Romania	8	None	-
Lithuania	2 large DSOs	Small number, representing 13% of connections	Two local distribution systems have their own CHP: 21,5 MW and 24,2 MW.
Slovenia	1	None	-
Bulgaria	4	Only one small DSO operating only 0,1% of the grid	No
Poland	18	4 small DSOs. Account for less than 1% of the share	Yes
Hungary	N/A	None	-
Spain	329	More than 300 small DSOs, less than 3% of connections	Yes, small capacity
The Netherlands	11	6 small DSOs, they cover 3% of connections	No
Austria	135	119 small DSOs (12% of connections)	Yes
Germany	950	900 small DSOs	Yes
Denmark	120	112 (43% of connections)	No

Table 11: DSOs with less than 100000 connections

Most countries have not found any difficulty caused by the existence of small DSOs. This is the case of Czech Republic, Slovakia, Romania, Lithuania, Germany, Denmark, Slovenia, Poland and Hungary.

In Austria, the detrimental impact on DER integration due to the existence of small integrated DSOs is negligible. Unbundling would hit severely very small DSOs that 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 DER employment since some of these integrated DSO invest innovatively in DER – presumably *because* they integrate generation and distribution.

In Spain, some conflicts of DER 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 unbundling requirements at the regional level, where these companies have a long tradition, nor at the national level.

In the Netherlands, there are also no specific obstacles to DER 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 operator as will be the case from 2008 compared to a 'lean' DSO as it used to be. 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 Bulgaria, the unbundling creates complication with the procedures and increase the administrative personal. This represents major barrier for the only small DSO, which cannot be overcome by such small enterprise serving only several hundred customers.

To sum up, it is recommended to allow each MS to decide whether to keep the exemption clause for small DSOs, but ensuring that there are transparent planning, operation and accounting mechanisms. Some measures in order to avoid discriminatory network access where vertically integrated small DSOs exist are required and might be country specific. The approach implemented for the connection charges is especially relevant for this issue. Under a deep connection charges philosophy, vertically integrated DSOs may have more room for discrimination than under a shallow charging methodology. Moreover, averaged and regulated charges are preferable over negotiated ones. A deeper discussion on connection charges can be found in section .

3.7 DSO and demand response actions

Demand Side Management (DSM) will presumably become a key instrument to promote sustainability in electricity systems. DSM mechanisms can be classified in two: energy efficiency, aimed at reducing overall energy consumption, and demand response. Demand response is another way to ensure more optimal use of the network system. It can be understood as temporary reduction of electricity consumption from the side of the consumer and shift of this consumption to other periods of the day. This reduction and/or shift of electricity consumption can help in diminishing peak loads at critical periods in time.

Article 14/7 of the EU Directive 2003/54/EC requires DSOs to consider DER, together with energy efficiency measures and demand side management (DSM), as an alternative to network expansion. Demand response, defined as those mechanisms aimed at reducing peak demand, is included within the concept of DSM. Therefore, it should be considered together with DER and energy efficiency as an instrument to defer network investments.

Demand response can be regulated from the side of the DSO. Several mechanisms can be thought of, with different time horizons and DSO intervention levels. Firstly, price-based demand response can be considered. This can be done (ordered according to how long in advance the signal is sent) through time-of-use tariffs, day-ahead hourly pricing (for example the one resulting from the generation dispatch), critical peak pricing (CPP) or real time pricing (RTP). However, in a fully unbundled electricity system the design of energy prices would be responsibility of retailers. Another mechanism would consist of demand bidding in reserve markets to modify their consumption profile. Small consumers could do so under aggregation. Nonetheless, these markets are generally run by TSOs and not DSOs.

Demand response under the responsibility of DSOs could be done through the control of loads connected to their networks. Being this the case, DSO would be qualified to switch off certain consumers as stipulated in a contract between DSO or energy supplier and consumer. The consumer would obtain lower electricity or network tariffs in exchange. The control over the loads could be made indirectly, through voluntary agreements with consumers that would reduce their consumption at specific periods of time; or directly, thanks to an extensive use of telecommunications and smart metering. The former approach is only feasible for large, mainly industrial, consumers; whereas the latter seems more suitable for domestic and commercial consumers due to their number and characteristics.

This chapter will analyse what possible cooperation is possible between the DSO and consumers in the field of demand response. It must be considered that in certain regulatory frameworks DSOs are remunerated according to the amount of energy delivered. Therefore, either the regulation should be modified or additional incentives ought to be implemented. This would be the case, for instance, in those countries where a price cap remuneration scheme is adopted or where a revenue cap is applied together with an incremental revenue term dependent on the quantity of energy delivered.

The questionnaires filled in by the project partners show that the most commonly applied mechanism to displace demand from peak hours to valley hours is based on time-of-use charges. Time differentiation may vary between seasons of the year, day of the week or hour of the day. However, this methodology, in spite of representing an incentive to modify consumption habits, does not ensure that peak demand will be actually reduced. On the other hand, load shedding performed by the DSO or TSO indeed ensures that demand will lower when this is required to maintain security levels. This alternative is implemented in several SOLID-DER countries and regulated according to interruptibility contracts or market based mechanisms. Finally, some countries are starting to install smart meters, which once deployed at large scale will provide a wider range of demand response options. Smart meters will become an essential component of the electricity grids of the future known as Smartgrids, which are characterized by an active network management approach, the development of a communications network in parallel with the electricity network and a large penetration of DER.

Demand response actions	**Countries**
Time-of-Use tariffs	Slovakia, Romania, Lithuania, Hungary, Slovenia, Bulgaria, Poland Spain, Austria
Interruptible consumers	Lithuania, Hungary Spain, The Netherlands, Austria
Smart meters (domestic loads)	Spain, The Netherlands, Denmark

Table 12: Demand response actions

Table 12 highlights the fact that nowadays DSOs (and TSOs) play a poor role regarding demand response actions, particularly in new MS but also in the EU-15 MS. Time-of-use tariffs, despite having the potential to shift peak demand, do not require an active behaviour from DSOs neither they are flexible enough to react to changes in the situation of the grid. On the other hand, load shedding is generally only applied to large industrial customers in case of emergency, whereas it might be more efficient to reduce but not switch off the consumption of several smaller consumers distributed along the network. Undoubtedly, this will require modifying the network configuration and the operation, control and planning procedures.

The demand response actions in each country are as follows:

In Slovakia, the following programs are practised: regulation of loading, education and consultant service, price and tariffs structure, labelling and financial incentives. DSOs offer customers with consumption greater then 60 MWh/year the possibility to benefit from lower tariff in the night hours.

In Romania, there are regulated time-of-use tariffs for industrial users but also as an alternative for domestic consumers. On the competitive retail electricity market, it is possible to use any incentive in the tariff and also to negotiate consumption reduction.

In Slovenia, there is a two-period tariff system for households and three-period tariff system for industrial consumers. Time intervals for individual tariffs are fixed. In households, for example, the lower tariff is over night and during weekends.

In Bulgaria, there are “weekend tariffs” for large consumers connected to the transmission system. There is no similar practice at distribution level.

In Poland, the tariff policy includes tariffs differentiated by day/night, peak/off peak hours, weekdays/weekends and seasons. Nowadays there are also many energy efficiency campaigns. In a recent System Ordinance, an entry introduces the obligation on the DSO’s to inform the TSO about all the undertakings regarding electricity demand management..

In Lithuania, a two time zone tariff exists. A large capacity surplus still exists in the Lithuanian power system. Thus, usually there is no need to disconnect energy consumers in peak hours. There are only few such consumers at the moment. It is planned to apply this method in the future.

In Hungary, a cheaper night period tariff is available for household consumers. DSOs can switch off and on electric equipment, mainly water heaters. Besides, some DSOs have developed energy saving information campaigns via advertisements or via the web site. Finally, large consumers can bid at the tertiary reserve market to lower their consumption, although they seldom do it.

In Denmark, demand response is very limited. Only very large customers are on real time metering, and just a fraction of them is billed based on day ahead hourly prices

In Spain, there are five different options of time-of-use differentiation which vary from a basic two-period tariff for domestic consumers to a tariff for large industrial consumers where the days of the year are classified in four groups and each day divided in three periods. High voltage consumers may opt to an interruptibility contract and benefit from a decrease in their annual energy expenses. Four different options exist, depending on duration of the interruption and how long in advance the customer is informed. The number of allowed interruptions is limited. In 2006, it became mandatory for the electric utilities to install smart meters to new customers or when replacing old ones for every demand lower than 15kW. Given that this process has just started, no demand response mechanism for domestic or commercial customers has been implemented yet.

In The Netherlands, demand response is mainly applied by the industrial sector. Large industrial interruptible demand participates in the market for reserve power. The TSO is currently contracting 300 MW of wholesale demand response reserves as so-called emergency reserves. Additionally, households can choose for a very basic two-period tariff. The Ministry and DSOs have signed an agreement for an obligatory roll-out of smart meters for all connections of small consumers in a six year period[14]. The ministry

[14] At the same time, there is still disagreement about the functional requirements of the meters, which has suspended the roll-out of smart meters.

is quite optimistic about the development of new services, like demand response, if smart metering is fully implemented. A standardisation protocol for communication protocols has been drafted. Several DSOs are experimenting with smart metering, in some cases with demand response on basis of pre-paid payments for defaulters.

The situation in the SOLID-DER countries shows that demand response is still at a very early stage of development. The first step, which already takes place in several countries, is to implement time-of-use tariffs. However, little differentiation is made yet, as in most countries there is only a two-period tariff, and in some cases the possibility is restricted to large consumers. Further differentiation that reflects the impact on the network ought to be made, albeit this would probably require replacing existing metering equipments.

Smart meters offer numerous benefits for every agent involved in the electricity sector deriving from the increased observability and controllability of demand:

- Consumers could lower their electricity expenditures, improve quality of service since fault restoration times could reduce thanks to the smart grids, and be offered new value added services.
- Retailers receive more information from their clients, thus they can offer them customized services and reduce their risks in energy purchasing.
- DSOs may obtain many operational advantages due to the greater intelligence of the network: real time monitoring can lower operation and maintenance costs, higher knowledge on the energy flows allowing for investment reductions, better and easier integration of DER.
- System operators may improve load-generation balancing and manage energy flows up to lower voltage levels, improving optimum levels of quality and security of supply.
- Regulators decision-making process is facilitated by the increased information on the network and market situation.

The penetration of smart meters and the implementation of demand response mechanisms for automatic metering should be a progressive process. In the first stages, a one way communication would allow for automatic metering and time-of-use tariffs. Nonetheless, as the process evolves bidirectional communication between demand and operator would support real time monitoring, improve DER integration or partial domestic load shedding. In the end, smart meters together with smart appliances would let consumers program their own energy consumption patterns in platforms known as Home Automation Networks (HAN).

The implementation of these mechanisms requires solving quite a number of problems of very different nature. Some regulatory issues may arise regarding the relationship of retailers and DSOs or the remuneration of DSOs. The replacement of such a large number of equipments should, if the cost is allocated to the DSOs, be recognized in the asset base. Another possibility is to charge them to consumers, although, being this the case, complaints may arise. Additionally, some technological problems might appear mainly caused by the little experience with such huge communications and information management needs. There is a clear need for standardization of equipments and communication protocols. Finally, demand response will only become a useful tool if the final consumers, who until now have behaved merely as a passive element of the network, are involved and convinced about its advantages.

4. Final conclusions and recommendations

4.1 Conclusions

The previous sections have shown that EU-15 MS have started to implement new regulation to improve DER integration, albeit further steps ought to be taken. Considerable shares of DER have taken place in countries with an unprepared regulation, most probably at the expense of efficiency. A significant case is that of Spain, which in spite of having one of the largest shares of DER in Europe, distribution regulation has not evolved much yet. Moreover, Germany is the only country with a cost of service regulation. As a consequence, German regulation concerning losses, quality of service, DER-related incremental costs or innovation is far from complying with the guidelines proposed in this report. However, a new regulation is bound to be passed in 2008 which will implement incentive based remuneration for Germany DSOs since 2009. It is expected that most of these issues will be addressed too.

DER shares in new MS, rarely over 10%, are generally low when compared to the EU-15 countries. Thus, it would be reasonable that regulation has not evolved yet to allow large-scale integration of DER. In spite of this fact, most of these countries have already implemented incentive regulation and consider losses and quality of service. This constitutes an adequate starting point for a forthcoming scenario with large penetration of DER, although an efficient integration will still require several improvements.

Nonetheless, DER shares cannot only be judged on the basis of network regulation; penetration is also dependent on how “generous” the support scheme is, and how it overcomes the impediments or disadvantageous components of DSO/TSO regulation. Also, in EU-15 MS the DER support schemes usually had started earlier than in new MS, so there was more time for the evolution of DER shares.

Additionally, it has been shown that as a consequence of a regulation that disregards DER, DSOs tend to consider them as an added difficulty to their activity. Therefore, they will be biased against DER and may create barriers for them. This problem can be worsened as penetration levels increase. Therefore, as the contribution of DER to electricity supply grows, the implementation of herein suggested regulatory changes becomes more and more important.

Table 13 summarizes the situation of the regulation of the distribution activity in all the SOLID-DER countries. Some additional EU-15 member states have been included for illustrative purposes. Especially relevant is the case of the UK since this country is probably the most advanced MS regarding distribution regulation. It is also useful to compare the regulatory framework for distribution in each country with its corresponding share of DER (see Figure 2). It must be said that the shares of DER were computed considering as such only facilities connected to distribution networks with a capacity of 50MW or less. Therefore, every large hydro plant and a considerable percentage of CHP and wind capacity is left out from this definition and not included for the calculations of DER shares in the SOLID-DER MS.

	Country	DER remuneration			Connection charges			DER payUoS charges		Type of DSO remuneration	Incentive based			Incentives to reduce losses			
		FIT and premiums	Tradable Green Certificates and Quota Obligations	Tenders	Deep	Shallowish	Shallow	Yes	No	Cost of service	DER-related incremental costs not considered	DER-related incremental CAPEX considered	DER-related incremental CAPEX & OPEX considered	No	Upper limit	Losses bought at the market (controllable cost)	Incentives to reduce losses below targets
New MS	Bulgaria	✓					✓		✓			✓					✓
	Czech Republic	✓			✓				✓				✓				✓
	Hungary	✓			✓				✓				✓				✓
	Lithuania	✓			✓				✓			✓			✓		
	Poland		✓				✓		✓		✓						✓
	Romania		✓		✓			✓			✓						✓
	Slovakia	✓			✓			✓			✓						✓
	Slovenia	✓					✓		✓		✓				✓		
EU-15 MS	Austria	✓					✓	✓			✓			✓			
	Denmark	✓		✓ (Off-shore wind)			✓	✓					✓				✓
	Germany	✓					✓		✓	✓				✓			
	Netherlands	✓		✓ (Off-shore wind)	✓ (>10MW)		✓ (<10MW)		✓		✓ (>10MW)	✓ (<10MW)				✓	
	Spain	✓		✓ (Off-shore wind)	✓				✓		✓						✓
	France	✓					✓		✓	✓						✓	
	Italy		✓				✓	✓				✓				✓	
	UK		✓			✓		✓					✓				✓

	Country	Incentives to improve quality of service			Incentives for innovation			Type of DSO unbundling				DSO owned DER			Share of connections by small DSOs	Demand response mechanisms		
		No	Regulated targets	Non-regulated targets	No	Implicit incentives	Explicit incentives	Legal	Functional	Ownership	Public DSO	No	Yes	Only small DSOs		Time-of-Use tariffs	Interruptable consumers	Smart meters
New MS	Bulgaria		✓			✓		✓				✓			0.1%	✓		
	Czech Republic	✓				✓		✓				✓			0%			
	Hungary		✓			✓		✓				✓			0%	✓	✓	
	Lithuania		✓			✓		✓						✓	13%	✓	✓	
	Poland	✓					✓	✓						✓	1%	✓		
	Romania		✓			✓						✓			0%	✓		
	Slovakia			✓	✓			✓				✓			0.5%	✓		
	Slovenia		✓		✓						✓	✓			0%	✓		
EU-15 MS	Austria	✓			✓			✓						✓	12%			
	Denmark		✓			✓		✓						✓	43%			
	Germany	✓			✓			✓					✓		n.a.			
	Netherlands		✓			✓		✓		✓ (1 small DSO)		✓			3%	✓	✓	✓
	Spain		✓		✓				✓					✓	3%	✓	✓	✓
	France	✓			✓				✓				✓		5%	n.a	n.a	n.a
	Italy		✓			✓		✓					✓		n.a.	n.a	n.a	n.a
	UK		✓				✓	✓				✓			1%	✓	✓	✓

Table 13: Country overview

4.2 Recommendations

The recommendations provided in this report are particularly relevant for those countries that have already reasonably high DER share in electricity supply and can be subdivided into two groups:

1. **Economic signals for DER to promote its active integration in distribution networks**

DER should be provided with economic signals that promote efficient operation and location. These could be done via **network charges**, i.e. connection and UoS charges, and incentives for the provision of AS. The implementation of DER network charges that comply with the following recommendations constitutes a regulatory change that could be carried out in the short term. On the other hand, the provision of AS by DER might require further research and analysis in certain cases. The observability and controllability of DER by DSOs is a key issue in this regard.

It is clear that DER should pay network charges to provide them with economic signals that promote efficient operation (differentiation per voltage level, peak and off-peak production…) and efficient location (network reinforcements needed). To assess the adequacy of these charges, it is necessary to take into account what kind of support mechanism is in force in each country. For instance, it has been recommended to implement use-of-system charges for DER in order to promote efficiency. However, where feed-in-tariffs or premiums are used to remunerate DER, these can be used as a complement or a substitute to obtain the same results. Moreover, it is needed to charge or remunerate differently according to the voltage level of the period of time. For instance, those DER connected at low voltage level are better positioned to reduce energy losses and improve quality of service; especially where a more active management of the network is used.

In summary, DER should pay **cost-reflective UoS charges**, especially in those countries where flat FIT or quota obligations and tradable green certificates are applied. For example, in Poland, where the share of DER is around 5% and mostly CHP, the main support mechanism is a tradable certificates system and purchase obligation on every agent selling energy to end consumers, in spite of which DER do not have to pay UoS charges. On the contrary, other countries that also apply tradable certificates such as Romania, Italy or the UK have already implemented DER UoS charges. Among the countries with flat FIT and no UoS charges for DER can be mentioned Slovenia (alternative to sell at the market), Bulgaria, Lithuania or Spain (except CHP and alternative to sell at the market). These countries should implement either UoS charges or more differentiated FIT.

It is important to bear in mind, however, that in most countries where DER do not pay UoS charges, only consumers pay them. Implementing UoS charges for DER is not advisable unless conventional generators pay them too. Otherwise, instead of attaining the desired effects, they would constitute a discriminatory measure against DER.

Connection charges should be averaged, regulated, and shallow or at least shallowish, especially for small DER. The rest of the reinforcement costs can be partly socialized and recovered via consumer UoS tariffs, and the other part via the above recommended DER UoS tariff so as to provide a **locational signal**. This way a high upfront connection investment cost can be avoided. Negotiation between DSOs and DER promoters ought to be avoided by all means so as no discrimination can be made. Discrimination can be caused either by the lack of complete unbundling between DSOs and DER (any remaining ownership link between a DSO and a DER company may cause discrimination to other DER independent of the DSO and its owner) or by the fact that most DSOs regard DER as a source of problems rather than as an active element that can contribute to the operation of the network. Some conflicts have been reported in the following countries: Romania (charges are sometimes said to be too high), Slovenia (lack of transparency), Bulgaria (DSOs have sometimes discriminated certain DER or DER promoters have blackmailed the corresponding DSO), Spain (DSOs may favour the DER belonging to the same group over others), Netherlands (wind farms have had to negotiate hard), and Hungary (distant connection location requirements, excessive prices and discrimination in favour of own DER).

DER can positively contribute to network operation and system security by providing reserves, voltage support, losses compensation, black start, etc. However, DER participation in AS is almost negligible in most countries, even in those where they are legally entitled to do so. This allows concluding that DER are not given the right incentives to provide AS. In order to change this situation, the contribution of DER, especially controllable generation, should be recognized and compensated by commercial arrangements between TSO/DSO and DER. These agreements could be done through bilateral contracts, network related markets, acknowledgement in UoS charges or payments from TSO/DSO.

2. **DSO and network regulation to enhance the share of DER**

First of all, it is strongly recommended to **implement incentive based regulation** for DSOs. Otherwise, the remaining regulatory recommendations could not be easily applied. It has been shown that most countries have already implemented this type of regulation, with only a few exceptions as Germany, which will change the regulation in 2009, or France. All new MS remunerate their DSOs under a price or revenue cap formula.

DER connection and operation may cause incremental costs for DSOs, especially as penetration levels increase, which in case of not being recognized leads to DSOs considering DER as a burden (costs) to their activity. Therefore, some specific regulatory measures to compensate for these extra costs should be designed, taking into account the regulatory framework in each country. The recovery of CAPEX is especially important where shallow connection charges are paid. Nevertheless, there are several countries that do not fulfil this guideline such as Poland, Slovenia or Austria. On the other hand, DER-related incremental OPEX, mainly related with incremental energy losses, are not generally compensated. In those countries where these costs are remunerated, the most common approach is to report those costs to the regulator and include them for the calculation of network tariffs. In the UK some explicit incentives to efficiently integrate DER have been implemented. First, a revenue increment per kW of DER connected has been included in the DSOs remuneration. Furthermore, if a DER connection is qualified as RPZ (Registered Power Zone), this revenue is considerably incremented during five years. RPZ promote innovative and in a longer run potentially more cost-effective ways to connect DER into the network, recognises a higher rate of return (cost of capital) in the UoS network tariff to reflect increased business risk, and let DSOs to keep the incentive for a period of time. It is recommended to add a revenue driver to the remuneration of DSOs associated with DER production (in kWh) in areas with high penetration/concentration levels, in order to compensate for incremental losses. This money could come from the UoS tariffs paid by these generators. Even though some of these mechanisms can be already implemented at the present time, as shown in the UK; their adequacy should be assessed and improved over time.

Additionally, DSOs should also receive economic signals in order to reduce energy losses and improve quality of service. In both cases some reference values ought to be set and from that point DSOs should receive an incentive in exchange for any improvement and a penalty for not complying with the reference values fixed. It has been explained that the amount of these economic signals must be sufficient to compensate for any incremental expenditures that must be undertaken to achieve the desired level. If the incentive is too high, energy loss reduction or quality of service will reach levels over what is economically reasonable. On the other hand, if it is too low, no improvement will be achieved regardless of the reference value chosen. Quality of service and energy losses improvement incentives should be implemented in the short term in those countries where this kind of regulation does not exist.

However, there are still quite a few MS where DSOs remuneration is independent of these elements. For instance, in Austria and Germany DSOs perceive no incentives to reduce losses, whereas in Lithuania and Slovenia DSOs are only penalized if exceeding certain level of losses but are not incentivized towards further reductions. The recommendation for these countries is to implement some measures that fulfil what is described above. It has been told that DER can have a considerable impact on energy losses, especially where high penetration levels exist. Therefore, the effect of DER on losses cannot be neglected when computing the reference values. For example, in the UK there was a proposal to take into account the impact of DER on distribution losses. This mechanism modifies the level of DSO reported losses depending on a site-specific Loss Adjustment Factor (LAF) and the export volume of the generator. Moreover, UoS charges for DER could also be set for any increment or reduction of losses, i.e. positive charges or negative charges respectively.

Quality of service is not addressed in the remuneration of DSOs in Czech Republic, Poland, Austria, Germany and France. It is very important, especially under incentive based regulation, to implement explicit incentives for DSOs related with quality of service levels. On the other hand, DER controllability should increase so that they can help improve quality of service indexes, for instance working in islanding mode, or providing ancillary services such as voltage control, frequency reserve, or black start.

Note that frequency control and system restoration are TSO tasks, not DSOs'. However, DER, especially intermittent generation, are mainly seen as a source of quality of service problems rather than as an element that can improve it, even in countries like Bulgaria where the share of DER does not even reach a 5%. Nonetheless, further RTD would allow overcoming these particular barriers. As a consequence, future regulation should seek for:

a. Promotion of network transformation to a more active management, increasing DER observability and controllability
b. Incentives for DER to participate in the provision of ancillary services

To accomplish the aforementioned **network transformation**, innovation is needed from the DSOs and TSOs side. It can be argued that incentive regulation by itself promotes innovation since DSOs can benefit for any improvement in efficiency they achieve during the whole regulatory period. However, regulatory periods do not generally last for longer than five years and R&D expenditures do not always provide efficiency gains in the short term. What is more, DSOs rather have the incentive to reduce costs as much as possible including innovation costs, especially under benchmarking. Hence, specific regulatory mechanisms to promote innovation are required in the short term. In spite of this fact, only a few countries have arranged innovation specific measures. In Poland, the costs from projects and services that reduce energy and fuel consumption by consumers and provide an economically justified alternative to avoiding the development of new sources of energy and of the network can be included in the tariffs.

In Hungary, DSOs (just as any other company) are allowed to spend 0.3% of their annual revenues on **innovation projects** instead of paying this amount to the state budget as innovation tax. This is similar to the IFI in the UK, where DSOs can spend up to 0.5% of their Combined Distribution Network Revenue on eligible projects. An additional incentive for innovation in the UK is the RPZ mechanism explained above. However, a long-term and deeper transformation on distribution networks will probably be required, partly due to the large penetration of DER into the system. It is advisable that regulators, in cooperation with DSOs, formulate and test new regulatory instruments and develop new regulatory scenarios with a shared vision.

Regarding the **unbundling of DSOs** from other non-regulated activities, it is recommended to adopt as soon as possible measures intended for a higher level of compliance with that stipulated by Article 15 of EU Directive 2003/54/EC. Legal and some form of functional unbundling ought to be effectively implemented, not only in law. The transparency and monitoring of this process is essential. For the time being, it is not possible to asses whether ownership unbundling or the creation of Independent System Operators (ISO) is needed, in spite of this, however, the Netherlands and Denmark are moving towards ownership unbundling. A particular case is that of Slovenia where the only existent DSO is public. DSOs, unless they serve less than 100000 connections, are not generally entitled to own DER. Some conflicts, mainly related to the discrimination of some DER to favour DSOs' own generators, have arisen. Nonetheless, in order to assess the importance of these conflicts, future country specific surveys might be needed.

The existence of small vertically integrated DSOs is permitted by the exemption clause in article 15 of EU Directive 2003/54/EC. In most cases, their influence is negligible as less than 5% of customers are served by them. The only countries where the share of connections exceeds this value are Lithuania (13%), Austria (12%) and Denmark (43%). Even though some problems regarding small DSOs have been reported, none of them has taken place in the latter countries. Consequently, it is recommended to allow each MS to decide whether to keep the exemption clause for small DSOs. Some measures in order to avoid discriminatory network access where vertically integrated small DSOs exist are required and might be country specific.

Finally, this report analyzed the different **demand response mechanisms** and the participation of DSOs. It can be concluded that demand response is still scarce across the EU and the situation does not seem likely to evolve in the short run, with the only exceptions of some MS like Netherlands or Spain. The most common instrument used to displace demand from peak hours are time-of-use, either UoS or full service, tariffs; although generally only a two-period differentiation is available. Interruptible consumers, either through contracts (Spain) or participation in tertiary reserves market (Hungary, Netherlands), also exist in some countries, although system operators may exercise these contracts only in case of emergency and exclusively to large consumers. Last but not least, some countries are starting to install smart meters, which once deployed at large scale will provide a wider range of demand response options. Smart meters will become an essential component of the electricity grids of the future known as Smartgrids, which are characterized by an active network management enhanced by the development of a communication network in parallel with the electricity network and large penetration of DER.

Smart meters offer numerous benefits for every agent involved in the electricity sector deriving from the increased observability and controllability of demand, from consumers to the regulator including retailers and DSOs. However, the deployment of smart meters still requires solving quite a number of problems of very different nature. Some regulatory issues may arise regarding the relationship of retailers and DSOs or the remuneration of DSOs. The replacement of such a large number of equipments should, if the cost is allocated to the DSOs, be recognized in the asset base. Another possibility is to charge them to consumers, although, being this the case, complaints may arise. Additionally, some technological problems might appear mainly caused by the little experience with such huge communication and information management needs. There is a clear need for standardization of equipments and communication protocols. In addition, demand response will only become a useful tool if the final consumers, who until now have behaved merely as a passive element of the network, are involved and convinced about its advantages. The process should be made progressively, starting with a limited number of equipments and functionalities and little by little progressing towards a large scale penetration of distributed intelligence that allow for an active network management and a close to real time monitoring and operation of the distribution network, including demand and DER.

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