GEODE REPORT

Flexibility in Tomorrow's Energy System

DSOs' Approach

GEODE Working Group Smart Grids

May 2014

The Voice of local Energy Distributors across Europe

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FOREWORD

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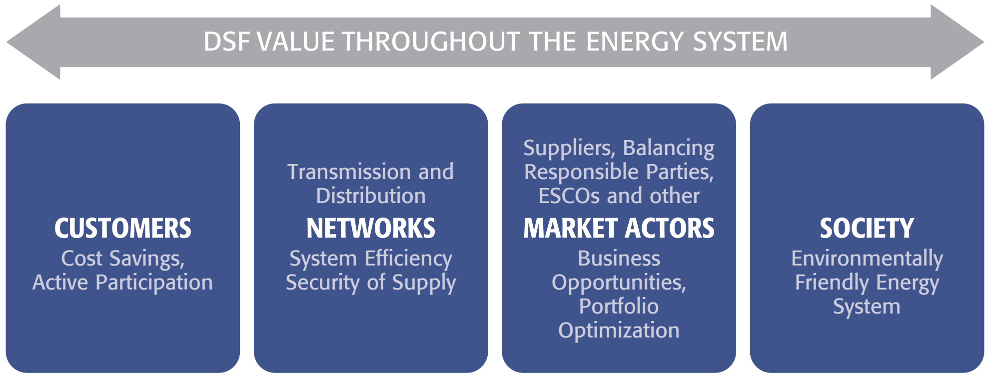
The electricity sector is undergoing significant change as a key facilitator in the transition to a low carbon economy. The need to 'future proof' the distribution and transmission networks means having to rethink how we build, operate and maintain the electricity networks to meet the challenges ahead. This report from **GEODE** focuses on an important part of that process as the ability to deliver greater flexibility through smarter networks will be vital to the success of the Distribution System Operators (DSOs) across the European Union in the coming years.

An area of particular interest to the network companies is Demand Side Flexibility (DSF) – a unique and innovative method whereby customers choose to respond to a signal to change the amount of energy they consume from the electricity network at a particular time. This report clearly sets out what can be achieved through DSF and how greater flexibility in the system can deliver real benefits for DSOs and most importantly for customers.

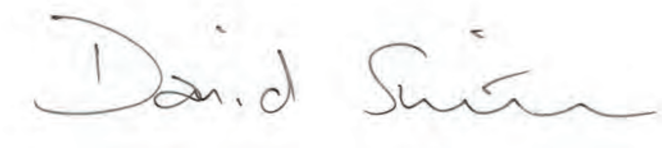


Source: GEODE

From the perspective of network operators, DSF has the potential to lower costs, enhance security of supply and contribute to sustainable energy development through facilitating the low carbon technology roll-out. Already DSOs have to play a more active role in the electrical system to handle demand in an age of increased renewable and

intermittent energy. DSF and smart networks will be vital to enabling that level of interaction as the need for it increases in the future. The paper also focuses on the impact DSF can have on small customers and the way they consume energy. Technology alone is not enough to bring about the change that is needed, and the 'smartness' of the grid will be determined by the customers' behaviour. Therefore, presenting a clear vision to small customers of how DSF can lower their energy bills with the minimum of effort will be fundamental to ensuring the technology delivers the maximum benefit. This report highlights the importance of DSOs and regulatory authorities engaging with customers to increase understanding and build trust in the technology, which will ultimately be key to its success.

Increased DSF holds substantial potential benefits for the whole energy system, and I encourage you to read this **GEODE** Report for insights into how flexibility will help meet future challenges across the EU's internal energy market.



David Smith

FLEXIBILITY IN THE SYSTEM

Flexibility

"On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterize flexibility in electricity include: the amount of power modulation, the duration, the rate of change, the response time, the location etc."[1]

The European Union faces the need for a major change in the way it generates, distributes and consumes electrical energy. The traditional way of producing electricity in large plants and distributing it uni-directionally to customers is starting to change and this will continue in the future. The increasing numbers of intermittent production facilities connected at various voltage levels to the electricity grid, of which a substantial part will be connected to the distribution grids, with the increase of electric vehicles and the development of new consumption patterns, will change the energy system, hence assigning DSOs new tasks and responsibilities.

A functioning European internal energy market[2] is therefore necessary for two main reasons:

1. To enable customers to take advantage of the greater market potential with increased competition and thereby, hopefully, lower electricity prices and energy bills;
2. To be able to manage large quantities of renewable intermittent electricity production, which, by their nature, it is not possible to constrain. A European internal energy market will allow the flow of substantial quantities of electricity through a well interconnected European energy system in order to balance generation and demand, while also contributing to achieving the EU targets on the decarbonisation of the energy system.

POWER AND ENERGY ARE NOT THE SAME

Power (W, kW, MW, GW, etc.) means the temporary flow of energy and describes the electrical size of a component (generator, engine, fridge, lamp, etc.) or a system/grid. The main fuses in a building's fuse box set the limit for the power that can be used in that building.

[1] Flexibility and Aggregation Requirements for their interaction in the market - Eurelectric January 2014 and EC Task Force Smart Grids Implementation - EG3 report, Flexibility chapter- version May 2014

[2] Members States agreed to complete the internal electricity market by 2014 at the European Council of 4 February 2011

Energy (kWh, MWh, GWh, etc.) defines the amount of energy produced or consumed during a certain period of time.

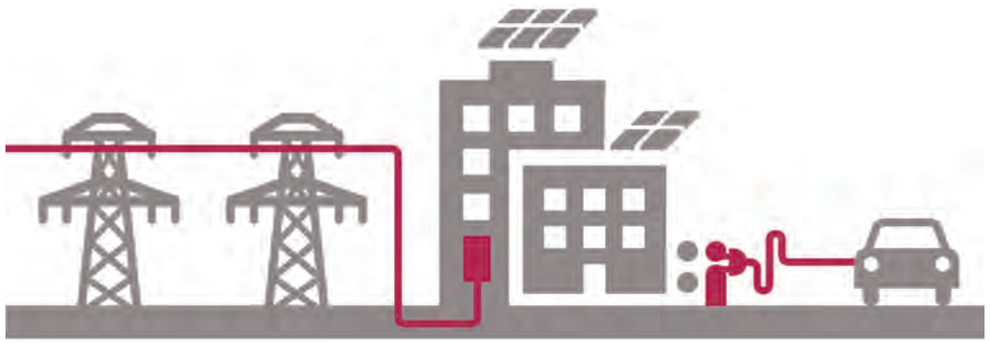
It is fundamental to understand the functioning of an electrical system to distinguish between these two units: power and energy.

Every electrical system has to be in balance every second, i.e. the produced and consumed amounts of electrical power have to be equal - otherwise the entire system becomes unbalanced. In a balanced system, the frequency is stable (50 Hz in Europe). If production and consumption start to differ, the frequency will begin to deviate from 50 Hz. It increases if production exceeds consumption and decreases if production goes below the required level of consumption. This is crucial since an unbalanced electrical system can make certain electrical components malfunction or, cause real damage. This can apply to power generators in many industrial installations, electrical devices in households and even, the electrical network as a whole. If the unbalanced situation continues, there is a risk of system break-down.

Some production sources are possible to control (e.g. hydro power and gas fired power plants), while others are not - the so-called intermittent electricity production from wind, solar, wave power etc.

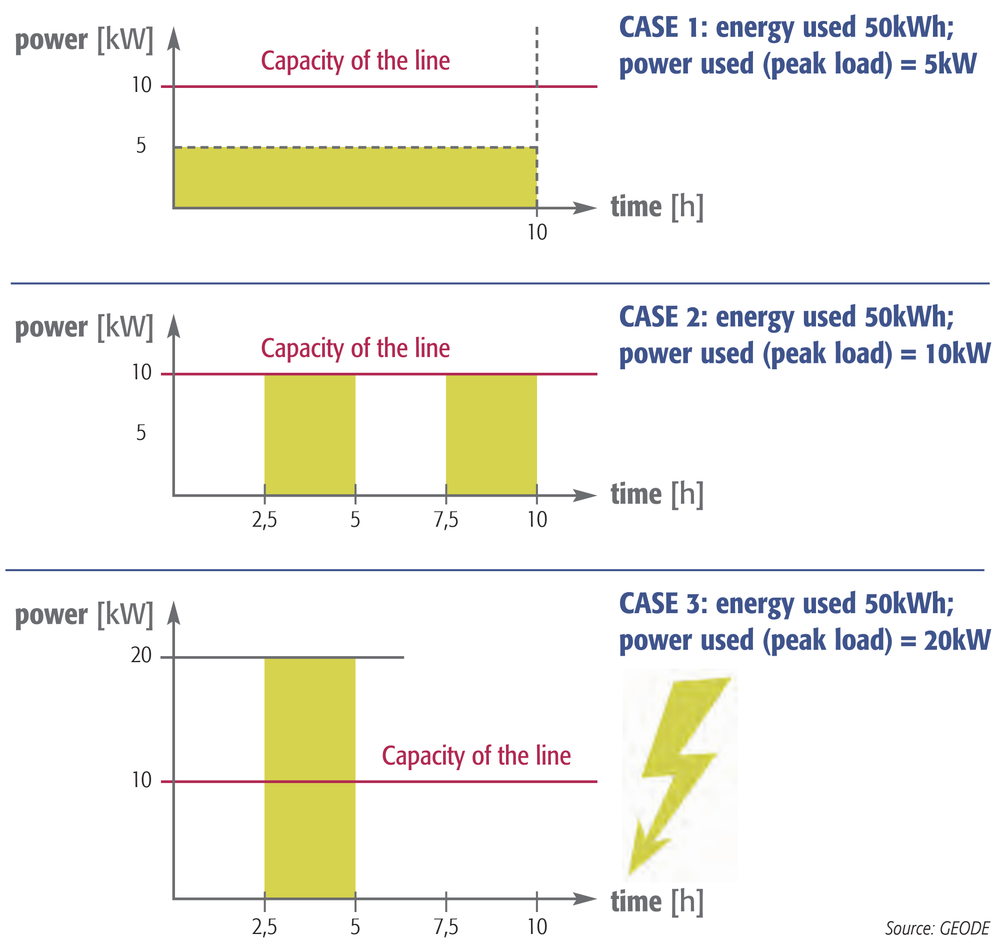
In order to provide enough power into the electricity system at all times there has to be a sufficient amount of available power production and flexibility in the system.

The diagram below shows the electricity supply of a residential customer and illustrates the impact of energy (kWh) and power (kW) on the electricity distribution grid.



Source: GEODE

In this example three simplified load profiles are used. In all three cases the same amount of energy (the grey area) is consumed, whereas the required peak load and the corresponding network capacity required are significantly different.



Source: GEODE

The following table summarizes the three load profiles and their consequences for the grid:

	Capacity of the line [kW]	**Peak load** [kW]	**Used energy** [kWh]	**Network losses**[3] [%]
Case 1	10 >	5	50	100% (baseline)
Case 2	10 >	10	50	200%
Case 3	10 <	20	50	400%

[3] The network losses in Case 1 (100%) is the baseline figure for the calculation of the network losses in Case 2 (200% or 2 times higher) and Case 3 (400% or 4 times higher)

Although the energy used in all three cases is the same, in Case 2 the capacity of the distribution line is exhausted, whereas in Case 3 the line is substantially overloaded. In Case 3 the line has to be reinforced or 'smart' measures are required to keep the grid conditions within its borders. The relationship between load peaks and network losses is illustrated through a significant increase (by a factor of 4) compared to Case 1 (baseline).

Case 1 shows an ideal situation from the perspective of grid operation in terms of maximising the hosting capacity while minimizing network losses.

Cases 2 and 3 clearly show the risk of shifting consumption according to the energy market price only. For example, when Case 2 is the regular situation, and the customer has dynamic pricing and installs a DSF system that shifts consumption to the cheapest energy hours (hours 2.5 – 5 in the example), the DSF system would lead to the situation outlined in Case 3. It is thus important to take into consideration that shifting load according to the energy price can create congestion on the DSO side. Optimization between market price and the efficient use of the network needs to be found.

The situation in Case 1 is the ideal, but, in practice, hardly ever achievable, as the customer's typical behaviour produces load peaks in the distribution grid. A first step in the right direction to mitigate peak loads would be to introduce power based grid tariffs[4] which provide customers with incentives to reduce their personal peak loads.

The peak load is the key dimension for grid planning and operation. In the future (in some areas this is already happening) decentralized generators such as PV will be able to provide the needed power for a certain period of time, but the grid still require the full capacity for situations when, due to weather or market conditions, decentralized power plants are not producing sufficient energy.

Today's electricity grids were dimensioned to cope with the loads envisaged back in the past, but their planning did not take into account today's challenges, including:

- Charging processes of electric vehicles
  - uncontrolled charging is particularly challenging
- Changed behaviour of customers
  - new appliances (such as heat pumps) need a lot of power, but not much energy
  - price signals to customers can lead to an unexpected simultaneity in electricity consumption and thus to local grid congestion
- High numbers of decentralized production
  - can cause overvoltage problems

[4] For more information see GEODE report on the Development of the DSO's Tariff Structure. September 2014 (to be downloaded at www.geode-eu.org)

In summary, **for a DSO, power**[5] **is the key dimension for operating and planning an electricity distribution grid, whereas the volume of transported energy (kWh) is of less importance.**

DEMAND SIDE FLEXIBILITY SAVES POWER NOT ENERGY

The objective of DSF is to give customers the opportunity to consume the same amount of electricity but at a time when the demand is lower, instead of consuming it at times of peak demand.

Since power is the limiting dimension for a grid, it is important to strive to even out electricity consumption over time, as much as possible. A more even rate of consumption uses the grid capacity more efficiently, which is important for DSOs managing their grids. High consumption peaks require expensive reinforcements of what are often the less utilised parts of the network.

THE VALUE OF ELECTRICITY IS VARIABLE

To encourage the market to react when there is a power deficit in the electricity system, efficient **price signals** are needed. This means that the price of electricity should reflect the variable costs of the energy system in which case, when demand is a lot higher than all available production, the price of electricity should peak. On the other hand, when there is too much electricity produced, compared to the demand prices should be very low, and, on rare occasions, even with a negative value.

The price signal mechanism provides similar incentives to the DSF system described above. It should encourage a rebalancing effect in the electrical system when production costs go up or if the grid becomes unbalanced. As for production this happens when electricity users limit or shift their consumption when electricity is expensive; for the grid this could be done by setting power limits for individual grid users. Again, one way to implement these price signal mechanisms is to introduce dynamic pricing in supply and **a power based tariff structure for DSOs.**

[5] With an increasing number of Distributed Generators their impact on the voltage level, especially in rural grids, is growing in importance

- The future EU smart electricity system will contain a substantial amount of renewable, often intermittent production mainly connected to the distribution grids. More efficient ways to consume energy, like electric vehicles or heat pumps will at the same time change consumption patterns. All these upcoming challenges have an impact on the DSOs' activities, assigning them new tasks and responsibilities that require a more active management of the grid.
- The objective of DSF is to give customers the possibility to consume the same amount of electricity but to reduce their load during peak demand with high prices transferring the consumption to a period when demand is lower.
- For a DSO, power is the key dimension for operating and planning an electricity distribution grid; the volume of transported energy (kWh) is of less importance.

BENEFITS OF DEMAND SIDE FLEXIBILITY

***Demand Side Flexibility** provides benefits to the whole energy system. It provides the possibility to optimise usage and balancing of networks and electricity production and consumption for example by consuming less during peak times or by facilitating the integration of electricity from variable renewable energy sources and micro-generation[6].*

There are a lot of benefits to be gained from demand side flexibility. These benefits include price reduction, environmental friendly consumption, overall system efficiency leading to lower network costs, improved security of supply and integrating fluctuating energy production.

From a wider market perspective, DSF is a tool which may be used by market participants to manage their contractual positions as an alternative option or in conjunction with other commercial arrangements. Therefore DSF could be a useful tool to minimise commercial exposure in the electricity market; and/or maximise commercial opportunities in the electricity market, e.g. sell "products or services" to other market participants.

BENEFITS OF DEMAND SIDE FLEXIBILITY – CUSTOMERS

Benefits for large customers

Large electricity customers already have a lot to gain from DSF, since they usually have access to sophisticated energy management systems to optimise their energy usage to secure economic benefits. In a future with more volatile electricity prices, industrial customers will be able to choose to move energy intensive production from high to low price times, thereby lowering their costs. This is especially important at extreme demand peaks when the electricity system risks shutting down and prices are very high[7]. Smart meters and dynamic pricing will enable large electricity customers to avoid these price shocks by reducing their consumption during peak hours.

[6] CEER definition of DSF - Regulatory and Market Aspects of Demand Side Flexibility. A CEER Public Consultation Document- 8 November 2013

[7] Denmark 7th of June 2013 - www.scancomark.com/Market/How-shortage-of-wind-supply-in-Denmark-lead-to-record-expensive-electricity-prices-190907062013

Benefits for small customers (Residential & SMEs)

Most of today´s energy systems offer comparatively weak incentives to small customers to encourage them to engage in flexibility markets, and it is not always possible to offer any incentives at all. Prices are fairly stable and the tariff systems are usually not dynamic. Also, there is no effective price signal to stimulate changes in the electricity system such as increased demand or lower production capacity.

Higher volatility on the electricity market will increase the incentives available to domestic customers to engage in DSF activities, as there is more money to be saved on each kilowatt-hour that is consumed during periods of lower prices, or simply not consumed at all.

The current developments with smart housing and home automation will enable domestic customers to be more active in the DSF market. Appliances will be able to automatically adjust their electricity usage without instructions from the owners. This kind of automatic feature will facilitate the participation in DSF by residential customers. These appliances will be able to, for example, connect themselves to the electricity spot market or react to an incentive given by a smart meter. As an example, some heating systems and refrigerators are already today able to connect to the electricity spot market in order to adjust their electricity usage in accordance with the price. As "thermal slow" appliances, they can store heat or cold for a long period of time before the change in temperature has any adverse effect. This can be done without affecting the living standard of the user which is, of course, essential.

The customer will therefore have to weigh up the economic benefits of DSF for their energy bill on the one hand and, on the other hand, the possible investments that will be required in intelligent appliances and steering devices and/or the changes needed to the customer's behaviour.

Media stories that customers will be forced to do their laundry at night or have to get up before dawn to prepare breakfast are quite false and examples of how DSF can be misunderstood.

Residential customers can then sell their flexibility capacity to **energy aggregators** who optimize the electricity usage of many consumers, acting as one entity on the electricity market, thereby creating an economy-of-scale business model where smaller customers are paid to participate. Participating in DSF programs also lowers the customers' vulnerability to increasing electricity prices, and could be an effective way to counterbalance energy poverty.

Consumers' Trust

Market flexibility and demand response will bring a lot of changes to the energy market. In the future, smart meters and special consumption or load orientated tariffs will play an important role in developing a flexible market and changing consumption behaviour. This could also bring a lot of uncertainties especially for consumers and some might be worried by these changes.

A study by the European Commission[8] published in 2012 shows that consumers display a low level of trust in energy service providers in comparison to other sectors. Therefore, to gain trust and to encourage everyone to participate, it will be important to provide consumers with comprehensive information about the reasoning, outcomes and benefits of energy market flexibility and demand response.

This information should be provided to consumers not only by DSOs' or other market players but, in the first place, by national and local regulatory authorities, as well as by consumer organisations in the respective Member States.

The potential to reduce their electricity bill will be a real benefit for customers and a motivation to actively participate in DSF. But the potential of DSF is higher for large customers while households will still need the further development of home automation and smart housing.

OPTIMISATION OF DISTRIBUTION NETWORKS IN A SMART METERING ENVIRONMENT

From the DSO perspective, DSF has the potential to help optimise the operation and planning of distribution networks.

The resulting decrease in peak demand or the ability to be able to call on the immediate use of locally produced energy could support the DSOs in stabilising the grid without further network expansion.

It should be noted that **new tariff models** (e.g. power based tariff structures) based on metering data may be particularly helpful to the DSO to technically optimise distribution networks. To achieve higher energy efficiency in the electricity market, the DSO and the supplier need to work closely together.

[8] http://ec.europa.eu/consumers/consumer_research/editions7docs/8th_edition_scoreboard_en.pdf

BENEFITS OF DEMAND SIDE FLEXIBILITY – ENVIRONMENT

DSF offers environmental gains. The environmental impact of electricity production and usage depends on how the electricity is produced. Electricity from renewable production adversely affects the environment less than electricity from power plants using fossil fuels.

The marginal cost of renewable energy production (solar, wind) is lower than conventional energy sources, namely gas and coal. When there is a lot of wind and solar available, low marginal costs bring down the electricity wholesale price. When there is no wind or solar, wholesale prices tend to rise and peak when all of the available conventional capacity is in use (e.g. gas turbines). However, for the energy system to work properly, a certain amount of controllable energy sources is a necessity.

The customer, who by using appropriate DSF functions, moves his electricity usage from high to low price periods is not only saving money, but also helping to produce energy in a more environmental friendly way, as it allows the feed-in of more energy produced by intermittent energy sources without destabilizing the grid.

- The main purpose of DSF should be to improve the overall efficiency of the whole energy system.
- To gain customers' trust and to make them participate in DSF activities, it is highly important to provide them with comprehensive information about the reasons, outcomes and benefits of DSF.
- In addition to energy market players and DSOs, this information should be provided to consumers, primarily by national and local regulatory authorities, as well as by consumer organisations in the respective Member States.
- The greatest potential of DSF lies in large customers provided with management systems and competences that allow them to optimize their energy usage for economic benefits. The potential benefits for small customers are much less.
- Most of today´s energy systems offer comparatively weak incentives to small customers to engage in DSF programmes, even though this could be an effective way to reduce the customer's vulnerability to increasing electricity prices as well as counterbalancing energy poverty.
- From the DSO perspective, DSF in combination with smart metering data has the potential to contribute to optimising the operation and planning of distribution networks.
- In order to encourage the majority of residential customers to actively participate in DSF, smart automatic household appliances will most certainly be needed.

DEMAND SIDE FLEXIBILITY POTENTIAL

Demand can offer flexibility to the market in several ways. Demand can have an active role in the spot market and react to spot prices. Demand resources can also be activated for balancing purposes and ancillary services. DSOs could also use flexibility to postpone or to replace network reinforcements.

DEMAND SIDE FLEXIBILITY – WHERE IS THE POTENTIAL?

The potential of flexibility that can be offered to the market depends greatly on the electricity consumption patterns and habits of each Member State. For example in the Nordic countries the power consumption peak takes place during the coldest hours of the year, whereas, in Italy, the power consumption peak is during the summer. This is why the issue of available flexibility potential needs to be addressed country by country and/or by region.

The flexibility potential is greatest in electrical appliances that consume significant amounts of power and that are used for significant periods of time and/or their usage time can be shifted easily without the customer being affected. These appliances also need to be used, as usual, during times when flexibility is needed (e.g. national consumption peaks). With thermal appliances, the greatest flexibility potential lies in solutions that can store energy such as hot or cold in e.g. water boilers or inside a building. Heating, cooling and also different kinds of storage solutions seem to have great potential. Also refrigerating appliances could have a significant potential, at least in commercial solutions. The potential of other household equipment such as washing machines is smaller and less reliable and difficult to control from the system's point of view.

It would be essential to know how different customer groups can benefit from DSF and to what extent customers are willing to participate in flexibility programs. Today, most residential customers consume electricity whenever they choose to and at affordable prices, which is a comfortable situation for customers.

The potential of flexibility should be evaluated through **cost-benefit analysis** at individual Member States' level to identify the best solution for each area. Member States need to know which realistic vs. theoretical DSF potential is currently unused, and what upfront investments will be necessary.

There will be no "one size fits all" solution that would provide benefits to all European countries, and any future EU legislation should take into consideration the different realities throughout Europe. Equally each Member State should make sure that their own national policy measures do not hinder the use of flexibility or decrease its potential.

REGULATION SHOULD NOT HINDER FLEXIBILITY POTENTIAL

The main purpose of **demand side flexibility is to improve the overall efficiency of the whole energy system.** This should be the main guideline in all energy related legislation, both at EU and national level.

Any future regulation must not prevent or restrict the existence or the use of flexibility potential. In fact the opposite, regulation should facilitate the use of flexibility potential and promote the controllability of the equipment.

There is a risk if energy using appliances or systems are regulated looking only from the energy efficiency perspective. The best approach will find a balance between energy efficiency and the capability for flexibility.

INCENTIVISING FLEXIBILITY - ELECTRICITY COSTS STRUCTURE

There will be no flexibility in energy markets without **proper incentives**. **GEODE** believes that offering flexibility should be voluntary and based on agreements and incentives. Small electricity consumers could offer their share of flexibility to the markets. However, this requires proper incentives to be in place.

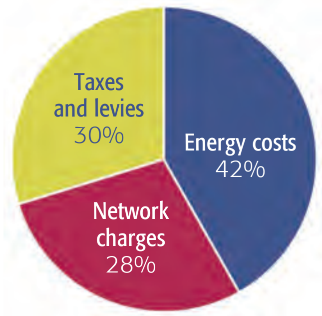
A pricing structure with **time of use pricing** in retail prices and **power based network tariffs** could provide the end user with the proper cost reflectiveness of the electricity market and network charges. For instance, it has to be taken into consideration that there is a significant risk of energy prices being low at the same time the DSO price is high, and the other way around. If cost reflectiveness reaches the customer, the benefits of participating in DSF become visible. When consumption data is detailed and frequently made available, the customer will better understand the potential offered by DSF.

The purpose of DSF and flexibility services is not to reduce energy usage but to shift it to another time which is more beneficial from the overall system's point of view. However, with a high share of the electricity customer bill not dependent on retail and/or network tariffs, and with taxes in some countries such as Germany and Denmark[9] close to 50 percent of the bill, it is hard to create sufficient incentives for electricity users to participate in DSF as long as only the electricity price and grid tariffs are changed.

According to Eurostat, an average of 30 % of the retail electricity bill paid by consumers relate to different taxes, levies and other governmental fees in the EU. This reality reduces the choice of customer incentives to engage in DSF.

[9] Source: Eurostat 2013:
http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Electricity_and_natural_gasprice_statistics

Average composition of the electricity bill for EU households



Source: European Commission Retail Energy Market Background Document to Public Consultation, Jan 2014

Since taxes are fixed and not linked to the customers' time-of-use, customers can only influence the other parts of their electricity cost. **Flexible taxes** related to the volatility of the electricity price could usefully increase the influence of the price signal available to the customer. Incentives for smarter energy usage would then increase dramatically.

GEODE identifies the following **main barriers for Demand Side Flexibility caused by the current DSO tariff structure** across Europe:

- Current tariff structures do not encourage changes in customers' behaviour to optimise the use of the distribution systems infrastructure. This can result in expensive grid reinforcements. The current DSO tariff structures focus on energy consumed and do not provide viable financial incentives for the customer to adapt their electricity consumption in a way which is in harmony with the perspective of network capacity.
- Current tariff structures do not reflect costs appropriately. If a customer varies consumption, his costs will change; however the DSO's cost may not change in the same proportion. A reduction of energy consumption without a reduction of the maximum demand will reduce the DSO's revenues but not the DSO's fixed grid costs.

Hence, the current tariff structure has to be developed further, to address the absence of adequate cost reflectivity and to improve customer incentives to enable network optimisation, customer savings and the necessary investments by DSOs.

If the DSO tariff is based on power incentives to decrease the capacity demand, this should result in cost savings in the long run. Moreover, power based pricing encourages customers' demand response actions. Such pricing methods encourage customers to reduce their peak loads. As the network capacity utilisation rate increases, the long-term costs decrease, which is financially beneficial to the customer.

So **GEODE** recommends the development of grid tariffs that are based on power. This approach will help to meet the (previously) referenced targets[10].

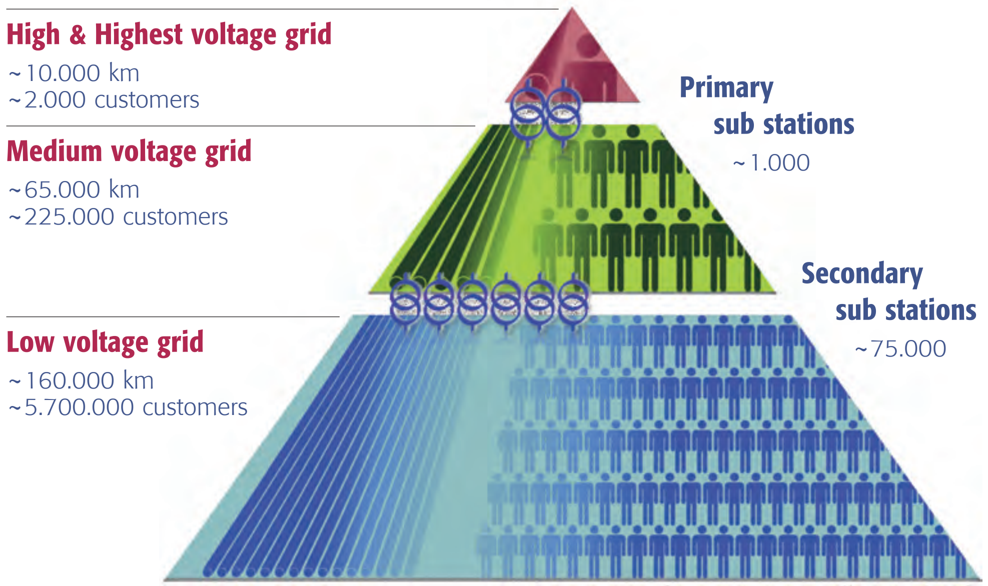
[10] For more information see GEODE report on the development of DSOs tariff structure, September 2013 (available at www.geode-eu.org)

Another important aspect to contribute to incentivising customers is the format of the **customer's electricity bill**. Regardless of the market model in use, the customer should be able to see how his electricity bill is composed. The bill should clearly state the supply price, the network tariff, and taxes, levies and other governmental fees. These three key components will provide transparency and allow the customer to properly compare current retail prices.

Energy companies have been working hard to make energy bills easier to understand, which will facilitate switching between energy suppliers and making tariff comparisons. These activities should not be limited or hindered.

INNOVATION, RESEARCH & DEMONSTRATION

The transition of the distribution grids towards a smart grid is often described as bringing the intelligence that has already been implemented in the transmission grids to the distribution grids. However, the numbers of lines, transformer stations, nodes, customers and decentralized energy resources (DER) are a lot higher in the distribution grid. The diagram[11] below illustrates this and gives an indication of the different dimensions of the transmission and the distribution grids (number of lines, transformers, customers etc.). The red part of the pyramid can already today be seen as a smart grid. The changes in the energy system, as explained previously, will require an increase in smart grid technologies on the green and blue parts of the pyramid.



[11] Source: Statistikbroschüre 2013; E-Control

In this context Research, Development and Demonstration (R&D&D) is vital to help develop systems and concepts which are tailored for the distribution grid's specific conditions.

The "worst case" scenario would be to monitor and control every line and node in the distribution grid. The optimal level of controllability and monitoring ability has to be found that will allow us to cope with the future challenges and at the same time to keep the necessary network investments at an adequate level.

R&D&D is also required to assess the capability of smart metering systems to support the DSOs' grid operations and planning, when there is limited access to the available metering data (due to privacy guidelines) and a communication infrastructure which is not real-time-capable. New concepts for grid operation/planning need to be developed to obtain maximal benefits from the smart metering systems.

At an early stage, it is vital to let innovation be market driven in terms of the development of DSF products and services. The capacity of the market to innovate should lead to a huge variety of various products offered to customers.

Simplicity and transparency of products and offers is essential. An uncoordinated introduction of time of use (ToU) pricing and Real Time Pricing (RTP) products, etc. may not be easy to understand and compare for customers, hence creating confusion. On top of this, RTP also carries the risk that consumers will receive bigger electricity bills if they do not react to the price signals. Therefore R&D&D is also important to test which products and offers achieve the greatest benefits for customers.

R&D&D is the best way to evaluate the benefits of innovative intelligent technology, to accurately estimate costs, to learn about customer behaviour and the barriers to be overcome, and lay the foundation for possible further deployment. Demonstration projects in particular will, in future, grow in importance to facilitate the further development of active grid management and operation.

In most Member States current regulation models used to set grid tariffs focus on short term cost reductions, and provide almost no incentives for innovation. In order to fully take advantage of the new technology, the regulatory models also have to be updated.

It is essential that DSOs are empowered by a satisfactory regulatory framework so they can play an active role in technology innovation. It has to be ensured that the above mentioned short term cost reduction orientation of the current regulation does not hinder innovation in the longer run.

- The flexibility potential needs to be addressed by each country and/or area separately since it depends greatly on the electricity consumption patterns and habits of that country or area.
- It is essential to know about the potential of DSF of different customer groups and that the willingness of customers to participate in flexibility programs may differ significantly.
- Cost-benefit analysis to evaluate the potential of flexibility at Member States level is a key issue.
- There will be no "one size fits all" solution providing DSF benefits all over the EU. Any future EU legislation should take into consideration different realities existing across Europe.
- GEODE believes that offering flexibility should be voluntary and based on agreements and incentives. There will be no flexibility in markets without proper incentives.
- The retail electricity bill paid by EU consumers contains an average 30 % of taxes, levies and other governmental fees. This reality reduces the scope of customer incentives to engage in DSF activities.
- A pricing structure with elements of time of use pricing in retail prices and power based network tariffs could provide the end user with the proper cost reflectiveness of the electricity market and network charges, improving the customer's understanding of the potential offered by DSF.
- Current grid tariff structures focus on energy consumed, do not reflect grid costs appropriately, and do not provide incentives to customers to optimize the use of the distribution grid (reducing peak loads).
- In GEODE's opinion a first step towards increasing the cost reflectivity of grid tariffs would be to implement power based grid tariffs.
- A strong commitment of DSOs to R&D&D projects is key to pave the way towards a smart grid and to get the most benefit from smart metering systems.
- Current incentive models focus on short term cost reductions and thus do not allow DSOs to commit to innovation and R&D&D projects.
- Innovation will be at the core of developing future DSF services.

THE ROLE OF DSOs AND THEIR RELATIONSHIP TO OTHER PLAYERS IN THE FLEXIBILITY MARKET

THE ROLE OF DSOs

The DSOs' role in the electricity market is to be the neutral **market facilitator** that ensures the reliability and stability of the system while facilitating the commercial activities of other market actors and above all safeguarding the interests of customers. In this chapter this role will be analysed in the context of evolving flexibility markets.

From the operational perspective DSOs will have a key role in tomorrow's electricity system. This will include:

- enabling the connection of distributed generation and other Decentralised Energy Resources (DER)
- enabling the necessary hosting capacity for it
- enabling demand flexibility including new actors for aggregation
- safeguarding their own DSO network operation
- playing a role in the overall system operation.

Different market actors with diverse and often contradictory interests are acting within the energy market. Hence, working in parallel: DSOs, TSOs, suppliers, aggregators or balancing responsible parties may all have an interest in a particular flexibility service of a customer or another DER.

This conflict of interests requires **coordination** - whether to safeguard the interests of the market or the interests of the parties responsible for grid stability - the network operators (DSOs and TSOs).

Operational areas

DSOs act locally. For grid operation purposes, it is essential to take the spatial location of grid users into account, namely the location of grid users within the area of a specific primary or secondary substation and/or the connection to a specific power line, etc. For example, when there is an over voltage problem, or congestion on a low voltage line, only the customers connected to this line can offer an adequate flexibility service to solve this problem. As a consequence, only a very limited number of grid users often can actually help the DSO to solve local problems on its grid.

On the other hand **market actors** such as suppliers, aggregators, balancing responsible parties, TSOs or ESCOs act on a more **global level**; the location of the customer in the distribution grid is of minor importance to them and not relevant to their activities as long as the "traffic light grid status is green"[12].

The same holds true for the price building process on power exchanges; a vital source of price signals from suppliers to customers (e.g. peak prices or negative prices due to volatility of wind and PV injection).

Nevertheless, all activities of market actors willing to change the expected behaviour of grid users in order to procure a flexibility service or via tariff signals have a direct impact on the distribution grid. For example, a price signal sent to customers based on electricity wholesale prices can lead to an unexpected simultaneity in the customers' electricity consumption, thereby creating congestions in the local distribution grid.

GEODE proposes, as a general principle, that market actors can act freely as long as the distribution grid is not put at risk - e.g. the traffic light grid status is green. In all other situations a **priority access to flexibility services** is crucial for the DSOs to fulfil their core tasks as the party responsible for grid stability and secure grid operation. So, for example, decentralized generators should act to cope with overvoltage problems (which they have caused).

A prerequisite necessary for the DSO to fulfil its role as market facilitator and for the introduction of a traffic light scheme is to **increase the monitoring ability and controllability** in the medium and low voltage distribution grid.

Therefore, the low and medium voltage grid, secondary transformer stations, critical nodes etc. require the right technical equipment (sensors, automation devices etc.) and an adequate ICT infrastructure which allows real-time data exchange and grid operation. The next step would be to include decentralized generators, the charging processes of electric vehicles and consumers in real-time smart grid operations.

[12] Source: The traffic light system - M490 WG Methodology Annex B – German Association of Energy and Water industries (BDEW)

New actors and their interdependencies

An **aggregator** would be a relevant player for small customers, allowing them to sell their flexibility to TSOs, DSOs, and suppliers or balancing responsible parties (BRPs). Aggregators can be suppliers or third parties. They may act as an intermediary between customers who provide the flexibility and the procurers of this flexibility.

Aggregators may offer DSOs' services for local grid balancing. In order to do so, the knowledge of the spatial location of the flexibility offers (customers) in the distribution grid is a prerequisite.

If an aggregator is not a supplier, a decrease/increase of electricity consumption or production initiated through an aggregator might lead to an imbalance for the supplier of the relevant customer. This means that suppliers and/or balancing responsible parties are affected by the actions of other market players if their customers are involved. This interdependency has to be taken into account and metered appropriately. The best way of handling this will require further analysis and discussion.

Obviously the complexity of the future energy system is increasing and therefore **new arrangements between different market actors** are needed.

In that respect **GEODE** supports **direct contracts** between DSOs and customers to procure flexibility services as an appropriate management tool, due to the local dimension of DSOs' requirements and the need for priority access to flexibility services when the distribution grid is put at risk. If residential customers do not have a direct contract with the DSO, the above principle should be implemented in the contractual arrangements between the customer and the supplier. The aggregator can also be part of these commercial arrangements.

It needs to be ensured that new service providers entering the energy market act in such a way that their actions do not hinder security of supply, or the safety and the data privacy of customers and other market players who have to interact with them. This should be ensured via national legislation. Also, for example, operating permits can be introduced if needed.

DSOs AND SMART METERS

GEODE recommends that the DSO in its role as market facilitator should retain the **responsibility for metering** as the meter is the end point of the DSOs' electrical grid (the exceptions are Germany and the UK).

The **customer is always the owner of their data**. The DSO is responsible for ensuring that customers' data is utilised only for regulated duties (to DSOs, suppliers and BRPs for e.g. billing, balancing and network operation). Any other data sharing must be approved by the customer. All suitable market players should be granted access to consumption data in a secure and non-discriminatory way through a standardised open interface[13]. This is guaranteed when the party responsible for metering is the DSO, a regulated and by definition neutral entity.

To what extent smart metering systems have the ability to support DSOs in operation and planning of the grid is a matter closely related to the data the DSOs are allowed to gather from the smart meters. Obviously the benefits for DSOs to improve the operation and planning of the grid are reduced if they are not allowed to collate load profiles in an anonymised way. **GEODE** believes that the privacy of customers is of key importance and needs to be ensured through a strict data protection regime (encryption abstracts, etc.).

GEODE therefore must emphasise that smart metering is much more than a simple exchange of meters. The roll-out of smart metering systems requires substantial investments in today's non standardized smart metering technology, concentrators and ICT upgrades or the replacement of existing IT systems to cope with the expected amount of additional data. In particular, hourly or quarterly settlement for small customers is needed for DSF requirements, also changes to the suppliers' own IT systems.

For smart metering systems to be put in place, huge investments by the DSOs are required. Since the business of the DSO is regulated, it is very important that the DSO is allowed by the regulator to re-finance these investments through grid tariffs or other revenue streams[14].

[13] For more information see GEODE Report on Bringing Intelligence to the Grid, May 2013 (available at www.geode-eu.org)
[14] For more information see GEODE Report on Bringing Intelligence to the Grid, May 2013 (available at www.geode-eu.org)

FLEXIBILITY AND SMART METERING SYSTEMS

Smart metering systems provide the relevant metering data for billing and settlement of tariff products like time of use tariffs, power based grid tariffs, etc.

In order to allow customers to provide flexibility services to the market, smart meters with a reading interval corresponding to the settlement period time unit of the market (the time unit used in markets to balance consumption and production, e.g. 1 hour), are a technical prerequisite.

Nevertheless, it has to be underlined that smart meters will be able to meter only the overall change in the consumption of electricity within the metering period (e.g. hourly), but will not be able to validate a single flexibility order of, for example, a specific device in a family home. See the following practical example:

> *A customer has agreed that an aggregator can control his water boiler (installed behind the meter) based on spot market prices. The aggregator sends a command to the boiler to shut down at a certain time. The control system works perfectly and, the water boiler shuts down for the next hour. At the same time the customer turns on his air-conditioner and as a consequence no change in customer's consumption for that metering period is registered by the meter. However, the aggregator's control has worked as predicted.*

This example illustrates that a single smart meter is not able to validate if a flexibility order related to a particular appliance has been executed or not, and the impact on the supplier concerned is not made visible. Therefore depending on the DSF solution, **an additional disaggregated validation system behind the smart meter might be required.** From **GEODE**'s point of view the implementation of possible additional metering systems, behind the smart meter, is a task that should be left to the market.

DSO – TSO COORDINATION/ RELATION

Electrical systems are physical "living" systems. They are closed systems, meaning that consumption has to be met every second with equal production. This is called power balance. The TSO is responsible for this balancing operation, as the overall system responsible party for each country or control area.

On the legal basis of the EU Network Codes (NCs), TSOs have the ultimate responsibility for the safe operation of the power system and setting up the criteria for the technical requirements needed from different parties and players, including the DSOs. Criteria are also established for the design of market models to support the operation of the grid. New requirements placed on DSOs due to the obligations introduced by NCs will inevitably lead to increased costs.

The ongoing efforts to develop and further implement the NCs may be seen as a first step towards a framework which enables market actors to buy and also allows flexibility providers to offer flexibility services on a level playing field. These institutional developments are key to define the functioning of the future energy markets.

The co-operation between TSOs and DSOs covers all time frames:

- DSOs must register connected production and customers offering DSF and balancing services, including aggregation, and inform the relevant TSO in the form of a predefined set of data.
- DSOs must take part in the planning phase. This means delivering demand and production plans of customers connected to the DSO grid.
- DSOs must - in some cases in real time and in others by time stamped data - be involved in both the technical operation needs of the system and new market functions such as DSF and balancing services - aggregated or not.

These services are transited by and through the DSOs networks, to TSOs and the market actors. It is becoming obvious that there is a vastly **increased need for more complex IT systems and communication between TSOs and DSOs** and also with significant producers, customers and aggregators, offering DSF balancing services. The communication needs to include both measuring/monitoring data and control signals.

MICRO-GENERATION IN A FLEXIBLE MARKET

Prosumers, electricity producing consumers, are gaining ground in the electricity market. The promotion of electricity from renewable energy sources has created a strong incentive in many countries for many consumers to produce energy for their own consumption or even more than that.

The term "micro-generation" refers to a wide variety of energy sources, like river or pumped storage power plants, photovoltaic, wind, biogas or small cogeneration installations, all of which having unique production profiles. Particularly impressive solar photovoltaic has shown how peak demand can be met by local production - as long as the sun shines. For this reason distribution networks need to be more flexible and a greater variety of local energy production is needed to balance weather-dependent issues.

From the economic perspective, the installation of such technologies will secure real consumer benefits by providing financial gains, depending on each Member States' subsidy policies, from feed-in tariffs and / or bill savings from not buying electricity from the grid.

The future challenge for the DSO will be to create dynamic databases bringing together consumption and decentralised production on a spatial level. At this level, efficient energy management including heat and gas is crucial. The coordinated control of a large number of distributed energy sources, with probably conflicting requirements and limited communication, is problematic and will create higher costs for the DSO.

A large number of micro-generators can impact the operation of distribution networks. For this reason, the DSOs may need real time information from micro-generators. For this information flow a separate information channel is needed, because smart metering systems are not designed to provide this real time information.

The unbundling provisions of the Third Package Directive and the ongoing efforts to implement the NCs, may be seen as a first step towards a framework to develop locally optimised market models. This goal can be achieved by the deployment of the right infrastructure together with an adequate legislative framework.

- The actions of market players always have an impact on the local distribution grid.
- GEODE proposes as a general rule that market players can act freely as long as the distribution grid is not put at risk - traffic light[15] grid status: green.
- Decentralised generators can contribute towards balancing the local distribution grid. Therefore these production units need to be made accessible to the DSOs for grid planning and operation purposes.
- In all other situations priority access to flexibility services for DSOs is a key element to fulfilling their task as responsible for grid stability and secure grid operation.
- For the DSO to fulfil its role as market facilitator it is necessary to increase the real time monitoring ability and controllability in the distribution grid.
- As the complexity of the future energy system is increasing, new arrangements between the different market players are needed.
- GEODE recommends that the DSO in its role as market facilitator should remain responsible for metering as the meter is the end point of the DSOs' electrical grid (exceptions in Germany and the UK).
- DSOs benefit from smart meter data to improve the operation and planning of the grid decrease if they are not allowed to collect load profiles anonymously.
- For smart metering systems to be put in place, huge investments by DSOs are needed. It is crucial that the DSO is allowed by the regulator to re-finance these investments through grid tariffs or other revenue streams.
- In order to allow customers to provide flexibility services to the market, smart meters with a reading interval corresponding to the settlement period time unit of the market (e.g. 1 hour), are a technical prerequisite.
- There is a vastly increased need for more complex IT systems and communication between TSOs and DSOs, significant producers, customers, and aggregators, offering DSF balancing services.
- The future challenge for the DSO will be to create dynamic databases bringing together consumption and de-centralised production on a spatial level.

[15] Source: The traffic light system - M490 WG Methodology Annex B – German Association of Energy and Water industries (BDEW)

RECOMMENDATIONS

GEODE believes that the following recommendations should be taken into consideration for the development of Demand Side Flexibility (DSF) in appropriate conditions.

Consumers' trust is essential

To encourage consumers to participate in DSF markets it is highly important to gain the consumers' trust. In addition to energy market players and DSOs, national and local regulatory authorities, as well as consumer organisations in the respective Member States should provide consumers with comprehensive information about the reasons, outcomes and benefits of DSF.

In order to encourage the majority of residential customers to actively participate in DSF, smart automatic household appliances will most certainly be needed.

The overall efficiency of the energy system should be the main guideline in future regulation

Future regulation both at EU and/or national level must not prevent or restrict the use of flexibility potential, and the promotion of the controllability of the equipment.

Potential of flexibility needs to be pinpointed locally

The flexibility potential varies in each Member State. A cost-benefit analysis to evaluate the potential of flexibility at individual Member States level is needed in order to identify the best solution for each country. There is no "one size fits all" solution.

DSOs' Tariffs

There will be no flexibility in markets without proper incentives. Power based grid tariffs which provide customers with incentives to reduce their personal peak loads would be the first step in the right direction.

Definition of roles and responsibilities

The actions of market players will always have an impact on the local distribution grid. Therefore they can act freely as long as the distribution grid stability is not put at risk. The increasing complexity of the market requires new arrangements as well as complex IT and communication systems put in place between market actors.

Smart Meters

To allow customers to provide flexibility services to the market, smart meters with a reading interval corresponding to the settlement period time unit of the market (e.g. 1 hour), is a technical prerequisite.

For smart metering systems to be in place, huge investments by DSOs are needed. It is crucial that the DSO is allowed by the regulator to re-finance these investments through grid tariffs or other revenue streams.

Innovation and R&D&D

Current incentive based regulation models focus on short term cost reductions and do not allow DSOs to strongly commit to innovation and R&D&D.

GLOSSARY - ABBREVIATIONS

BRP - Balancing Responsible Party

CBA - Cost-Benefit Analysis

Consumer - encompasses households and small and medium-sized enterprises,(SME) as well as the "Prosumers"

Customer - everyone connected to the grid

DER - Decentralised Energy Resources

DR - Demand Response can be described as the mechanisms to manage consumer consumption in response to supply conditions[16]. GEODE considers the concept of Demand Side Management (DSM) and Demand Side Flexibility (DSF) as being part of the Demand Response scheme.

DSF - Demand Side Flexibility

DSM - Demand Side Management refers to the direct load control of devices and interruptible load which aim to affect both the timing and level of electricity demand. It responds to a price or a technical signal.

DSR - Demand Side Response

DSO - Distribution System Operator

EED - Energy Efficiency Directive

ESCO - Energy Services Company

ICT - Information and Communication Technology

NC - Network Codes

Prosumers - electricity producing consumers

PV - Photovoltaic

[16] European Commission Communication on Smart Grids 12 April 2011

R & D - Research & Development

R & D & D - Research & Development & Demonstration

RES - Renewable Energy Sources

RTP - Real Time Pricing

SME - Small and Medium-sized Enterprises

ToU - Time of Use Tariff

TSO - Transmission System Operator

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