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Report on regulatory aspects of the Demand Response within Electricity Markets

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REPORT ON REGULATORY ASPECTS OF THE DEMAND RESPONSE WITHIN ELECTRICITY MARKETS

CIGRE WG C5.19

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EXECUTIVE SUMMARY

The power system stakeholders all share the ambition of a more economically efficient system and a lower environmental impact. To this aim, many solutions can be found not only on the generation and network sides, but also on the demand side, i.e. involving the electricity end-consumer. Among them, Demand Response (DR) solutions refers to **the ability of consumption sites** (e.g. residential or industrial) **to respond in a coordinated manner to market and power system conditions on a short term perspective.** This ability, often called a flexibility and which should be distinguished from energy efficiency, can then be used either for the supply-demand equilibrium or for network management providing it allows to reach for a better optimum in term of social welfare.

Previous studies made the observation that several DR technical solutions already exists. Furthermore, among these technologically mature solutions, some are very promising in the sense that the estimated social surplus they can bring can be higher than their estimated costs depending on the local context. Thus, for a given set of local drivers for DR, referring to the need for the services provided by DR and the cost of alternative solutions, several DR opportunities already appear profitable from a social surplus perspective.

However, power system regulations inherited from the past may not be adapted to products based on DR since power systems have been organized around the idea that production sites would be the main source of flexibility ensuring the system reliability and optimal dispatch. As a consequence, DR may not appear profitable to investors (public or private) for various reasons including the fact that the market design in a liberalized system or the regulated activities in a more integrated organization do not value properly the services that a DR opportunity could provide.

Therefore**, an adapted power system regulation is a key element to reach for an optimal DR development**. Such adapted regulations should cover a large panel of DR enablers allowing to implement, offer and exchange the services provided by products based on DR (e.g. capacity or energy products). In fact, several countries around the world have started to implement DR oriented policy addressing these enablers to overcome existing barriers to DR development.

To support power system stakeholders' actions and public decision toward DR, a benchmark performed in this study aims at identifying the factors of success and the lesson learned from these current experiences on DR regulation. This benchmark is built on a detailed survey over 15 power systems over the five continents, covering a diversity of liberalized and integrated systems, with zonal or nodal pricing and more or less central or decentralized dispatch, is based on the situation as in 2014 or early 2015.

The preliminary analysis of the country electricity mix confirms that different drivers may lead to different optimal levels of DR development. For instance some country face very high load peaks during winter or summer, some countries deal with more or less dispatchable energy sources including different level of renewable sources. More generally, the drivers include the cost of electricity supply, the long term dynamic of the demand as well as of the generation mix (e.g. the observation that the electricity security of supply is at risk), the need for short term flexibility compared to the flexibility of the existing generation mix (e.g. the share of flexible hydropower) and the general policy toward demand-side management.

Given these DR opportunities and drivers, the study then focuses on the enablers necessary to unleash DR development and identifies the following factors of success and lesson learned among the regulations implemented in the country surveyed.

First of all**, an adapted regulation lies probably more in combining several possibilities to give value to DR that complete each other** than in selecting a single option that would be best than all others. This principle is for instance observed in the fact that while giving implicit value to DR though a time varying price signal (such as Time of Use pricing) is widely used in almost all systems, there are more and more opportunities to give explicit value through exchange of products based on DR in the liberalized countries. This may reveal that while time varying price signals may be adapted in many cases, some services are better served by an explicit product that require an adapted market design. In particular, the survey shows that among the services DR could provide, several new dedicated products have been created to exchange DR opportunities providing system services to ensure short term reliability. Similarly, both upward and downward modulation of the consumption of a site can benefit to the power system stakeholders and should be valued as such. Besides, the market design or system organization should be able to value not only the activation of a flexibility but also its availability. Indeed, several DR opportunities have a rather low fix cost and rather high variable cost compared with alternative existing solutions. They can be optimally used only if their availability is correctly valued. Therefore, the countries offering, for instance, capacity mechanisms or markets, or giving value to reserves for short term reliability have a better chance to benefit from such DR opportunities.

Then, concerning liberalized markets or more generally the market-based organizations, **it is important to ensure that there is no entry barriers** to DR participation, i.e. that DR is allowed to compete fairly with products based on generation capacities for the market to drive optimal investment and operational decisions. Obviously, the first condition is that the market design should allow the participation of consumption sites. Beyond this simple statement, the **roles should be clearly defined** and the regulation should ensure a **fair competitive environment** between actors that could contribute to DR development. In particular, the analysis of the market design or integrated system organization around the products shows that in addition to the bilateral relation between the supplier and the consumer, some countries such as France and the US (for instance in PJM) have adapted their rules so that a third party, acting as DR operator can develop DR solutions in a competitive environment where they do not require the supplier's agreement. This is expected to drive both commercial and technical innovation to reach for new DR opportunities.
There are also enablers which absence can constitute a barrier to DR development. For instance, **Measurement and Verification** can be to some extent included into a larger certification process driven by a regulatory framework offering confidence in the product based on DR effectiveness which should ease the exchange of these products. Similarly, **allowing the aggregation** of several consumption sites when participating explicitly to the markets or to a regulated DR program is expected to ease the participation of small consumption sites and the exchange of more reliable products. This enabler has been implemented in Europe and in the US.

Finally, 10 out of the 15 countries surveyed have implemented one or more dedicated DR support schemes showing that favoring DR has been deemed necessary to support its development toward its full potential. They include in most country a financial support to R&D with in some cases dedicated features in the market design, normalization support, public awareness programs, or direct financial support.

In many countries, the evolutions of the regulation enabling DR development were at some point triggered by a strong political will, sometimes at the occasions of wider energy transition plans. As the drivers for DR gets strong, the regulation may be required to evolve at a fast pace to remove the barriers to DR development.

In the implementation process, even if these regulatory evolutions should be tailored to each local context, it is always best to learn from the experiences of others. To this aim, the knowledge extracted from the survey offers a picture of DR regulation as in 2014 in a diversified panel of context. In addition to the analysis based on the survey, some case-studies about DR regulation in specific areas have been summarized in the appendix.

Further work should focus on the link between DR and distributed energy resources and on the constant evolution of the DR related regulation that may have to be adapted to the new consumption patterns (e.g. electric vehicles) and to next generation of DR and storage technologies.

LIST OF ACRONYMS AND CENTRAL DEFINITIONS

Glossary

Term	Definition proposed for this survey
Adequacy	Ability of an electric power system to supply the aggregate electric power and energy required by the customers, under steady-state conditions, with system component ratings not exceeded, bus voltages and system frequency maintained within tolerances, taking into account planned and unplanned system component outages[1]. In this survey, adequacy covers both generation adequacy and network adequacy.
Ancillary services	Services necessary for the operation of an electric power system provided by the system operator and/or by power system users System ancillary services may include the participation in frequency regulation, reactive power regulation, active power reservation, etc[2].
Balance Responsible Party	Entity responsible, over an assigned perimeter, for the equivalence between injection and subtraction of electricity from the grid. It subsequently compensates financially the System Operator (SO) for negative imbalances observed in real time, or receives financial compensation from the SO in case of positive imbalances. It contracts with consumers and producers to carry out this function, and does not therefore need any physical assets[3].
Balancing	All actions and processes, on all timelines, through which a System Operator ensures, in a continuous way, to maintain the system frequency within a predefined stability range[4].
Baseline consumption	Consumption curve of a customer or a group of customers if no control actions are executed. It has to be estimated and is used to calculate the load modification obtained from the control action[5].
Capacity market or mechanism	Solution to deliver long-term system adequacy by valuing reliable and firm capacity and thereby providing signals for necessary existing capacity to stay online or new capacity to be developed[6]. Capacity market refer to a market-based solution.
Critical peak pricing (CPP)	CPP is a hybrid version of TOU (Time of Use) and RTP (Real Time Pricing). The basic rate structure is TOU. The normal peak price is

[1] See Electropedia from the International Electrotechnical Commission. This a larger definition than the one suggested by the NERC which distinguish adequacy on a long term perspective from reliability on a short term perspective.
[2] See Electropedia from the International Electrotechnical Commission
[3] See CIGRE WG C6-09 Brochure (No. 475) on Demand Side Integration
[4] See Final Draft Network Codes on Electricity Balancing from the 23 December 2013.
[5] Based on CIGRE C6-09 definition
[6] See Eurelectric, “a reference model for European capacity markets”

	replaced with a higher CPP event price triggered by specific conditions such as reliability levels or high supply prices. The specific number of periods with CPP, the number of hours per event and per season or year is normally defined in the rate.(CIGRE C6-09).
Curtailment Service Provider (CSP)	Depending on the country or region a CSP may be an entity providing reductions in demand or more generally an entity providing demand response services, in such a case it may also be called Demand Response Provider (DSP).
Demand Response or Demand Side Response	Action resulting from management of the electricity demand responding in a coordinated fashion to electric power system or market conditions[7]. Demand Response is a potential source of flexibility for power systems. In this report both expressions Demand Response and Demand Side Response are used with the same meaning
Demand Response Operator or DR Operator	As defined in Chapter IV, this role can be performed by the consumer itself or involve a different actor with an aggregation function or the concept of service provider in some areas. The DR Operator can act for instance as • Technical operator participating to the operation of the technical solution resulting in the demand response of a consumption site • technical aggregator participating to the operation of the technical solution allowing a coordinated response combining several consumption sites • Commercial operator offering a product based on DR to a market • Commercial aggregator offering to a market a product based on DR combining several consumption sites
Demand Side Management	Process that is intended to influence the quantity or patterns of use of electric energy consumed by end-use customers[8]. In this survey, this term is used with a broad meaning covering various actions on the demand side of a power system, either long term energy efficiency actions or short term ability to respond to market or system conditions.
Demand Side Resource	End-use resources on the customer side of the meter. This may include distributed generation, storage, dispatchable load and other on-site resources capable of impacting demand for network supplied electric service[9].
Dynamic pricing	The price level that customers pay to the supplier and notification time may dynamically vary within some constraints. Critical Peak

[7] See Electropedia from the International Electrotechnical Commission and the Demand Side Resource definition used by the CIGRE WG C6-09.
[8] See Electropedia from the International Electrotechnical Commission.
[9] See defintion used by the CIGRE WG C6-09.

	Pricing and Real Time Pricing are included (CIGRE C6-09).
Implicit valuation of DR	Giving value to a DR action or availability of action through varying price signals received by the consumer for instance for its energy bill.
Incentive based DR	Incentive-based demand response programs pay participating customers to reduce their loads at times requested by the program sponsor, triggered either by a grid reliability problem or high electricity prices[10].
Interval metering	Process by which a meter (designated as an interval meter) measures and records consumption data at regular time intervals, for instance every 10 min.
Load Serving Entity (LSE)	Load serving entities (LSEs) provide electric service and electric energy to end-users. LSEs include the retailers that sell electricity to end users[11].
Load shedding	Process of deliberately disconnecting preselected loads from a power system in response to an abnormal condition in order to maintain the integrity of the remainder of the system. For instance this disconnection may be used to balance supply and demand in emergency situation.[12]
Load shifting	It involves shifting load from one time period to another time period, for instance from on-peak to off peak periods.
NEBEF	Mechanism to value electricity load reductions in the wholesale energy markets in France (see appendix B)
Net benefit test	A Net benefit test has been defined in PJM following FERC order 745 to determine the level of compensation cleared DR receives in the PJM's wholesale energy market whether that demand response creates a savings to the system greater than the cost of paying that demand response the full LMP value for its reduction [13].
Nodal price or Locational Marginal Price (LMP) or Locational Based Marginal Price (LBMP)	The nodal price or Locational Marginal Price (LMP) is the marginal cost of the next increment of energy at a specific location (node) on the electric power network, taking into account both supply (generation/import) bids and demand (load/export) offers and the physical aspects of the transmission system including transmission and other operational constraints[14].
Peak shaving (or peak clipping)	Reduction of the peak load.

[10] See U.S. Department of Energy, "Benefits of Demand Response and Recommendations"
[11] Definition based on ERCOT definition and PJM glossary.
[12] See Electropedia from the International Electrotechnical Commission and CIGRE WG C6-09 Brochure (No. 475) on Demand Side Integration
[13] See a description of FERC Order 745 by PJM for a mathematical definition of the test.
[14] See definition by California ISO and PJM Glossary

Price-based Demand Response	Price-based demand response such as real-time pricing (RTP), critical-peak pricing (CPP) and time-of-use (TOU) tariffs, give customers time-varying rates that reflect the value and cost of electricity in different time periods. Armed with this information, customers tend to use less electricity at times when electricity prices are high[15].
Reliability (of an electric power system)	Probability that an electric power system can perform a required function under given conditions for a given time interval. Reliability quantifies the ability of an electric power system to supply adequate electric service on a nearly continuous basis with few interruptions over an extended period of time.[16] Electric system reliability can be addressed by considering two basic and functional attributes: adequacy and security[17].
Real-Time-Pricing (RTP)	A retail rate in which the price of electricity typically fluctuates hourly reflecting changes in the market price (CIGRE C6-09)
Security (of an electric power system)	Ability of an electric power system to operate in such a way that credible events do not give rise to loss of load, stresses of system components beyond their ratings, bus voltages or system frequency outside tolerances, instability, voltage collapse, or cascading.[18]
Time of Use (TOU) pricing	Method of pricing electricity using different prices at different times of the day and seasons of the year.[19]
Valley filling	Encompasses increasing load in off-peak period.

Acronyms

BEMS	Building Energy Management System
BRP	Balance Responsible Party
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
CIPU	Contract for the Injection of Production Units
Cogen	Cogeneration
CM	Capacity Market or Mechanism
CSP	Curtailment Service Provider
DNO	Distribution Network Operator
DR	Demand Response
DSO	Distribution System Operator
DSR	Demand Side Response
DSM	Demand Side Management
EDC	Electricity Distrbution Company
EE	Energy Efficiency
EU	European Union

[15] See U.S. Department of Energy, "Benefits of Demand Response and Recommendations"
[16] See Electropedia from the International Electrotechnical Commission
[17] See ENTSO-E Metadata Repository (EMR) Glossary
[18] See Electropedia from the International Electrotechnical Commission
[19] See CIGRE WG C6-09 Brochure (No. 475) on Demand Side Integration

GHG	Greenhouse gas
ISO	Independent System Operator
LSE	Load Serving Entity
M&V	Measurement and Verification
OCGT	Open Cycle Gas Turbine
R&D	Research and Development
PV	Photovoltaic
PX	Power exchange
SO	System Operator
TNO	Transmission Network Operator
TSO	Transmission System Operator