# Future demand response services for blocks of buildings

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**Abstract.** Research surrounding demand response (DR) is beginning to consider how blocks of buildings can operate collectively within energy networks. DR at the level of a block of buildings involves near real-time optimisation of energy demand, storage and supply (including self-production) using intelligent energy management systems with the objective of reducing the difference between peak-power demand and minimum night-time demand, thus reducing costs and greenhouse gas emissions. To enable this it will be necessary to integrate and augment the telemetry and control technologies embedded in current building management systems and identify potential revenue sources: both of which vary according to local and national contexts. This paper discusses how DR in blocks of buildings might be achieved. The ideas proposed are based on a current EU funded collaborative research project called "Demand Response in Blocks of Buildings" (DR-BOB), and are envisaged to act as a starting-point for future research and innovation.

**Keywords: demand response (DR), smart electricity networks, micro-grids, blocks of buildings.**

## 1. Introduction

Demand response (DR) provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based tariffs or other forms of financial incentives. DR is widely recognised as being beneficial for customers, smart energy networks and the environment [1, 2 and 3]. Specifically DR offers a number of benefits to energy systems including:

- Increased efficiency of asset utilisation;
- Supporting increased penetration of renewable energy on national energy grids;
- Easing capacity issues on distribution networks to facilitate further uptake of distributed generation on congested local networks;

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- Reducing required generator margins and costs of calling on traditional spinning reserve;
- Bringing associated environmental benefits through reduced emissions.

Research surrounding DR is beginning to consider how blocks of buildings can operate collectively within energy networks [4]. However, the majority of DR implementations aimed at small or medium scale customers have failed to meet their expected potential [5]. In this sense the value chain of DR service provision in blocks of buildings for the different actors involved has yet to be demonstrated [3]. These actors include (but are not restricted to) Distribution Network Operators (DNOs), Energy Retailers, Transmission Service Operators (TSOs), Energy Service Companies (ESCOs), IT providers, Aggregators[1] and facilities owners and managers.

The potential value of DR service provision in blocks of buildings depends on the telemetry and control technologies embedded in the building management systems currently deployed at any given site and the potential revenue sources: both of which vary according to specific local and national conditions [3]. In this context, to encourage the growth of DR services and reap the potential benefits of DR, it is necessary for current research to demonstrate the economic and environmental benefits of DR for the different key actors required to bring DR services in blocks of buildings to market. This is the aim of a current EU funded project called "Demand Response in Blocks of Buildings" (DR-BOB) which is co-funded by the EU's Horizon 2020 framework programme for research and innovation.

To demonstrate the economic and environmental benefits of DR for the different key actors required to bring DR services in blocks of buildings to market the DR-BOB project has the following ambitious but achievable objectives[2]:

- Integrating existing technologies to form the DR-BOB energy management solution for blocks of buildings with a potential Return on Investment (ROI) of 5 years or less.
- Piloting the DR-BOB energy management solution at 4 sites operating under different energy market and climatic conditions in the UK, France, Italy and Romania with blocks of buildings covering a total of 274,665 $m^2$, a total of 47,600 occupants over a period of at least 12 months.
- Realising up to 11% saving in energy demand, up to 35% saving in electricity demand and a 30% reduction in the difference between peak power demand and minimum night time demand for building owners and facilities managers at the demonstration sites.
- Providing and validating a method of assessing at least 3 levels of technology readiness (1-no capability, 2-some capability, 3-full capability) related to the technologies required for consumers' facilities managers, buildings and the

[1] DR aggregation services providers are being to emerge in some EU energy markets. In Explicit Demand Response schemes (sometimes called "incentive-based") the aggregated demand side resources are traded in the wholesale, balancing, and capacity markets by energy aggregation service providers [6].

[2] The DR BOB project's aims and objectives are detailed in the DRBOB Grant Agreement (No 696114) and as such they are also listed on the European Commission's Community Research and Developments Information Service (CORDS).

local energy infrastructure to participate in the DR energy management solution at any given site.

- Identifying revenue sources with at least a 5% profit margin to underpin business models for each of the different types of stakeholders required to bring DR in the blocks of buildings to market in different local and national contexts.
- Engaging with at least 2,000 companies[3] involved in the supply chain for DR in blocks of buildings across the EU to disseminate the projects goals and findings.

## 2. Moving beyond the state of the art

There is a lack of integrated tools supporting optimisation, planning and control/management of supply side equipment [5]. As such, the majority of demand response implementations aimed at small or medium scale customers have failed to meet their expected potential [5] largely due to a lack of:

1. Relevant real-time information reaching customers from utilities due to outdated metering technologies and/or undue complexity in the presentation of information;
2. Means and abilities for customers to respond to real-time prices and demand signals, and few real incentives for them to do so;
3. Scalable integrated tools supporting optimisation, planning and control/management of supply side equipment which helps to perpetuate the energy industries general assumption of demand inelasticity [6, 7, and 8].

The assembly of existing technologies, software components and concepts into a scalable, low cost and open optimisation platform for supply/demand optimisation and its evaluation in four representative demonstrations in EU member states are the key technical innovations in the DR-BOB project. Therefore the innovation in the project lies, not in the development of new technologies but rather in the integration of existing technologies and their application for DR at the level of blocks of buildings. The approach adopted will advance the state-of-the-art and address the barriers to DR for medium scale customers through:

1. The application of compact and efficient optimisation models to fully integrate supply and demand side optimisation for de-centralised neighbourhood scale power networks involving blocks of buildings and micro-grids;
2. The assembly and testing of a low-cost and mostly open source implementation platform for de-centralised DR in blocks of buildings, micro-grids and other neighbourhood scale power networks;
3. The configuration and augmentation of existing technologies to provide simple and effective user interfaces to encourage effective DR in

[3] This figure while ambitious is based on the DRBOB project partners experience of what is achievable during projects of this type.

decentralised neighbourhood scale power networks involving blocks of buildings and micro-grids.

## 3. Demand response energy management solution

The key functionality of the DR-BOB DR energy management solution (see Fig. 1) is based on the real-time optimisation of the local energy production, consumption and storage. It is envisaged that solution will be operated by an ESCO or energy management company/ energy management department within an organisation. The criteria for the optimisation will be adjusted to either maximise economic profit or to minimise $CO_2$ emissions according to the requirements of the user. The energy management solution is intelligent in the sense that it is automated and can adapt to fluctuations in the energy demand or production, subject to dynamic price tariffs and changing weather conditions.

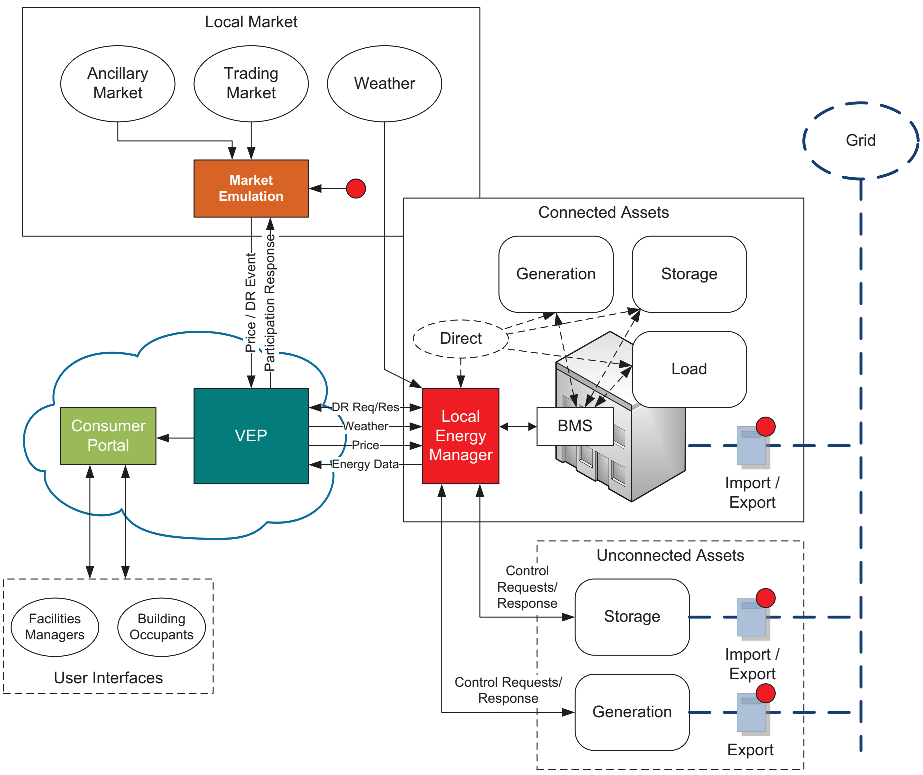


Fig.1. DR-BOB DR energy management solution

The DR-BOB DR energy management solution will provide an innovative scalable cloud based central management system, supported by a local real-time energy management solution which communicates with individual building management systems and generation / storage solutions within a block of buildings. This will be achieved by integrating the following three tools and technologies:

- Virtual Energy Plant (VEP) – Siemens DEMS® [9] & Siemens DRMS [10]
- Local Energy Manager (LEM) –Teesside University IDEAS project Product [11]
- Consumer Portal – GridPocket EcoTroks™ [12]

The VEP will provide macro-level optimised energy management and the LEM will provide micro level optimised energy management, while the EcoTroks™ Customer Portal will provide user interfaces for energy management and community engagement. The solution will be applicable at all voltage levels, directly with low voltage (LV) and medium voltage (MV), depending on the sites at which it is deployed, in the case of high voltage (HV) the applicability will be indirect as many DR requests are sourced from the Transmission Network Operator (TSO).

### 3.1 Virtual Energy Plant (VEP)

The VEP sits at the centre of the DR-BOB DR energy management solution; its role is to manage the balancing of supply, through connected and unconnected assets, and demand through the building management system across a number of buildings and sites. The VEP will take inputs on forecasted weather and current market prices to ensure the aggregated assets are best utilised. The VEP will also be the central point for demand response events and will manage the requests for generation, demand or storage to satisfy the request. As Fig. 1 illustrates, not all assets, particularly generation and storage, are directly connected to buildings, but they can be owned by building's owners and as such these owners may want to take advantage of generation and demand balancing. This is where the VEP plays a significant role, by managing the overall view of the assets (including connected and unconnected generation, storage and demand) and by making use of pricing and weather information the owners can make better use of their investments by managing energy or participating in DR events.

As indicated in the previous section the VEP consists of two Siemen's products (DEMS and DRMS), which will be integrated to create a single platform for combining generation, storage and demand energy management. DEMS provides a flexible platform for forecasting, scheduling and optimisation of distributed energy generation and load reduction. Taking weather and market prices into account, this product creates a schedule which it executes and monitors through its SCADA system. The key functionality of DEMS includes:

- **Forecasting:** Electrical and thermal loads are typically forecast as a function of the type of day (work day or weekend, for example) and time of day. The forecast of renewable energy generation is also important, and is based on the weather forecast and the characteristics of the power plants. With parameterisable forecast bandwidth, it is possible to determine the reserve and risk strategies for plant operation in advance.
- **Planning**: Short-term scheduling for all the configured units is carried out in order to minimise the costs of power generation and plant operation in

accordance with the general technical conditions and the terms of contracts. This is done in a 15-minute time grid for up to a week in advance. The calculated dispatch plan minimises generation and operating costs. DEMS takes both economic and ecological factors into consideration and can accommodate complex energy-supply/purchase contracts with power-zoned energy prices, time-dependent tariff structures, power bands, and energy limits.

- **Optimisation:** The optimised dispatch plan for thermal power plants takes into account power-up costs, maximum output ramps, minimum operating and shutdown times, fuel quantity limits, and energy limits, as well as time-dependent fuel prices. With regard to energy demands, equipment dispatch planning differentiates between three types of loads: independent loads, switchable loads, and controllable loads. Storage systems are managed according to specific user requirements. Real-time optimisation can be achieved based on the dispatch plan, any deviations are distributed cyclically at minimum cost among generators, storage systems, and loads, so that the planned value can be met. In this way, any external stipulations relating to import, supply, or corresponding contracts can be fulfilled.

DRMS (see figs 2 and 3) allows utilities and ESCOs to manage all aspects of their DR programs through a single, integrated system which provides an automated, integrated, and flexible DR solution.

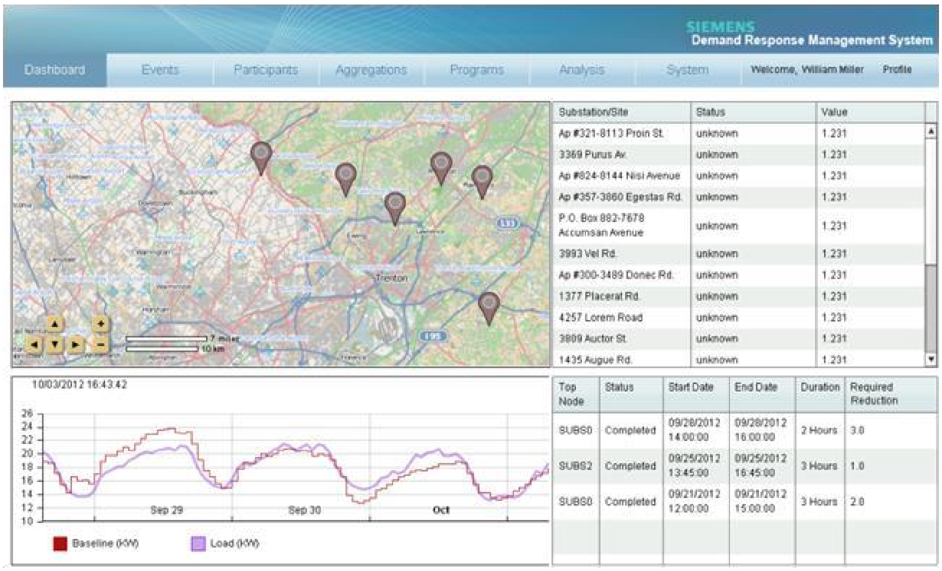


Fig. 2. DRMS Dashboard

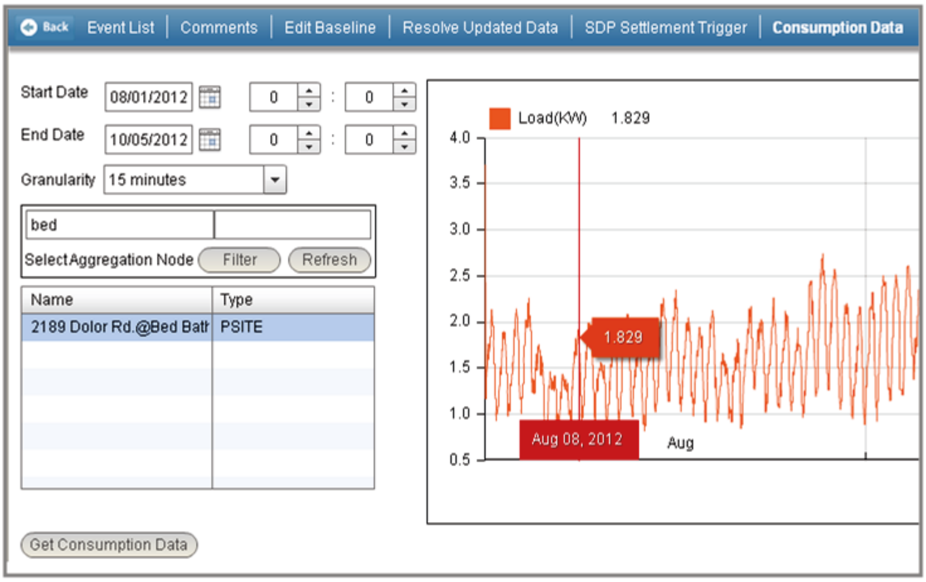


Fig. 3. DRMS Consumption Data screen

DRMS compliments DEMS by providing load reduction through surgical DR as it provides the ability to target, a single asset or all assets in an area, or all assets attached to a given network device (such as a feeder or transformer).

- DR capacity can be cost effectively scaled by automating the manual processes that are typically used to execute DR events and settlement.
- DR resources can be used in a more intelligent and efficient way by planning and executing load shed at grid locations where the utility has more benefit.

DRMS can be configured to support multiple types of DR programs providing both emergency and economic dispatch. DRMS can interface with residential, commercial, or industrial sites to provide more flexibility in how ESCOs create their DR programs. DRMS also provides the ability to define workflow processes so that DR events are managed according to utility business processes.

### 3.2 Local Energy Manager (LEM)

The VEP capability will be further enhanced by the introduction of a Local Energy Management tool (LEM). Instead of the VEP having to scale to meet the real-time needs of potentially many buildings and their specific energy management requirements; and for the VEP to be continually updated in real-time with status information; the VEP will hand off this responsibility to individual LEMs. This will improve reliability and reduce costs because the communications and centralised computing will be kept to a minimum. As the LEMs will be deployed locally to the buildings (if they are close enough), they will be able to manage the energy usage much more effectively.

Building management has come a long way since it was first introduced, the methods used to control the HVAC, lighting and other energy consumers is becoming much more sophisticated. However, when looking at a DR Energy Management Solution such as that discussed here, where some of the buildings, and the BMS solutions they have deployed, are becoming antiquated in their capabilities and unable to manage the addition of generation and storage assets, the LEM plays an important role in the energy management of the building by providing the additional capabilities needed to optimise the operation. The LEM will be based upon a rack-mounted industrial server supplied by Siemens and will be equipped with heat and electrical load prediction and compact commitment/dispatch optimisation software developed previously in the IDEAS project. Fig. 4 presents a screen shot of the IDEAS tool demo version.

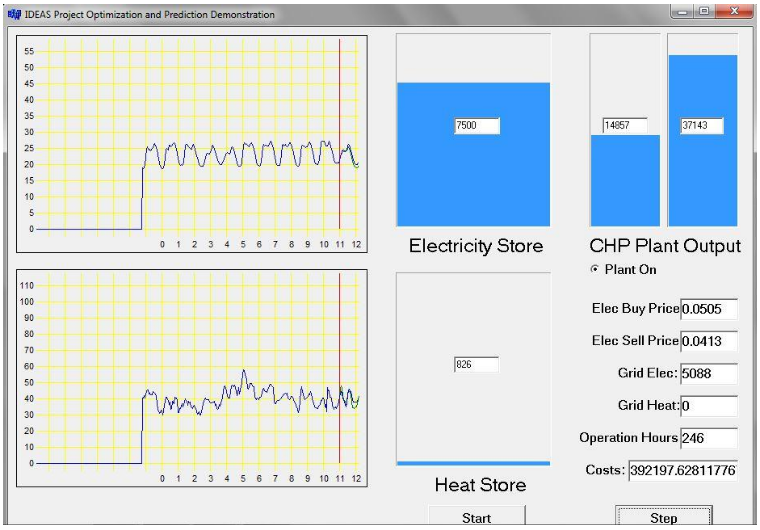


Fig. 4. IDEAS neighbourhood energy optimisation and prediction tool

The LEM will integrate with the local generation and storage assets and BMSs to manage demand. This integration will enable the LEM to manage the assets locally by taking a local view of the buildings environment. Also, where assets aren't directly connected to the BMS, which is often the case with generation, the LEM will be able to integrate directly. By taking this local view the LEM will be able to take the responsibility for the decisions on what load, storage or generation it has to spare, informing proactively, or on-demand, the VEP of its status so that DR events can be dispatched appropriately. Technically, the marginal prices for shifting and shedding load will be regularly communicated in the form of contract options to the VEP which acts to reduce peak loads. Following the occurrence of a specific DR event in the local market, the LEMs may also resolve the local commitment/dispatch optimisation problem subject to additional inequality/equality constraints to recover a specific price for implementing the DR request, which is communicated back to the VEP. This is a form of two tiered decentralised optimisation which is known to be effective in smart-grid applications [13]. In addition to reducing computational demands upon the VEP, the proposed integration with the LEM will increase security, as detailed internal operational information related to a building does not need to leave the domain managed by LEM

The optimisation embedded in the LEM will build on work conducted as part of the IDEAS project.[4] The generic approach shown in the Fig. 5 illustrates how the real-world data and predictions will be used for optimisation and decision support. It is planned to handle direct automation with building energy infrastructures via interfaces to BMS. As with many technology evolutions, the components that go to make up the whole are kept separate to prove their capabilities before being combined to reduce costs in the production process and for the end user. Following this philosophy the LEM, the BMS and other generation controllers are to be kept separate for this project to prove the concept; it is perfectly feasible to assume that this functionality could be embedded in the BMS at a future stage.

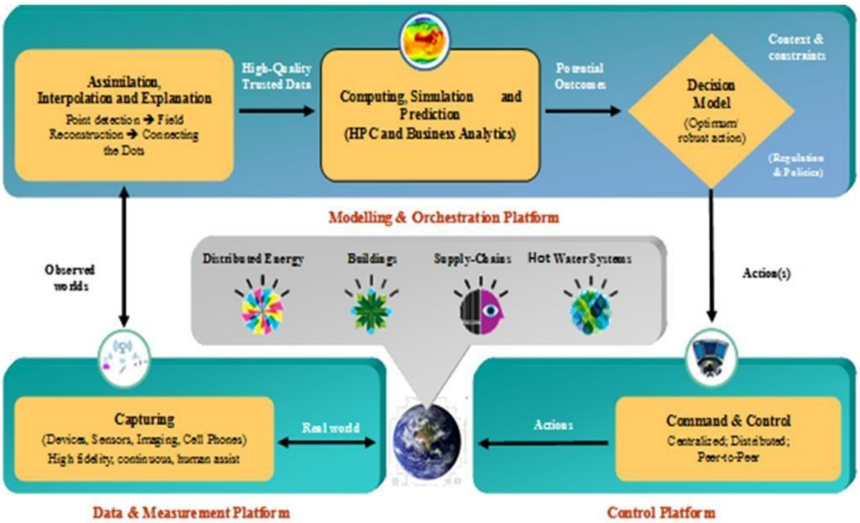


Fig. 5. Optimisation and decision support architecture

### 3.3 EcoTroks™ Customer Portal

[4] IDEAS Collaborative Project (Grant Agreement No. 600071) which was co-funded by the European Commission, Information Society and Media Directorate-General, under the Seventh Framework Programme (FP7), Cooperation theme three, "Information and Communication Technologies', http://www.ideasproject.eu

The EcoTroks™ application is multi-device friendly and based on unified platform for all web browsers, including tactile web terminals [12]. It has several customisable features and extendable widgets and supports multiple languages. Essentially it will provide a customer portal (see Fig. 6) with an online guide and stimulation tool for energy users. EcoTroks™ can be used to engage users in DR using functionalities based on behavioural theories designed to improve smart grid stability and performance. EcoTroks™ motivates people to reduce energy consumption, use DR tools and shift consumption to off-peak hours by proposing gamification scenarios, personal and group challenges, auto-reflexive consumption visualisation and contact with relevant communities. It helps users to understand the impact of actions on energy consumption via personalised interfaces, accessibility of EcoTips and achieves sustainable change by motivating users via virtual currency.

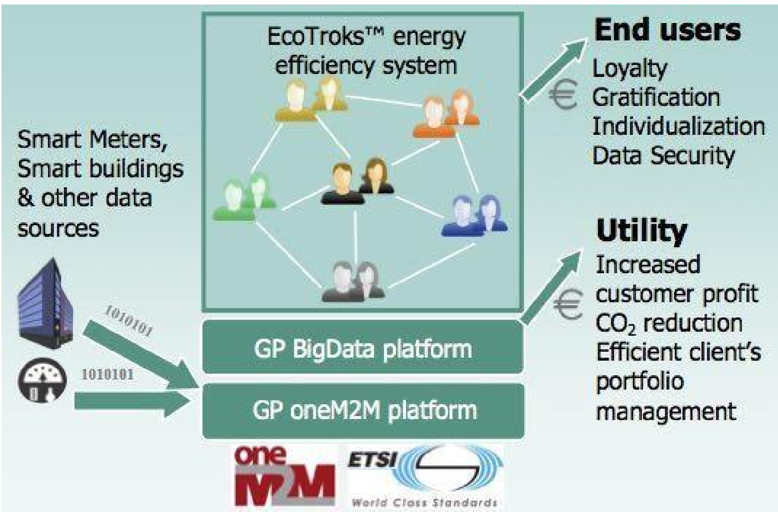


Fig. 6 GridPocket EcoTroks™ platform overview

Consumption analysis features include:

- Analysis of daily consumption graphics;
- Historical daily, monthly, weekly, yearly consumption insights;
- Real-time consumption analysis;
- High level data disaggregation (air-conditioning, heating system, hot water);
- Peak / Off peak hours consumption control;
- Actual energy costs and spending (support multiple tariffs);
- Consumption prediction for performance analysis.

### 3.4 Systems configuration

The configuration of the DR-BOB energy management solution will allow energy management companies to provide varying levels of control from the centralised macro-view, through to localised complete control of the energy systems at the building level, the micro-view. The solution will utilise existing standards such as IEC60870-5-104 and OpenADR, and an architecture that will enable new adaptors to be added to support new standards in the future. These standards allow access to most generation, storage and load assets. It is expected that any new interfaces between the platform and the ESCO could form the basis for new standards.

In combination, DR-BOB DR solution will provide open connectivity to both SCADA/utility communications and customer side advanced metering infrastructures. The decentralised approach – allowing both supply side and DR to be hierarchically optimised between blocks of buildings and other infrastructures, with automatic distribution of results via building management systems – removing some of the burden and alleviating the complexities involved in individual customer or resident participation.

The advantage of Siemens products in this solution is their support for standards such as IEC61879-5-104 and OpenADR, and flexible architecture that will enable new adaptors to be added to support new standards in the future. These standards allow access to most generation, storage and load assets. It is expected that any new interfaces between the platform and the ESCO could form the basis for new standards.

## 4. Demonstrating the DR-BOB energy management solution

The DR-BOB energy management solution will be demonstrated at four pilot sites over a period of twelve months. The pilot sites include two public university campuses one in the UK and one in Romania, a technology park in France and a hospital block in Italy (see Table 1).

Siemens PSS®SINCAL [16] software will be used to provide decision support at the four pilot sites regarding optimal number and type of buildings to be part of the block of building energy management system, placement of distributed renewable energy generation, CHP plants, storage and electric vehicle charging stations, as well as built-in passive flexibility of buildings within the block while meeting thermal comfort requirements. PSS®SINCAL is a mature technology that is used by over 500 organisations worldwide, including some 300 in Europe. PSS®SINCAL provides a full unbalanced power system model for high, medium, and low-voltage grids and supports the design, modelling and analysis of electrical power systems, as well as pipe networks, such as water, gas, and district heating/cooling systems. Through its modular and fully integrated design PSS®SINCAL enables a high level of customisation according to individual needs, making it the optimal solution for all planning tasks in the areas of generation, transmission, distribution and industrial grids.

Table 1. DR-BOB pilot site characteristics

| Site | Buildings | Technologies | Climate[5] | Market [6] | Targets |
|---|---|---|---|---|---|
| UK | Educational, office, catering + low rise residential | CHP, EV charging stations, RES (PV) | Temperate oceanic (Cfb) | British Isles | -17% el. demand<br>-7% en. demand<br>-30% peak-min d.<br>ROI 5 yrs. |
| FR | Workshop, training centre, office | Microgrid, EV charging stations, RES (PV), electric storage | Temperate oceanic (Cfb) | Central Western Europe | -11% el. demand<br>-11% en. demand<br>-30% peak-min d.<br>ROI 5 yrs. |
| IT | Healthcare + office | RES (PV), thermal storage, CCHP (trigeneration), DH | Humid subtropical (Cfa) | Apennine Peninsula | -9% el. demand<br>-6% en. demand<br>-30% peak-min d.<br>ROI 1 yr |
| RO | Educational, leisure, office + high rise residential | RES (PV, wind), thermal storage, CHP | Temperate/ humid continental (Dfb) | Central Eastern Europe | -35% el. demand<br>-10% en. demand<br>-30% peak-min d.<br>ROI 3.9 yrs. |
| **Total** | **274,665 m$^2$**<br>**47,600 occupants** | **8 different technologies** | **Represen-tative of 61% EU** | **4 out of 7 EU markets** | **-8% en. demand**<br>**-21% el. demand**<br>**-30% peak-min d.**<br>**ROI < 5 yrs.** |

The demonstrations will be conducted in three main phases:

- The first stage will investigate application and acceptance of the DR measures at the demonstration site in the UK, including market analysis and financial implications.
- The second stage will involve the implementation and monitoring of the cloud based infrastructure performance at the other three demonstration sites in France, Italy and Romania, including the decision support tool for control management, and user interfaces at all four demonstration sites over a period of one year.
- The third stage will develop and evaluate EU wide deployment strategies and business models to fit different energy markets operating across Europe. It will illustrate the value proposition underpinning the business cases for all stakeholders and discuss specific investment strategies.

[5] According to Koppen climate classification [13]
[6] Regional wholesale electricity markets [14]

## 5. Demand Response Markets

The ability to realise the benefits of DR is dependent on the market structure and the way in which varies across the different countries in the EU. In the case of the utilities the business value to be gained from investment in DR in part, is dependent upon how the supply, distribution, transmission and generation functions of the utilities industry are distributed between the different actors in the energy supply chain. This varies across the EU depending upon the degree to which, and way in which, different EU countries have unbundled these traditionally vertically integrated markets. Essentially the way in which the functions of the utilities are separated affects the impetus to promote integrated resource planning and therefore decreases the value proposition underpinning load management initiatives [17]. This is illustrated by research, which indicates that the way in which the utilities industries have adapted their corporate structures to adhere to the EU directives for the unbundling of the utilities industry effects the value creation available from renewable energy generation and investment in smart metering and smart networks [18]. These findings are further emphasised by research which highlights that the liberalisation of the utilities industries can have conflicting consequences for the implementation of demand side management within energy supply and sustainable business practices in general [19].

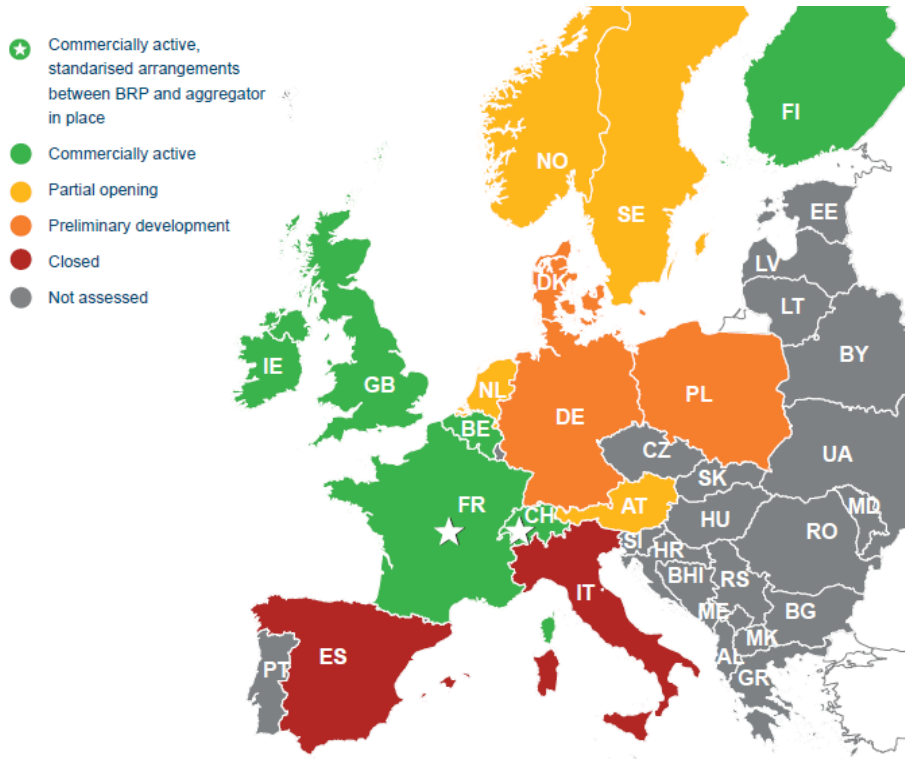


Fig. 7. Demand Response Map of Europe 2014 (Source [6])

Some European energy markets are more mature in terms of their support for demand side management than others: particularly in relation to the introduction of variable and time of use tariffs [4]. Nevertheless, a market for DR is emerging in some EU countries [6]. Six European countries already provide a regulatory framework allowing for the development of DR services: Ireland, Great Britain, Belgium, France, Switzerland and Finland (see Fig. 7). Although there are remaining regulatory issues. Explicit DR is a commercially viable product offering [6]. In the UK for example the potential revenue sources for Energy Retailers, Distribution Network Operators (DNO) and Transmission Systems Operators (TSO) are growing (see Fig. 8 and Table 2).

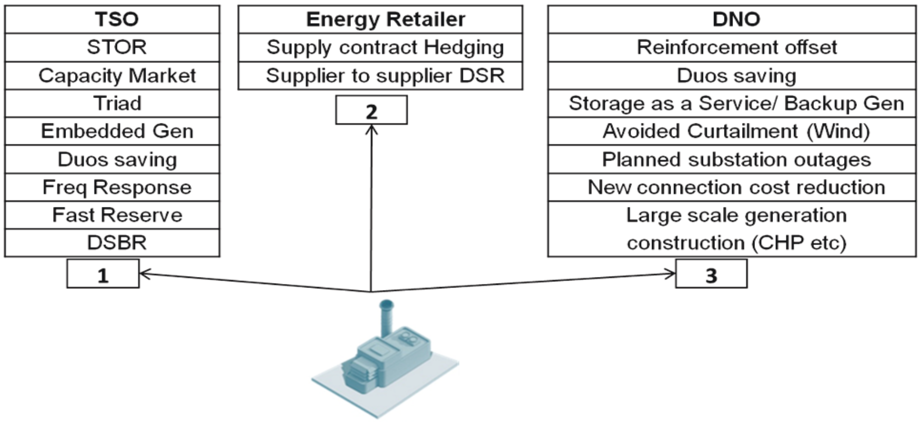


Fig. 8. Contract models – new and pending – where an asset could participate[7]

Table 2: Available UK contract model descriptions

| Programme | Description |
|---|---|
| STOR | UK National Grid Short Term Operating Reserves (STOR) programme is part of National Grid's Balancing Mechanism. The programme is open to both supply side and demand side generators. The primary purpose of the programme is to provide frequency regulation in response to short term interruptions to supply. |
| Capacity Market | The UK government has introduced a capacity market to ensure the electricity system has adequate supplies available in the future. The available capacity payment may make it economical to build small, quickly despatchable distributed generators without needing to rely on energy market revenues. |
| Triads | The Transmission Network Use of System (TNUoS) charges or 'Triads' are the three half-hour periods that electricity demand is at its highest across the UK. These periods can fall between the beginning of November and the end of February. Energy supply companies will charge medium-large enterprises significantly more during these three half-hour periods to penalise consumption during peak times. Through triad management medium and |

[7] Model developed by Siemens from literature and conversations with regulator and market participants.

| | |
|---|---|
| | large enterprises can lower their energy demand or take their businesses off the network and run on standby generators when the peak half-hour period is expected to occur. |
| DUoS | Distribution Use of Systems (DUoS) is a time of use tariff similar to triads. However, DUoS happens on a daily basis and is added onto the monthly electricity bill. It is the charge for receiving electricity from the national transmission system and transferring it to the distribution level to be used in homes and businesses. DNOs charge energy supply companies, such as British Gas, E.ON, and others, who then pass these charges onto electricity bills to cover the costs of installing, operating and maintaining the network. DUoS can account for up to 12% of the charges on an electricity bill for half-hour meter industrial and commercial customers. |
| Frequency Response | System frequency is a continuously changing variable that is determined and controlled by the second-by-second (real-time) balance between system demand and total generation. If demand is greater than generation, the frequency falls while if generation is greater than demand, the frequency rises. The UK TSO, National Grid, will pay a premium for participation in such events. |
| Fast Reserve | Active power delivery must start within 2 minutes of the despatch instruction at a delivery rate in excess of 25MW/minute, and the reserve energy should be sustainable for a minimum of 15 minutes. Must be able to deliver minimum of 50MW. Fast Reserve provides the rapid and reliable delivery of active power through an increased output from generation or a reduction in consumption from demand sources, following receipt of an electronic despatch instruction from National Grid. |
| Retail Supply Side Contract Hedging | Retailer specific demand response includes: being able to optimise the market based transactions that can have the ability to help realise significant savings being utilised as a hedge against their supply-side contracts, or generate maximum revenues at times of high demand and increased supply prices. Essentially suppliers will use demand side response (DSR) within-day (period between day-ahead and gate closure) to re-align their positions. |
| DNO Traditional Network Reinforcement Offset | Used by local network to avoid or defer network reinforcement. The DNO will use DSR to tackle planned outages and unplanned outages as well as critical peak scenarios. Requirements for planned outages are generally known at least one day in advance. For unplanned outages, DSR will need to be called sufficiently quickly to prevent a circuit trip or risk of unacceptable loss of asset life due to thermal stress on network components. For subsequent outage days, DSR units may have 24 hours of notice. |
| Avoided Curtailment | Increase demand to avoid wind curtailment or to soak up solar output. These issues are intrinsically related to the management of intermittent generation (intermittency Management). Suppliers (vertically integrated entities), the Service Operator (SO) or even wind portfolio players may wish to increase demand to avoid wind/solar curtailment or reduce demand to mitigate the effects of low wind periods (low wind periods typically coincide with peak price periods especially in the winter).<br><br>In addition, the SO may wish to use DSR to reduce the level of peak generation capacity needed on the system. This will be incentivised through the capacity payment. |

To address the uneven development of markets for DR in blocks of buildings the DR-BOB project will seek to identify how mechanisms for DR from more mature markets could be implemented in EU countries with less mature markets for DR. The results will provide feedback to the market participants with recommendations on how that country could adopt a new mechanism and what value there is in doing so for the different actors involved in the value chain required to bring DR in blocks of buildings to market.

## 6. Conclusion

The assembly of existing technologies, software components and concepts into a scalable, low cost and open optimisation platform for supply/demand optimisation and its evaluation in four representative demonstrations in EU member states are the key technical innovations in the DR-BOB project. The proposed work is ambitious in that specific solutions to identified problems and barriers to effective DR are intended to be developed, but also realistic in its stated aims.

The individual components required for the DR-BOB DR energy management solution are already in existence and in some cases mature. For example, open communication architectures, protocols and standards definitions (e.g. IEC 60870-5/6, OpenADR) and efficient open-source Mixed Integer Linear Programming (MILP) tools such as LPsolve are in widespread use. In addition, several proposals have been made for decentralised supply/demand optimisation in micro-grid environments using agent-based techniques. However the effectiveness and reliability of these latter techniques has not been extensively demonstrated in real-test systems', and this is seen as a key impediment to their widespread use. The approach presented in this paper seeks to remove that impediment. The DR BOB project will run from March 2016 until February 2019 and the first results of the project are due in 2017

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