Business Models for Electricity Distribution in Europe: Evidence from the JRC DSO Observatory 2018

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ABSTRACT

This paper presents information on how European DSOs operate their business, including management of smart grid features. This work builds on the data collected and presented in the Distribution System Operators (DSO) Observatory report, held by our team in the Joint Research Centre (JRC). We first give a summary of the DSO report, presenting aggregated information on the technical data characterizing the DSOs as well as on the smart grid dimension. Further on, we present information on how the DSOs are distributed in Europe according to the clients they serve and their annual distributed energy. Patterns formed with respect to the DSOs at European member states are given. In addition, we give feedback on how the DSOs contribute to the smart grid realization, for instance by applying Demand Side Flexibility (DSF) programs and in the coordinated operation of transmission and distribution networks.

INTRODUCTION

After the liberalization of European energy markets, when analyzing electricity grids researchers have focused mainly on transmission issues. Recently however, thanks to the surging role of Renewable Energy Sources, which need to be efficiently integrated and managed within the electricity system, Distribution System Operators are becoming more and more crucial. in steering the transformation of the European electricity system into a de-centralised, multi-centered structure. Understanding the challenges that electricity distribution is facing to transform itself and harness the RES technological change is critical in shaping policies that effectively pursue the objectives of de-carbonisation of the power system and empowerment of end-customers. For this reason, the JRC has embarked since several years in analyzing European DSOs, publishing two issues of its DSO Observatory report and several other publications on specific aspects of DSOs operations[1].

The aim of the work here presented is twofold: first, depicting the current status of European distribution grid operators and their business models, thus providing a valuable tool to the research community for examining the power distribution system from a technical and economical point of view and further on, providing information about the differences on the DSOs European business models, setting the scene for an economic benchmark of DSOs just ahead of the approval of the Clean Energy Package, which provides for a significant evolution of the role of DSOs in Europe, including e.g. the creation of a European DSO representative entity. For the sake of completeness, we analyse the smartening of electricity grids and the extent at which fundamental issues, like smart metering, data handling, flexibility programs have been applied. Such information is pointed out in the Clean Energy Package [1], a set of ambitious legislative proposal to enhance the functioning of European energy market and progress towards their supra-national integration. The problem we wish to address lies behind the fact that the characteristics of the distribution grid are usually confidential information, therefore, it is hard to obtain valuable and reliable knowledge on how European DSOs operate. When the Clean Energy Package will be implemented. This work is based on the most recent Distribution System Operators Observatory report [2] issued by JRC, which presents the aggregated analysis of data collected from the most important European DSOs, after their participation in an open survey. Building upon the information from [2] we present information about the business models of the European DSOs and we give a hint of how they are organized and operated across EU countries.

In this paper, we first present the main conclusions of the DSO Observatory 2018. The data collected represent 99 out of the 191 larger DSOs (>100,000 customers, thus subjected to EU unbundling provisions). As a further step, we give information of how European DSOs with different business models are distributed and how these DSOs are moving toward a smarter grid system. The rest of the paper is structured as follows: Section II summarizes some of the main findings of the DSO Observatory report. Section III gives insight on how the different business models work in several European countries. Section IV concludes the paper, pointing at how these different business models might evolve with the application of the Clean Energy Package and what could be the implications to be further investigated after this legislation enters into force.

[1] All JRC publications on the topic are available for free at ses.jrc.europa.eu

II. EUROPEAN DSOS – TECHNICAL DATA AND SMART GRID DIMENSION

In recent years the energy sector has experienced a deep transformative change, where new challenges emerged such as: rising of distributed energy resources, smart meters deployment, integration of electric vehicles recharging infrastructure, demand side management and DSO-TSO coordination. To this aim, the main outcomes, of the DSO Observatory report, in terms of, technical data and insights about the smart grid dimension, are presented.

A. TECHNICAL DATA FROM DSO OBSERVATORY

Fig. 1 shows the energy coverage per country, which account for 84.6% of the total number of customers of those DSOs who replied to the survey. The largest DSOs, included in the JRC DSO Observatory, serving energy are ENEDIS in France and ENEL in Italy.

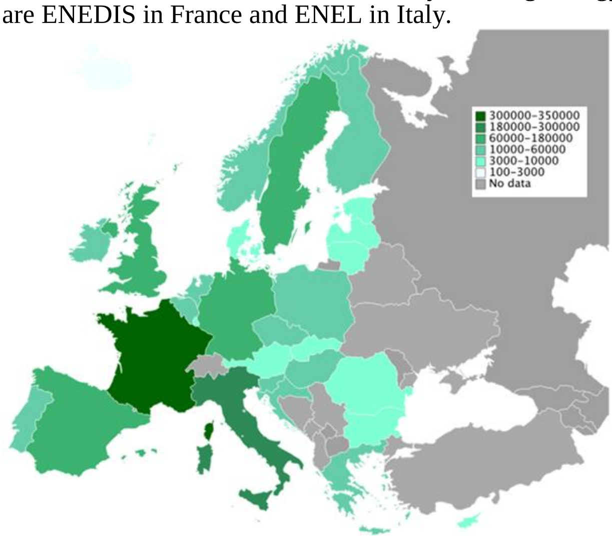


Fig. 1: Energy served in GWh by DSOs included in the JRC DSO Observatory per country, [2].

Within the technical section 37 different indicators, divided into 3 main sections, were built. The network structure and reliability indicators point to significant differences among the European DSOs, and are reported in Table **1**.

Table 1: Sample of technical DSOs' indicators, [2]

Parameter	Mean	Max
LV consumers per MV consumer [no.]	671	2500
LV circuit length per LV consumer [km/LV]	0.03	0.21
LV underground ratio [%]	66	100
LV consumers per MV/LV substation [no.]	86	275
MV/LV capacity per LV consumer [kVA/LV]	4.7	14.5
MV underground radio [%]	61	100

Regarding the transformation capacity of MV/LV substations in urban areas 3 main typical values are observed, which see 630kVA the most adopted (60%), plus 400kVA and 1000kVA. Concerning the rural areas wider option have been implemented: 50, 100, 250, 400 and 630 with the 400 kVA accounting for 40% of the cases. The installed distributed generation power in percentage (left axis) and in absolute value (right axis) connected at the LV level is plotted in Fig. **2**. It reveals that Photovoltaic is the predominant technology installed at LV level (84%).

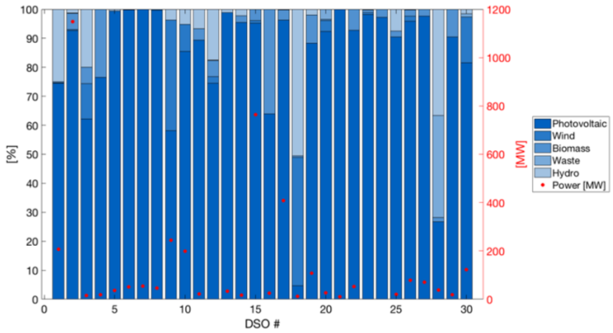


Fig. 2: Distributed generation power at LV level of European DSO, [2].

B. SMART GRID DIMENSION

The JRC DSO observatory addresses issues regarding the smart grid dimension: if smart grid applications are implemented by the DSOs and how. Here, we present some conclusions with respect to: the usage of non-frequency ancillary services (i.e. demand side flexibility programs); the DSO-TSO data management; the meter data management.

The survey showed that almost 57% of DSOs affirms that no Demand Response (DR), Demand Side Management or Flexibility programmes (DSM or DSF) are currently put in place. Out of the DSOs that have replied positively (32%), it is noticeable that 15% use DR, DSF or DSM to alleviate constrained networks, 14% uses ripple control and 3% for mass remote control purpose, [2]. Fig. **3** shows this situation.

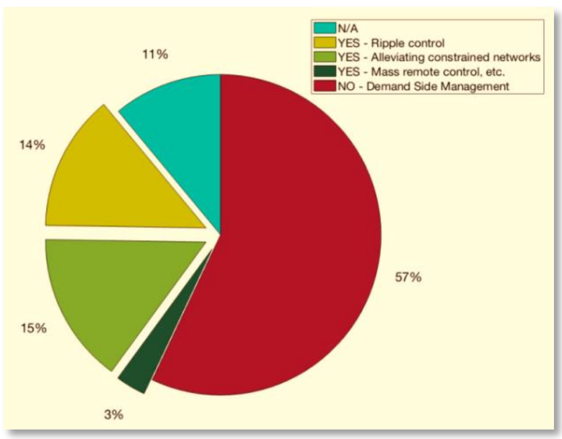


Fig. 3: Participation in Demand Side Flexibility programs, [2].

With respect to the DSO/TSO data exchange, a very diverse picture has emerged. There are cases in which no communication is exchanged at all between them and on the opposite, cases in which active and reactive power measurements are shared in real-time for relevant agreed nodal areas.

Furthermore, the smart metering roll-out situation has been depicted. The analysis has been divided into countries with positive, negative and non-available Cost-Benefit-Analysis (CBA). It is shown that some countries have already completed the smart meter roll-out, whereas some others are far behind from this goal. Table 2 gives respectively the positive and negative CBA picture regarding smart metering roll-out at member states level.

Table 2: Member States smart metering roll-out CBA overview, [2].

Country	Wide-scale roll-out (2014)	DSO Observatory Result (2018)
Austria	Yes	3% - 100%
Denmark	Yes	NA
Estonia	Yes	100%
Finland	Yes	100%
France	Yes	37%
Greece	Yes	37%
Ireland	Yes	0%
Luxembourg	Yes	41.6%
Netherlands	Yes	85.2%
Poland	Yes – Official Decision pending	1% - 11.5%
Romania	Yes – Official Decision pending	12% - 14%
Sweden	Yes	90% - 100%
United Kingdom	Yes	NA
Belgium	No	NA
Czech Republic	No	Pilot projects
Germany	Selective	2% - 15%
Latvia	Selective	45%
Lithuania	No	NA
Slovakia	Selective	18%
Portugal	No	NA

For more details on the results gathered from the DSO observatory, please refer to [2].

III. BUSINESS MODELS FOR DSOS

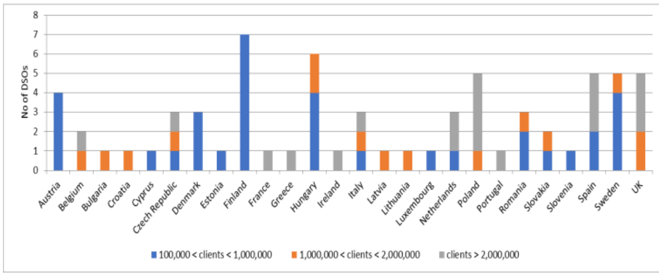
A. DSOs DISTRIBUTION

For most countries, the data gathered represent a good percentage of customers covered, namely over 70%. Indeed, only for Austria, Bulgaria, Denmark and Germany we have customer coverage lower than 70%, namely 27.9%, 34.3%, 41.2% and 49.7%. However, Germany follows a special pattern with respect to the DSOs, as will be explained in this section. To analyse the situation in the EU member countries regarding the DSOs, we first divided them in categories depending on how many customers they serve and secondly on the energy supplied. Three categories have been formed, DSOs serving: between 100,000 and 1 million clients (small DSOs); between 1 million and 2 million clients (medium DSOs); above 2 million clients (big DSOs). The choice of the categories reflects current proposals for the organisation of the future DSO representative entity at European level. Fig. **4** illustrates the situation for each country and the categorization of their DSOs. In Fig. **4**.a it is shown the number of DSOs according to the categorization based on the clients they serve, whereas Fig. **4**.b shows the percentage of customers these DSOs represent. It should be mentioned that for visibility reasons, Germany is not shown in Fig. **4**.a. The numbers for Germany are: 22 small, 5 medium and 4 big DSOs (31 in total)

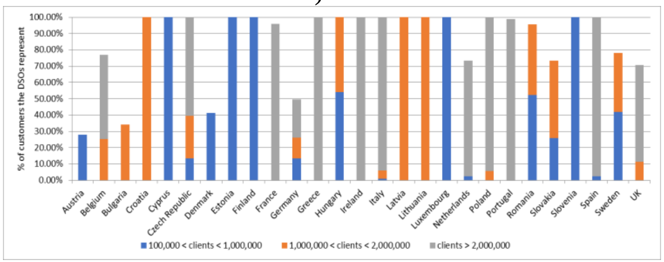
As it can be observed from Fig. **4** plus Germany (not included in the chart), there are several different patterns with respect to the DSOs at European Member States level, which are explained hereby:

1. There are several countries with a single DSO, either this is big, medium or small. Namely, the countries falling into this category are: Cyprus, Estonia, Luxembourg, Slovenia (small DSOs), Croatia, Latvia, Lithuania (medium DSOs) and Greece, Ireland (big DSOs).
2. There are other countries in which there is one main DSO (former incumbent electricity company) that covers more than 90% of the customers plus other smaller DSOs, namely Italy, France and Portugal.
3. Similar pattern is followed by Belgium, Netherlands and Romania, where 2 or 3 DSOs seem to cover more than 70% of the clients (77%, 73.3% and 95.5% respectively). It should be mentioned here that we have information from few DSOs in the equivalent countries, namely 2 out of 15 for Belgium, 3 out of 8 for Netherlands and Romania.
4. Poland and Spain seem to have 3 and 4 big DSOs (respectively) that cover more than 90% of the customers plus a medium DSO (for Poland) and two small ones (for Spain). UK follows a similar pattern with 3 big DSOs plus 2 medium ones that cover over 70% of customers.
5. The majority of the customers in Sweden and Hungary are covered by 4 small DSOs (with percentages of 67.1% and 54.2%) plus 1 or 2 medium ones. In general, the number of DSOs remains relatively low (6 in total).
6. In Austria, Finland and Denmark it seems that the DSOs are small, since all the information obtained is from small DSOs. However, it should be noted that only for Finland the data obtained covers the 100% of the clients, whereas for Austria and Denmark the percentages are modest.
7. In Czech Republic there are few DSOs (3 in total), whereas their size varies (big, medium and small).
8. Bulgaria is the country for which little information is obtained, namely 1 medium DSO covering 34.3% of the clients.
9. Germany is the country that seems to follow a

completely different pattern, with 75 big DSOs in total, of which 31 have provided feedback in our survey. The majority of these 31 DSOs are small (22), whereas the rest of participant DSOs comprise of 5 medium and 4 big DSOs. It is noteworthy that the big DSOs cover more than one fifth of the customers.



a)



b)

Fig. 4 a) No of DSOs per country according to the clients they serve, b) percentage of total customers the DSOs represent

Another categorization of the DSOs can be made with respect to their distributed annual energy. We have clustered the potential distributed energy in 5 categories: below 3,000 GWh (very low); between 3,000 and 10,000 GWh (low); between 10,000 and 60,000 GWh (medium); between 60,000 and 100,000 GWh (high); above 100,000 GWh (very high). The categorization is indicative, and other values can also be used as well. As it is expected, the level of distributed annual energy depends on the number of customers each DSO serves. Fig. 5 shows the situation with respect to the distributed annual energy (E) of the DSOs. It should be noted that for visibility reasons, Germany is not included in the graph. The distribution of the DSOs according to their annual distributed energy in Germany is: 15 DSOs with very low energy, 8 with low, 6 with medium, 1 with high and 1 with very high. The main findings from Fig. 5 including Germany's pattern are:

1. The countries with at least one DSO with very high annual distributed energy are France, Italy, Spain and Germany.
2. There are few DSOs with high annual energy and these are in Germany, Spain and Sweden.
3. In Germany, the 31 DSOs, for which feedback is available, cover the whole span of the categories for the annual distributed energy. Most of them (15) provide very low annual energy.
4. In Spain, the 5 available DSOs cover the whole range of possible distributed energy, from very low to very high. Similar pattern is followed in Italy, from very low to very high, although only 3 DSOs are operating there.
5. For the countries with one DSO operating, the annual distributed energy is from low to medium. Such countries are: Greece, Ireland, Slovenia, Croatia (medium energy); Latvia, Lithuania, Luxembourg, Cyprus, Estonia (low energy).
6. Countries that rely mainly on DSOs with medium distributed energy are Belgium, Netherlands, Portugal and Czech Republic. For these countries, the number of DSOs participating in our survey has been up to 3, whereas the customer coverage achieved is for all of them over 70%.
7. Poland and UK also rely mainly on DSOs with medium distributed energy. For both of these countries, the feedback relies on 5 DSOs which cover over 70% of the customers.
8. Countries that rely entirely or almost entirely on DSOs with low energy are Austria (3 DSOs with low energy plus one with very low); Romania, Slovakia, Bulgaria (all available DSOs with low energy); Hungary (5 DSOs with low energy plus one with medium). It should be noted however, that for Austria and Bulgaria the client coverage is relatively low (24.2% and 34.3% respectively).
9. The countries that entail 3 or more DSOs with very low distributed energy are Finland, Denmark and Sweden. It should be noted however, that none of these countries rely completely on DSOs with very low annual distributed energy. In Sweden there is also one DSO with medium and one with high energy; in Denmark there is one with low energy; in Finland there are 2 with low and 1 with medium distributed energy.

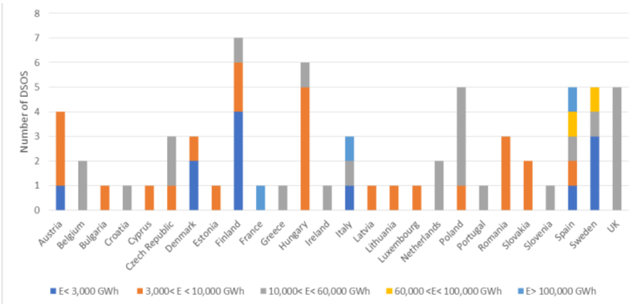


Fig. 5: No of DSOs per country with specific distributed annual energy (Germany is not included in the graph)

B. DSO CONTRIBUTION FOR THE REALIZATION OF THE SMART GRID

As it has been mentioned in Section III, the DSOs and the smart grid dimension has been examined in the DSO Observatory report. It is worth analysing a bit further how different DSOs in European countries are smartening their grid system, for instance by applying Demand Side Flexibility (DSF) programs and in the coordinated operation of transmission and distribution networks. It is highlighted at this point that the feedback we have for the smart grid dimension comes from 65 DSOs, which participated in the latest version of our survey. Out of 65 only 32% of the DSOs have affirmed that manage demand response or demand side flexibility programs. Table 3 shows how these DSOs are distributed in the various European countries. It also gives a hint of how many customers these DSOs serve according to the categorization explained in Section III.A.

Table 3: No of DSOs with DSF programs

Country	No of DSOs with DSF programs	Country	No of DSOs with DSF programs
Austria	2	Portugal	1
Czech R.	2	Spain	1
Finland	2	Sweden	1
Hungary	6	UK	2
Poland	1	Germany	2
20 in total out of which: 11 small, 6 medium and 6 big DSOs			

Another crucial aspect to consider is the issue of TSO-DSO cooperation [3], looking at how data are exchanged between them. For this purpose, information is divided into the data exchanged from the DSOs to TSOs, namely: the demand and generation forecasts; the data management – scheduled data of each power generating facility; the real time measurements (i.e. SCADA); the ex-post measurements (metered data); and the data exchanged from the TSOs to DSOs, like data on network conditions. It is reported below with respect to each type of data exchange, how many DSOs provide such of a service in which country. A hint is also given with respect to the number of clients these DSOs serve, as categorized in Section III.A.

DSOs communicate data to the TSOs on:

- Demand generation and forecasts: 24 DSOs in total, out of which 10 small, 8 medium and 6 big. Categorization by country: Cyprus (1), Hungary (6), Slovakia (1), Czech R. (2), Italy (1), Slovenia (1), Germany (3), Netherlands (1), Spain (2), Greece (1), Poland (2), Sweden (1).
- Scheduled data of each power generation facility: 15 DSOS, out of which 6 small, 4 medium and 5 big. Categorization by country: Austria (1), Germany (2), Netherlands (1), Spain (1), Cyprus (1), Hungary (1), Poland (1), Czech R. (2), Italy (1), Portugal (1), Finland (1), Latvia (1), Slovakia (1).
- Real time measurement: 30 DSOS, out of which 11 small, 9 medium and 10 big. Categorization by country: Austria (2), Croatia (1), Cyprus (1), Czech R. (1), Finland (2), Germany (4), Hungary (6), Ireland (1), Italy (2), Netherlands (1), Poland (2), Portugal (1), Slovakia (1), Spain (4), UK (1).
- Ex post measurement: 40 DSOs, out of which 18 small, 11 medium and 11 big. Categorization by country: Austria (1), Croatia (1), Cyprus (1), Czech R. (2), Finland (3), Germany (5), Greece (1), Hungary (3), Ireland (1), Italy (2), Latvia (1), Netherlands (1), Poland (2), Portugal (1), Romania (2), Slovakia (1), Slovenia (1), Spain (5), Sweden (3), UK(2).

DSOs receive data from TSOs on:

- Network conditions: 37 DSOs in total, out of which 17 small, 9 medium and 11 big. Categorization by country: Austria (3), Croatia (1), Cyprus (1), Czech R. (2), Finland (2), Germany (4), Greece (1), Hungary (2), Ireland (1), Italy (3), Latvia (1), Netherlands (1), Poland (2), Romania (3), Slovakia (1), Slovenia (1), Spain (5), Sweden (3).

As it can be concluded, the DSOs are more active in the exchange of ex-post measurement data, secondarily in real-time measurements, whereas scheduled data of each power generating facility attracts the least interest among the DSOs. It is also worth noticing that DSOs of all size categories fulfil this data exchange. It can be observed that data on network conditions is a common form of data exchange from TSO to DSO.

IV. CONCLUSIONS

This paper provides valuable insights on some of the main aspects of how European DSOs operate their business today, including the management of smart grid features. Such overview is helpful especially in light of the forthcoming approval and entering into force of the Clean Energy Package under discussion at European level: once the package will be approved, a convergence across the different business models might be observed, although it is impossible to know to which model this convergence will be inspired. The paper therefore sets a consistent reference point to evaluate the future evolution of European DSOs in the coming years, on the basis of the unique body of knowledge gathered by the JRC DSO Observatory report 2018.

REFERENCES

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[3] S.Y. Hadush, L. Meeus, 2018, "DSO-TSO cooperation issues and solutions for distribution grid congestion management", *Energy Policy*. vol. 120, 610-621.