Preliminary definition: A Smart Grid is an electricity network that can intelligently integrate the behaviour and actions of all users connected to it - generators, consumers and those that do both - in order to efficiently ensure sustainable, economic and secure electricity supply.

**ABSTRACT**

This paper is a summary of information on the existing level of the Smart Grids environment, the nature of the distribution grid and networks development businesses in many European countries, based on a survey among EURELECTRIC members. It includes details on drivers for Smart Grids, networks development, investments, new services expected for Distribution System Operators (DSOs), active grid management, smart metering and regulation.

**INTRODUCTION**

Smart Grids is a new concept for electricity networks across Europe. The electricity industry is looking forward to the rising challenges and to the opportunities expected to bring benefits to all stakeholders and society as a whole. The initial objectives of “Smart Energy Networks” are to increase the efficiency, safety and reliability of the European electricity and gas system and networks, e.g. by transforming the current electricity grids into an interactive (customers/operators) service network, and to remove the technical obstacles to the large-scale deployment and effective integration of distributed and renewable energy sources as required by the recently adopted Renewables Directive.

**THE ROLE OF FUTURE ELECTRICITY NETWORKS**

Efficient electricity transmission and distribution systems are a fundamental requirement for providing European citizens and companies with an essential energy source and meeting the demands of the 21st century. The need to strengthen Europe’s electricity networks, meet growing electricity demand, support rational use of energy, develop a trans-European electricity market and integrate more distributed sustainable generation resources, including renewable sources, presents major challenges. The role that future electricity network design and investment will play in achieving wider EU energy policy objectives is decisive. To that end, the networks technologies will be the key enabler for the wider and deeper penetration of distributed low-carbon generation.

EURELECTRIC encourages the European Commission and Member States to give attention to electricity networks and their future role in this respect.

**EURELECTRIC SURVEY AND ANALYSIS**

Reflecting this situation, EURELECTRIC decided to collect information on the current level and future development of Smart Grids-specific activities in electricity DSOs in Europe. Comments, analysis, observations, conclusions and - as far as possible – an interpretation based on this data should create value for EURELECTRIC members as this can be used as one source for developing strategies on how to cope with this new situation.

EURELECTRIC believes that monitoring the current status of implementation of the Smart Grids concept, specific technologies and activities by DSOs in different Member States could be of interest for further investigations and future projects.

In a survey conducted within the EURELECTRIC structure, members of the Working Group on Distribution Smart Grids were asked to provide information on the “Present Status and Prospects of Smart Grids Implementation in Distribution Companies” and to define the main aspects of their experience with this issue. As different countries are at different stages of liberalisation and have different regulatory structures and objectives, it is rather difficult to make direct comparisons between different Smart Grids practices. However, a number of common topics emerge from the comments received.

**Purposes of the EURELECTRIC survey**

The main purposes of the EURELECTRIC survey on the “Present Status and Prospects of Smart Grids Implementation in Distribution Companies” are:

- To improve understanding of the current operating framework of electricity distribution networks
- To describe the smart network characteristics in each member country.
- To provide information on the scope, characteristics and present degree of innovation in the electricity distribution networks and business.
- To provide a high-level understanding of the outputs which the implementation of the Smart Grids concept and businesses are expected to deliver.
In order to achieve this aim, data on the Smart Grids concept and practical implementation in distribution companies have been collected and summarized. This data collection gives a first idea of what Smart Grids really means in many European countries. In order to create more value for EURELECTRIC members, comments on the data and analysis of surveys have been added. Further, observations regarding the data are included. Finally conclusions are drawn and some views and guidance on interpreting the data are given.

**Type of responding DSOs**

The survey is based on data provided by 27 DSOs from 14 European countries. This may be perceived as a rather small number of DSOs compared with the total number of existing DSOs in Europe. However, the large majority (89%) of the respondents of the questionnaire represent large European DSOs.

More than 30% of the respondents are urban DSOs and more than two thirds are mixed urban-rural. In terms of voltage level, 74% of responding DSOs are operating networks with voltage above and 78% below 20 kV.

<table>
<thead>
<tr>
<th>Type of DSO</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large DSO (&gt;100,000 customers)</td>
<td>89</td>
</tr>
<tr>
<td>Rural DSO</td>
<td>15</td>
</tr>
<tr>
<td>Urban DSO</td>
<td>31</td>
</tr>
<tr>
<td>Mixed urban-rural DSO</td>
<td>70</td>
</tr>
<tr>
<td>Voltage level: &lt;=20 kV</td>
<td>78</td>
</tr>
<tr>
<td>Voltage level: &gt;20 kV</td>
<td>74</td>
</tr>
</tbody>
</table>

Table 1. Type of responding DSOs.

**Drivers for Smart Grids**

The EURELECTRIC survey shows that the application of the Smart Grids concept can improve customer service. This result gives rise to the question whether the respondents think that the whole Smart Grids concept needs to be applied or only a component of it, “smart metering”. It seems that Smart Grids is not felt to be a necessity for the integration of distributed generation, renewable energy sources and plug-in (hybrid) cars into the electricity grid. Utilizing Demand Side Management (DSM) for improvements in overall system efficiency (such as avoiding investments in peak generation) and customer tariff systems with incentives is a driver. But respondents do not see ageing assets as a big driver and a need for investments in end-of-life electricity grid renewal. However, progress in technology is a big driver and at the same time may be regarded as an opportunity (Fig. 1). In addition, increasing flexibility in network operation (DSM, etc.) as well as optimisation between economic issues including profitability & network operation are significant drivers.

**New Services expected for DSOs**

In principle, DSOs support DSM in facilitating customer awareness at the efficient use of electricity. However, the exact role DSOs have to play in this respect is not clear to all respondents and needs further discussion.

EURELECTRIC analysis shows that the DSO has a role in facilitating the real time balancing of the network. However, not all survey responses support this view.

Telecommunication and IT services are business activities outside the traditional (regulated) business of electricity networks. Most of the survey participants do not expect DSOs to enter these markets in the future (Fig. 2).

It is not clear whether DSOs will offer automated load management to residential customers. This may depend on the tariffs used.

Introduction of Smart Grid concept with active management, Virtual Power Plants (VPPs), Smart Metering & related services, etc. will change the existing business model, but how this change is going to take place in practice is not clear for the moment.

Data flows managed by the DSOs will increase as a result of more interaction between the DSO and other stakeholders, but the costs should be carefully justified.
Network Development

Major changes in MV network architecture are not expected by all DSOs, but more prominent changes seem to be expected in LV network architecture.

Bidirectional flows of electricity at distribution level are expected to still be an exception. The power will flow mainly in the usual top-down direction (from T to D). The power flow from distribution level to the overlying level will only occur on specific spots and for limited durations (ex. rural networks with on-shore wind farms).

Future distribution network operation is still an issue and the distribution network will not be operated like a transmission network.

Distributed Generation developments will influence future networks investments and the expected installed capacity for DG will be a criterion in network dimensioning (Fig. 3).

**Figure 3. Network development and DG influence.**

The expected mass introduction of electric plug-in (hybrid) vehicles gives rise to the question what challenges DSOs expect in facilitating the network integration.

Integrating the charging of electric vehicles (EVs) in electricity networks does not require any new technology to be developed. The existing European electricity infrastructure can be used in most of the countries for charging vehicles. If cars are charged at night even a standard household socket would be sufficient. The grid is robust enough to allow a significant number of electric plug-in (hybrid) vehicles to charge simultaneously without any severe impact on the network in off-peak time.

The EURELECTRIC survey shows that electricity distribution network development for plug-in vehicles is not an immediate issue to be addressed. However, more discussion is needed.

Advanced storage devices (batteries, compressed air systems, etc.) are used in some cases in DSOs operation, however, no breakthrough of advanced storage devices in DSOs operation is to be expected.

Advanced technologies enabling the island operation of parts of the electricity distribution network are occasionally implemented, but island operation of parts of the distribution network is not yet expected by all DSOs.

Half of the responding DSOs expect electricity demand to increase more than in the previous years despite the increased energy efficiency due to substitution of other sources of energy.

The existing centralised generation mix will still remain the key factor for energy balance. It must be flexible enough and work in parallel with the decentralized power in order to cover the electricity demand.

Active Management of the Grid

Most DSOs see active management of the grids an alternative to network reinforcement.

The actual degree of networks automation will increase in order to ensure better quality of service to customers.

The impact of Virtual Power Plants on the power flow is not clear, and nor is the role of DSOs in their "operation". DSOs have a key role in system security and a role in enabling DG to contribute to the system security. The question is how this should take place in practice.

Network Investment

The results of EURELECTRIC analysis show that the present replacement rate of assets in DSOs is maintained except smart metering.

There is no need for all DSOs to install higher distribution capacity wires and cables for renewables.

At distribution level, the investment issue can be solved at national level; detailed harmonisation between different countries is not strictly necessary. The distribution network (that part of the network with end users connected) should be financed by customer charges incorporated in the distribution tariff for maintenance and refurbishment of the network, but also in part by connection charges related to the development of the existing network. New investment in distribution networks is also needed to comply with demand growth, and the growing share of distributed generation also has a large impact on the expansion of distribution networks [1].

Today in many countries there are no explicit incentives for expansion and modernisation of the distribution networks through the tariff system. On the contrary, the distribution activity is often regulated through a price cap mechanism, with no incentives to encourage quality of service, although there is a system of penalties linked to quality of service.

The main challenge remains to look into the future of the electricity business. The widely discussed concept of “Smart Grids” is pointing to new concepts of designing and managing distribution grids in a more decentralised way in the coming decades (Fig. 4). In this respect, the European Technology Platform on Smart Grids has defined a set of strategic research priorities for such future networks. Investments are needed to develop these future networks.
But in order for any major "paradigm shift" to take place, a new business logic for more decentralised grids is needed, and, more importantly, this must be simultaneously provided for distribution regulation. Undoubtedly, this shift would alter the role of the current distribution system operators.

**Smart Metering**
The EURELECTRIC study shows that DSOs will install smart metering devices for residential customers and most DSOs plan to invest in customer awareness initiatives or energy consumption.

DSOs may themselves benefit from smart metering systems. The potential benefits come from remote operation, for instance through lower meter reading costs, remote disconnection and connection etc. Other potential benefits result from improved knowledge of physical displacement of energy flows and increased load management capability and so on. In other words, improved data flows and communication may allow DSOs to improve how they run their systems, identify outages quicker and reduce some losses [2].

**The Change**
New competences are needed to fill the technological gap between today and tomorrow. More customers are becoming producers and are getting greater influence in the electricity market. Although not all DSOs realise this, EURELECTRIC believes that this is subject to further developments. Therefore the trend can be generally acknowledged.

**Regulation – key success factor**
Legislators and regulators need to take into account the new tasks of DSOs in contributing to the environmental goals of the European Union (“20-20-20 goals”). They should incentivise DSOs to invest in the most efficient way for the benefit of market participants and the society as a whole. Support for technical research and development could be considered as well. However, the risks associated with new technology are covered only to a limited extent by the existing regulatory framework and more work should be done in order to cover this technological risk (Fig. 5).

Incentives given by Regulators to DSOs for their involvement in R&D work and for the development and deployment of new technologies supporting Smart Grids should be improved.

**EXPECTATIONS AND NEXT STEPS**
In compiling this document, the expectation is that electricity distribution business representatives can use it as a point of reference in carrying out comparisons between companies in a better-informed way. This may also prove beneficial in discussing with regulators, and may itself aid the sharing of best practice and improving efficiency.

The authors recognise that this survey and resulting paper are not, in any way, a benchmarking study. Rather, they provide the context for understanding the similarities and differences between companies and the level of implementation of the Smart Grids concept in Europe. It is likely that reviewing the data will encourage questions, and lead to further collaborative work to promote better understanding.

**Acknowledgments**
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**REFERENCES**