The Implications of “Smart Buildings” and the “Smart Grid” on Future Energy Usage and Management in Commercial Buildings

1  - Energy Efficiency in Europe

1.1  - Meeting the European 2020 Goals

Energy efficiency is high in political agendas (U.S., Europe, Asia...) as it is widely considered as an obvious source of benefits for societies: avoiding investments in generation, reducing energy dependence, reducing carbon footprint, growing the economy, creating jobs...

In the U.S. several regulations encourage energy efficiency\(^1\). In the specific case of Japan energy efficiency has turned out to be a critical need in the frame of the current lack of nuclear generation. Energy efficiency is also one of the European Commission’s 2020 targets: cut CO2 emissions by 20%, reach a 20% share of renewable and achieve energy savings up to 20%\(^3\). In the longer term the European targets are even more aggressive: reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050\(^4\). The European vision regarding the energy sector is driven by three main goals: tackle the climate change, guarantee the security of supply and ensure competitive prices for energy. Energy efficiency is seen as a key to achieve these goals.

Meeting these 2020 targets becomes a matter of urgency: while Europe is likely to reach both the -20% greenhouse gases (GHG) goal and a 20% share of renewable energy, the energy efficiency related goal is lagging behind: only -10% expected by 2020. In this context new rules regarding energy efficiency are being proposed in order to bring the EU back on track and achieve its objective.

\(^{1}\) http://energy.gov/eere/efficiency/buildings
\(^{2}\) http://database.aceee.org/
\(^{3}\) http://ec.europa.eu/clima/policies/package/index_en.htm
Reducing energy consumption in the transportation sector remains a challenging objective. While the industrial sector is achieving significant energy reductions, the building sector (40% of final energy consumption) is the main target of European energy policies: the benefit/cost ratio is favorable, technical solutions exist and specific markets can be created to promote energy efficiency, capacity, demand response, flexibility, etc.

1.2 Enforcing Energy Efficiency through Directives and Regulations

Among several European regulations targeting energy efficiency the 'Energy Performance of Buildings' Directive (Directive 2002/91/EC, EPBD\textsuperscript{5}), first published in 2002 required all EU countries to enhance their regulations regarding buildings and to introduce energy certification schemes. With the 2010 version of EPBD (Directive 2010/31/EU\textsuperscript{6}), EU Member States face new challenges towards new and retrofitted nearly-zero energy buildings (NZEB) by 2020 (2018 in the case of public buildings). They also try to develop a cost-optimal methodology for setting minimum requirements for the buildings' envelope and the technical systems.

More recently, the Energy Efficiency Directive (Directive 2012/27/UE, EED\textsuperscript{7}) aims at achieving EU's objective by 2020. In this frame Public bodies will need to buy energy-efficient buildings, products and services, and refurbish 3% of their buildings each year to reduce energy consumption. Energy utilities will have to encourage end users to achieve efficiency improvements. Energy audits will control actual progress being made at consumers' levels. Consumers will be able to better manage their energy consumption thanks to information provided on their meters and bills. National regulators will also have to take energy efficiency into their decision processes.

To ensure an effective success of these recent measures the European Commission will carry out thorough evaluations of progresses being made by Member States, with possible regulatory adaptations if needed.

In parallel, several energy efficiency labels and requirements are emerging. Energy Star, the widely known U.S. energy efficiency label has now been implemented in Europe (EU-Energy Star\textsuperscript{8}) and provides databases of energy efficient appliances for residential and business sectors, as well as energy consumption calculators. In addition, the Ecodesign Directive (2009/125/EC\textsuperscript{9}) sets ecological requirements for energy related products sold in the EU Member States (for instance, lighting equipment, refrigerators, boilers, TVs, etc.).

At International level, ISO 50001:2011\textsuperscript{10} specifies the requirements for establishing, implementing, maintaining and improving energy management systems. Its purpose is to follow a systematic approach in achieving improvement of energy performance, including energy efficiency and energy use.

\textsuperscript{5} http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm
\textsuperscript{8} http://www.eu-energystar.org/
\textsuperscript{10} http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=51297
Over the last few years several Member States have defined regulations and national directives targeting energy efficiency (energy performance certificates, retrofitting, 'white certificates', and promotion of renewable energy resources...). These regulations have specifically increased the level of constraints for new constructions. In this already constrained regulatory environment, some Member States have set up objectives going beyond NZEB’s requirements, including zero energy buildings (Netherlands), positive energy buildings (France), climate neutral new buildings (Germany) and zero carbon standards (UK). National Plans can include "Intermediate targets for improving the energy performance of new buildings, by 2015". More than half of EU’s Member States have set such intermediate targets. A majority of countries define these targets as minimum energy performance requirements\(^\text{11}\).

1.3 - Stringent Energy Efficiency Targets in France

In France, the NF EN 15232\(^\text{12}\) standard defines the performance of control systems for energy efficient buildings while NF EN 16001\(^\text{13}\) deals with energy efficiency in buildings.

On the regulatory side the current RT2012\(^\text{14}\) (Technical Requirement 2012) sets targets for new buildings: 50kWh/m\(^2\) (average value expressed in primary energy, with a 2.58 conversion factor between electricity and primary energy). This RT2012 is in line with increased regulations at 2020 and beyond (RT2020 already plans positive energy buildings in France).

Energy consumption targets defined in primary energy can be questioned as they can prevent the use of thermal electric appliances currently being the main source of flexibility in buildings. In particular, buildings codes enforcing stringent energy efficiency goals could hamper the integration of electric water heaters in new buildings which are in fact an efficient enabler of CO2-free electricity generation thanks to their significant shaping effect on the French load curve\(^\text{15}\). The drawback of such measures would be that electric water heaters would be replaced by gas water heaters being intrinsically CO2 emitters.

\textbf{Takeaways:} Various regulations at European and Member States' levels enforce energy efficiency targets, renewable energy volumes and GHG reduction goals. These policies can interfere. The combined effects of these regulations need thorough system wide and sectors' wide evaluations, especially in a context of high expectations towards GHG reductions in Europe.

1.4 - More Energy Efficient Technologies in Commercial Buildings

Heating and cooling (depending on countries, season...) represent a significant share of the overall buildings' energy consumption. Commercial buildings tend to be comparatively more recent than residential buildings (in

\(^{11}\)Source: http://sedc-coalition.eu/

\(^{12}\)http://www.afnor.org

\(^{13}\)http://www.afnor.org

\(^{14}\)http://www2.ademe.fr/servlet/doc?id=72073

\(^{15}\)The remote control of millions of residential electric water heaters during low-load periods (nights...) allows a full integration of CO2-free base generation
Europe at least). It implies that a significant share of these buildings already meet certain energy efficiency requirements (while keeping a large potential for improvement overall). On the other hand, the energy costs in commercial buildings are quite low when comparing them to the cost of property/rent or labor costs of the employees working in these buildings. The level of ‘natural’ economic incentive to carry out significant energy efficiency targeted improvements has been rather limited so far.

On the technical side the main steps towards Energy Efficiency in buildings are: reducing energy demand, using efficient electricity appliances, etc. Technological breakthroughs help achieving these goals: thin insulating panels, external insulation, variable speed HVAC, heat pumps, etc. Thermodynamic systems like efficient heat pumps are spreading in commercial buildings along with passive cooling systems (free-cooling, geocooling).

Regarding hot water in commercial buildings we have seen several improvements targeting current hot water systems' performance but also the emergence of specific heat pumps for hot water production or combined solutions using renewable energy (solar thermal).

Lighting is also a very active domain with the development of energy efficient and innovative solutions. Significant progresses are expected over the coming years thanks to LEDs, OLEDs, use of natural light, etc.

Takeaways: The use of several energy efficient technologies and passive buildings insulation techniques allow significant energy reductions. Non-technical factors like customer engagement still need further efforts (investigations, research activities, communication, and training).

2 - Demand Response and Flexibility in Europe

2.1 - Directives and Markets Evolutions Encourage Demand Response

Greater demand flexibility enables the internal energy market to increase the amount of wind and solar power. Nevertheless the growing share of renewable generation results in a more complex energy system to plan, control and match supply and demand. Enabling DR technologies and services, including (thermal and electric) energy storage, allow mitigating these variations while reducing infrastructure costs and capacity needs.

The 2012 Energy Efficiency Directive\(^\text{16}\) requires that regulators and TSOs allow consumer access to markets through DR programs and enable the participation of aggregators “Member States shall ensure that national regulatory authorities encourage demand side resources, such as Demand Response, to participate alongside supply in wholesale and retail markets”.

In addition, the Agency for the Cooperation of Energy Regulators (ACER\(^\text{17}\)) also encourages the participation of DR, renewable and intermittent energy sources in balancing markets. The baseline is then that DR should be comparable to generation regarding energy markets and related opportunities.

The volume of controllable load in the EU reaches tens of GWs and presents a significant potential to reduce peak load periods (inducing less needs for generation peakers). Commercial buildings could be seen as the

\(^{16}\) http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

\(^{17}\) http://www.acer.europa.eu/Pages/ACER.aspx
immediate storage resource of Europe: these buildings can be pre-heated and pre-cooled and should be able to offer this flexibility to the market. Furthermore, DR and energy efficiency can work well together in commercial buildings (heating and cooling controls and management systems can be used for demand response).

Demand response is progressing slowly in the EU (specifically when comparing with the PJM market in the U.S.) Demand side products and programs are being created within the wholesale electricity market, with several aggregators coming in the markets (UK, France, etc.). Entry barriers to balancing and reserve markets still exist but are gradually being removed.

In terms of economic benefits, providing DR at peak-load is not always sufficient to cover DR provider’s required investment to manage loads. Nevertheless the trend looks favorable as new electricity uses (EV for instance) and new connected devices are likely to play a growing role. In parallel, DR equipment cost reductions are expected (standardization, interoperability, information systems embedded in the building from the construction phase). In addition, new flexibility products offer a wide range of services, going beyond the common DR activation at peak-load.

**Takeaways:** A favorable context at European and Member States’ levels increases the role of DR. Commercial buildings have a potential to provide DR and flexibility for dedicated markets. DR services are developing but a comprehensive evaluation of all economic benefits (system’s capacity investments and operational costs, grid costs, avoided GHG, etc.) needs to be undertaken. The development of AMI infrastructures should increase DR capabilities. Demonstration projects, encouraging the identification of advanced control strategies (including DR, renewable generation, energy storage, etc.) and their economic benefits, should be encouraged.

### 2.2 - Demand Response in France

France is among the European leading countries regarding market design for effective DR implementation.

EDF has used demand response activations for decades: some 12 million electric water heaters (representing about 26 TWh of annual consumption), associated with peak/off-peak electricity tariffs, shape the French load curve and allow a proper matching between CO2-free base generation and electric demand.

In several European countries, the growth in peak demand is higher than the growth in global demand (peak consumption is increasing by +1.6% year, while total demand increases slightly every year +0.8%/year). This reinforces the need for DR participation.

RTE, the French TSO, operates flexibility markets where DR is an additional efficient way to keep the balance between generation and demand and to ensure power system security in any situation. Since 2003, DR has been playing a growing role. Since 2008 RTE has been contracting DR capabilities in its system reserves traded on the balancing mechanism.18

In 2010, France passed a law to reform the organization of electricity markets and tariffs. This Act "New Organization of Electricity Markets" (NOME19) introduced a capacity market in which suppliers will have an obligation to obtain capacity certificates proportionately to their peak demand.

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19 [http://www.cre.fr/glossaire/loi-nome](http://www.cre.fr/glossaire/loi-nome)
Basically RTE relies on two main types of DR: large DR volumes provided by industries (ability to postpone load...), or aggregation of dispersed DR volumes. In 2013 the total DR capacity offered on the balancing mechanism reached up to 900MWs. The annual activation of DR volumes represents some 20 GWh.

In addition, DR is also seen as an efficient way to cope with local (regional) power system constraints: the EcoWatt\textsuperscript{20} initiative deployed in Brittany and the South-East allows to thousands of participants to reduce their load upon power system requests (for instance, Winter peak demand in Brittany or Summer peak demand in the South-East leading to local grid constraints).

AMI infrastructure can be used to provide demand response thanks to specific modules proposed by the retailers. This implementation can turn out to be very efficient to reduce the cost of DR for customers (reduction of the communication infrastructure costs in comparison to a solution where specific DR equipment needs to be implemented at the customer's premises). The Linky smart meter, about to be rolled out by ERDF, the French DSO, will then be an efficient enabler towards increased DR capabilities in buildings.

There are still discussions regarding the real value of demand response activations and their impacts in terms of CO2 emissions. Other discussions point out the fact that capacity markets should be compatible across Europe through the interconnections (thus allowing capacity from foreign countries).

An important point regarding the implementation of DR programs is to assess their overall economic benefits and the actual creation of social surplus (for instance when avoiding investments in additional peaking generation). DR options are then to be compared to alternative solutions like the procurement of power system flexibility through interconnections, the use of CO2-free flexible generation (hydro for instance), etc. It turns out that there are no obvious answers in this domain and only a careful assessment of all economic parameters at the scale of the considered power system can end up with sound and objective conclusions.

\textbf{Takeaways:} Market integration of demand-side products can provide new tools to manage peak demand and facilitate the integration of renewable on the grid. Initiatives like EcoWatt in France have proven to be particularly efficient to reduce local peak demands and reduce grid constraints. Thorough economic evaluations of DR options and possible alternatives should drive directives, strategies and investment decisions.

\section*{2.3 - Communication Protocols for Demand Response in Buildings}

Various dedicated communication protocols are emerging: they ensure the controls, measurements, feedback, etc., between the different elements of the (sometimes complex) energy management chain of buildings. Some of these protocols are vendor specific while others rely on open standards. Most of the time several communication protocols co-exist in the same building (ensuring different functions, provided by different vendors at different times...)

\textsuperscript{20} \url{www.ecowatt-paca.fr}
Examples of communications protocols for demand response and buildings:

- **BACnet**\(^1\) is a common standardized (ANSI, ISO) communications protocol for building automation and control networks. Its applications are heating, ventilating, and air-conditioning control, lighting control, access control, fire detection systems...

- **KNX**\(^2\) is a communication protocol dedicated to homes and buildings controls (lighting, energy management, HVAC systems, monitoring systems, shutters, security... KNX is approved by ISO/IEC, CENELEC, CEN and Chinese Standards.

- **OpenADR2.0**\(^3\), an open communication protocol specifically designed for DR, is gaining momentum in the U.S., Asia and Europe. Initially developed by Lawrence Berkeley Nat. Lab OpenADR2.0 is now supported by an influential Alliance while more and more vendors integrate it into their technical products. Some vendors acting in the building energy management business start implementing OpenADR2.0 from design phases. OpenADR is certified by OASIS and has recently been approved as a Publicly Available Specification (PAS) by the IEC. A working group is also working on an harmonization between OpenADR2.0 and CIM.

- Some other communication protocols are widely used though not being real standards. They are still closely linked to vendors’ solutions which implicitly hamper the interoperability with equipment proposed by other companies.

Takeaways: As for the smart grid area standardized communication protocols for DR in buildings need to be encouraged: standardization reduces technical and economic risks. On the equipment side interoperability between building’s equipments, meters, sensors and energy management systems is essential. Along with standardization and interoperability a thorough assessment of these communication protocols’ cyber security needs to be undertaken.

3 - Energy Management in Buildings

Buildings turn out to be efficient and active elements regarding energy management. The use of thermal and electric storage provides extended flexibility while energy management systems allow additional optimization.

3.1 - Thermal Energy Storage in Buildings

Thermal storage allows the use and the production of heat to be desynchronized, thus leading to active demand management. Benefits are numerous and span across peak shaving, possible reduction of installed power capacities, optimization of generators' efficiency, optimal operation of

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renewable energies, valorization of waste heat (industry) and improvement of buildings’ occupants comfort (thermal inertia).

The main storage technologies are:
- Sensible heat storage [50-70 kWh/m3]: thermal inertia of buildings, water tanks...
- Latent heat storage [100-150 kWh/m3]: phase-change materials...
- Thermo-chemical storage [300-500 kWh/m3]: endo/exothermic reactions...

Regarding hot water, several technologies are available: the resistive electric water heaters (Joule storage) are a very efficient optimization lever (as mentioned earlier). Thermodynamic hot water heaters represent the future of electric hot water heaters (though there are some inadequacies with current peak/off-peak tariffs, and the limited power induces extended charging time...).

As for heating / air conditioning, there is a need to enhance the thermal inertia of buildings in order to limit the impacts on occupants’ comfort. Additional storage capacities can allow longer DR activations. Seasonal storage solutions are also being studied (thermo-chemical storage), in particular to take benefit of the summer solar radiation.

Takeaways: Thermal energy storage remains a particularly efficient energy management solution for buildings. Several technologies allow flexibility services over different timeframes and meet most of the current and future electric power system flexibility needs.

### 3.2 - Electricity Energy Storage in Buildings

Distributed energy storage has a potential to be integrated into commercial buildings, with or without local generation (PV for instance). Different services or combination of services can be envisaged. EDF R&D studies show that a main service (voltage smoothing\(^{24}\) or primary frequency regulation) can be associated with complementary services: reduction of distribution investments linked to a SAIDI criterion, and energy arbitrage on markets.

Storage in commercial buildings can also be used to optimize the demand charges or energy subscription (fixed amount basically depending on the peak load a consumer can drag from the electric grid). Some examples\(^{25}\) already show the potential of this type of application (specific and favorable regulations apply).

The combination of different services provided by energy storage in commercial buildings is often seen as way to increase its benefits. Nevertheless it is necessary to limit the investment cost (adequate sizing regarding kW/kWh, storage cycles, efficiency, etc.) depending on the expected services to be provided. In this process it is critical to properly define the priority between grid services (for instance to define the priority between grid outage and energy arbitrage, or between frequency response procurement and energy arbitrage). It turns out that some combinations are simply incompatible (unless oversizing the storage capacity, resulting in excessive investment costs). Some combinations are compatible but with partial loss of value. Some types of services can also induce wear and tear on storage technologies.

Regulatory environment is also critical to reach the full value of energy storage: some services will benefit to the grid operator (say the DSO) while others fall into deregulated businesses (energy arbitrage...)

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\(^{24}\) In the case of overvoltage on the LV grid due to a PV producer

\(^{25}\) For instance in the frame of CPUC’s Self Generation Investment Program in California
Though the appraisal of energy storage costs and benefits highly depends on local conditions (grid constraints, load profile, local generation profile, regulatory environment…) current R&D studies show possible profitability around 2020 (based on certain assumptions regarding the reductions of storage systems' investment costs).

Takeaways: Investment costs and regulatory environment still limit the development of stationary energy storage in commercial buildings. R&D activities and experiments (smart grid demonstration projects…) allow the identification of possible sets of services that might become profitable in the medium-term (in specific situations, locations, etc.).

3.3 - Energy Management Systems

Energy Management Systems are widely recognized as critical equipment towards more energy efficient and smart buildings. Major vendors propose technical solutions covering a large range of solutions. Basically BMS systems are not new technologies as for decades we have seen building automation jumping into C&I markets (most of the time these systems cope with buildings' HVAC systems).

More recently, new features have been added on BMS that are now able to handle lighting, security, dynamic behavior depending on building's occupation, local electricity generation, water management, etc. In addition progress has been made in building monitoring systems that can dynamically represent the important variables that building operators and managers use to set up their optimization strategies (e.g. optimal operation of electric generation, use of energy storage and thermal inertia to take benefit of time-of-use tariffs, etc.).

Takeaways: Energy Management Systems allow an increasing range of functions and services benefiting to commercial and industrial buildings. The main challenge appears to be the integration of legacy equipment (previous generations' HVAC systems…), local generation (like PV or CHPs), and more innovative solutions like stationary electric energy storage.

3.4 - Building's Data allows New Services and Technical / Economic Optimization

Smart buildings extensively rely on the use of information, data and communications (inside the building but also with the outside world, and in particular with enterprise energy systems, energy providers, aggregators, weather forecasting systems, building managers, etc.). Building Management Systems connect different equipment within the building (or between buildings) with external information (weather for instance), energy management platforms, etc.

BMSs already gather data of diverse natures: formats (including temperatures, humidity, building occupation, alarms, security images or videos…) Data analytics techniques allow building managers / operators to analyze information in order to optimize energy use, users' comfort, revenues.. Data generated by smart building allow the emergence of new services to buildings' occupants. Some of these services are web-based / cloud-based.

Load disaggregation technologies build up on the availability of data (from AMI infrastructures, sub-metering, etc.). They allow a deeper knowledge on consumptions by equipment, energy efficiency related analysis, impact assessment of dynamic pricing programs, evaluations of occupants' behavior towards energy conservation, etc. In parallel, Building Information Modeling allows a continuous follow-up from design phase, to construction, to operation, etc. BIM is based on a numerical model of the building integrating its physical and technical descriptions, data from measurements and operations, etc.
Gaming techniques where buildings' occupants commit themselves (individually or in teams) to cut energy consumption are jumping into the professional world and allow companies to set up energy related challenges. Gaming parties mostly rely on near real time smart meters' data and are limited in duration. The aim is to raise the awareness of occupants regarding their use of energy, based on tangible results obtained along the games.

**Takeaways:** Data is a critical part of the smart building concept. Managing and exploring data can provide added value. Innovations combining data analytics, load disaggregation and gaming techniques penetrate the professional world, support the implementation of energy efficient measures, and raise the awareness of buildings' occupants regarding energy conservation.

### 3.5 - Zero-Net Energy Buildings Still Rely on the Electric Grid

Ensuring Zero-Net Energy Buildings (or Positive Energy Buildings like French 'BEPOS' planned in the RT2020) does not mean that these buildings are fully autonomous: even though the energy balance can be met (or exceeded) over a long period (say a year) the energy exchange with the electric grid at any moment of time is obviously needed, especially during high demand & no-generation (PV for instance) periods (e.g. late afternoons in the Winter season), or virtually no-consumption / high in-house generation periods (e.g. during early afternoons in the Summer season).

Basically ZNEBs behave like conventional buildings and rely on the electric grid whether it is to provide the full electricity consumption at peak load, to export the full in-house generation to the grid, or simply to keep the synchronous link with the electric grid and match any unbalance between generation and demand. Though the use of energy storage can help mitigating the energy transfers to/from the grid it seems unrealistic to think of purely energy independent buildings (in terms of overall economics at least).

The electric grid also provides voltage and frequency stability, the ability to drag inrush electric currents (thanks to sufficient grid short circuit power), power quality, backup power, etc.26 In this context the value provided to consumers-producers by the electric grid remains high (thus justifying investments regarding the grid's planning, dimensioning, operations, etc.)

In this context the real benefits of ZNEBs for the electric power system need to be carefully assessed: impact on the grid infrastructures and investments, impacts on bulk generation capability, power system flexibility needs to cope with increased needs for ramping (sharp increase of the net demand in the end of afternoon for instance27), impacts on ancillary services, etc. A proper evaluation of costs and benefits is needed to ensure fair grid costs allocations.

**Takeaways:** Favoring in-house generation (renewable energy) in buildings and increasing energy efficiency and flexibility through DR still needs recognition of the critical importance of the electric grid. The grid ensures a continuous energy supply and a high level of power quality while allowing the development of renewable energy, the full access to energy related markets, an economic optimization at large scale, etc.

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3.6 - Emergence of New Stakeholders and Market Players

Large companies operating in the market of buildings energy management are developing their commercial offerings and are looking for new market opportunities. New market players jump into energy efficiency and DR related activities: aggregators, service providers, startups proposing new technical solutions or businesses. In this context, large vendors of building equipment tend to develop additional activities in energy services to strengthen their relationship with customers. They can now offer bundled products: equipment and services. Some market players also offer financing services for energy efficient equipment (in that case customers engage on medium-term or long-term contractual relationships).

Stakeholders operating in buildings construction sector are also looking for new opportunities in energy efficiency and DR, aside of their core activity. IT and Telco companies are as well expecting growing market shares: extensive use of telecommunications, data, storage... In addition, the business of energy audits and certification is developing.

**Takeaways:** In this domain, the roles and interactions between stakeholders can be complex: several types of interactions and contracts between asset managers, property managers, facility managers, renters, energy managers, equipment providers, cities’ energy managers, energy providers, grid operators, energy planners... The assessment of the various stakeholders' roles can be challenging.

4 - EDF Activities regarding Energy Efficiency and Demand Response

EDF is particularly active in the domains of energy efficiency, flexibility solutions and markets, energy in buildings.smart buildings, etc. Some examples are presented hereafter (please note that these few examples do not cover the EDF Group’s whole field of activities and services in these domains).

4.1 - EDF R&D

EDF R&D supports EDF’s Business Units regarding energy efficiency (residential, commercial, and industrial sectors). EDF R&D researchers have developed specific skills and carry out advanced researches in energy efficient technologies (heat pumps, lighting equipment, insulation techniques, advanced HVAC systems, thermal and electric energy storage, cooling/heating, etc.) and energy management strategies. Through several R&D labs, field tests, demonstration projects and actual implementations, EDF R&D with EDF’s Business Units and partners assess the effectiveness of the proposed solutions. In parallel, EDF R&D develops simulation tools to assess power system needs regarding flexibility and cost/benefit analysis of different options. Regulatory and economic analysis of markets allow evaluations of best strategies, in the interest of the entire society.

4.2 - Netseenergy

Subsidiary of EDF, NetSeenergy specializes in energy efficiency and services. Its purpose is to improve the energy performance of businesses and local communities and reduce their consumption, their bills and their

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30 https://www.netseenergy.fr/
impact on the environment. NetSeenergy has acquired an almost unique expertise in the monitoring of energy and fluids in buildings and industrial processes, in the analysis of different uses (heating, cooling, lighting, process, etc.) and occupant comfort, in the optimization of energy consumption (operational experts and algorithms based on years of R&D), and in the field of I&C and communications protocols for buildings.

4.3 - EDF Optimal Solutions - EOS

Subsidiary of EDF, EOS provides energy efficiency solutions for building construction and retrofitting as well as services in building operation. Furthermore, it designs, constructs, operates and maintains Combined Heating (and Cooling) Power plants, as well as district heating/cooling networks. EOS has developed more than 2,500 projects in Europe (France, UK, and Poland) and China. EOS has more than 2,000 customers in different sectors: commercial, industrial, data centers, cities/districts, military facilities...

4.4 - Smart Electric Lyon

EDF is actively involved in Smart Electric Lyon, a project aiming at developing a wide range of innovative equipment and services to customers - experimenters to validate their relevance and measure how consumers will integrate, or not, individualized solutions for energy management. Conducted over 4 years, it is a life-size experiment, allowing 25,000 individual customers, retailers, businesses, communities and social landlords Grand Lyon experiment electrical systems of tomorrow. These customers will benefit from smart energy efficiency solutions proposed by French electricity and telecommunications companies, coupled with tariff offers and innovative services. With these solutions, customers will be involved in their consumption for comfort and economy. This project benefits from the French Government’s investment program managed by ADEME.

4.5 - NiceGrid

The project’s objective is to test the operation of a “smart” power grid with enhanced communication and response capabilities, including a high proportion of dispersed solar power sources connected to individual energy storage units. Nice Grid will develop an energy management system that will optimize the balance between power consumption and generation of electricity at the district level (residential and commercial customers). The energy management system monitors grid operating conditions (i.e. forecast solar power generation, forecast consumption, and technical constraints) as well as the extent of flexibility, in terms of generation, demand management and storage, offered by the various industry participants (electricity supplier, distribution network operator, aggregator). This project benefits from a granted funding under France’s Future Investments Program.

Takeaways: EDF is committed to providing energy efficiency related services and expertise to commercial customers: Netseeenergy and EOS specialize in this sector. Several projects and demonstrators help figuring out the best control strategies to ensure energy efficiency, power system flexibility, integration of renewable energies, and valuable services to energy consumers. EDF R&D supports the entire EDF Group with advanced research activities in energy efficiency, integration of renewable energy, and energy conservation.

31 http://www.edfoptimalsolutions.fr/accueil/index.php
32 http://www.smart-electric-lyon.fr/
33 http://www.nicegrid.fr/