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DR-BOB

DEMAND RESPONSE IN BLOCKS OF BUILDINGS
DELIVERABLE: D2.2 – DEMONSTRATION SCENARIOS

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Project Consortium

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DoA	This task focuses on the definition of the four demonstration scenarios. In particular: ➢ The four demonstration cases (i.e. buildings' structures, local context, available technical equipment, occupants, stakeholders/decision makers, specific objectives, technical/socio/economic-constraints, known issues, areas of improvements, etc.) are analysed and described. ➢ A workshop with stakeholders/decision makers of the four pilot sites, the experts from the Energy Expert Group (EEG), and other relevant actors is conducted to understand expectations and discuss possible scenarios. ➢ Based on the results of the above activities, a sample of demonstration scenarios is defined and described.		
	The deliverable D2.2 provides the following items: ➢ detailed description of the four demonstration cases; ➢ detailed description of the demonstration scenarios for each pilot site; ➢ stakeholders' expectations report and insights.		
Contribution of partners	NOBATEK has structured this report and coordinated the collection of information from the different partners involved in task 2.2. The partners involved in the management of the pilot sites of the project (TU, NBK, FPH, TUCN) have provided the information related to the demonstration sites and elaborated the demonstration scenarios on the basis of the draft of demonstration scenarios provided by NOBATEK for the French pilot site. Each pilot site manager (TU, NBK, FPH, TUCN) has conducted individual discussions, workshop and interviews with the local stakeholders in order to collect the information which is provided in annex E (see section 6.5). GP and a member of the Energy Expert Group (EEG) have peer reviewed the document and formulated comments.		

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EXECUTIVE SUMMARY

This report establishes scenarios for demonstration of economic, environmental and social benefits of DR management through a detailed description of four DR-BOB demonstration sites. The demonstration sites are described through:

- Geographical location, which determines climate conditions and types of power network;
- Building parameters such as building structures and available technical equipment;
- Energy production and consumption information during the past years;
- Local context which relates to regulatory framework with its incentives and limitations and technical/social/economic constraints.

Depending on its operation and existing electricity market conditions, Demand Response (DR) can provide a large variety of economic, technical, environmental and social benefits to both internal and external stakeholders. This document assesses the needs and expectations of local relevant stakeholders, which are directly benefitting from the DR management. It provides also the general description of management tools which will be implemented on sites. This report constitutes a strong basis for later implementation of DR scenarios planned within the timeframe of Work Package 4 and for development of the monitoring and validation strategies being part of Task 5.1.

The methodology employed is based on the collection of information and data about demonstration sites by the standard methods including questionnaires, discussions with people, individual interviews, collective workshops and literature and internet searches. The local stakeholders who have been interviewed are those with high influence and power related to implementation of a local DR management (D2.1). They are owners, decision makers, facility managers, estates and maintenance services. The list of interviewed people has been proposed by the demonstration site managers according to their availability. The demonstration scenarios definition has been developed by the demonstration sites' managers with the support of all the consortium partners and the members of the Energy Expert Group (EEG).

The DR-BOB solution will be implemented at the four demonstration sites:

- University of Teesside (United Kingdom). This demonstration includes a single block of buildings with four old and recent educational buildings located closely in Middlesbrough. The buildings of this demonstration site are governed by a single owner;
- Technology Park Montaury (France). This demonstration includes a single block of buildings with three recent office and workrooms buildings located closely in Anglet. Each building in this block of buildings is governed by an independent owner;
- Private hospital, Fondazione Poliambulanza (Italy). This demonstration includes a single block of buildings with four recent medical and health care buildings located closely in Brescia. The buildings of this demonstration site are governed by a single owner;
- Technical University of Cluj-Napoca (Romania). This demonstration includes several blocks of buildings spread over the city Cluj-Napoca with twelve old educational and residential buildings. This demonstration site is governed by a single owner.

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These demonstration sites allow testing DR management for business-models (developed in Task 2.4) with one single BOB owner, with multiple owners, and within different energy related use cases:

- Educational buildings with high electricity consumptions related to computers, cooling, ventilation and lighting at UK demonstration site. The electrical energy is mostly imported from the grid but is supplemented by local generation systems: a CHP of 230 kWe power and a PV system of 35 kWp. Diesel-fired backup generators, which have a capability to respond at very short time, within some seconds, are installed to provide power to IT servers in the case of blackouts or for maintenance needs. The buildings are highly occupied during the daytime (8:00-17:00), computers and cooling systems show potential for shifting of energy during the occupancy period, and electric vehicle charging could be shifted to avoid peak network rates.
- Educational and student's dwelling buildings with high energy consumptions related to HVAC, lighting and computers/personal electronics at Romanian demonstration site. The heating energy is produced locally by some gas boilers and small CHP (40 kWt), the electrical energy is mostly imported from the grid and supported by local small CHP producing energy for swimming pool (20 kWe) and small PV generation system (4 kWp) used for educational purposes. The gas is used for space heating, DHW and for cooking in the 2 restaurants. The lighting system is responsible for more than 35% of the total electricity use; one energy optimisation action related to installation of presence detectors and new more efficient LED lightings is planned during the DR-BOB project. AC units and servers cooling have a highest potential for shifting of energy, it could be time-shifted for at least 15 to 30 minutes. The dishwashers and washing machines could also be involved into shifting to off-peak periods.
- Medical and health care buildings with very high energy consumption related to chillers, air conditioning systems, lighting and specific machines for production of steam and hot/cold water at the Italian demonstration site. The heating energy is provided by district heating and produced locally by some gas boilers, the electrical energy is mostly imported from the grid and supported by a PV system of 121 kWp of power. Five diesel-fired backup generators, which are never used, are installed at the site to backup energy for vital medical services. A trigeneration CCHP (Combined Cooling, Heat and Power) plant of significant output power is planned to be installed during the period of the DR-BOB project. It is anticipated to cover about 80% of total energy demand. The buildings are mostly occupied 24h/24 7d/7. Many of the buildings' loads are critical since the comfort and safety of all patients must be guaranteed. The measures that appear to be the most suitable and feasible for DR are related to curtailing of lighting, setting back of chillers, shifting of non-critical loads to off-peak periods and switching to onsite backup generation.
- Block of tertiary buildings with low energy demand and electricity consumption related to heating, ventilation, computers and specific machinery at the French demonstration site. The electrical energy is mostly imported from the grid and supported by a PV

generation system of 59 kWp. Another PV system of 30 kWp is installed in one building; and all its energy produced is sold to the grid. The heating energy is produced by heat pumps, gas and wood boilers. Small UPS are present to backup energy for IT servers. The buildings are highly occupied during the daytime (8:00-19:00); heating systems, ventilation and computers represents high potential for time-shifting of energy.

All these demonstration sites are linked to local electricity market conditions which may or may not have explicit, active demand response programmes. However, the potential DR scenarios at each site have been mapped against the Demand Response Program Templates identified in the OpenADR 2.0 Demand Response Program Implementation Guide (OpenADR Alliance, 2016). The most suitable and feasible DR programs for a BOB are Direct Load Control (DLC) program, and Distributed Energy Resources (DER) program.

It is to be highlighted that in most of European countries the electricity DR markets, where they exist, are effectively open only to large industrial consumers, because they can offer a significant potential for power and energy reduction. Blocks of buildings can't typically offer such significant power reduction and in this way can't meet sole minimum power reduction requirement to participate into the electricity market. The BOB resources need to be aggregated with other resources by some third parties such as aggregators or balance responsible entities. The electricity markets accepting aggregated resources to participate in are the UK and French markets. Italian regulation allows access to the market for flexible consumers in a single or aggregated form, but the conditions for participation into balancing and DR programs aren't yet defined. In the Romanian case, there is no regulation, or existing DR or balancing programs. The regulation framework is to be defined.

The scenarios for DR have been defined for each demonstration site and the main characteristics of these scenarios are summarised in the following tables. These scenarios will be trialled first but may be updated or supplemented during the implementation of the project as additional information or ideas are identified by stakeholders or local market opportunities change.

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
UK pilot site				
Electrical Demand Reduction	Self-consumption of local energy production	CHP Plant	Switch on CHP plant and reject heat when grid electricity demand exceeds supply	Capacity is not large (220 kW) Contract issues with Ener-G require negotiation
	Modification of HVAC and Chiller operations	Chillers	Temporary increase of ambient temperature set-points (chillers)	Capacity may not be large
		HVAC	Temporary reduction / suspension of HVAC operations	Capacity may not be large Current controls do not function well: some improvements may be required
Electric Demand Increase	Cease self-consumption of local energy production	CHP Plant / Boilers	Switch off CHP plant and activate boilers to cover heat load when grid electricity supply exceeds demand	Capacity is not large (220 kW) Contract issues with Ener-G require negotiation
Electrical Peak Demand Reduction	Shifting of local energy consumption	Open access Labs / EV Chargers	Shifting of usage of lab equipment and EV charging to better times	Requires setting up an email list of technical lab managers, EV users and user screens
Frequency Regulation/Emergency Load Shedding	Shedding of local electricity consumption in critical conditions	IT Server UPS / Diesel generators	Fast load curtailment during times of grid distress (low frequency)	Capacity may not be large, requires simulation models and installation of frequency measurement equipment

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
French pilot site				
Electrical Peak Demand Reduction	TOU (Time-of-Use)/ similar to TOU (Tempo) tariffs	All electricity powered	Shifting of the important loads from Peak-hours to Off-peak hours	Need to be contractualised between supplier and consumer
	TOU (Time-of-Use)/ similar to TOU (Tempo) tariffs	All electricity powered	Shifting of the important loads from the red and white days to blue days of Tempo tariff	
Electrical demand reduction	Load curtailment or shedding of important loads	Heat pumps of building	Shifting of outside block of heat pumps composed by the compressor, evaporator and condenser	Depends on the functionalities of the BMS
		Cooling heat pumps for server room	Precooling and Temporary increase of ambient temperature set-point	
		On/off secondary pumps of heat pumps (NBK)	Shifting of secondary pumps by optimising management of pump controller by: - Temporary decrease of ambient temperature set-point during winter months; - Temporary increase of ambient temperature set-point during the summer months;	Depends from the functionalities of BMS

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
			Temporary switching from the Comfort mode to the mode No Frost	
		Computers (NBK, FCMB, BI)	Wide use of laptops by NBK and FCMB staff allows the manual (or automatic if possible) switching to the batteries supply	Possible nuisance for the users affecting willingness
		EV batteries/ UPS backup power batteries for server room	Use the electricity stored in the EV or UPS backup power batteries installed in NBK building during the peak hours or during the periods of peak tariffs	Absence of company's EVs; Need of multiple EVs ; Limitation for use of EVs by staffs
Gas demand reduction		Heat production systems of FCMB	Temporary decrease of ambient temperature set-point during the winter	
Electrical demand reduction	Self-consumption of local energy production inside the demonstration site area	PV panels	Self-consumption of local production during the workdays by the building producing energy Exchange of electricity locally produced between loads of the buildings belonging to the BOB considered	Need to be contractualised between utility and consumer; Areas for new plants are limited or not available The electrical distribution systems of buildings need to be interconnected

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
Italian pilot site				
Electrical demand reduction	Load shedding program	Lighting	Dimming or turning off lights in non-critical areas (limited to some small areas)	Safety issues related to not lighted areas. The BMS doesn't allow a single lamp control.
		Cooling and heating assets	Modify temp. setpoint in unoccupied areas. Switch cooling/heating system	User comfort during start up time
		Ventilation	Dynamic ventilation control according to the occupancy	CO2 sensors required an VSD on AHU fans
		Non Critical Appliances	Turn off appliances that can be disconnected without functional risk – (i.e. automatic PC hibernation after 30min of unused)	Users resistance to change.
		Water distribution pumps	Regulate flow rate based on actual demand with VSD	Need to buy and install VSD to the pumps and implement a system regulation.
Electrical Peak Demand Reduction	Load shifting	Food preparation	Warming up food for patients can be shifted in case of necessary for a small period of time (30min)	Part of the activities of the personnel must be reschedule
		Cooling/Heating	Pre or post cooling or heating areas	Risk of discomfort for a limited period of time.

DR-BOB project DR program/Impact target	**Possible DR measures at BOB scale**	**Building assets to be targeted by the DR measures**	**DR measure's description**	**Barriers**
		Ventilation	Over ventilate areas prior to an event	Risk of discomfort for a limited period of time.
		Mobility, electric vehicles, Electric storages	During off peak, electric vehicles can be recharged.	Risk of delay in charging the vehicles
Electrical demand reduction	Self-consumption from CHP system	Electric energy, thermal energy, refrigeration	Use the electric energy and the thermal for the most time possible. Never sell electric energy to the grid. Use absorption chillers or electric ones as convenience	None
Romanian pilot site				
Electrical Peak Demand Reduction	Time-of-Use tariff (virtual solution for the moment)	All or most of the electricity powered equipment	Shifting of the important loads from peak hours to normal usage hours	No such tariff program for public entities in Romania yet. A contract has to be signed between supplier and consumer
Gas demand reduction **Partial Electrical demand reduction;**	Load curtailment or shedding of important loads	Heat production systems of Buildings used for Teaching and Management	Temporary decrease or increase of ambient temperature set-point during the winter. Different temperature set-points for workday, weekend, daytime and night-time periods.	Limitations of Control Systems

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
			Different set-points around the building according to rooms/ classrooms usage.	
Gas demand reduction; **Partial Electrical demand reduction;**		Heat production systems of Dormitories	Temporary decrease or increase of ambient temperature set-point during the winter. Shifting the work period of the heating system out of peak power demand period	Limitations of Control Systems
Electrical demand reduction **Electrical Peak Demand Reduction**		Cooling systems (Chillers)	Temporary decrease or increase of ambient temperature set-point during the summer. Shifting the work period of the chillers out of peak power demand periods	Limitations of Control Systems
Electrical demand reduction		Data Centre, Data Centre Cooling System	Temporary decrease work load of data centre servers, Temporary increase of ambient temperature set-point	To be agreed with the IT department
		Washing machines and Dishwashers	Rescheduling of using of washing machines and dishwashers outside of peak power demand periods and towards night time	Possible nuisance for the students affecting willingness

DR-BOB project DR program/Impact target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Barriers
		Student Dormitories Electrical Equipment	Reduce for a short period of time the students electricity usage Reward students if a consumption target is reached	Possible nuisance for the students affecting willingness
Electrical Peak Demand Reduction		Swimming pool water treatment and heating equipment	Rescheduling of equipment work hours outside of peak power demand periods	
Electrical demand reduction	Self-consumption of local energy production inside the pilot site locations	PV production	Self-consumption of local PV production during the workdays by the building producing energy and by the buildings belonging to the same BOB	Low production capability; Not available when special laboratory experiments are carried out on the PV Panels;
		Storage unit of PV production system	Fully charge from the grid batteries of the PV production system during normal or low power demand periods; Totally discharge the batteries into the local building network during peak power demand periods	Willingness of the associated research laboratory staff

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Acronyms and Abreviations

AC	Air Conditioning
ACBA	Agglomération Côte Basque et Adour
AHU	Air Handling Unit
BEMS	Building Energy Management System
BI	Business Incubator
BMS	Building Management System
BOB	Block of Buildings
CCHP	Combined Cooling, Heat and Power also known as trigeneration
CHP	Combined Heat and Power, also known as cogeneration
CRE	Commission de Régulation de l'Energie
DNO	Distribution Network Operators
DR	Demand Response
DREG	Distributed Renewable Energy Generation
DRMS	Demand Response Management System
DSBR	Demand Side Balancing Reserve
DSR	Demand Side Management
DTU	Demand Turn Up
EEG	Energy Expert Group
EFR	Enhanced Frequency Response
EPC	Energy performance contract
ESCo	Energy Service Company
EUI	Energy Use Intensity
FCMB	Fédération Compagnonique des Métiers du Bâtiment
FPH	Fondazione Poliambulanza Hospital
GIA	Gross Internal Area
GP	Grid Pocket
LEM	Local Energy Manager
NBK	NOBATEK
RES	Renewable Energy Source

SSM	Supply Side Management
TNO	Transmission Network Operator
TOU	Time-Of-Use
TSO	Transmission System Operator
TU	Teesside University
TUCN	Technical University of Cluj-Napoca
UPS	Uninterruptible Power Supply
VEP	Virtual Energy Plant

GLOSSARY

Asset is a type of resource that represents a specific collection of physical loads. Resources can be composed of Assets, and an Asset may be Resource, but Assets cannot be further decomposed into multiple Assets or Resources.

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.

Demand response aggregation designates third-party aggregators which enlist end users to participate in demand response curtailment and sell the combined load reduction to utilities and independent system operators (Siemens, 2011).

Demand Side Management (DSM) is commonly used to refer to demand side electrical load management. It involves actions that influence how much energy is used or when energy is used. The goal of DSM is to encourage users to use less energy during peak hours, or to move the time of energy use to off-peak times such as night-time and weekends.

Distribution Network Operators (DNOs) are often also referred to as Distribution System Operators (DSO). They are responsible for the transport of electricity at a regional level and as such they transport electricity at gradually reducing voltages from national grid supply points to final customers, both residential and none residential. Throughout the EU, electricity distribution is a regulated monopoly business.

Dynamic electricity tariffs often referred to as real-time pricing. Prices change usually on an hourly basis reflecting the cost of generating and/or purchasing electricity at the wholesale level at the time of delivery.

Direct Load Control (DLC) is a Demand Response activity by which the program sponsor remotely controls a customer's electrical equipment (e.g. air conditioner) on short notice. These programs are primarily offered to residential or small commercial customers.

Distributed renewable energy generation (DREG) or local, decentralized renewable energy production involves solar photovoltaic (PV), small hydroelectric, small-scale biomass facilities, and micro-wind.

Distributed Energy Resources (DER) DR program is a demand response activity utilized to smooth the integration of distribute energy resources into the smart grid. Customers with DER resources that can harvest energy and store it can minimize the cost of purchasing electricity from the grid during high price periods by first utilizing stored energy resources, followed by implementing load shedding strategies.

Energy performance contract (EPC) is a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings.

Energy Supply Contract, the key element in this type of contract is the efficient supply of energy. The contracting partner provides products/services such as supplying electricity, gas, heat. Financing, engineering design, planning, constructing, operation and maintenance of energy production plants as well as management of energy distribution are often all included in the complete service package. For example district heating providers are the most widely implemented example of energy supply contracting in the residential sector.

Electrical Load management, often referred to as simply load management, is achieved through controlling the power flow in the electric system at the generating end (supply side management) or the customer end (demand side management).

Electricity Supply is the process of buying electricity in bulk and selling it on to the final customer. Electricity supply in most EU countries is a competitive market.

Energy Suppliers buy electricity and /or gas in bulk and sell it to final consumers.

Energy Service Company (ESCO) is a company that offers energy services which may include implementing energy-efficiency projects (and other sustainable energy projects). The energy services supplied by ESCOs can include a wide range of activities such as energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property/facility management, energy and/or equipment supply, provision of service (space heating/cooling, lighting, etc.) advice and training,

DR event is a notification from the utility to demand side resources requesting load shed/shift starting at a specific time, over a specified duration, and may include targeting information designating specific resources that should participate in the event.

Local renewable energy sources include solar PV, wind and hydro power, as well as other forms of solar energy, biofuels and heat pumps (ground, rock or water) that is generated within 100 kilometres of the neighbourhood.

Opt Behaviour means the expected response from the demand side resource owner (or facility manager) upon receipt of an event. This response may take the form of OptIn or OptOut indication whether or not resource will participate in the event.

Private wire networks are local electricity grids that although connected to the local distribution networks that are privately owned.

Resource is the entity that is enrolled in the DR Programs and is capable of delivering some sort of change to their load profile in response to receiving a DR signal.

Supply Side Management (SSM) is commonly used to refer to supply side electrical load management. It refers to actions taken to ensure that energy generation, transmission distribution and storage are conducted efficiently, on the supplier's side of the energy supply chain.

Time-based pricing is a pricing strategy where the provider of a service or supplier of a commodity may vary the price depending on the time-of-day when the service is provided or the commodity is delivered. Therefore dynamic electricity tariffs are a form of time-based pricing. The rational background of time-based pricing is expected or observed change of the supply and demand balance during time.

Transmission network operators (TNOs) are responsible for the bulk transport of electricity by high voltage power lines from power stations to grid supply points. The transmission system is generally referred to as the national grid. Throughout the EU Transmission is a regulated monopoly business.

Utilities industry in its broad sense refers to electricity, gas and water supply companies and integrated energy service providers. The term is most often used to refer to the companies involved in the generation, transmission and distribution of energy.

1 INTRODUCTION

1.1 AIMS AND OBJECTIVES

The deliverable D2.2 constitutes the output of Task 2.2 aiming at developing the demonstration scenarios on the basis of the two following items:

- the four demonstration sites considered within the project, their description and analysis in terms of buildings' structure, local context, technical equipment, occupants and stakeholders/decision makers profiles, specific objectives, technical/socio/economic constraints and identified areas of improvement,
- interviews and workshops conducted with the local stakeholders and decision makers associated to the pilot sites aiming at collecting the needs, understand expectations of these local actors and discuss the possible DR scenarios and opportunities.

The report starts with a detailed description of the pilot cases focusing on the perimeter considered within the project, the energy systems installed and used inside this perimeter, the local context to be considered and that could have an impact of the scenarios definition. The second part of the document (Section 3) focuses on identification of the demonstration scenarios and their detailed description.

The results contained in this report will serve as a basis for the identification and development of the technological requirements conducted in Task 2.3.

1.2 RELATIONS TO OTHER ACTIVITIES IN THE PROJECT

The work conducted in Task 2.2 is closely related to Task 2.3 as it establishes the technological requirements and needs for each part of the whole tool. It also forms the basis for the demonstration that will be realised in WP4 and WP5 as it identifies the demonstration scenarios that are compliant with the end users' needs and the local context.

The deliverable D2.2 also provides useful information for the future developments to be conducted within WP3 in which the requirements associated with the interfaces and consumers' engagement will be used as a set of specifications for Task 3.4.

1.3 REPORT STRUCTURE

The introduction of D2.2 (Section 1) sets the main content of Task 2.2 and explains how the work conducted in Task 2.2 is connected to the work being conducted in the other tasks and WPs of the project.

Section 2 of the document is dedicated to the detailed description of the demonstration cases and pilot sites. The perimeter and boundaries of each pilot site is defined and inside this perimeter, information related to the occupancy and energy usages is provided in order to better capture the functioning of the sites, the identified issues/areas of improvement and the local expectations. Furthermore, the local context is described in terms of stakeholders and decision makers involved in the functioning and optimisation of the site in order to identify potential barriers or drivers that could prevent or benefit to the application of DR scenarios.

Section 3 starts with a description of the DR programs that could apply for each demonstration case. Then the demonstration scenarios are set out from these DR programs in line with the interviews conducted with the local stakeholders.

In order to aid readability and reduce the size of the deliverable, some descriptive information related to the pilot sites has been put in an annex. The main information required for the understanding of the pilot cases has been kept in the main body of the document.

2 INTRODUCTION TO THE FOUR DEMONSTRATION SITES

The DR-BOB project aims to demonstrate the economic and environmental benefits of demand response in blocks of buildings. The DR-BOB integrated solution will be demonstrated at four sites operating under different energy market and climatic conditions in the UK, France, Italy and Romania over a period of at least 12 months.

The four demonstration sites are a single block, or are considered as a single block, of buildings located closely or spread over several locations at a city including from three up to twelve buildings. The term Block of Buildings has been defined in the DR-BOB project context as a group of real buildings (minimum, 3 buildings):

- Sharing a common energy governance;
- Used the whole year or during the workdays by multiple schedules of occupancy;
- Served by the same Distribution Network Operator (DNO).

The following sub-sections describe the four demonstration cases providing:

- detailed description of the buildings included in each pilot site (buildings' structures, available technical equipment, occupants typology, energy consumptions profiles…);
- identification of the known issues as well as areas of improvements that could be the ground for the application of the DR tool developed as part of the project;
- analysis of the local context which provides the technical/socio/economic constraints that the project should handle (main stakeholders involved in the pilot site, national or local context for the DR implementation, incentives and barriers …).

Finally, the following sub-sections also provide the expectations identified by the stakeholders, decision makers and other actors involved in the energy management of the demonstration sites.

2.1 UK PILOT SITE

2.1.1 GENERAL DESCRIPTION

The UK pilot site is situated in the Teesside University main campus located near Middlesbrough town centre.

Some 20,104 students and 2,319 staff work and study in the campus buildings which house offices technical labs and lecture theatres etc. In total the campus has 33 buildings, 5 of which provide residential accommodation for students. Teesside University has a town centre location at the mouth of the river Tees in North East England. The site is approximately 4.3 square miles. Its main purpose is to facilitate teaching and research activities.

For the UK demonstration site of the DR-BOB project, a block-of-buildings that are connected to a common BMS system (Schneider) and which could benefit from demand response are proposed:

- Stephenson Building
- Middlesbrough Tower
- Constantine Building

- Brittan Building

The main block of buildings is shown in Figure 1, and termed the Middlesbrough Tower Complex.

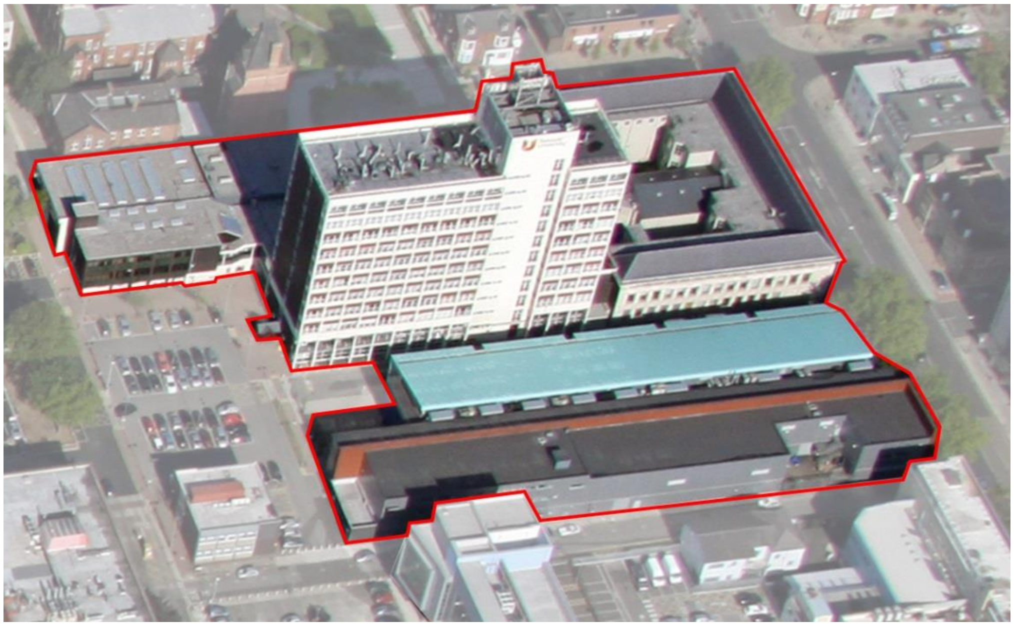

Figure 1: Middlesbrough pilot site, main block

The overview of the site is shown in the Appendix A. UK Demonstration Site together with the list of buildings.

The buildings are used for teaching, research, administration, IT support, estates and facilities management.

2.1.1.1 Buildings' structures, available technical equipment

The year of construction and useable floor area of each building considered in the pilot site are given in the following table.

Table 1: GIA of each building

Name of Building	Year of Construction	Gross Internal Area (m^2)
Middlesbrough Tower Complex		28196
Middlesbrough Tower	1963	11399
Stephenson Building	1997	8106
Constantine (including film archive)	1930	4875
Brittan Building	1964	3369

- A CHP plant (230 kWe, 358 kWth) is used as a local energy production system for the site contributing to part electrical and thermal demand.
- The distribution is done through a district heating system connecting the Middlesbrough Tower, Stephenson, Constantine and Brittan buildings and which is fed by the CHP and

two other gas boilers. Heat is dumped during summer months to maintain electrical generation.

- A temperature of 24°C is used for cooling and a temperature of 21°C is used for heating. These temperature set points can be modified only by the facilities manager.
- Some extractors units and chillers are present with no possibility for the occupants to influence the settings directly except some localised on/off control.
- Three backup generators are present (diesel-fired). They are tested once monthly and are used to power IT servers in conjunction with a UPS.
- There is no other energy production system in the area covering the block of buildings.

2.1.1.2 Occupants' profile and electricity usages

The occupants of the UK pilot site are mainly academic and non-academic staff and students.

The occupancy of the UK pilot site is highly variable (however, could be considered as 100% occupied during the workdays) with a reduced occupancy and energy use during week-ends and during summer months. Table 33 in the Appendix A (see paragraph 6.1) synthetises the type and number of occupants for each building composing the pilot site.

Table 2 below provides an overview of the main energy intensive activities in each building. HVAC and air condition systems, PCs and office equipment, kettles, fridges and other domestic appliances are the main electrical loads. There are also server rooms and laboratory equipment consuming electricity. The most important potential for reduction is identified as the computer clusters and cooling activities. The asset survey determined that the Brittan building has no major ventilation or cooling assets, or high demand computing facilities.

Table 2: Main electricity usages in each building

Building:	Rooms	Functions/ uses	Type of occupants and estim. nrs	Energy consumption related to:	Timing of occupancy	Potential for shifting	Potential for reduction
Stephenson	…	Computer Lab / Classroom	Students:	Computers, Cooling	24 Hours	++	++
Stephenson	All		Students / Academic & Non-academic staff	Cooling	08:00-17:00	(??)	--
Constantine	…	Lecture Theatre	Students & Academic staff	Ventilation	08:00-17:00	(??)	--
Tower	All		Students / Academic & Non-academic staff	Cooling	08:00-17:00	(??)	--
Brittan	All		Students / Academic & Non-academic staff	Lighting and plug load	08:00-17:00	--	--

2.1.1.3 Stakeholders/decision makers description

Table 3 provides the list of the main existing stakeholders associated with the demonstration site.

Teesside University owns the properties and is hierarchically managed. TU is responsible for the maintenance of the buildings as well but some key equipment (e.g. CHP plant) has separate maintenance contracts.

Table 3: Stakeholders related to each building

Stakeholders	Role or provided service	Users and estimated number of users	Stakeholder's impact on energy system	Benefits/uses of DR management for stakeholders
Teesside University	Building Owner / Administrator / Estates and Facilities Management	1,000	High	Reduction in peaks, meeting CO_2 targets, reduction in energy bills
Students	Users without responsibilities who require lecture rooms to be maintained at required comfort levels while they are educated	16,000	Low	No Direct Benefit
Northern Power Grid	Electricity DNO	-	High	Improved efficiency and security of supply
Electricity supply company	Connection, metering, billing securing of energy	-	Medium	Improved business practices
Charge Your Car (CYC)	Electric Vehicle charging administration	50-100	Low	Lower operating costs, reputational advantage
Maintenance companies	Maintenance of the CHP and HVAC units	--	Low	No Direct Benefit

2.1.2 ENERGY PRODUCTION/CONSUMPTION INFORMATION

The three main energy sources used for the UK pilot site are electricity, gas and diesel. The gas comes from the gas network via piping, and is mainly used for heating and driving CHP engine, whereas some is used for hot water production (a negligible amount is used for cooking).

All the energy consumptions information comes from the BMS connected to site and building metering systems. Building level metering and online TEAM Sigma Energy Management Software allows the extraction and analysis of historical data.

Annual/monthly values of energy consumptions/productionsTable 4 provides the energy demand (per energy type) for each building considered for the UK pilot site on a yearly and daily basis. Concerning electricity, the Middlesbrough Tower is by far the largest consumer followed by the Stephenson building.

Table 4: Yearly and daily energy consumptions for each building of the UK pilot site

Building	Data source	Yearly energy demand (kWh/a)	Daily Average energy demand (kWh)
Brittan	Brittan Total Electricity	118,361.3	324.3
Brittan	Brittan Total Gas	354,072.4	970.1
Constantine	Constantine Total Electricity	408,895.9	1,120.3
Constantine	Constantine Total Gas	512,380.3	1,403.8
Middlesbrough Tower	Mbro Tower Building + CHP Elec	1,381,438.9	3,784.8
Middlesbrough Tower	Mbro Tower CHP Heat plus Gas	2,970,690.8	8,138.9
Stephenson	Stephenson Total Electricity	707,848.0	1,939.3
Stephenson	Stephenson Total Gas	859,139.7	2,353.8

For comparison, the following figures display the yearly energy consumptions (gas and electricity) of the buildings:

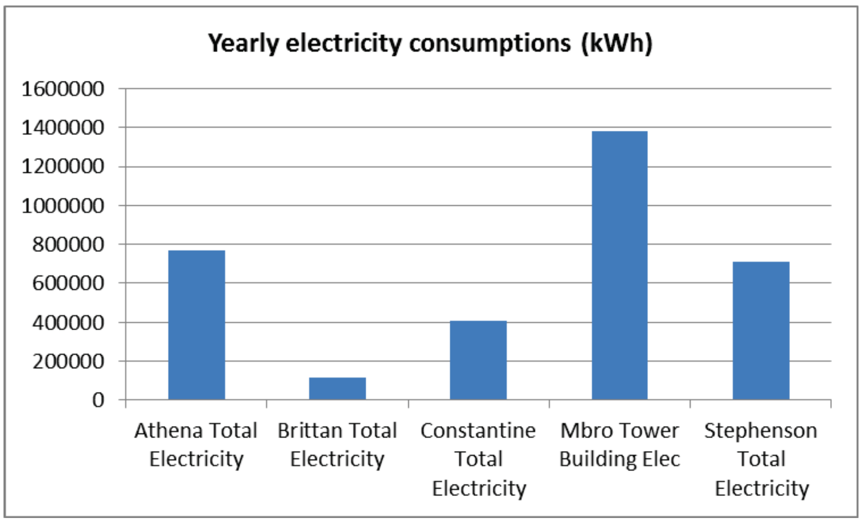

Figure 2: Yearly electricity consumptions (kWh)

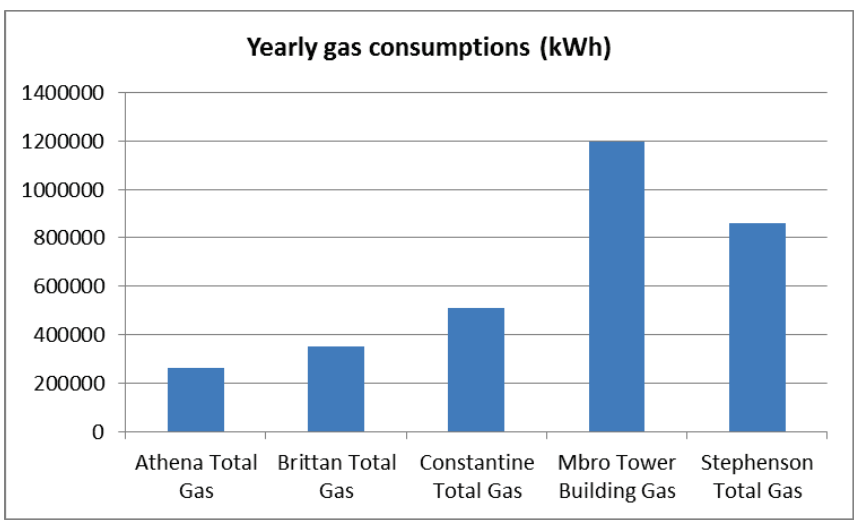

Figure 3: Yearly gas consumptions (kWh)

2.1.2.1 *Energy consumptions profiles*

Figure 4 and Figure 5 show the monthly energy consumption profiles for gas and electricity for the different buildings which are components of the UK demo site. Student vacation reductions in occupancy are clearly reflected in the consumption profiles of some buildings.

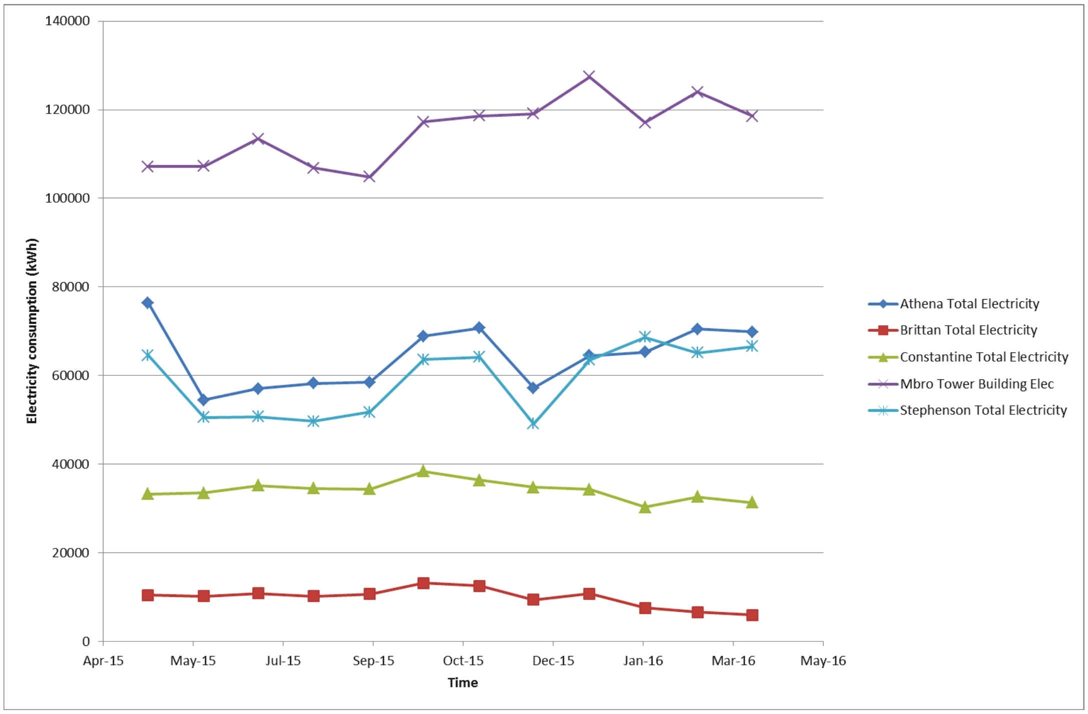

Figure 4: Monthly electricity consumption profiles of the buildings composing the UK demo site

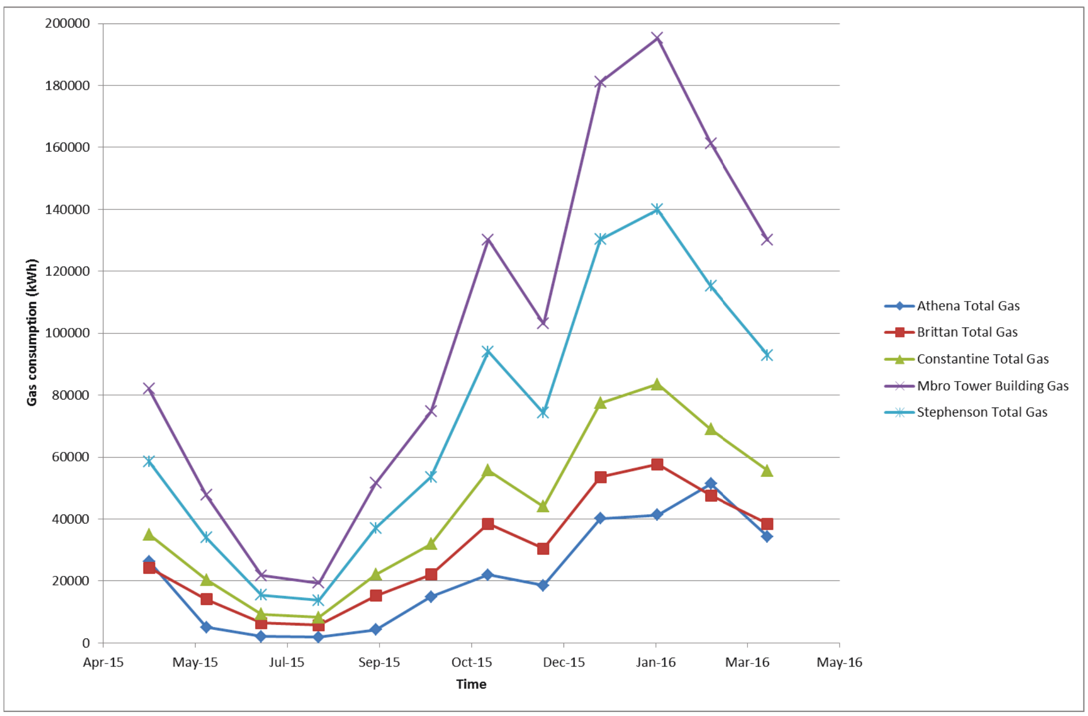

Figure 5: Monthly gas consumption profiles of the buildings composing the UK demo site

At a more granular level in time, the Teesside University main site electricity half hourly consumption profile is presented below. Averaged over the year, half hour peak consumption is approximately double minimum consumption. Total consumption has reduced over recent years but the profile has remained substantially the same.

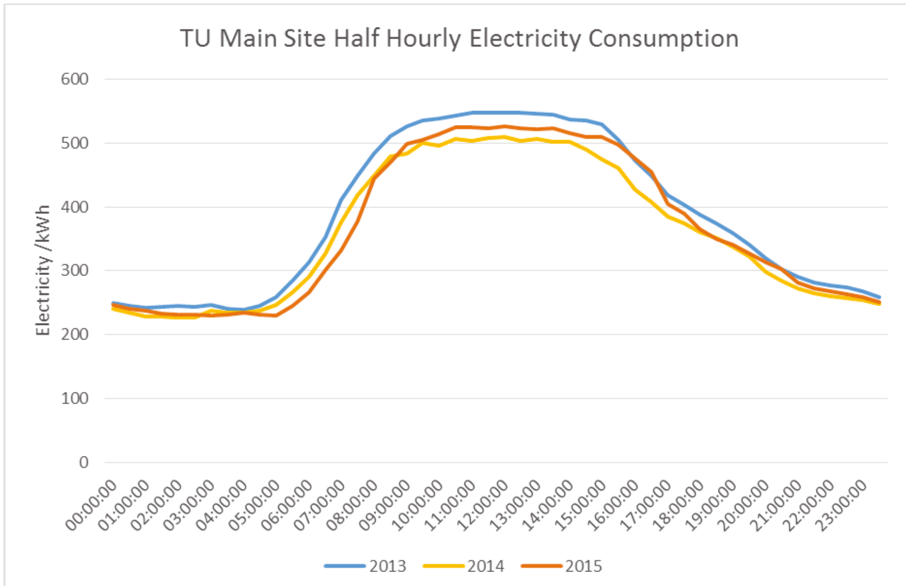

Figure 6: Half hourly electricity consumption profiles of the main site

This comprises of both imports from the grid and onsite generation from the CHP unit located in the Middlesbrough Tower. The following graph illustrates the mean site import and generation from the CHP; one year's data is shown for clarity. There is a sharp reduction in imports at 04:00 as the CHP activates and conversely an increase at 21:00. It is immediately apparent that changing operation of the CHP could substantially alter the apparent demand on the local electricity network.

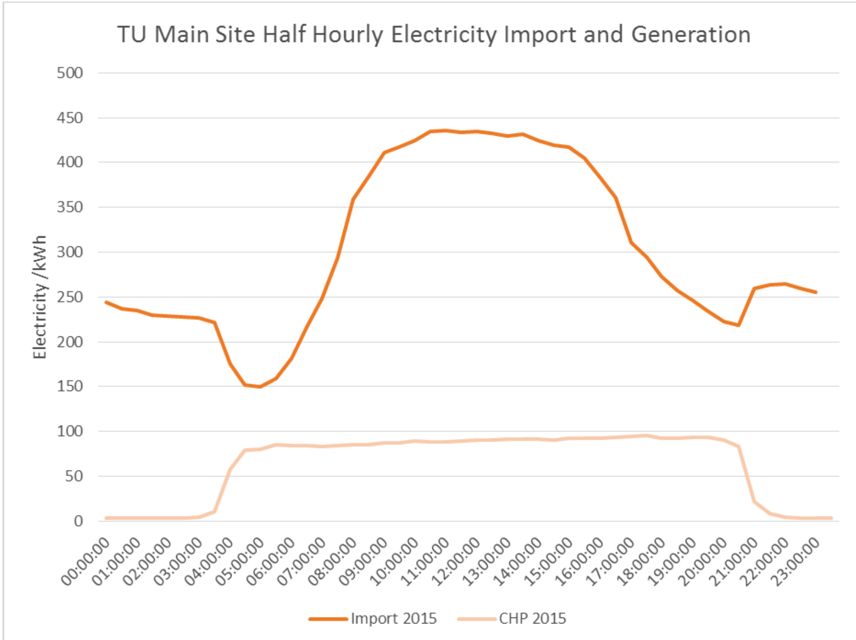

Figure 7: TU main site half hourly electricity import and generation

Gas is used directly for heating and indirectly for electricity generation in the CHP unit. Its consumption for the buildings in the Middlesbrough Tower Complex has a broader profile, than for electricity, but with faster rates of change. Averaged over the year, half hour peak consumption is approximately ten times greater than minimum consumption.

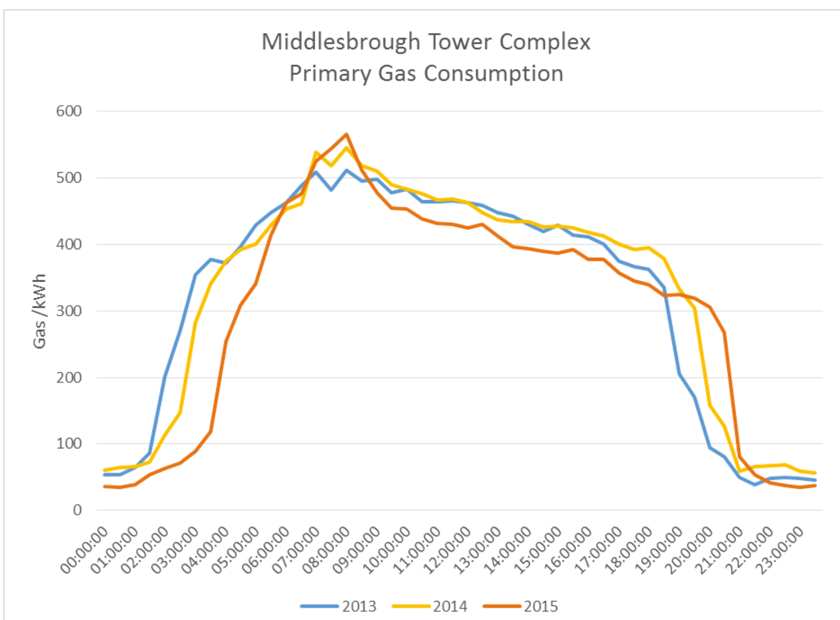

Figure 8: Middlesbrough Tower Complex Primary Gas consumption

2.1.2.2 *Energy savings opportunities*

Teaching functions cannot be interrupted so the possibility of shifting lighting is small.

The temperature set points could be manipulated and predictive pre-heating / pre-cooling employed. This would need to be carefully managed in case teaching was interrupted. Installation of CO2 sensors could improve efficiency of HVAC.

Heat from CHP is dumped during summer months. Air conditioners and chillers contribute to large afternoon peaks during summer months. Some air conditioning systems may run inefficiently/unnecessarily as occupancy levels are not directly monitored (e.g. with CO_2 sensors). Computing labs consume large amounts of energy and are 24-hrs open access, and this may not be very efficient.

The most attractive DR measure for the local stakeholders is the following:

- ✓ Peak reduction, using the CHP for capacity bidding (if economic enough to warrant change to maintenance contract).
- ✓ Electrical Peak Demand Reduction, to benefit from savings in Triad and DUoS charges.

2.1.3 LOCAL CONTEXT AND TECHNICAL/SOCIO/ECONOMIC CONSTRAINTS

- ➢ A utilisation voltage of 230V nominally (+10% / -6%, typically operates at 240 V) is used whereas a high voltage (110kV) arrives on the site. All CHP electricity currently generated on site is consumed locally (electricity base load is high enough such that CHP electrical output always offset the main incomer). Currently at the pilot site level, a flat-rate tariff is used for gas and electricity units with variable network charges on top. Teesside University pays the energy bills. There is one bill each for gas/electricity. Teesside University is responsible for the maintenance of the buildings but some key equipment (e.g. CHP plant) has maintenance contracts.
- ➢ At national level, interest in Demand Response programmes is on-going and seen as a large part of the adoption of smart grid in the UK (Jenkins et al. 2015). On a domestic/small commercial scale, it is planned for every household to have a smart meter by the year 2020 and for these meters to be connected to an Advanced Metering Infrastructure. By leveraging the existing or planned ICT components of an AMI (e.g. 4G or Powerline connection to utility backhaul network, smart meter with TCP/IP communication stack) and co-locating an appliance scheduling algorithm on a residential smart meter, a lower-cost pathway to allow end users and utilities to achieve the potential benefits of residential DR could be achieved.
- ➢ In terms of the market place for DR programmes, the UK has recently introduced many new products as a part of the 'Power Responsive' initiative (Proffitt, 2016). Products such as Frequency Control by Demand Management (FCDM), Enhanced Frequency Response (EFR), Demand Turn Up (DTU) and Demand Side Balancing Reserve (DSBR) services have been introduced in 2016 as part of this range of new products. FCDM is a tendered balancing service which requires that a load is shed by participants within 2 seconds of the system frequency falling below a preset threshold, for minimum duration 30 minutes.

EFR extends traditional primary frequency controls to the demand side in the manner described above, but the product is still in development and the technical and contractual requirements not yet fixed. DSBR and DTU provide a means whereby demand can be requested to either increase or decrease at relatively short notice (10-20 minutes) to better match the output of renewables. Along with traditional products such as a Capacity Bidding and Short Term Operating Reserves (STOR), the UK market for DR is (at the time of writing) the most advanced among all EU member states with respect to BoB (Crosbie et al. 2016; Jenkins et al. 2015). Further details are given in Appendix A. UK Demonstration Site (see paragraph 6.1.3).

2.1.4 EXPECTATIONS FROM THE PILOT SITE

2.1.4.1 Stakeholders' expectations and insights

- A series of semi-structured one-to-one interviews and a stakeholder workshop were conducted during June and July 2016. Primary feedback from internal stakeholders revealed a general interest and enthusiasm for the strategic objectives of the project. Discussing demand response, one stakeholder commented *"If we can't do it here then where can we do it?"* noting the diverse, but representative, buildings at Teesside University.
- The enthusiasm for demand response was, however, tempered by a desire not to compromise "the student experience". The University is undergoing a period of modernisation. Multiple stakeholders reported that the current ongoing process of semesterisation[1] reduces flexibility in the timetabling of classes in teaching rooms and laboratories. This was understood by stakeholders as having an impact on the possibilities for demand response.
- All stakeholders spoke of how control of the internal environment is centralised in the BMS, which has both benefits and problems. For instance, it was mentioned that students try to circumvent this control by propping doors open. Ventilation of computer laboratories in the Stephenson Building was identified as an area for further investigation prior to any demand response requests. The project team may also have to be aware of other pre-existing issues with the internal environment: including novel acute events such as sticking radiator valves, and how they interact and alter perceptions of DR interventions.
- Multiple organisational units (academic schools) occupy the different blocks of buildings under consideration as part of the DR-BOB project pilot at Teesside University. Some stakeholders identified further school managers who may be productive points of contact for identifying potential problems and disseminating information. These managers are currently being contacted in follow-up sessions.

[1] This involves the universities teaching moving to a Semester system where the academic year is split into two sections from a term system in which the academic year was split into three roughly 10 week terms.

- There is some evidence of existing recognition of implicit Demand Response incentives, with the Teesside Universities estates staff instructed to avoid 4PM-6PM charging of campus electric vehicles. However, whilst Triad[2] warnings are made available to the University by the electrical supplier, stakeholders could not identify that they acted on these warnings.
- In terms of trialling new demand response interventions on existing mechanical assets, one stakeholder noted concerns about additional wear and tear. The frequency of DR events should therefore be well characterised or delimited in advance. If this concern is persistent then such use cases will be assessed by simulation, until a business case can be established.

2.1.4.2 Specific objectives

All stakeholders felt that there were sufficient strategic benefits to justify efforts to implement DR, especially if cost savings were substantial. No-one raised concerns that split incentives, actions taken by one party (e.g. staff) primarily benefiting another (e.g. the institution), would hamper the project. However, DR actions should be carefully planned and monitored to minimise the impact on passive user groups such as students in lecture theatres. Some specific subject groups may be more understanding or engaged in the topic, e.g. electrical engineering students, so the opportunity to actively participate in DR would be trialled first in these groups if possible.

Full details of proposed use cases / demonstration scenarios are outlined in section 3.1.1.

2.1.4.3 Areas of improvements

- University policy has been generally supportive of energy conservation; however, new developments may work against this. Shifting towards 24/7 availability of library, lab and computer resources may also have implications, both positive and negative for consumption, moving away from peak times but potentially increasing total consumption. For instance, it was raised that the overnight "power down" policy for central computer clusters had been removed recently. These background trends will have to be considered when assessing baseline data.
- DR-BOB should enable greater response to existing sources of information e.g. Triad warnings. Energy consumption data is gathered and shared with staff via the internal website but it is not clear how this drives any existing programme of reductions. Wider consideration of DR may also support better optimisation of estate utilisation if it can prompt new users to respond e.g. students in computer clusters, laboratory managers with control over fume hoods. The University currently does not participate in any specific DR programmes: this is an obvious area in which DR-BOB can help to improve.

[2] Defined as the three half-hours of highest demand on the GB electricity transmission system between November and February each year, the Triads are part of a charge-setting process. This identifies peak electricity demand at three points during the winter in order to minimise energy consumption.

2.2 FRENCH PILOT SITE

2.2.1 GENERAL DESCRIPTION

The French case study area is located in the Business technology park Montaury in Anglet, in the South West of France.

The Technology Park Montaury was born in 2008 from the will of the community of agglomeration of Biarritz-Anglet-Bayonne to install companies and private research laboratories on a dedicated site. The technology park aims at becoming a centre of excellence in the field of construction and green building industry.

The Montaury area located between city centre and rural spaces hosts four sites amongst others:

- ✓ Training centre of The Compagnons du Tour de France[3] (abbr. FCMB) being part of the French network of training centres for building trades. This building hosts office rooms, classrooms and workrooms. It has been built in 2009 and has received the HQE certification[4]. The building is energy positive thanks to its 250m² of PV panels installed on the roof of the building and thanks to the woodchips boiler fed by wastes of wood coming from the activities of the centre.

Figure 9: Building of The Compagnons du Tour de France

- ✓ Technology research centre NOBATEK[5] (DR-BOB project partner) hosting some 35 employees working in the field of sustainable construction (Figure 10). NOBATEK has initiated an ISO50001 approach for its building aiming at put the energy management as a priority area in its activities. The building has received the BBC label.[6]

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[3] French organization of craftsmen http://en.wikipedia.org/wiki/Compagnons_du_Tour_de_France
[4] HQE certification is the French certification for High Quality Environmental standards for buildings.
[5] http://www.nobatek.com/
[6] BBC = Bâtiment Basse Consommation, or Low Energy Building

Figure 10: NOBATEK's Building

- ✓ Future Business Incubator (BI) (Figure 11) dedicated to sustainable and bio-construction start-ups. This building is currently under construction (the delivery is planned in 2016) and will host office rooms, classrooms and workshops. This building will be HQE and BREAM certified and aims at being energy positive as well.

Figure 11: Business Incubator building

- ✓ A portion of the technical college CANTAU. Some 1420 students and around 80 staff work and study in the college buildings which house offices, technical labs, classrooms, and dwellings etc. In the frame of the DR-BOB project, only four buildings hosting dwellings for the students and one building hosting classrooms and laboratories will be part of the demonstration site.

The following figure shows an overview of the French demonstration site.

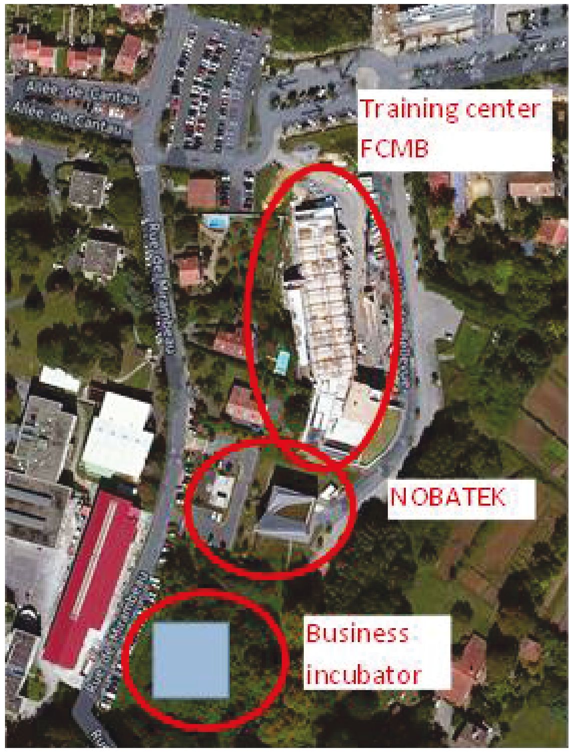

Figure 12: Overview of the French demonstration site

Therefore the French pilot site is considered as a block of buildings composed by:

- ✓ Buildings of different ages mixing different usages;
- ✓ Buildings with different owners;
- ✓ Different energy production systems (three kinds of PV panels);
- ✓ Multiples Electrical Vehicles charging stations with electrical vehicles planned;
- ✓ Three different BMS systems.

This specificities variety allows to define multiple use cases and provides various demonstration scenarios representative of a real block of buildings.

2.2.1.1 Buildings' structures, available technical equipment

The main characteristics of each building (year of construction, number of levels, net floor area, occupancy, energy use intensity, peak power demand) are provided in appendix B (section 6.2).

The following table provides an overview of the systems equipping each building of the French pilot site. It should be highlighted that there is no energy production/distribution systems at the scale of the whole demonstration site. Moreover there is no storage system associated to the local energy production systems except the UPS backup power supply for the server rooms in NOBATEK and Business Incubator buildings.

Table 5: Energy and technical equipment available in each building

Building	Main energy systems	Specific system in the building
Training centre of The Compagnons du Tour de France	>Woodchip boiler Hargassner WTH110 (102 kW) used for space heating generation (primary source). > Gas boiler Atlantic Guillot Azurinox (97,5 kW) used for space heating generation (secondary source) >PV system (surface: 250m², polycrystalline modules) installed on the roof (simplified building integration). Peak power = 30 kWp. Annual generation 2015= 31642 kWh. Selling of total energy produced to the national grid (contractualised).	>BMS (Jung) managing lighting system, ventilation, shutters, opening/closing of exterior gates and windows >1 EV charging station >Specific machines (electric saws, chipper) used in the workshop during the daytime: 8:00-12:00 from Monday to Friday and 13:00-17:00 from Monday to Thursday
Technology research centre NOBATEK	>2 Air/Water heat pumps HITACHI RAS-10HRNME-AF, connected in series. Total nominal power is about 64 kW. The heat pumps provide heating and cooling which are distributed to the heating and cooling underfloor in every stage and to 16 fan coils supplied by 2 AHU for the space preheating. >Electrical water heater 1000 W. >Ventilation of the building is realised thanks to 2 Air Handling Heat Recovery Units and 16 fan coils >No RES	>Lift >Specific machines used intermittently in the laboratory >BMS (Trilogie Manager) providing an automatic management of lighting (presence detection and room brightness), ventilation and hot water production
Future Business Incubator	>1 Air/Water heat pump AERMEC NRK0300HE03 providing space heating. The total nominal power is about 52 kW. The space pre-heating is realised by fan coils and the heating is delivered through radiant panels. >Cooling heat pump system is used for server room: cooling unit Daikin RXR42EV (outside unit) and Daikin FTXR42EV (internal unit). >An electrical hot water production system >1 Air Handling Unit Swegon Gold 12. Nominal flow of supply air: 4300 m³/h. Extracted air flow: 3515 m³/h >1 extraction chamber FRANCE AIR Primero 10/10 for the Workshop. Power: 0,55/2 kW >PV system providing a planned annual generation of 61700 kWh. Self-consumption mode with selling of surplus of electricity produced: 200 m² of single-crystal panels, 40 kWp 400 m² of amorphous panels, 19 kWp.	>EV charging station meter >Specific machines used in the workshops >BMS providing an automatic management of heating, lighting and ventilation

2.2.1.2 *Occupants' profile and energy usages*

Table 6 synthetises the type and number of occupants for each building composing the French pilot site. It also provides the largest share of electricity consumption.

Table 6: Buildings' occupancy

Building:	Number of Rooms	Functions/uses	Type of occupants and estimated numbers	Electricity consumption related to:	Timing of occupancy
Training centre of FCMB	…	Classroom	Students, teachers; from 8:00 to 17:00	Specific machines	Daytime
		Workroom	Students, teachers; from 8:00 to 17:00	Lighting	Daytime
		Offices	Administrative staff; from 8:00 to 17:00	Computers	Daytime
			Administrative staff, Students, teachers; from 8:00 to 17:00	Ventilation	Daytime
NOBATEK	9	Offices	Engineers, technicians, administrative staff; 35 people; from 8:00 AM to 19:00	Heating/Cooling	Daytime
				Water heater	
				Lighting	
				Computers	
				Motor Forces	
				Lift	
	3	Laboratory		Machines	
	3	Building testing platform	Usually empty, casual occupancy by 1 person	Heating/Cooling	Daytime
				Lighting	
Business incubator	25	Offices	Engineers, technicians, apprentices	Heating/Cooling	
				Lift	
				Ventilation	
				Computers	
				Lighting	
		Workroom	Technicians	Machines	

2.2.1.3 *Stakeholders/decision makers description*

The following table provides the list of the main existing stakeholders associated to each building. This list comprises internal stakeholders as well as actors implied directly or more indirectly in the management (technical, administrative…) of the buildings.

Table 7: Stakeholders related to each building

Stakeholders	Role or provided service	Users and estimated number of users	Stakeholder's impact/potential action on energy system	Benefits/possible use of DR management
Nobatek general direction	**Nobatek** administrative management	Direction, 4	High/Decision maker	Low energy costs
Nobatek staff	Users with responsibilities	Architects, engineers, technicians, About 20	Medium/Changing ambient temperature set point, switching on/off PC displays and special machines in laboratory	
Nobatek apprentices	Users without responsibilities	Students, 2-4	Low	No direct benefit
Enercoop	Electricity supplier for **Nobatek**'s building		Medium	Improved business practices
Training centre of FCMB- Administration	**Training centre of Compagnons du Tour de France** administrative management	Direction, 8	High/Energy efficiency decision making, changing ambient temperature set-point	Low energy costs
Training centre of FCMB-Teachers and staff	Users with responsibilities	12	Medium/Switching on/off special machines in workshop and lighting	
Training centre of FCMB - apprentices	Users without responsibilities	68	Low	No direct benefit
Arrambide maintenance	**Nobatek** and **FCMB** electricity maintenance company		Low/Maintenance of technical equipment	Lower energy costs in the case of P1 maintenance contracts
ENGIE	Electricity and Gas provider and distributor of the **training centre of FCMB**		Medium	Improved business practices
ACBA direction	**BI** administrative management; Urban planning/economic development of the city		High/Decision maker for the **BI** Decision maker for the **Technological park Montaury**	Low energy costs for the **BI** Low energy costs for the whole **Technological park Montaury**
Facility management company	Management of the **BI** energy systems (if will be	Engineers, technicians	Low	

Stakeholders	Role or provided service	Users and estimated number of users	Stakeholder's impact/potential action on energy system	Benefits/possible use of DR management
	presented) and maintenance			
Electricity and gas providers and distributors	**BI** Electricity provider and distributor Gas provider and distributor		Medium	Improved business practices
EDF (Electricité de France)	French electric utility company, electricity provider and distributor			Lower risk of grid congestion
ERDF (Électricité Réseau Distribution France)	French Distribution System Operator (DSO) owned by EDF		High	Lower risk of congestion of distribution infrastructure

2.2.2 ENERGY PRODUCTION/CONSUMPTION INFORMATION

All the buildings of the French demonstration site are currently using 4 periods Time-of-Use tariffs for electricity supply. Those will be detailed in the paragraph **Error! Reference source not found.**.

Table 8: Conditions of Electricity Power Purchase Agreement versus prices of selling of local electricity production to the grid

Scale	Electricity Power Purchase/Selling Agreement conditions			
	HCE (off-peak hours Summer)	HPE (peak hours Summer)	HCH (off-peak hours Winter)	HPH (peak hours Winter)
NBK building	22:00-6:00	6:00-22:00	22:00-6:00	6:00-22:00
NBK buying prices per kWh (from the grid), € HT	0,0973	0,1029	0,1118	0,1233
FCMB Training Centre	22:00-6:00	6:00-22:00	22:00-6:00	6:00-22:00
FCMB buying prices per kWh (from the grid), € HT	0,04674	0,06394	0,07295	0,09856
FCMB selling prices per kWh (to the grid), € HT	0,2746			
Business Incubator	20:00-8:00 from Monday to Friday and 00:00-24:00 during the Weekends	8:00-20:00 from Monday to Friday	20:00-8:00 from Monday to Friday and 00:00-24:00 during the Weekends	8:00-20:00 from Monday to Friday
BI buying prices per kWh (from the grid), € HT	0,02841	0,03992	0,03855	0,05248

BI selling prices per kWh (to the grid), € HT	Not contractualized yet. Will be around of the selling price of the 2nd quarter 2016 for the simplified BIPV installations is fixed to 0,1261 €/kWh.

Nobatek has contractualized the Electricity Power Purchase Agreement with the renewable electricity supplier ENERCOOP which provides power from renewable energy sources exclusively (hydropower, wind turbines, PV and biomass).

Table 8 shows that the BI building will sell surplus of electricity produced to the grid at a price which could be very close to the HPH purchase price of electricity from the grid for Nobatek building. This fact allows imagining a new kind of business model when the buildings with different owners share the local energy production to nearby loads inside their geographical location. In this case we are speaking about microgrid concept that comprises low voltage distribution systems with distributed energy resources (DER) (micro-turbines, fuel cells, PV, etc.) together with storage devices (flywheels, energy capacitors and batteries) and flexible loads. It could potentially offer a lot of economic and technical benefits such as price reduction for end consumers, energy loss reduction, lower voltage variation and reliability improvement[7].

Table 9. Daily Electrical demand of the buildings of the French BOB

Scale	Daily electrical demand, [kWh]			
	Winter	Summer	Weekday	Weekend
FCMB	324	235	401	99
NOBATEK	226	154	200	151
Business Incubator	N/A	N/A	68 (estimated[8])	10 (estimated)
Proposed block Of Buildings	550	389	669	260

2.2.2.1 Yearly/monthly values of energy consumptions/productions

The table below and Figure 13 provide the monthly and yearly electricity consumptions of 2 (FCMB, NBK) among 3 buildings and annual electricity production capacities of the French pilot site. The electricity demand of BI building (which is not functioning yet) has been estimated at 45464 kWh/year.

[7] Source: book **Microgrid: architecture and control**, editor: Professor Nikos Hatziargyriou, National Technical University of Athens, Greece, 2014.

[8] This evaluation takes into account only the offices part of the building (PCs, lighting, lift, printers, and servers); the workshop demand will depend on the specific machines that will be installed inside. At the time of writing of this document, their number and specifications are not known yet.

Table 10: Annual production of PV panels on the French pilot site

	Annual electricity consumption, kWh			PV annual production, kWh			
	2013	2014	2015	2014	2015	Estimated 2016	Estimated 2017
FCMB	86360	36211	113820	N/A	31642	31642	31642
NBK	47443	44835	61182				
BI				N/A	N/A	20161[9]	61700
Total (kWh)	**133833**	**81046**	**175002**		**31642**	**51803**	**93342**

2.2.2.2 Energy consumptions profiles

Figure 13 and Figure 14 show the monthly energy consumption profiles (electricity, gas, wood) for the different buildings composing the French pilot site.

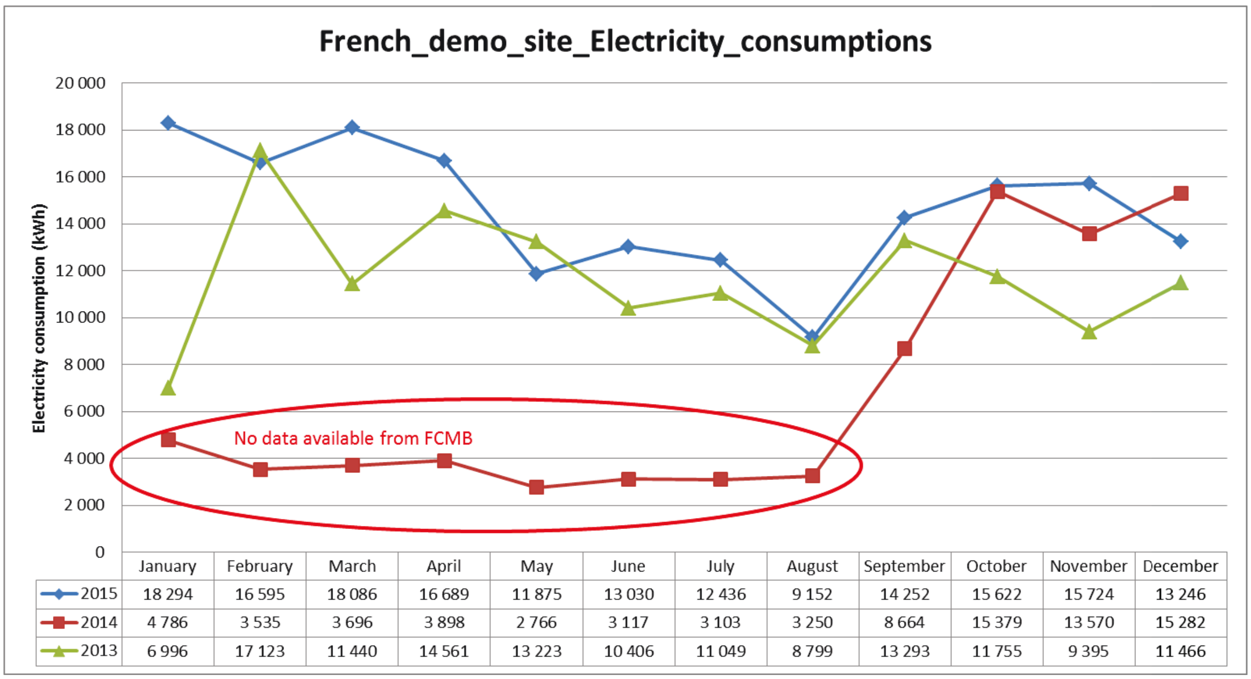

Figure 13: Electricity consumption profiles for 2013, 2014 and 2015

There is no data available for the FCMB building from January 2014 to August 2014. The values displayed for this period represent the electricity consumed by NBK's building only.

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9 This value has been evaluated on the basis of estimated annual production 61700 kWh, GHI (Global Horizontal Irradiation) monthly cumulated values in kWh/m^2 for Biarritz city taking into account the start of electricity production at the August 2016. The source for GHI values: Calsol tool, http://ines.solaire.free.fr/gisesol_1.php#

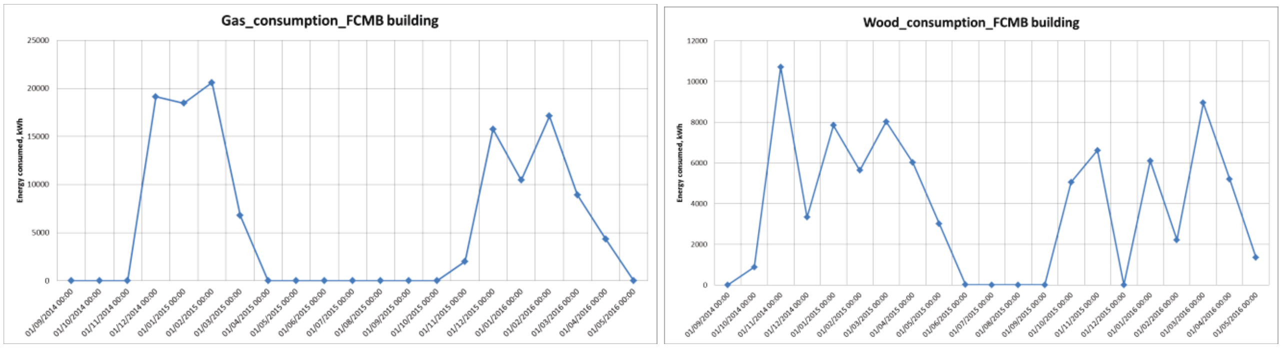

Figure 14: Gas and wood consumption profile for the FCMB building

The following graphs show the hourly electrical consumptions of NOBATEK and FCMB buildings for two different seasons. These graphs highlight for instance the electrical consumptions during inoccupation which is almost half the total consumption during the day for NOBATEK's building.

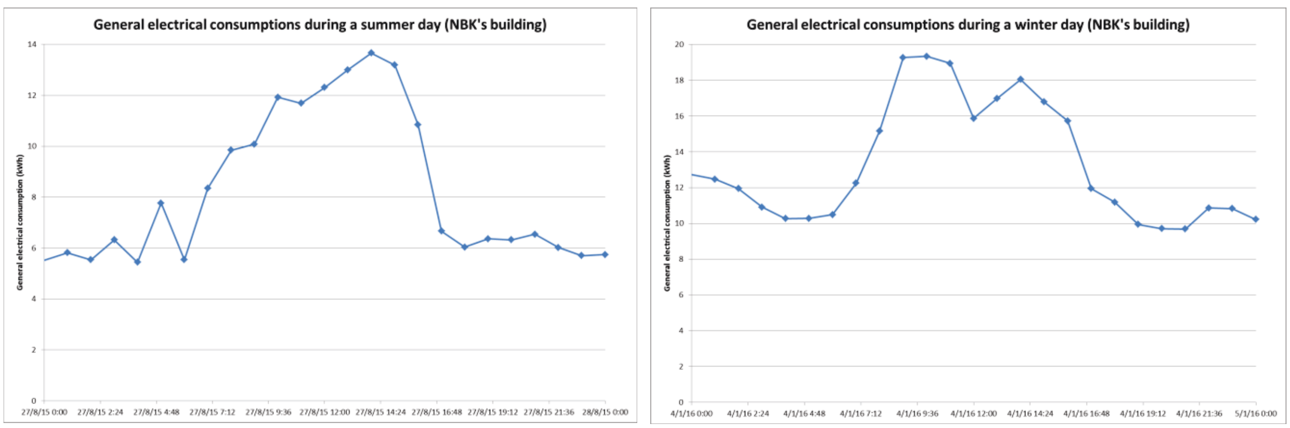

Figure 15: Hourly electrical consumptions profile for NOBATEK's building during a summer day and a winter day

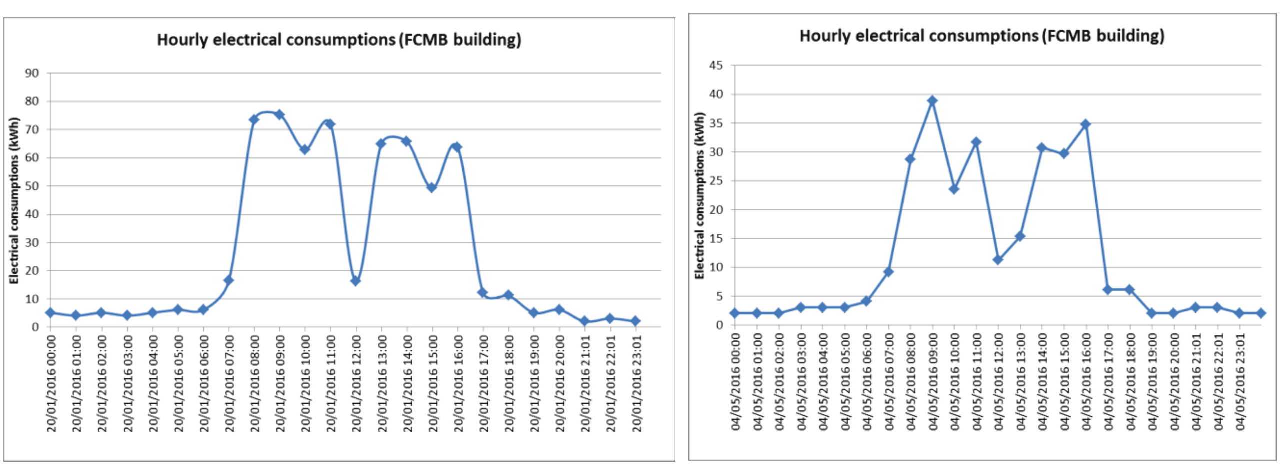

Figure 16: Hourly electrical consumptions profile for FCMB building during two different seasons

2.2.2.3 *Energy savings opportunities*

The three buildings that constitute the French pilot site are energy efficient in terms of design and systems. Nevertheless some savings opportunities are still present. Some manipulation on the temperature setpoint can be conducted for the FCMB building.

Offices activities cannot be interrupted so the possibility of shifting is small.

The DR measures that would be more attractive or interesting for the different stakeholders involved in the pilot site ate related to peak demand and energy consumption reduction.

The DR measures that appear to be the most suitable and feasible for the French pilot site are the following:

- ✓ Shifting of the important loads from Peak-hours to Off-peak hours.
- ✓ Load curtailment or shedding of important loads. This will concern many different assets of the different buildings (Heat pumps, Computers, EV batteries, Heat production systems
- ✓ Self-consumption of local production during the workdays by the building producing energy and possibly exchange electricity locally produced between loads of the buildings belonging to the considered BOB;

2.2.3 LOCAL CONTEXT AND TECHNICAL/SOCIO/ECONOMIC CONSTRAINTS

The distribution of electricity in the demonstration site is made at low voltage (400 V) and the distribution of electricity inside the buildings is made at 230 V or 400 V, at the frequency of 50 Hz. The 3 buildings of the French demo site are fed separately, with one electricity delivery point for each building. The buildings have also independent heat production systems. There is one monthly bill by building and by type of energy used.

2.2.3.1 *Regulatory framework for Renewable Energy Source (RES) installations in France*

In order to reduce the electricity demand of the consumers and smooth the daily load curve at the national level, French government tends to stimulate the RES independent generators functioning in self-consumption mode from few years.

French regulatory does not oblige the building owners to sell all the electrical energy produced by RES to the national grid. Each customer, residential or commercial, is free to sell all the electrical energy produced by RES to the grid or just the surplus that is not self-consumed locally. If a customer wants to sell his RES energy to the national grid (totally or partially), he needs to connect its RES installation to the electrical grid by EDF/ERDF, install an electricity meter by ERDF and choose a tariff from a grid operator (electric utility company). A lot of grid operators propose different tariffs with different prices of electrical energy purchase from the local producers. The purchase prices vary in function of date of request of grid-connection of RES installation.

For PV installations, the CRE (Commission de Régulation de l'Energie) fixes new purchase prices from independent generators every 3 months in function of number of RES installation projects registered in the last 3 months period. The purchase prices are fixed contractually for a duration of 20 years and do not change during this period[10].

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[10] Source : Le Service Public de la Diffusion de Droit
https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000023661449&categorieLien=id

Over the past 6 years, the purchase prices of local PV energy tend to go down by from 0 to 10% every year. The reason for this is that the number of requests for grid-connection of building-integrated (BIPV) or simplified building-integrated (Simplified BIPV or rooftop installations) installations and consequently of the renewable energy production rises constantly from one year to another[11].

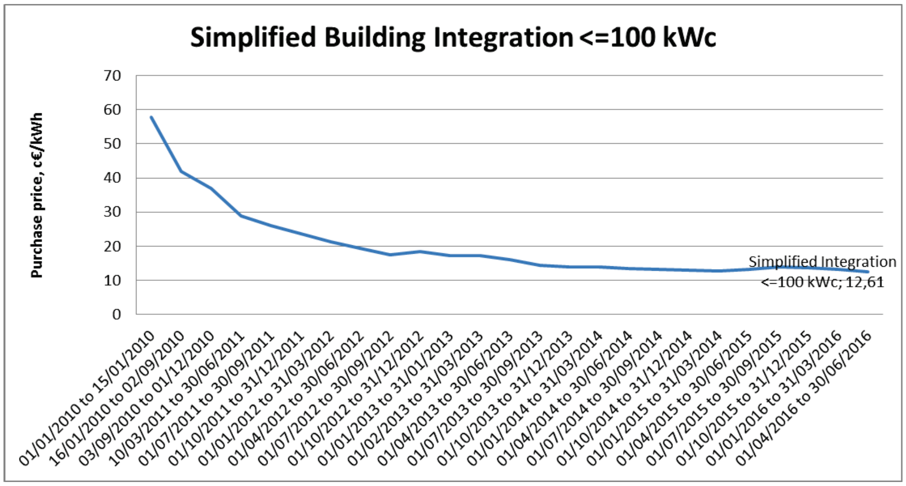

Figure 17: Electricity supplier purchase prices of local PV energy from independent generators in France during the last 6 years (Simplified Building integration case)[12]

It is easy to see that in few years, if this trend continues, the electricity purchase prices of PV generated energy by the grid will reach the selling prices from the grid and the selling of PV energy to the grid will not more be beneficial for independent generators.

For wind turbines installations, the purchase prices depend on annual duration of functioning and are fixed contractually for a total duration of 15 years: one purchase price for the first 10 years and another one for the last 5 years. These prices are re-indexed every year starting 2007. The purchase prices for wind turbines installations in 2007 are available in Appendix B. French pilot site (see paragraph 6.2.2).

2.2.3.2 Time-based demand response incentives in France

Other price-based demand response incentives in France which can induce changes in usage by customers in response to time-based changes of prices include Time-of-Use rates. Time-of-use (TOU) tariffs are proposed through different contract offers by the historical energy supplier EDF: the "Heures creuses / Heures pleines" contract, or the "TEMPO" contract.

- The contract "Heures creuses / Heures pleines" ("full hours / light hours") features a predefined schedule of peak (or full) hours / off-peak (or light) hours which are set by ERDF. During "light hours" (always 8 hours per day), electricity is 30% cheaper than during "full hours" (16 hours per day). Those are generally composed by 2 tariffs winter (HPH (full hour winter) and HCH (light hour

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[11] In 2015 renewable energy production increased by more than 23% (not including hydroelectricity), with 1,000 MW of new wind capacity and 900 MW of new solar capacity. Source: Embassy of France in the United Kingdom, http://www.ambafrance-uk.org/Renewable-energy-production-in-France-rose-23-in-2015

[12] Source: Ministère de l'Environnement, de l'Energie et de la Mer http://www.developpement-durable.gouv.fr/Quels-sont-les-tarifs-d-achats.html

winter)) and 2 tariffs summer (HPE (full hour summer) and HCE (light hour summer)). The time-blocks of these tariffs are different from one building to another (by default the light hours are predefined from 10PM to 6AM every day and full hours from 6AM to 10PM), but at seasonal level the winter tariffs last from the 1st of November to the 31st of March and the summer tariffs are active the rest of the year. The schedule of light vs. full hours is set when the contract is established with the customer, according to its location. It remains then unchanged.

- Tempo-like electricity supply contracts feature different prices, which apply depending on time and days. It includes “Red, White and Blue days” where red days correspond to high consumption periods of the year, white days are intermediate, and blue days are low consumption days. The price applied to each type of days varies between suppliers. The contract signed with the consumer sets that there will be every year 22 red days (fixed by blocks from 1 to 5 consecutive days), 43 white (fixed by blocks from 1 to 5 consecutive days), and 300 blue. The consumer is informed every day from 8pm of the colour for the next day (blue, white or red): RTE publishes the colour of each day into its website in day-ahead, and this colour applies to all consumers with a Tempo-like supply contract, regardless of the supplier they have chosen.

2.2.3.3 Access to the market mechanisms

The French law No.2013-312 (known as the “Loi Brottes”) introduces a new article concerning the selling of electricity demand reduction in energy markets and into the Balancing Mechanism. It introduces the experimental process conducted by RTE (called NEBEF) to manage blocks of energy exchange. There are a lot of mechanisms for the consumers to access the French or European electricity market. Some of them exist since a few years already such as Balancing Mechanism, some of them are more recent such as Mechanism of Capacity or NEBEF. But all these are reserved to large industrial consumers capable to reduce their peak power demand by at least 100 kW during the half-hour period which is too much for block of 3 tertiary performant buildings.

The overview of these market mechanisms is available in Appendix B. French pilot site (see paragraph 6.2.3).

2.2.4 EXPECTATIONS FROM THE PILOT SITE

2.2.4.1 Stakeholders’ expectations and insights

A series of semi-structured interviews with relevant stakeholders of the pilot site has been conducted during the June and July 2016. 7 people or group of people have been interviewed: FCMB direction, FCMB internal technical service, FCMB active occupant (teacher), FCMB passive occupant (apprentice), FCMB and NBK external maintenance subcontractor (the same company), NBK building manager, ACBA managers of BI construction.

The interviewed people have shown intense interest to energy optimisation actions for their respective buildings. The people who pay the bills are directly concerned by energy consumption reduction; the buildings’ occupants are much more interested in keeping the same comfort level as the one they had before the DR-BOB project. The general feedback is that the energy optimisation or demand response actions make no sense without taking into consideration the occupants’ comfort and the internal activities of the building (buildings’ occupancy, important events, meetings, building energy systems’ states). The buildings of the French demonstration site are recent buildings, and performing well energetically. So, their owners are mostly interested in CO_2 emissions savings.

FCMB has mentioned that there is an ambience temperature problem during the summer and the winter at the south façade of offices part of the building. Another issue at the FCMB building is related with heating systems functioning mode. Indeed, there is no automatic toggle between the woodchips boiler and the gas-fire boiler. The woodchips boiler is the primary heat generation system; the gas-fire boiler is a second. The woodchips boiler has a tank of 35 m^3 and is supplied by shavings produced on-site during the courses. If the tank is full, the system configuration ensures 2 weeks of autonomy. If the tank is empty, there is no automatic toggle to the heat production by the gas-fire boiler supplied by the national gas grid. The technical staff needs to monitor permanently the wood level in the tank. These issues need to be taken into consideration while implementing DR programs.

2.2.4.2 Specific objectives

All stakeholders are interested in the DR management at Block of Building scale, but it should be carefully implemented considering process of use of technical equipment in each building (intermittent RES, EVs, controllable and shiftable loads). It gives more of flexibility and allows finding new financing sources for principal activities into the buildings. ACBA and NBK see DR-BOB project as a good opportunity to develop a methodology of implementation of DR measures at neighbourhood scale, and could be also useful to the process of urban planning. FCMB is more interested into the rise of awareness about energy saving actions of the teachers and apprentices.

The grid-connected Microgrid business model, when the energy produced by RES is exchanged, counted and billed locally between the buildings with multiple owners, has been mentioned as subject of interest by NBK and ACBA. Currently, in France, there is no of regulatory framework authorising independent generators connected to the power network to sell the energy produced locally to neighbour buildings; there is also a lack of standard legislation and regulations in operating Microgrids. However, the significant number of performant and positive-energy buildings pushes RTOs and local governments to reflect about it.

2.2.4.3 Areas of improvements

In all the buildings of the French demonstration site, the energy and power consumption data are not analysed. The supervision interfaces of BMS systems are only used to manage or modify building operation for adapting it to different staff activities inside; a limited number of persons is involved in this process in each building (one-two persons).

2.3 ITALIAN PILOT SITE

Fondazione Poliambulanza Hospital (FPH) is private not-for-profit hospital built in 1997 in Brescia (Northern Italy, 90km from Milan). Poliambulanza's history is much older (1903) but the full hospital services started in that year.

Brescia is not only a city of 200,000 People but is also a province of 1.2 million people. FPH is the second hospital of the Province.

FPH is a multi-specialty, acute care and surgery focused hospital, providing high-quality treatments with high-qualified professionals and latest electro-medical and ICT technologies. In FPH there are available 600 beds for inpatient admissions, 23 intensive care beds, 12 sub intensive care beds, 18 operating rooms and a full range of medical and surgical specialties and diagnostic services.

FPH is also engaged in emergency management and there is an Emergency Room with EAS (Emergency High Specialty) with 20 beds for Short Intensive Observation.

Figure 18: Location of Brescia in Italy

FPH is one of the 10 best-ranked hospitals in Italy, accredited by the prestigious **Joint Commission International.** Only 650 hospitals in the World have been awarded with this quality excellence accreditation and 18 in Italy.

2.3.1 GENERAL DESCRIPTION

FPH is located in an area of 95.000 m² in which there are 3 buildings for health care activities, 1 building dedicated to the research centre (CREM) and training centre for employees, 3 parking areas and a building in which are installed the machines for the production of steam, hot and cold water. By the end of 2016, a trigeneration unit will be installed in a dedicated building close to the visitors parking.

The owner of all the building is the same (Suore Ancelle della Carità) but the management of the Hospital is Fondazione Poliambulanza, a foundation created in 2005.

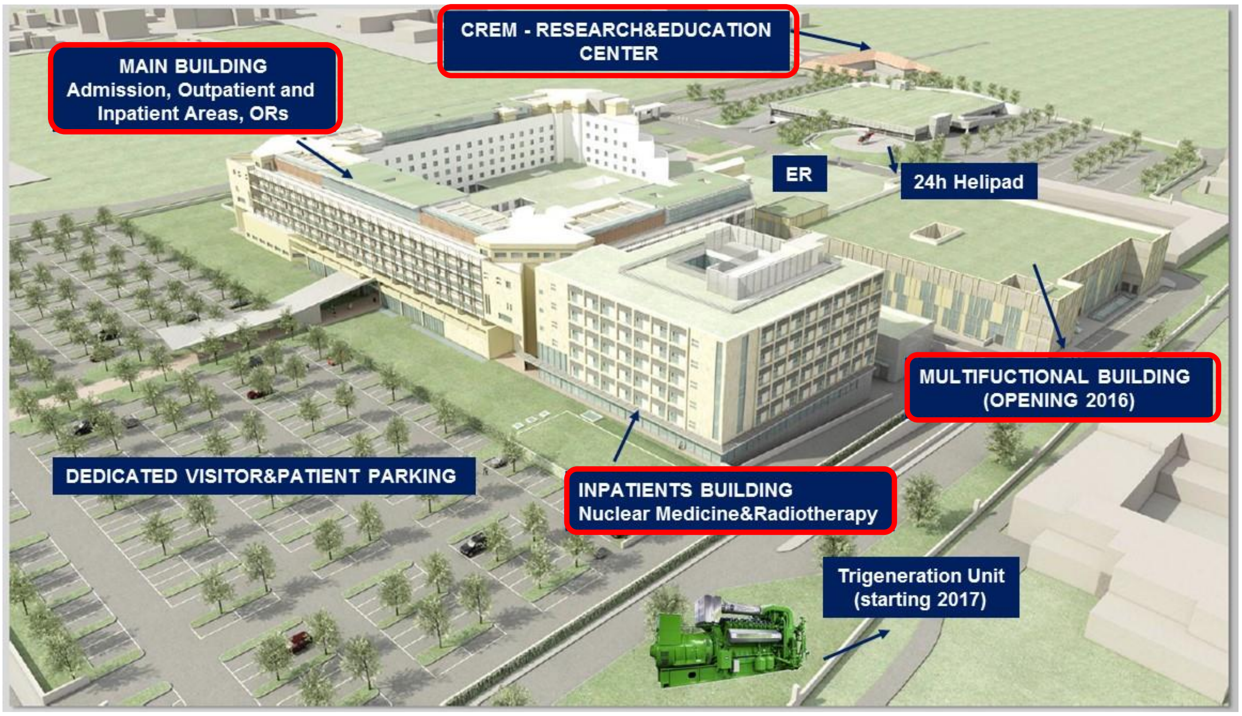

Figure 19: Overview of the Italian pilot site

The following table provides the list of buildings proposed to be part of the DR-BOB demonstration site.

Table 11: List of buildings involved in the Italian demonstration site and net floor area of each building

Building:	Year of construction	Number of levels	Net floor area (m^2)
Main Building	1997	6	37 000
Inpatient building	2012	7	8 500
Multifunctional building (operating rooms)	2016	4	9 000
Research Centre - CREM	2001	2	2 200

These 4 buildings are selected because some of them (the main building and the multifunctional building) share the heating plant and all of them are monitored through the BMS Siemens Desigo system located in the control room.

2.3.1.1 Buildings' structures, available technical equipment

2.3.1.1.1 Main Building and Inpatient Building

The Main Building was the first built in 1997. All the services (electro medicals and diagnostic systems, occupancy is mainly from 7:00 to 17:00 Monday-Friday) are mainly located in the ground floor and in the basement floor. From floor 2 to 5 there are mainly patients' rooms for all the different medical specialties (occupancy 24/7). The same configuration was used in the construction of the inpatient building in 2012. The main components and occupancy per room are given at the Appendix C. Italian

Demonstration site (see section 6.3). This part also provides a map showing all the departments and their location inside the Hospital.

2.3.1.1.2 Multifunctional Building

A new part of the hospital has been inaugurated in May 2016. The areas and activities planned in the 3 floors are listed in the Appendix C. Italian Demonstration site (see paragraph 6.3.1). Part of the activities today done in the Main Building will be moved to the new building.

2.3.1.1.3 Research Centre - CREM

This building was an old farmstead renovated and transformed in a research centre for staminal cells, telephone exchange for the booking centre and a training school for health workers and all the personnel. The main components and occupancy per room are given at the Appendix C. Italian Demonstration site (see section 6.3.1).

2.3.1.1.4 Available technical equipment

Concerning the energy systems, the following paragraphs describe the energy systems which are installed on site and deliver energy to the buildings.

The heating is produced with district heating heat exchangers. In the main building, since natural gas is currently cheaper than district heating, a steam-water heat exchanger is used to reduce the use of district heating. The heat emission is made through HVAC (heated air), fan coils (only in the offices), and chillers.

Table 12 provides the number of HVAC systems which are present in the different buildings considered in the Italian pilot site.

Table 12: Number of HVAC systems in the different buildings.

	Number of HVAC
Main building	49
Inpatient Building	7
Multifunctional building	21
Research centre	2

It could be envisaged to reduce the velocity or turn off HVAC during periods when ventilation is not strictly required. This can be made with the BMS system.

The following table provides the list of chillers that are used for air conditioning.

Table 13: Air conditioning systems installed in each building

Chiller	Model	Cooling capacity [kW]	Electrical power [kW]	Location
Trane 1	CVGD 045	2000	373	Main building
Trane 2	CVGD 045	2000	373	Main building
Trane 3	CVGD 030	1000	211	Main building

Trane 4	CVGF 0800	2500	4008	Multifunctional building
AERMEC 1	WSA 1602	423	97	Inpatient building
AERMEC 2	WF 3612A	1007	180	Inpatient building
RC GROUP 1	UNICO A.STD 260 F2 G8	243	78	CREM
RC GROUP 2	UNICO A.STD 110 Z2 G6	115	44	CREM

On April the 20th this year, FPH received the authorization to build a combined cooling, heat and power plant (CCHP) which will let them produce their own electrical energy, heating and cooling power to cover 80% of the energy demand. This power plant will let FPH be more free to choose when is more convenient to produce, consume or buy the required energy.

Table 14: Main characteristics of the CCHP to be installed in the Italian site

Trigeneration unit	
Electrical power	2 028 kW
Thermal power	1 857 kW
Cooling capacity	1 430 kW
Efficiency_electricity	44.3%
TOT efficiency	85.9%

The trigeneration plant will provide heat, cooling and power to the main building, the multifunctional building and the inpatient building. The research centre will not be supplied by it.

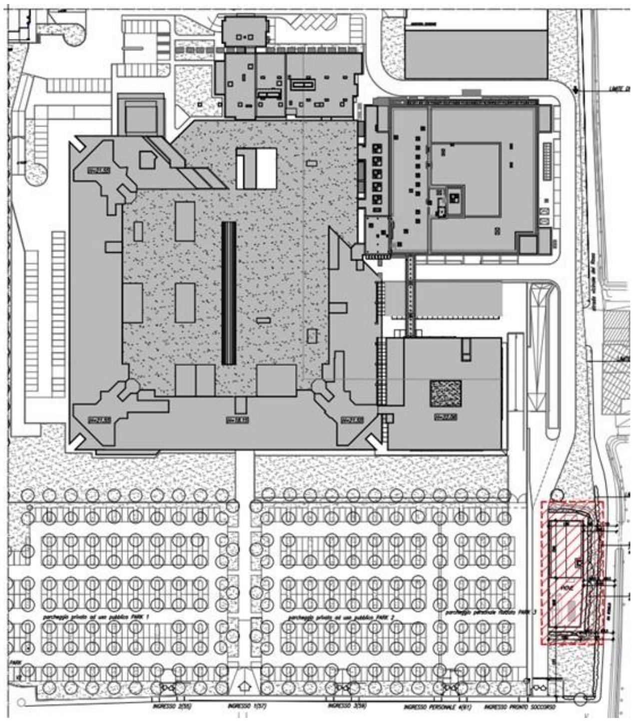

Figure 20: Location of the CCHP

Moreover, there are 5 diesel engines which are used to produce electrical energy in case of emergency however they cannot be used for any other reason.

All the buildings of the hospital are equipped with the BMS Siemens Desigo system. Temperature, humidity and all the sensitive parameters of the water and steam circuit are monitored from the control room. All the temperature set points can also be modified as required by the end users and occupants of the buildings in the control room using the BMS. In some rooms there is the possibility to change the temperature +/-3°C by the end user.

There are no standard set points for air temperature and humidity; however the following values are used as a reference.

Table 15: Main Set points for temperature and humidity used

	Temperature [°C]	Humidity [%]
Summer	>=26	50-60
Winter	<= 20	35-45

All the values read from Desigo can also be recorded even if today only the values that are related to the safety of people or machines are stored.

Today all the energy values are given by the provider and through the analysis of the energy bills. However, FPH is installing several energy meters to record and monitor real time electric and thermal energy consumptions.

Since the beginning of the DR-BOB project, 2 energy meters for steam, 2 for natural gas, 6 for the chilled water and 17 for the electrical energy have been bought. Currently, some work is conducted in order to install them and make the data available for the project. In that frame, a new energy monitoring system is currently being installed and will be able to get from Desigo the energy values connected to the Siemens system.

2.3.1.2 *Occupants' profile and energy usages*

All buildings are used 24/7 except the Research Centre building which has office time use (8:00-19:00 from Monday until Friday). During the month of August, holiday's period, less people occupy buildings.

The Hospital works 24/7. The research centre has equipment that must be powered 24/7.

2.3.1.3 *Stakeholders/decision makers description*

Table 16 provide the list of the main stakeholders involved in the functioning and management of the Italian Pilot site.

Table 16: Main stakeholders involved in the Italian pilot site

Stakeholders	Role or provided service	Users and estimated number of users	Stakeholder's impact on energy system	Benefits/uses of DR management for stakeholders
Poliambulanza general direction	Poliambulanza management	5	High – definition of an energy policy	Lower energy costs
Poliambulanza Maintenance workers	Plant maintenance	30	High impact – definition of the machine set point and temperature set point	
Hospital Patients	Users without responsibilities	>30000 per year		
Energy Provider	Energy provider (EE, district heating and GAS)		High impact on prices and energy volumes	Lower congestion on power grid
Doctors, nurses and staff	Occupants and active users of services	1800	Energy savings and small load shifting according to the DR program	Energy savings and environmental benefits

2.3.2 ENERGY PRODUCTION/CONSUMPTION INFORMATION

In FPH, electrical Energy, natural gas and District heating are used as energy sources. All the incoming energy is used and distributed to the whole Hospital from the energy substations.

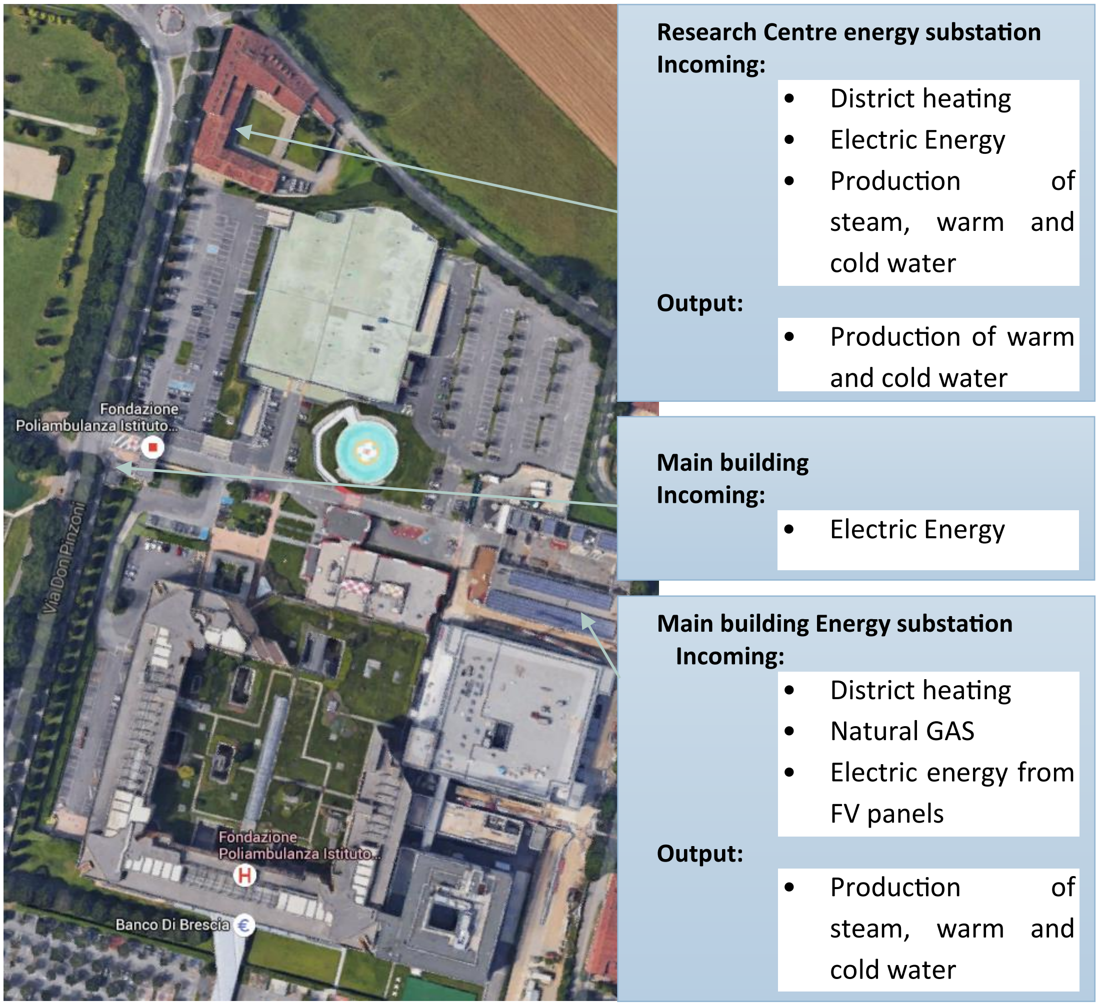

Figure 21: Locations of the substations and energy distribution description

For the electrical energy in FPH there are:

- 2 dedicated power lines (regular + Emergency) at 15000 Volts / 50 Hz for an available power of 4250 kW;
- 5 power generators for backup (diesel engines) which are rarely used;
- Photovoltaic panels: 121 kWp.

The maximum daily gas consumption is 7000 Sm3/day (Standard meter cubes) and is used in:

- 2 steam generators (2 MW and 3 t/h of steam each);
- Ovens and stoves for the cafeteria kitchen.

District Heating is delivered in two different areas: in the hospital energy substation and in the Research centre substation. The power available is:

- 61 m^3/h at 110°C for a total of 3500 kW available for the Hospital (5 heat exchangers);
- 3.87 m^3/h at 110°C for a total of 220 kW available for the Research centre.

The table below summarizes who are the local distributor and the energy provider (for electricity and gas, the provider can be different from the distributor who owns the power and gas network).

Table 17: Energy distributor and energy provider

Bills			
User	**Energy**	**Distributor**	**Energy Provider**
Research centre	**Electric energy**	**A2A**	**A2A**
Research centre	**District heating**	**A2A**	**A2A**
Hospital	**Electric energy**	**A2A**	**A2A**
Hospital	**District heating**	**A2A**	**A2A**
Hospital	**Gas**	**A2A**	**A2A**

2.3.2.1 Yearly/monthly values of energy consumptions/productions

Currently, monthly and annual energy bills are used for this site to calculate the energy use intensity.

Hourly data are available for the electrical energy consumed on site from the electricity provider: data in month N is available in month N+1 and is sent by email on demand.

The energy consumptions are available from the energy provider. Today, no energy meters are installed in FPH (an energy data manager and several energy meters are planned to be installed in all the hospital buildings).

ELECTRIC ENERGY – HOSPITAL

Figure 22 and Table 18 provide the monthly and yearly electricity consumptions of the whole hospital.

Chillers during summer season are the most important contributor to the electricity peak load in the whole hospital.

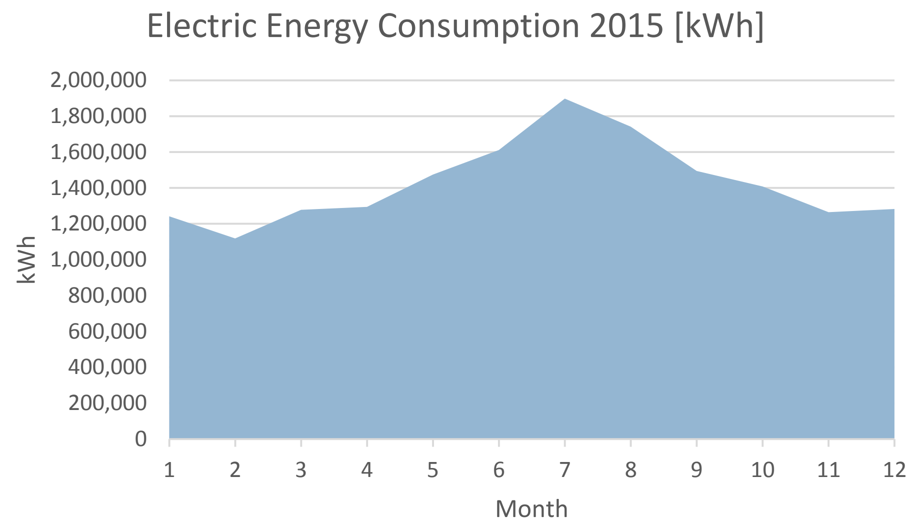

Figure 22: Monthly electricity consumptions for the whole hospital for the year 2014

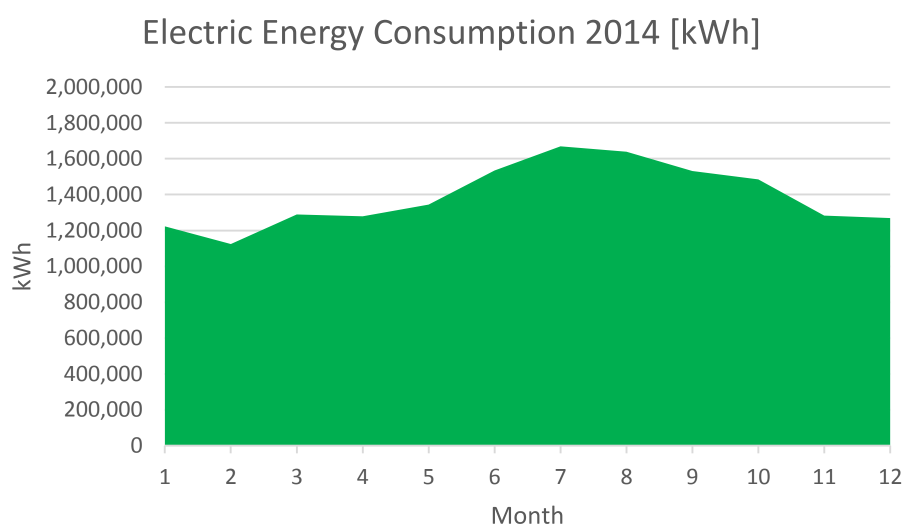

Figure 23: Monthly electricity consumptions for the whole hospital for the year 2015

Table 18: Yearly electricity consumptions for the whole hospital

Annual consumption [MWh]	
2012	16 467
2013	6 444
2014	16 671
2015	17 113

ELECTRIC ENERGY - RESEARCH CENTRE

Figure 24 and Table 19 provide the monthly and yearly electricity consumptions of the whole hospital.

For the research centre as well, the consumptions for the year 2015 are slightly higher than the other years. During the summer months (and mainly for July), the electricity consumption is up to three times greater than during the winter months.

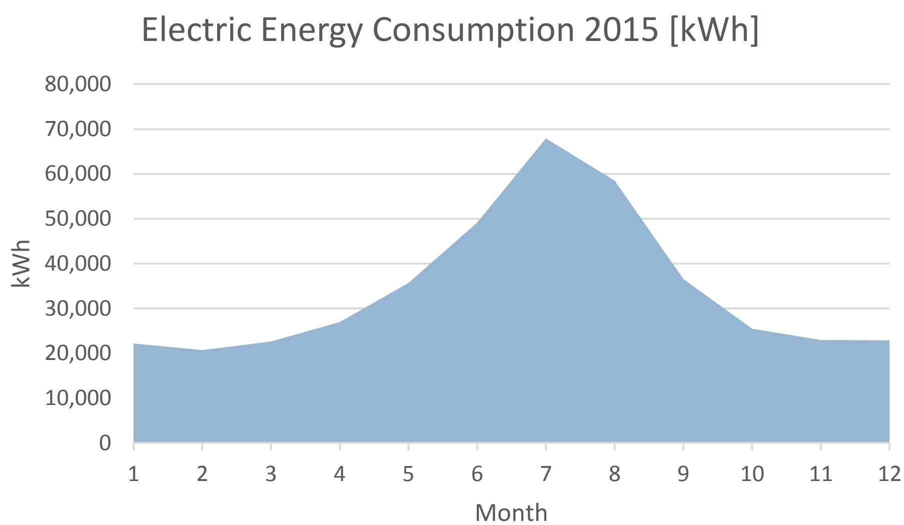

Figure 24: Monthly electricity consumptions for the research centre for the year 2015

Table 19: Yearly electricity consumptions for the research centre

Annual consumption [MWh]	
2012	374.6
2013	350.5
2014	349.1
2015	411.6

Figure 25 and Table 20 show respectively the monthly and annual PV production. This PV production fits well with the peak consumption observed for the research centre.

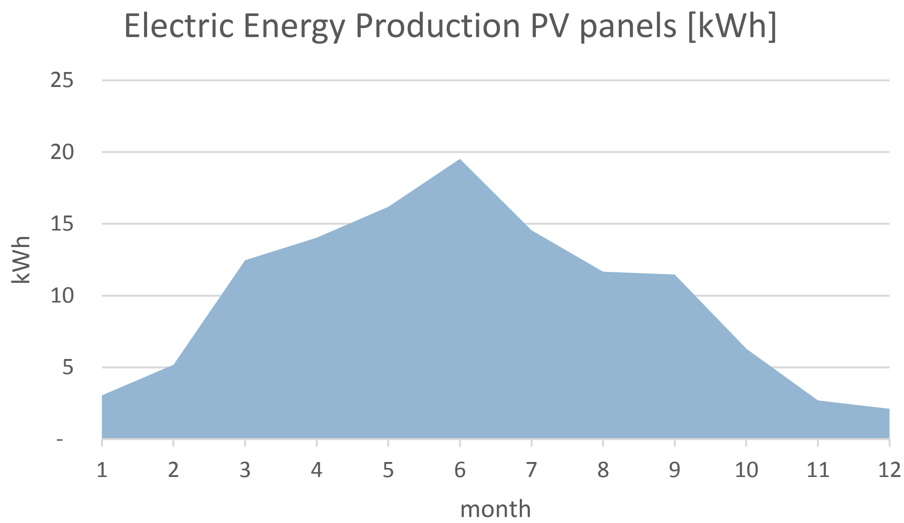

Figure 25: Monthly electricity productions through the PV panels installed on site for the year 2014

Table 20: Annual PV production

Annual production [MWh]	
2012	148,68
2013	136,95
2014	119,26
2015	95,57

In 2015 the PV production is reduced because of disconnection of some PV panels in order to build the new multifunctional building. In 2016, they were reconnected.

NATURAL GAS – HOSPITAL

Regarding the gas consumptions, natural gas is used in the kitchen for cooking and to produce steam for air humidification and hot water for heating. Indeed the Hospital heating is made both with steam and district heating. Figure 26 and Table 21 provide respectively the daily and yearly gas consumptions. As is the case for the electricity, gas consumptions are higher for the year 2015 in comparison to the previous years.

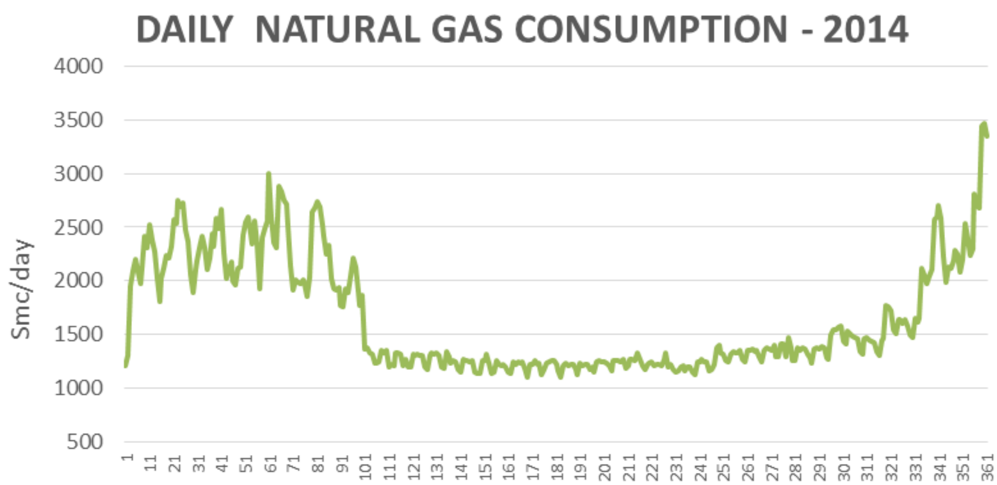

Figure 26: Daily gas consumptions for the whole hospital for the year 2014

Table 21: Annual gas consumptions

Annual consumption [Std. cubic meters – Sm3]	
2012	640,951
2013	608,267
2014	601,174
2015	761,857

DISTRICT HEATING – HOSPITAL

Figure 27 and

Table 22 show respectively the monthly and annual district heating consumptions.

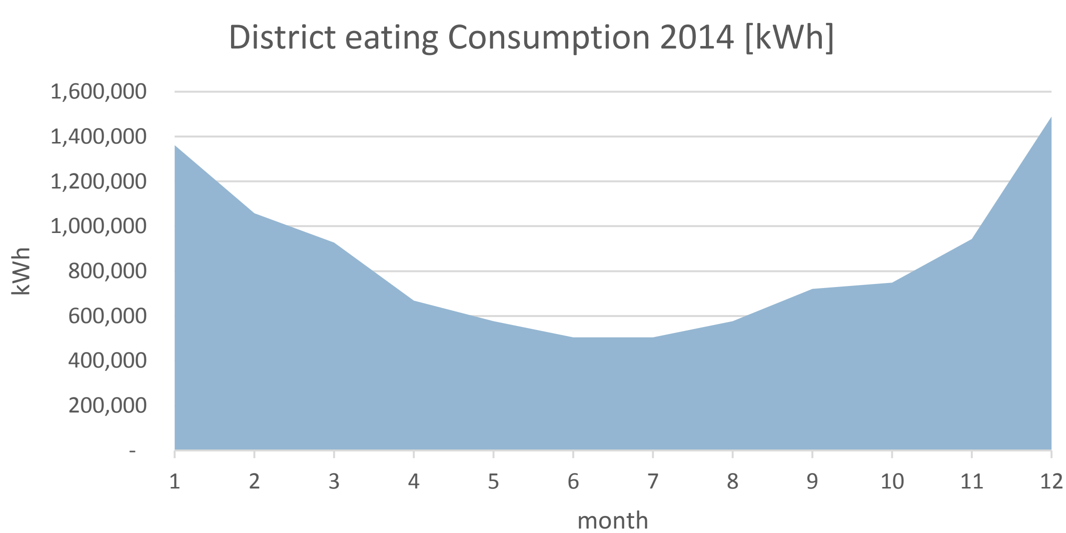

Figure 27: Monthly district heating consumptions for the whole hospital for the year 2014

Table 22: Annual district heating consumptions for the whole hospital

Annual consumption [MWh]	
2012	10,908
2013	11,664
2014	11,174
2015	9,586

Concerning the research centre, the district heating consumptions are given in Table 23.

Table 23: Annual district heating consumptions for the research centre

Year	Consumption [kWh]
2012	349.099
2013	395.243
2014	315.215
2015	323.905

2.3.2.2 Energy consumptions profiles

Figure 28 shows the daily electricity consumption profile for the whole hospital for the past 4 years. The profiles for these different years are very similar with a small increase for the year 2015. This can be explained because during 2015 Fondazione Poliambulanza has increased its services and employees because of an acquisition of another small hospital in Brescia.

In line with the occupancy profile of the site, the energy consumptions level during the nights is still high and represents about 70% of the consumption level observed during the whole day.

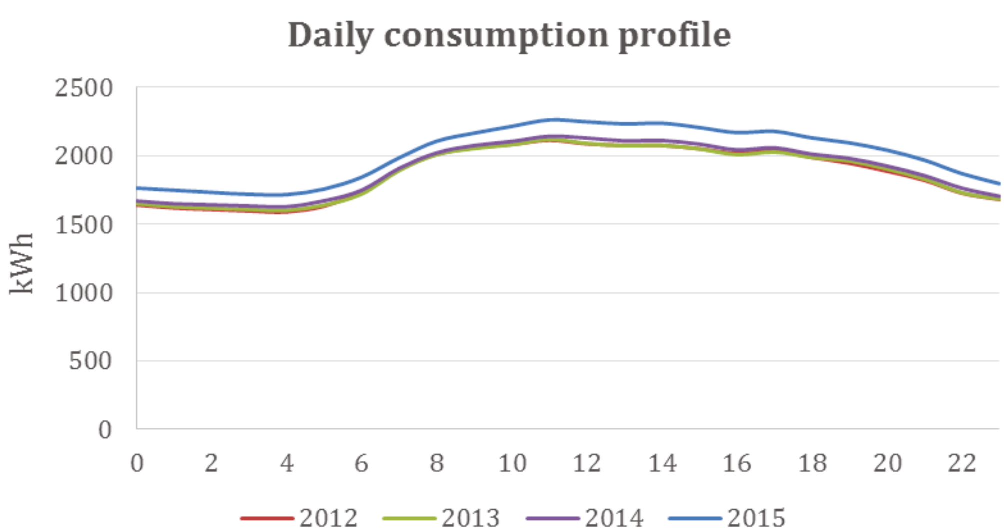

Figure 28: Daily electricity consumptions for the whole hospital

The following graphs provide the electricity and heat consumption breakdown among the different energy uses (estimations made during the energy audit based on installed power and average use of assets).

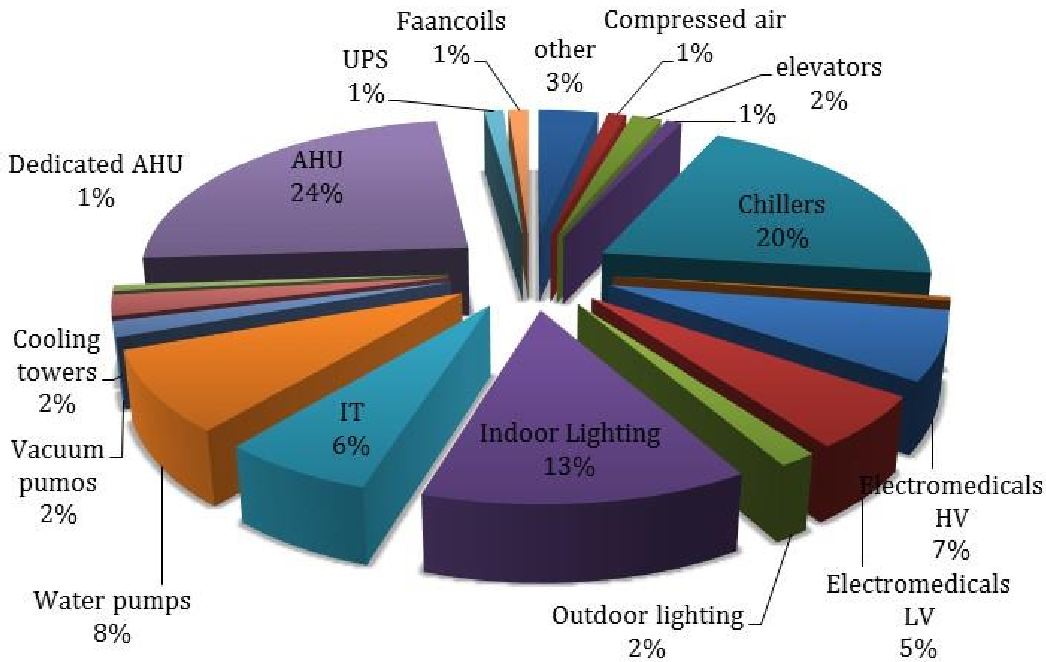

Figure 29: Electricity consumption breakdown

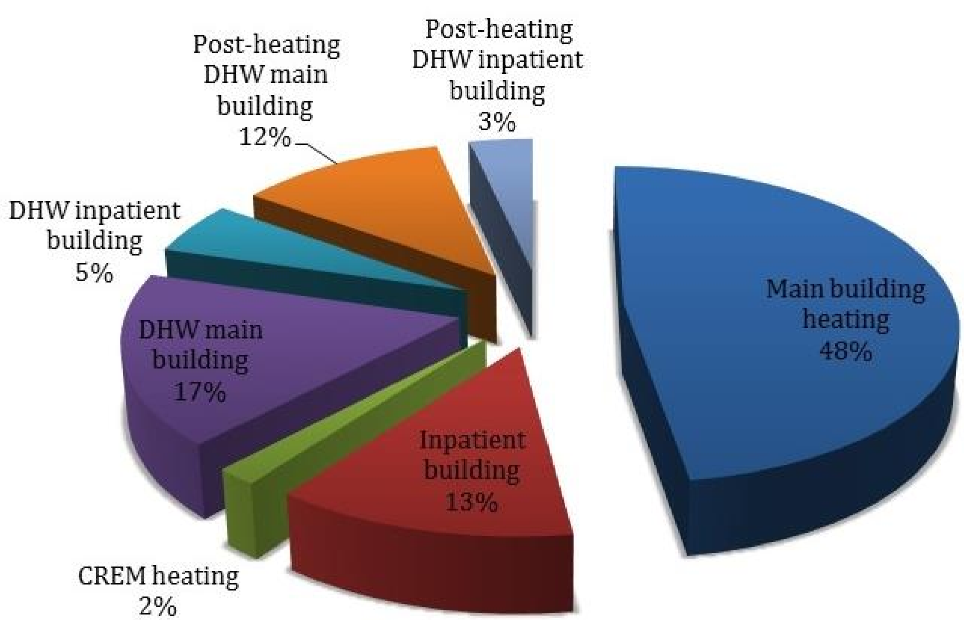

Figure 30: Heating consumption breakdown

2.3.2.3 Energy savings opportunities

Some measures have been implemented in the past few years in order to improve energy efficiency and generate savings. For instance, the light system has been revamped, new and more efficient steam generators have been installed, inverters on pumps and on some of the HVAC fans have been implemented. Nevertheless, some savings opportunities are still present, such as locking window to help reduce heat transfer during summer.

Within the hospital there are hard to shift energy needs since the comfort and safety of all patients must be guaranteed. What can be done is to best optimise the way the end energy is produced (gas vs EE) according to the market price of energy: cooling capacity for example can be made consuming electric energy in chillers or consuming natural gas in absorption chillers.

The DR measures that would be more attractive or interesting for the different stakeholders involved in the pilot site are related to peak demand and energy consumption reduction.

The DR measures that appear to be the most suitable and feasible for the Italian pilot site are the following:

- ✓ **Curtailing lighting.** Facility operators can curtail lighting in special-purpose rooms, such as cafeterias and lounges, when they are unoccupied. Operators can also reduce lighting in corridors. Rooms and corridors can use natural lighting if available. On average, reducing lighting loads in common areas, such cafeterias and lounges, can reduce a building's peak load by up to 5 percent.
- ✓ **Setting back chillers.** Setting the thermostat back can significantly decrease demand for cooling. In many cases, facility operators can raise temperature setpoints on chillers and slow pump systems while still providing adequate cooling. This strategy must be used carefully because other equipment within the chilled-water system may begin to work harder to compensate for the chiller's higher setpoint. Increasing setpoints by 0.5°C in hospitals can typically reduce overall peak load by 10 to 15 percent.
- ✓ **Shifting loads off peak.** Hospitals can shift certain processes to before or after a DR event. For example, facility operators can schedule food preparation, dishwashing, and laundry around a DR event. This strategy requires that hospital management effectively communicate scheduling requirements to staff so that they don't mistakenly turn on these loads during a DR event.
- ✓ **Using a building automation system.** Many modern healthcare facilities have complex BASs that use sensors and controllers to monitor and optimise lighting, temperature, humidity, and indoor air quality while minimizing lighting and HVAC energy use. If the BAS can communicate directly with the DR facilitator, the BAS can automatically adjust thermostat setpoints and reduce discretionary lighting loads upon DR notification—eliminating the need to manually adjust equipment. If a hospital doesn't have an automatic DR system, the staff or a facility manager would need to manually switch the BAS into DR mode to reduce HVAC and lighting loads through the BAS.

For these DR measures, the aggregator is relevant to consider in the whole process as he will send the signal for shifting loads.

The building manager is also involved as he is responsible for taking the actions in the pilot site. The beneficiary and potential user of these measures is of course FPH who manage the block of buildings as a whole.

2.3.3 LOCAL CONTEXT AND TECHNICAL/SOCIO/ECONOMIC CONSTRAINTS

For the energies used within the Italian pilot site, a fixed part of the tariff is proportional to the power required and the variable part is proportional to the energy used. The natural gas is cheaper than district heating: one MWh of district heating costs 65€ using gas just 39,5 € (considering gas price 0.38€/Smc). Considering this, the FPH prefers to minimize the use of district heating.

The Italian electric energy transmission system is composed from a first part that connect the production systems, with the local dispatching system, and have a network structure able to transmit through high distance in high voltage (>30.000 V). The Italian transmission system includes also the connection with the neighbouring countries with 400 kV power lines.

Terna Spa, the Italian Transmission System Operator (TSO) and network owners, is responsible for the transport and transformation of the electrical energy on the high voltage network. The second part of the grid, is used for the widespread distribution until the final consumers and is characterized by medium (10-20 kV) and low voltage distribution (<1kV). The selling, the transmission and transformation through the medium and low voltage network is responsibility of the local distributor (DSO). The Italian frequency used is 50 Hz with only slight fluctuations admitted of about 2%. The end user connections generally are done in low voltage for the domestic users and small buildings, but for the medium and big users, as the situation in FPH, is done in medium voltage thought a local substation situated near the property boundary.

The Italian tariff for the electrical energy purchased by the network is composed of four parts: the selling part, the dispatching, the network service and the tax service. Into these four parts, there are also two different types of weight for the electric energy, some fixed part of the tariff and some variable parts proportional to the energy used. The selling price is proportional to the energy used (kWh) and is differentiated in peak and off-peak for use time slot. This tariff covers the generation costs and the network losses. The selling price, for big consumers as FPH, is negotiated directly with the local distributors and can change year by year.

The dispatching tariff and the network service have some fixed monthly parts and some parts proportional to the energy used. This part of costs is regulated by the Italian authority called "Autorità per l'Energia Elettrica, il Gas ed il Sistema Idrico (AEEGSI)"[13].

The most important fixed part is paid normally once a month and depends on the maximum power requested and is calculated in €/kW each month, others fixed parts (€/month) cover the metering services, the distribution and some local fees.

[13] AEEGSI: http://www.autorita.energia.it

Another important element calculated into the network service is the reactive power share fee and cover the unbalanced load. From the 1st of January 2016, the Deliberation 180/2013[14] states that the relevant network operator may request the adaptation of the plants, on pain of suspension of the service, if they are not met, the following parameters:

- minimum level of the instantaneous power factor, at the maximum load for consumptions in high load periods, is equal to 0.9;
- minimum level of the average monthly power factor is 0.7.

Finally, the revenue taxes cover all the other taxes and the VAT. From this price structure it is clear that saving electricity is critical to reduce the bills, although other factors influence. Additionally, simply reducing the maximum power requested (e.g., shifting, without reducing the total energy consumption) delivers cost savings.

The regulatory framework in Italy allows that building owners export electrical energy produced by RES to the grid and promote the energy from RES with priority of dispatching from the energy produced by traditional plants.

The mechanism of selling energy to the grid provides for two options: the first one is called “Ritiro dedicato” and is regulated by GSE (Gestore dei Servizi Energetici). The price of selling depends on the average monthly price per time slot formed through the electricity market referred to the same area which the facility is connected to. For the small producer with electrical nominal power plants up to 1 MW, can receive a “guarantee minimum price” for the first 1,5 million of kWh per year placed on the network. The minimum price system is regulated by AEEGSI. For the 2016 the guarantee minimum price for photovoltaics plant with nominal power up to 1 MW is 39 €/MWh[15].

The second option is the sale of energy to private companies, with contracts lasting several years. Nowadays it is preferred to the “Ritiro dedicato” as it allows to negotiate, even for RES small generation plants, better conditions in terms of reduction of network charges/fees and a premium on the sale price on the market, and allows to negotiate the advance payment of the energy, while the terms offered by the GSE are equal to two months.

The regulatory framework also authorises building owners to self-consume the energy produced locally, and especially in the last years, is promoted the self-consumption against grid selling. At the moment, the most convenient option for industrial company is the self-consumption that is the option chosen in FPH. The energy production by RES has no application of taxes in case of self-consumption. Different situation is applied to CHP plants, because the energy produced is defined as assimilated energy and not as renewable energy. In this situation, the electric energy

[14] Deliberation AEEGSI 180/2013/R/eel - http://www.autorita.energia.it/it/docs/13/180-13.htm
[15] Source: AEEGSI - Prezzi minimi garantiti per l'anno 2016
http://www.autorita.energia.it/allegati/comunicati/160201tab.pdf

produced by a CHP plant, even if consumed on site, is taxed with a specific fee for the production of electric energy, from which renewable sources are exempt.

In the FPH site, a time-based tariff is used for the purchase of electricity. That means that the price of electricity bought from the grid varies according to the time periods of the day as in the following table:

Table 24. Italian time zone definition during the week

Time zone	Mon-Fri	Saturday	Sunday and festivity
From 7:00 to 8:00	F2	F2	F3
From 8:00 to 19:00	F1	F2	F3
From 19:00 to 23:00	F2	F2	F3
From 23:00 to 7:00	F3	F3	F3

During the last year of price monitoring and negotiation, FPH has paid for the electric energy a price within the limits of Table 25. In the Italian energy framework, the energy price partition in peak and off-peak or in time zones was the first attempt for market balancing through voluntary action aimed to move high loads in time periods with lower energy request, but until now, the balancing is far from being achieved.

Table 25. Electric energy price in Fondazione Poliambulanza Hospital (22% VAT non included)

	Minimum price [€/MWh]	Maximum price [€/MWh]
F1	154,37	156,90
F2	153,10	155,63
F3	140,42	142,94

2.3.4 EXPECTATIONS FROM THE PILOT SITE

2.3.4.1 Stakeholders' expectations and insights

In Italy, there aren't programs for demand response: the flexibility in the use of energy is still not directly incentivised. The market is still immature and the economic crisis, started in 2008, did not help in implementing a solution able to reduce congestions in energy transmission or inefficiencies on energy production since the overall energy demand has been reduced.

However, electric energy tariffs have some components which depend on time of use and on the peak power consumed every month. What is expected from the management of Fondazione Poliambulanza is to be able to become more flexible in energy consumption and have the total control of what, where and when the energy is used. The awareness of energy consumption will lead to energy savings and a reduction of greenhouse gas emissions.

2.3.4.2 Specific objectives

In 2017, a CHP plant with an absorption chiller will start producing energy for Fondazione Poliambulanza, the main objective being to maximise the energy self-produced and consumed by the power plant. The CHP has been chosen with a maximum power half way from peak and off-peak power required by the hospital so there will be moments in which the gap between production and consumption could be filled by buying or selling energy to the network[16].

The maximum energy and economic efficiency of the system can be achieved trying to flatten the consumption profile to get it closer to the straight line of the energy production (increase of self-consumption). This can be done by shifting, shedding or storing energy loads.

2.3.4.3 Areas of improvements

The main area of improvement is the automation and control of all loads in the hospital. In Fondazione Poliambulanza there is already a BMS but its potential is still not exploited as it could be. An energy monitoring system is also essential for this kind of actions and needs to be improved and expanded.

2.4 ROMANIAN PILOT SITE

2.4.1 GENERAL DESCRIPTION

Technical University of Cluj-Napoca (TUCN), being a public higher education and research institution, pays an increased attention to the energy efficiency of its own block of buildings, as the annual cost of utilities is currently around 5% of total costs. It is located in Cluj-Napoca which is the second most populous city in Romania, in the north-western part of the country. The climate of Cluj-Napoca can be described as temperate continental climate, characterised by warm dry summers and cold winters. The climate is influenced by the city's proximity to the Apuseni Mountains, as well as by urbanisation. Some West-Atlantic influences are present during winter and autumn.

[16] One should notice that the excess energy from the CCHP is not being paid by the energy provider.

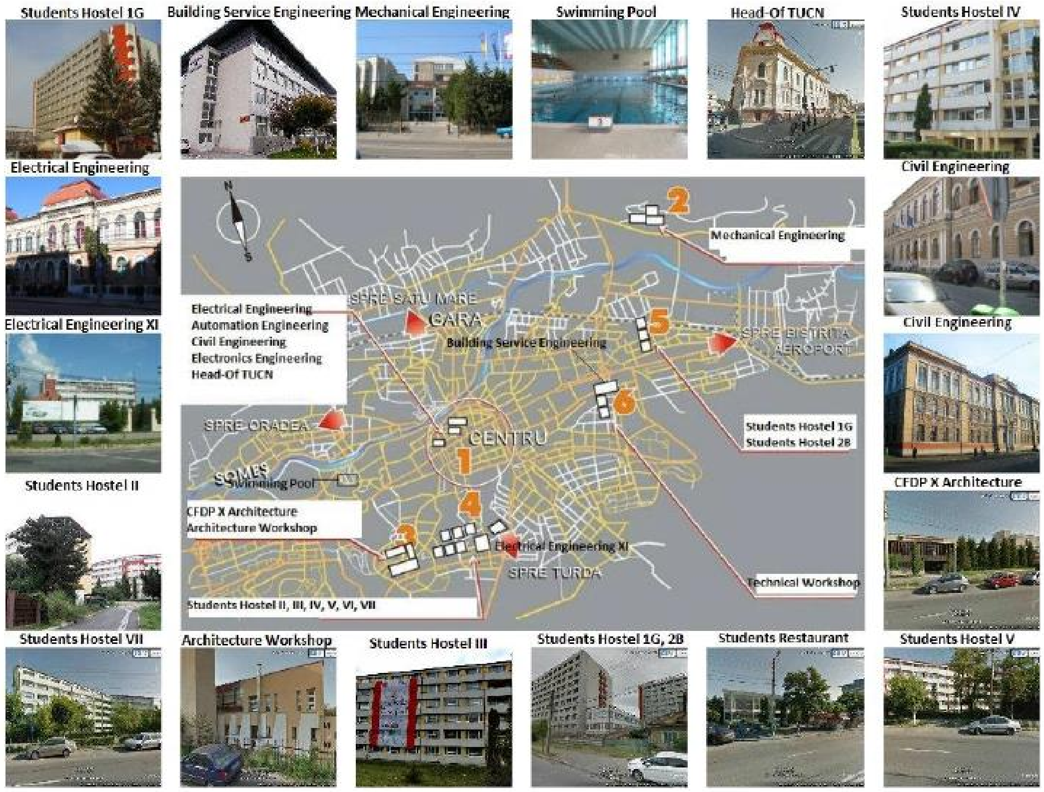

Figure 31: The different buildings pertaining to the Technical University of Cluj-Napoca

In 2014/2015, a holistic approach was performed for the energy efficiency potential evaluation of the whole block of TUCN buildings. All started from an enthusiastic team of 11 energy specialists within Technical University of Cluj-Napoca, who launched a series of energy investigations and implementations for all of TUCN 36 buildings, an equivalent of 108.397m².
Looking at a total annual utilities bill of 1.490.775 euro (28,26 GWh for both electricity and gas), with an average specific primary energy consumption of 330 kWh/m².yr, with all top management TUCN support, but more, with some 75 students of different profiles involved, so as to benefit of total energy & cost savings estimated at 10.840 MWh/yr and 1.092.000 euro, i.e. 73% financial gain with a 7,2 ROI.

The approach consisted in teamwork detailed energy audits and pilot implementations, all to prepare a realistic and attractive action plan to be put in practice. It resulted a whole range of energy saving solutions: integrated cloud energy management system using M&T (Monitoring & Targeting) and M&V (Measurement & Verification) tools, applied behavioural change strategies, smart lighting (pilot implementation in Building Services Faculty one amphitheatre, resulted in a power cut from 5,12 to 1,57 kW), Variable Speed Drive on pumps (pilot in Olympic Pool brought 7.800 euro/yr), free cooling on servers (tested on Computer Science Faculty), small CHP's of 20 kWe/40 kWt for the pool and student hostels to be implemented (IRR 32%), solar panels, wind turbine on Observatory building, photovoltaic panels on Electrical Engineering, thermostatic valves in hostels (14% savings), etc.

The initiative to undertake this project still relies on a strong partnership between teaching professionals and our students, outside the laboratory in real buildings environment. To act on students, means to act on future direct market players. Universities can be the catalyst of change in energy efficiency in both buildings and industry. TUCN shares thus a strong faith, know-how and efficiency results across to the wider community.

In the frame of the DR-BOB project, an energy monitoring system and a partial building energy management system will be implemented in 12 of TUCN buildings from the total of 36 buildings, those that have incorporated mechanical ventilation, centralized air conditioning and the possibility to control the indoor lighting. Those 12 buildings are distributed in 4 different locations over the city of Cluj-Napoca and proposed to be a part of the Romanian pilot site.

General layout maps of the buildings that are proposed to be a part of the Romanian demonstration site are as follow.

Location 01*: "G. Baritiu" street, No. 26-28 (****Electrical Engineering****)*

Legend:

B01 – Main Building
B02 – Secondary Building
B03 – Appendix B
B04 – Appendix D
B05 – Appendix S
B06 – Appendix H

Figure 32: Location of buildings 01, 02, 03, 04, 05, 06

Location 02*: "21 Decembrie 1989" street, No. 128-130 (****Faculty of Building Services****)*

Legend:

B07 – Main Building
B08 – Secondary Building

Figure 33: Location of buildings 07 and 08

***Location 03**: “Fabricii de Zahar” street, No. 58 (**Campus Marasti**)*

Legend:

B09 – Dormitories 1F
B10 – Dormitories 2B
B11 – Student Restaurant

Figure 34: Location of buildings 09, 10 and 11

***Location 04**: “Splaiul Independentei” street (**Swiming Pool**)*

Legend:

B12 – Indoor Swimming Pool
B13 – Outdoor Swimming Pool

Figure 35: Location of buildings 12 and 13

2.4.1.1 *Buildings’ structures, available technical equipment*

TUCN has a campus of 36 buildings, spread in the whole city, but can be considered as one block of buildings (Figure 31). 22 of them house Research and education activities, 4 are used for administrative purposes, 7 are student hostels and 3 are used for delivering services like restaurants, workshops, the Swimming Pool Complex, etc.

The total net useful surface area of the whole block of buildings is evaluated at 108,397 m^{2}and the net useful surfaces of the buildings being part of the Romanian demonstration site are amounting to 37,464 m^2; these are provided in Appendix D. Romanian demonstration site (see the paragraph 6.4.1).

The buildings chosen to be part of the DR-BOB demonstration site are spread throughout the city and there is no metering/data logging equipment available for the entire demonstration site. Digital electricity meters, and analogue gas and water meters are installed for groups of buildings by address: “G. Baritiu” street, No. 26-28; “21 Decembrie 1989”, No. 128-130; “Fabricii de Zahar”, No. 58; and “Splaiul Independentei”.

Also, there are some very small local energy generators for educational purposes in the TUCN laboratories, i.e. a 4 kWp Photovoltaic system connected to a 9 kWh batteries pack for energy storage at Location “G. Baritiu”, No 26-28.

The detailed list of main assets of the buildings is provided in Appendix D. Romanian demonstration site (paragraph 6.4.2).

With the exception of Baritiu group of buildings, where there is a photovoltaic unit of 4 kW, all the other buildings are using energy exclusively from the National Power Grid. There is a single energy contract with only one supplier. The methane gas is supplied by E.ON company through a gas distribution system. The gas is used for space heating, DHW and in the 2 restaurants for cooking.

There is a plan to install a small 20 kWel CHP in the Swimming Pool Complex. The CHP heating energy will be fully used for heating the water in the swimming pool.

Each building or group of buildings has individual thermal units controlled by the outdoor temperature and individual thermostats.

There is only one mechanical ventilation system in the Faculty of Building Services and it can be controlled by the occupants.

Almost all the buildings have Air Conditioning individual or centralized units. The control can be one by individual occupants and by the maintenance people for the centralized units.

There is no BEMS in either of the TUCN locations or buildings.

At G. Baritiu 26-28 location, there is an internet server room which has its own UPS emergency power system. In all the other locations there is only the emergency exit lighting system, with no impact on the emergency energy supply.

The utility costs 2013 associated to the buildings of the demonstration site are provided in Appendix D. Romanian demonstration site (paragraph 6.4.3).

2.4.1.2 Occupants’ profile and energy usages

Most of the buildings are mainly used for education and research activities, during the semesters (G. Baritiu 25, 26-28 --- C. Daicoviciu 15 --- 21 Dec 1989, 128 --- Dorobanti 71-73 --- Muncii 103-105 --- Observator nr 72 --- Observator nr 2 --- Observator nr 12). Therefore, these buildings are less used during summer months: July, August, September (especially August) and during winter holidays (20. December – 06 January). Memorandumului 28 is the main administrative building of TUCN and therefore is not used (almost not used) during summer holiday (August) and winter holidays (20 December – 06 January).

The dormitories (Observator 34, Piuariu Molnar 2) are used as student hostels all year, including during summer (July, August, September). In this period like 25% of the dormitories are used and the rest is closed. At the beginning of September there is a period of two weeks when all the dormitories are closed, cleaned and renovated (if necessary). During winter holidays the dormitories are almost closed 90% of students are on vacation.

The Swimming pool (Splaiul Independentei) has an inside pool and an outside pool which is open to the public during the summer (June-September), the inside pool being used only for training and sport events (in this period). The inside pool is opened all year long, except 1 of January.

Table 26 provides the estimated occupancy profiles of each building during a week as well as maximum occupancy of each building.

Table 26: Estimated occupancy profiles of each building

Buildings	**Max occupancy**	**Average occupancy, % from maximum occupancy**						
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
G Baritiu 26-28	6034	57%	45%	56%	48%	50%	4%	0.5%
21 dec 1989, 128	800	59%	54%	59%	52%	49%	4%	1%
Muncii 103-105	5278	57%	46%	51% 50%	38%	5%	1%	
Observator 34	3200	88%	90%	92%	89%	98%	74%	72%
Memorandumului 28	400	71%	64%	65% 62%	73%	5%	1%	
Splaiul Independentei	200	69%	75%	77%	85%	83%	84%	66%

Table 27 summarizes the buildings involved in the demo site as well as the occupants occupying these buildings and the main energy uses.

The lighting system is responsible for more than 35% of the total energy use. The hardware appliances, including the servers demand an estimated rate of 25%. The AC units require an estimated rate of 20%. AC, servers cooling, lighting, hardware equipment are most contributing to the electricity peak load of the buildings. By the way, AC units, servers cooling could be time-shifted for at least 15 to 30 minutes.

Table 27: Occupants per building and main energy uses in each building

Address	Building/s	Functions/Uses	Type of occupants and estim. hrs	Energy consumption related to:	Timing of occupancy	Potential for shifting	Potential for reduction
21 Decembrie 1989, No. 128-130	Main Building and Secondary building	Education and Research	Students, and Staff/ 8h/ term weekday	Heating	daytime	+++	+++
				Cooling	daytime	+++	+
				Lighting	all day	+	+++
				Computing	all day	+	++
Fabricii de Zahar, No. 58	Dormitories 1F, 2B and Restaurant	Administrative and Accommodation	Students; 16h/ day/ term	Heating	daytime	++++	+++
				Cooling	daytime	+++	+
				Lighting	all day	+	+++
				Personal Electronics	all day	-	-
G. Baritiu, No. 26-28	Main Building A, Secondary Building, Appendix D, S and H	Education and Research	Students, and Staff/ 8h/ term weekday	Heating,	daytime	+++	+++
				Cooling	daytime	+++	+
				Lighting	all day	+	+++
				Computing	all day	+	++
Memorandumului, No. 28	Main Buiding	Administrative	Staff/ 8h/ weekday	Heating	daytime	+++	++
				Cooling	daytime	+++	+
				Lighting	all day	+	+++
				Computing	all day	+	++
Muncii, No. 103-105	Building VIII, Appendix A,B,C,D+L,E+P,G+T,S Building IX	Education, Research and Administrative	Students, and Staff/ 8h/ term weekday	Heating	daytime	++	++++
				Cooling	daytime	+++	+
				Lighting	all day	+	+++
				Computing	all day	+	++
				Mec.Workshop	daytime	+	-
Observatorului, No. 34	Dormitories II,III,IV,V,VII and Restaurant	Administrative and Accommodation	Students; 16h/ day/ term	Heating	all day	+++	+++
				Lighting	all day	+	+++
				Personal Electronics	all day	-	-
Splaiul Independentei	Swimming Pool Complex	Services	Students, and Staff; during the day	HVAC	daytime	++++	+++
				Lighting	all day	+	+++
				Water Treatment	daytime	+++	++++

2.4.1.3 Stakeholders/decision makers description

TUCN is the legal owner of all the buildings. There is a Technical Department involved in the maintenance of all the buildings. Within the project, there will be designated a Local Energy Manager for TUCN buildings.

There is a General Administrative Director in charge of all executive decisions regarding the TUCN facilities, energy usage and implementation of all investments. All decision making regarding the project implementation will be handled by the General Administrative Director – Technical Department and local DR-BOB project coordinator, including the LEM. All the project description was already transferred to the Director and Technical Department and they are prepared to support the implementation.

TUCN pays all the energy bills (electricity, gas and water). Each of the buildings or group of buildings is charged separately, due to separate and local within the buildings energy meters. TUCN profits all the energy and cost savings.

TUCN has its own maintenance personal for the buildings and for the electrical system. Each lab has its own technician who is responsible for the maintenance of laboratory equipment. For major problems with heating or cooling systems TUCN has maintenance contracts with external maintenance service companies.

The following table lists the main stakeholders involved in the Italian pilot site.

Table 28: Main stakeholders involved in the Romanian pilot site

Stakeholders	Role or provided service	Users and estimated number of users	Stakeholder's impact on energy system	Benefits/uses of DR management for stakeholders
Rector of the University	General coordination of the University	1	Decision making for all issues	Additional resources for other investments in sustainability.
General Administrative Director	Administrative coordination of the University	1	Energy efficiency decision making	Cost reduction with utilities.
Accounting Department	Accounting	3	Present periodical reports regarding the energy costs to the top decision makers.	Cost reduction with utilities.
Technical Department	Engineering	5	Can improve the energy use in each building through adaptation of HVAC systems and by requesting specific investments to the top decision makers.	Additional resources for maintenance.
Workshops	Engineers, Technicians	20		Additional resources for maintenance.
Building Administrators	Asset Management	16		Additional resources for maintenance.

TUCN	Beneficiary	27450	TUCN is the highest energy consumer in the category of local municipality universities.	Energy Efficiency Better negotiation of energy price with the energy supplier Low impact in the municipal power grid, leading also to reduce power outages especially during summer.
Electrica Distribution Transylvania North	Distribution Electricity Operator	-	It is the only regional distribution operator for electricity.	Lower power losses and avoidance of increased investments in strengthen the municipal power grid.
E.ON	Regional Distribution Gas Operator	-	It is the only regional distribution operator for methane gas.	-
RDS RCS	Actual (2016) Electricity supplier	-	It provides electricity to almost all the public major energy users in Cluj-Napoca.	They are opened to an increased control in the energy use of their Clients, which can lead to advantageous energy contracting in the market and consequent prices for the users.
E.ON	Gas supplier	-	-	-
Centre for Resources in Energy Efficiency and Climatic Changes (CREESC)	Local Energy Advisory Board	-	Acting as a partner for TUCN in energy advisory and in the Energy Management together with TUCN for the Cluj-Napoca municipality.	Board of advisory specialists.
Servelect	ESCO	-	Acting as a partner for TUCN in demonstration energy efficiency projects.	Will provide support in the DR project for TUCN blocks of buildings.
Somes Water Company	Public Water Company	-	Provides water and waste water treatment for all users in Cluj-Napoca, including TUCN.	It is opened to implement any project that cans feasible lead to energy efficiency and power cuts.

2.4.2 ENERGY PRODUCTION/CONSUMPTION INFORMATION

With the exception of Baritiu group of buildings, where there is photovoltaic unit of 4 kW, all the other buildings are using energy from the power grid. The methane gas is supplied by E.ON company through a gas distribution system. The gas is used for space heating, DHW and in the 2 restaurants for cooking.

In Baritiu group of buildings there is a photovoltaic generation of 4 kW. This PV system is not associated with an electricity storage system.

There is a plan to install a small 20 kWel CHP in the swimming pool. The CHP heating energy will be fully used for heating the water in the swimming pool.

Each building or group of buildings has individual thermal units controlled by the outdoor temperature.

2.4.2.1 Yearly/monthly values of energy consumptions/productions

The administrative department of TUCN collects the data regarding energy consumption from electricity/gas/water bills. The data is analysed monthly and at the level of each year according to type of consumption (gas, water or electricity) and according to consumption location (according to group of buildings). Based on an agreement with the electricity provider, TUCN can obtain the electricity consumption at each location at one hour frequency for a specific required time period, but only offline, the day after. At the level of 2014 and 2015, the Electricity Load Curves have been plotted, for each of the buildings location by the DR-BOB TUCN Team, based on data acquired from the electricity provider company.

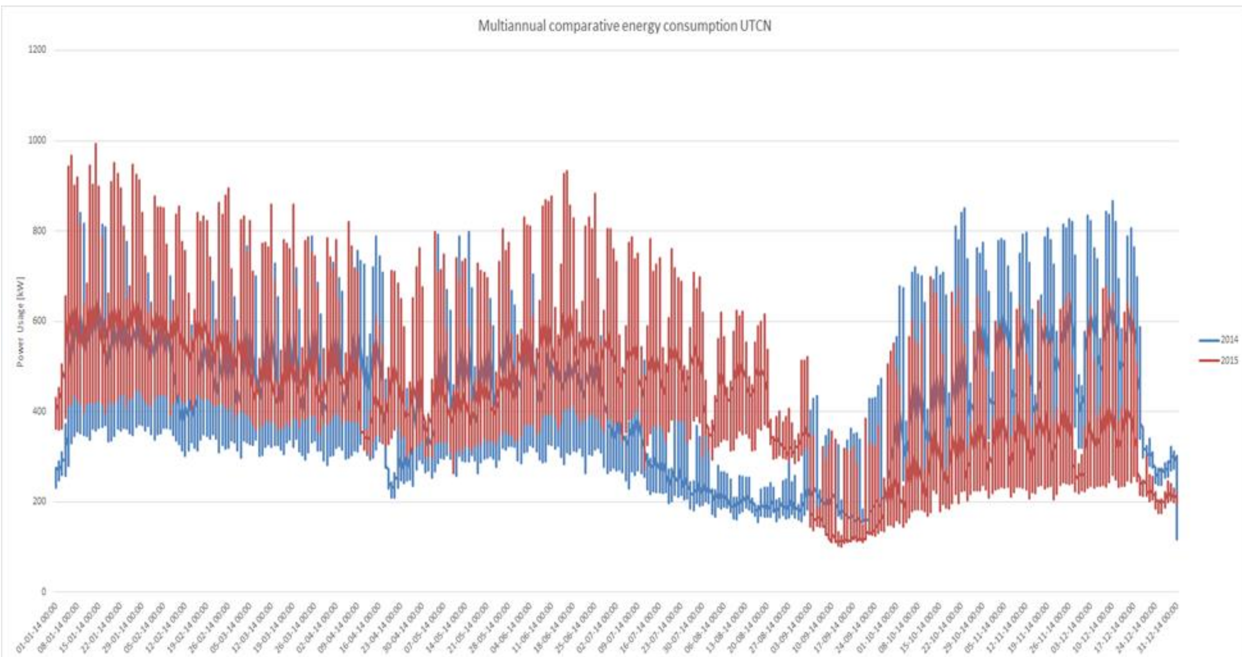

Figure 36: Total TUCN electrical energy consumption during a year

At the moment, there is a centralized sheet with all the energy consumption and energy costs, available both monthly and yearly. The specific energy cost per square meter is 11,5 euro/m² of net surface useful area.

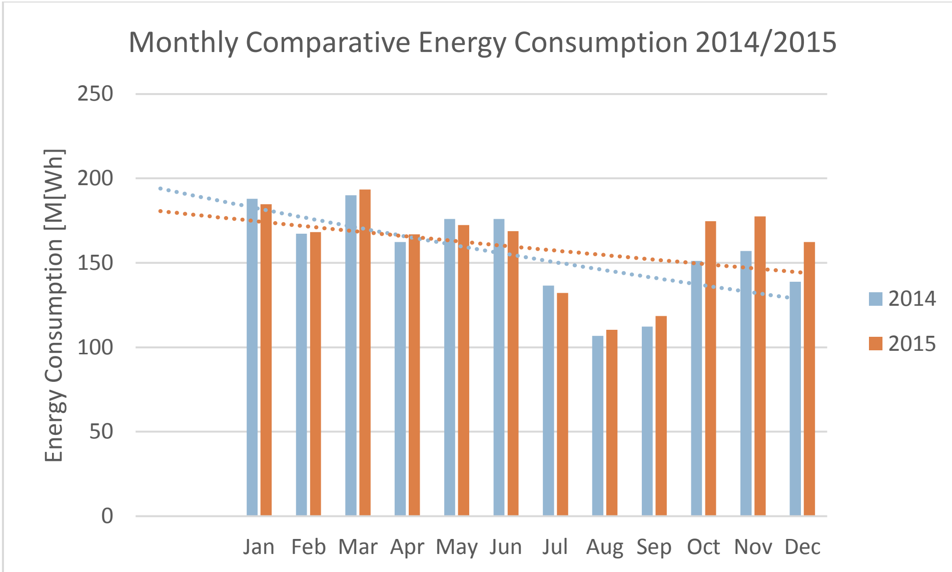

Figure 37: Monthly energy consumption

Here can be seen also the aggregated load curve for the block of buildings belonging to the TUCN pilot site:

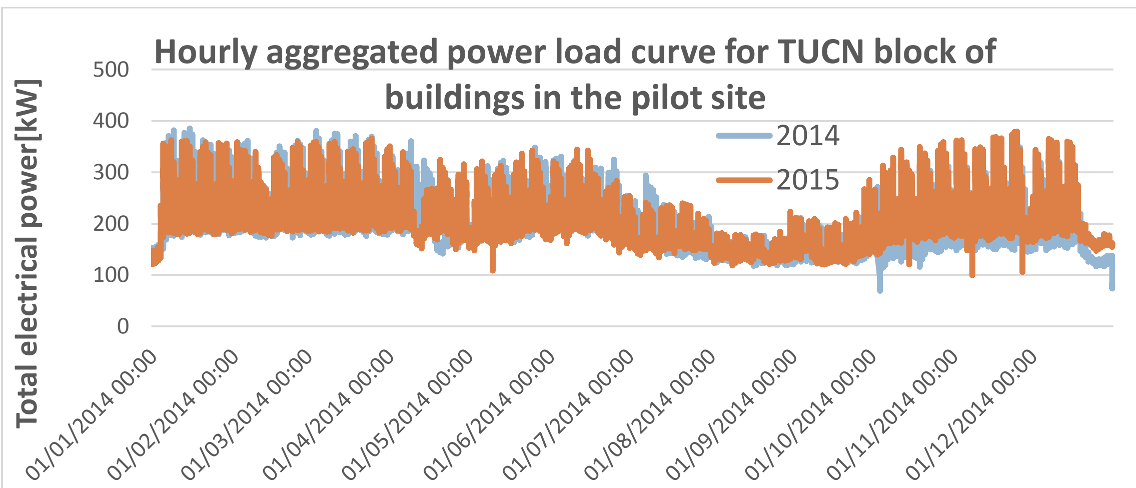

Figure 38: Hourly aggregated power load curve for TUCN BOB

The current CO_2 emissions associated to energy use is evaluated at a specific rate of 37,5 kg CO_2 emissions / m².

2.4.2.2 Energy consumptions profiles

The following pie chart shows the breakdown of gas consumption per building.

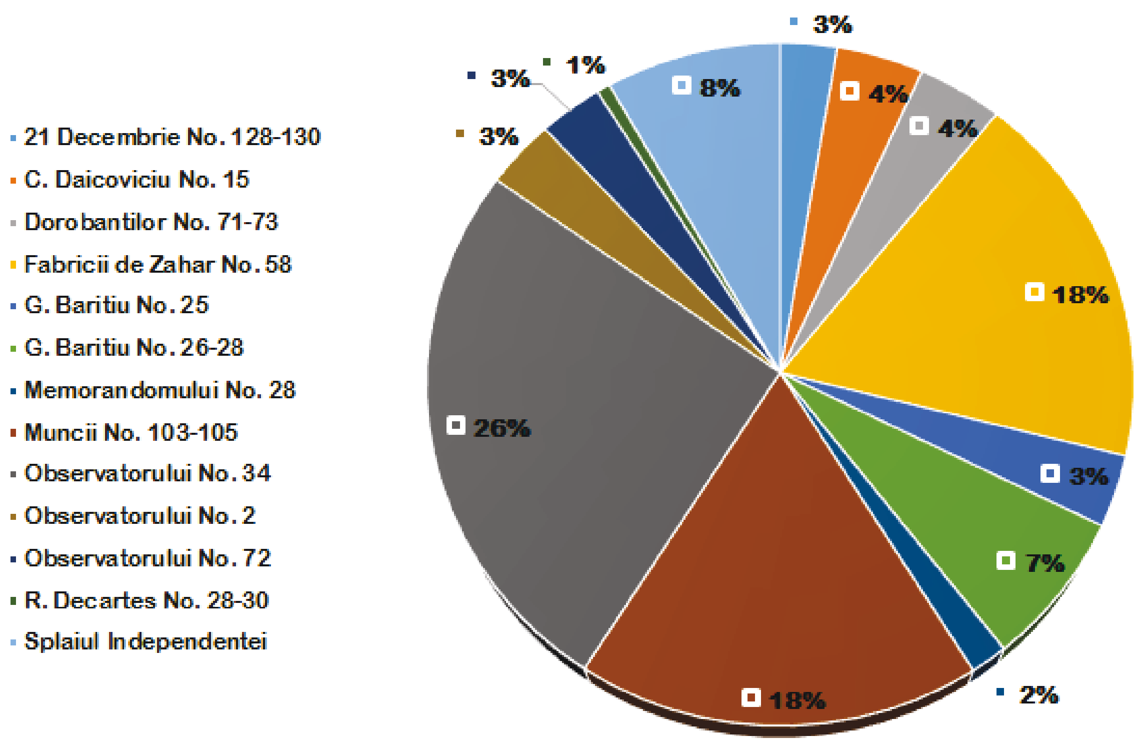

Figure 39: Total Gas Consumption distribution on TUCN pilot site locations

The daily energy demand is reflected in the following graphs.

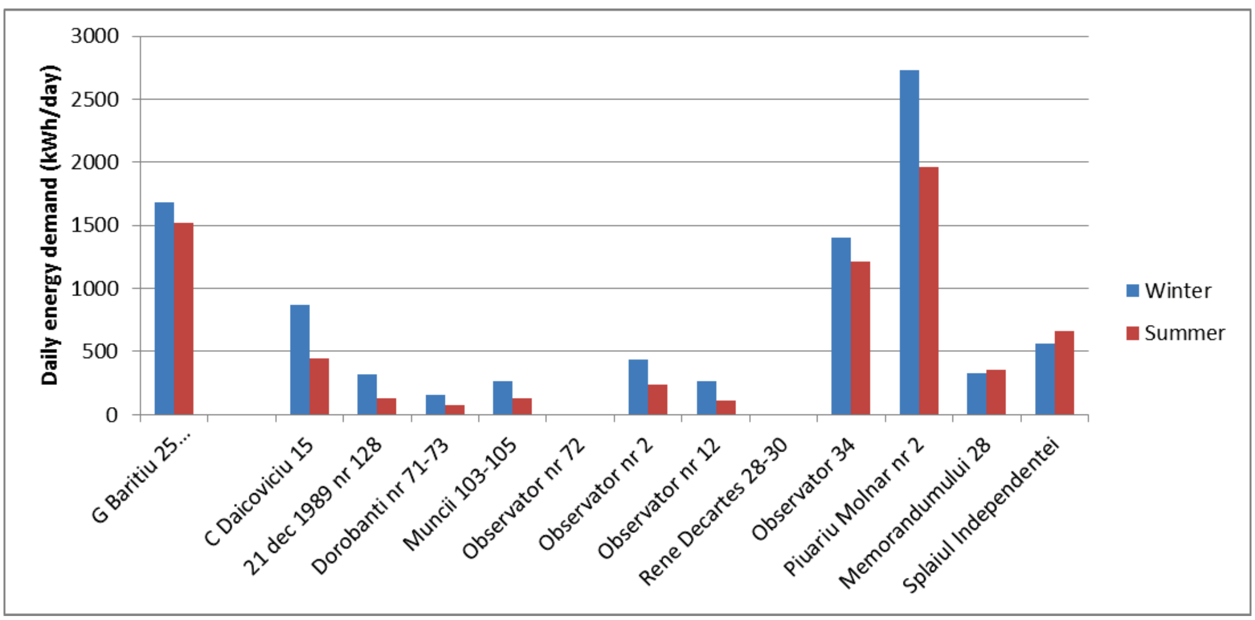

Figure 40: Daily energy demand per address during winter and summer

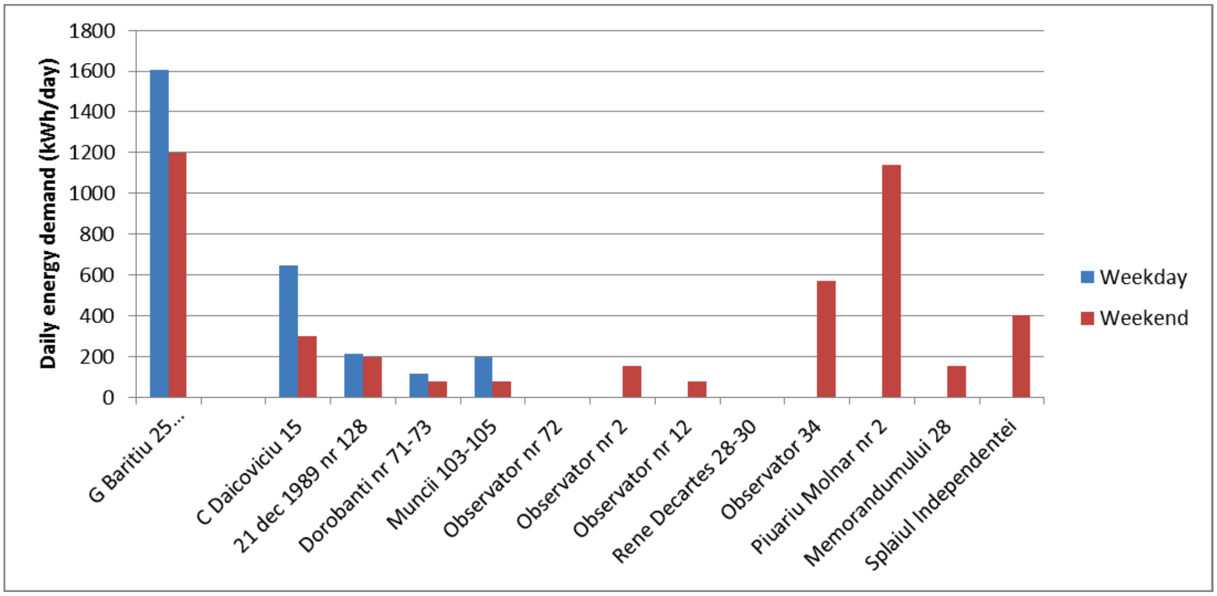

Figure 41: Daily energy demand per address during weekday and weekend

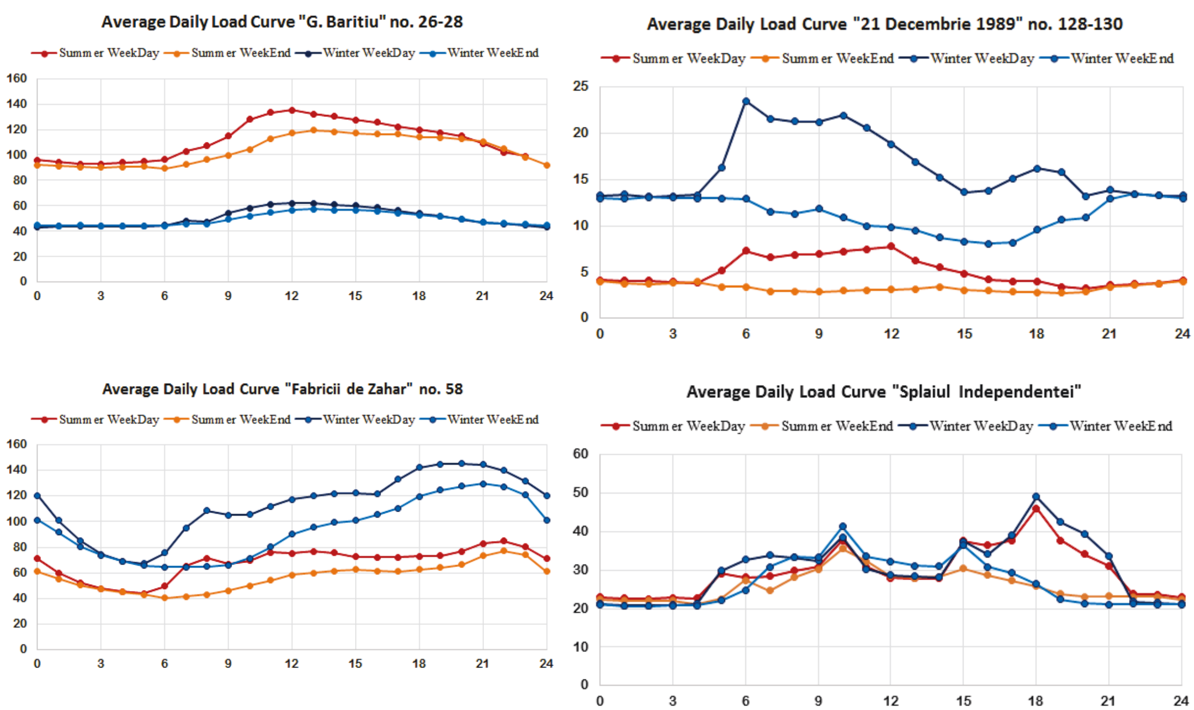

Figure 42: Daily energy demand per address during weekday and weekend

2.4.2.3 *Energy savings opportunities*

Students in dormitories can reduce their energy consumption by switching of lighting when is not necessary. A number of occupancy sensors has been planned to implement in corridors, toilets and other spaces for lighting.

Energy usage of the education and research buildings could be reduced by a better planning of the heating/cooling hours (setting different temperature set points during the day and during weekends), by a control of the lightning system, switching of the lights when and where is not necessary, by increasing the natural lightning in the course rooms.

At education and research buildings and at the dormitories, the energy consumption can be shifted by rescheduling the working hours of the heating & cooling systems. At the swimming pool energy consumption can be shifted by planning the water heating and recirculation periods. Another energy consumption shifting could be obtained by rearranging the students / the laboratories time tables for the laboratories with heavy electrical or mechanical equipment that have an increased electrical consumption.

It should be emphasized that the energy supply from the power grid in the case of the Baritiu group of buildings has serious issues of security and continuity in the energy delivery, a fact that has to be solved by installing an additional TUCN power transformer.

2.4.3 LOCAL CONTEXT AND TECHNICAL/SOCIO/ECONOMIC CONSTRAINTS

TUCN has to purchase the electricity and gas within a yearly public and transparent bid, with the main imposed criteria the minimum energy price, granted for at least 12 months. At the current moment, there is no price differentiation related to the time of use, seasonal dependence or existence of self-consumption.

Regulatory framework in Romania allows building owners export electrical energy produced by RES to the grid nevertheless there is no feed-in-tariff or other incentive. The price for exporting energy is thus not attractive and does not vary during the year. Regulatory framework also allows self-consumption of the energy produced locally. Self-consumption is the option which has been selected for the PV system installed in one of the block of buildings. There is no tax or fee associated to this self-consumption.

Currently, there is no differentiated energy price at all, but the electricity suppliers can offer this opportunity if the load curve and the energy consumption can be better predicted and controlled.

Presently there is no DR programme at national level in Romania.

The main barriers to DR approach in Romania lies in the lack of trust in the effects of DR, lack of priority, lack of funding, and lack of knowledge.

2.4.4 EXPECTATIONS FROM THE PILOT SITE

The expectation from the pilot site is to both improve the energy efficiency, by using the implemented energy monitoring system, and to successfully achieve and demonstrate Demand Response effectiveness in the selected block of buildings.

2.4.4.1 Stakeholders' expectations and insights

The majority of the stakeholders are expecting improvements in the area of energy wastage and energy cost savings through a better, centralised monitoring system of energy meters.

TUCN has also designated a Local Energy Manager, authorized by the Romanian Energy Regulation Authority (www.anre.ro) to coordinate the energy management activities, to provide data and suggestions to the stakeholders and to involve in all energy efficiency implementations and reflect their impact in DR-BOB project. The involvement of this Local Energy Manager as a specialized professional, along with the Local Energy Manager tool provided in the project by TU, was very well welcomed by the stakeholders.

2.4.4.2 Specific objectives

A specific objective for the pilot site would be the remote monitoring and accurate load curve plotting for the monitored block of buildings, in order to determine the potential for load shifting throughout the day and also to collect the so called low hanging fruits, with the help of the specialized Local Energy Manager.

2.4.4.3 Areas of improvements

There are a multitude of areas where the energy management can be improved, as there is room for energy reduction throughout the TUCN Campus of approximately 70%, as reflected from a recent Energy Audit Report.

3 DEMONSTRATION SCENARIOS

This section describes the demonstration scenarios of Demand Response technologies at the four pilot sites. It includes 3 subsections:

- A table summarising DR programs that could be implemented with their main parameters (description, building assets targeted, existing commercial or governmental DR programs related, type of signal, approximate number of events per year, beneficiary, feasibility and barriers). These measures have been designed by the pilot sites managers and are based on strong knowledge of assets and activities conducted inside their demonstration sites.
- Demand Response scenarios based on the DR programs mentioned above and interviews with local stakeholders with more clearly defined parameters relative to DR events (start time, duration, signal, opt behaviour, event targets, number of events per year). For some of demonstration sites, the link with existing commercial or governmental DR programmes is also given, if the energy market access requirements[17] are met. Some main parameters such as **Maximum expected impact** is difficult to be evaluated at this stage of the project because of the absence of monitoring systems or required test conditions (winter period, summer period).
- A short description of the management tools that will be used to implement these Demand Response scenarios.

The way these scenarios will be deployed is somewhat independent of the characteristics of these DR scenarios and is not described in this deliverable.

3.1 DEMAND/RESPONSE SCENARIOS

The following Demand Response scenarios are described using the next main parameters:

- For explicit DR, **Event** is a notification from the utility to demand side resources requesting load shed/shift starting at a specific time, over a specified duration and may include targeting information designating specific resources that should participate in the event. For implicit DR, the signal is simply the cost of electricity.
- **Start time** specify the time of the day when the event should start.
- **Event duration** is the length of the event.
- **Event Signal** is the actionable information contained in an event such as electricity pricing or specific levels of load shed requested or local weather signals that typically trigger some pre-programmed load shed behaviour by the recipient of the event.
- **Opt Behaviour** means the expected response from the demand side resource owner (or facility manager) upon receipt of an event. This response may take the form of OptIn or OptOut indication whether or not resource will participate in the event.

[17] The main barrier for the participation of block of buildings into electricity market is the minimum power reduction threshold. In most of European countries the electricity markets, if exist, are open to large consumers having a significant impact to a balance between demand and production. The minimum power reduction required for participation into the electricity markets is typically starting from 1 MW. However some programs in UK are open to all consumers and other programs in France are open to consumers with a minimum of 100 kW per half-hour power reduction.

- **Event Targets** are the demand side resources whose load should be modified upon receipt of a signal.
- **Response Time** is the time-period between receipt of an event and effective shifting/shedding of loads.
- **Dispatch Mode** means that the solution takes action to activate a response itself directly (Intervention) or it provides a signal via the Consumer Portal to the facility manager for a manual action (Notification). This mode is also called "Control Mechanism" in deliverable D2.3.
- **Notification** designates a period of time prior to the start time of an event where the demand side resource owner (facility manager) is notified of a pending event. The notifications could be sent to program participants via phone, email or SMS.
- **Maximum Expected Impact** is maximum energy or power reduction of upon receipt of an event. It could be attended by shifting event targets or switching them to storage.
- **Number of Events per year** designates a number of events days during one calendar year.
- **Report** designates the need of report to be provided by one or multiple parts of the DR-BOB solution containing the information about loads effectively shifted/shed and energy/power reduction realized.
- **DR Programme** is a commercial or national DR market programmes existing at markets of demonstration sites.

3.1.1 UK PILOT SITE

Four scenarios for the operation of demand response at the TU site are outlined in the table below. Fuller descriptions of the UK markets are given in Appendix A. UK Demonstration Site (see the paragraph 6.1.3).

Table 29. Demand Response programs for the UK pilot site

DR-BOB project DR program/ Impact Target	Possible DR measures at BOB scale	Building assets to be targeted by the DR measures	DR measure's description	Commercial or governmental DR programs	Type of DR signal	Number of DR event days per year	Beneficiary	Feasibility of DR action at BOB or building's scale	Barriers
Electrical Demand Reduction	Self-consumption of local energy production	CHP Plant	Switch on CHP plant and reject heat when grid electricity demand exceeds supply	DER (Demand Side Balancing Reserve in UK)	Activate during contracted availability period	Dependent upon contract, principally available during summer	Teesside University Northern Power Grid	Feasible, CHP can be dispatched via BMS	Capacity is not large (220 kW) Contract issues with Ener-G require negotiation
	Modification of HVAC and Chiller operations	Chillers	Temporary increase of ambient temperature set-points (chillers)	DLC (Probably STOR in UK)	Direct or Manual Load Control	To be agreed with the occupants and building manager, in order to have the ambient comfort conditions maintained. To be evaluated on the basis of the inertia potential of the building.	Teesside University Northern Power Grid	Feasible, chillers can be dispatched via BMS	Capacity may not be large
		HVAC	Temporary reduction / suspension of HVAC operations	DLC (Probably STOR in UK)	Direct or Manual Load Control			Feasible, HVAC can be dispatched via BMS	Capacity may not be large Current controls do not function well: some improvements may be required

Electric Demand Increase	Cease self-consumption of local energy production	CHP Plant / Boilers	Switch off CHP plant and activate boilers to cover heat load when grid electricity supply exceeds demand	DER (Demand Turn-Up in UK)	Activate during contracted availability period	Dependent upon contract, principally available during winter	Teesside University Northern Power Grid	Feasible, CHP and boilers can be dispatched via BMS	Capacity is not large (220 kW) Contract issues with Ener-G require negotiation
Electrical Peak Demand Reduction	Shifting of local energy consumption	Open access Labs / EV Chargers	Shifting of usage of lab equipment and EV charging to better times	Triad and DUoS (Distribution Use of System) charges	Triad warning emails and DUoS schedule	~20 Triad warnings for 3 events per year, DUoS has daily peak period.	Teesside University	Yes	Requires setting up an email list of technical lab managers, EV users and user screens
Frequency Regulation / Emergency Load Shedding	Shedding of local electricity consumption in critical conditions	IT Server UPS / Diesel generators	Fast load curtailment during times of grid distress (low frequency)	Frequency Control by Demand Management (FCDM)	Local measurement of low frequency	10 (approx.)	Teesside University Northern Power Grid	Yes, only under simulation	Capacity may not be large, requires simulation models and installation of frequency measurement equipment

Scenario 1 – Electric Demand Reduction

Event:

Start time: upon requirement, typically afternoon peaks

Response Time: 20 mins (STOR), two hours (DSBR)

Duration: 1/2 hours

Signal: Activation request, confirmed by facilities manager

Opt Behaviour: OptIn/OptOut

Event targets: CHP plant, HVAC, chillers

Maximum expected impact, kW: to be evaluated, approx. 400 kW

Number of Events per year: 24

Report: required

DR Programme: DER/DLC (DSBR/STOR in UK Market)

The largest market for DR in the UK is the Short Term Operating Reserve (STOR). It has a 20minute minimum alert time for response so it is possible to coordinate manually activated actions to reduce demand. In the case of the Teesside University pilot site this means that the larger units controlled by the BMS in a number of buildings could be activated together.

Scenario 2 – Electric Demand Increase

Event:

Start time: upon requirement, typically off-peak times

Response Time: At least 10 minutes, usually day-ahead

Duration: 1/2 hours

Signal: Activation request, confirmed by facilities manager

Opt Behaviour: OptIn/OptOut

Event targets: CHP plant

Maximum expected impact, kW: to be evaluated, approx. 220 kW

Number of Events per year: 24

Report: required

DR Programme: DER (DTU in UK Market)

The novel Demand Turn Up (DTU) scheme may incentivise the deactivation of the Teesside University CHP plant during summer months. This would reduce self-consumption and increase grid import. It could be particularly favourable at the TU pilot site as DTU periods (overnight and at weekends in the summer months) coincide with low heat demand on campus.

Scenario 3 – Electric Peak Demand Reduction

Event:

Start time: 16:00, peak-times

Response Time: At least 4 hours warning given

Duration: Up to 3 hours, nominally 30 minutes

Signal: TRIAD warning, DUoS schedule

Opt Behaviour: Voluntary action upon signal

Event targets: Laboratory equipment (servo motors, process rigs, PCs, fume hoods, clean room air conditioning), EV charging

Maximum expected impact, kW: to be evaluated

Number of Events per year: approx. 20 warnings for 3 events

Report: not required

DR Programme: Triad (Transmission Network Use of System) and DUoS (Distribution Use of System) charges in UK market

Triad charges are levied on all UK customers with half-hourly metering (100kW peak demand) and come into action during the winter in late afternoon and early evening. Warnings are given a day in advance which allows time for more distributed interventions that require communication and manual input. Examples of these would be individually turning off laboratory equipment or deactivating electric vehicle (EV) charging points.

Scenario 4 – Frequency Regulation / Emergency Load Shedding

Event:

Start time: upon requirement, random

Response Time: 2 seconds

Duration: 30 minutes

Signal: local low frequency measurement

Opt Behaviour: Week ahead availability agreement: no OptOut when agreed

Event targets: UPS/Backup Generators for IT Servers

Maximum expected impact, kW: TBC

Number of Events per year: random (Poisson), mean of 10/year

Report: required

DR Programme: Decentralised FD/AS (FCDM in UK Market)

Frequency regulation requires rapid automated response so is suitable for only a small number of loads. The TU IT servers are supported by an uninterruptible power supply (UPS) with backup generators which have the technical capability to respond in this time period but would have to be configured outside of the BMS. This scenario will be simulated before being trialled to establish that it is worth the technical burden.

3.1.2 FRENCH PILOT SITE

Actually there is neither of national, nor regional mechanisms allowing access to the electricity market for a block of buildings in France. The NEBEF mechanism is only one French mechanism potentially allowing it, but at its actual state the French demonstration site could not participate into this mechanism.

The Demand Response programs for the French pilot site are described in the following table.

Table 30. Demand Response programs for the French pilot site

DR-BOB project DR program	Building assets to be targeted by the DR program	DR program's description	Type of DR signal	Number of DR event days per year	Beneficiary (type of benefits/ opportunity)	Feasibility of DR action at BOB or building's scale	Barriers	Expected Impact Target
TOU (Time-of-Use)/ similar to TOU (Tempo) tariffs	All electricity powered	Shifting of the important loads from Peak-hours to Off-peak hours	Incentive, price signal	Variable depending of contract	NBK direction, FCMB direction, ACBA (BI building owner); RTE (TSO); ENEDIS (DSO);	All the buildings	Need to be contractualised between supplier and consumer	Annual Electrical demand reduction (from the grid); (P_{PEAK} - $P_{MIN\_NIGHT\_TIME}$)
	All electricity powered	Shifting of the important loads from the red and white days to blue days of Tempo tariff	Incentive, price signal	Red days: 22 White days: 43				
Load curtailment or shedding of important loads	Heat pumps of building	Shifting of outside block of heat pumps composed by the compressor, evaporator and condenser	Tariff Tempo (red days, white days); Wholesale market price signal; Local Weather signal	To be agreed with NBK direction and ACBA	NBK direction, ACBA (BI Building owner); ENEDIS (DSO)	NBK and BI buildings	Depends on the functionalities of the BMS	Annual Electrical demand reduction (from the grid); (P_{PEAK} - $P_{MIN\_NIGHT\_TIME}$)
	Cooling heat pumps for server room	Precooling and Temporary increase of ambient temperature set-point		To be agreed with the IT department		NBK and BI buildings		
	On/off secondary pumps of heat pumps (NBK)	Shifting of secondary pumps by optimising management of pump controller by:		To be agreed with the occupants and building	NBK direction; ENEDIS (DSO);	NBK and FCMB buildings	Depends from the functionalities of BMS	

		- Temporary decrease of ambient temperature set-point during winter months; - Temporary increase of ambient temperature set-point during the summer months; Temporary switching from the Comfort mode to the mode No Frost		manager in order to have the ambient comfort conditions maintained. To be evaluated on the basis of inertia potential of the building.				
	Computers (NBK, FCMB, BI)	Wide use of laptops by NBK and FCMB staff allows the manual (or automatic if possible) switching to the batteries supply		To be agreed with the occupants → habits to be changed	NBK direction, FCMB direction, ACBA (BI Building owner); ENEDIS (DSO)	All the buildings	Possible nuisance for the users affecting willingness	
	EV batteries/ UPS backup power batteries for server room	Use the electricity stored in the EV or UPS backup power batteries installed in NBK building during the peak hours or during the periods of peak tariffs		To be agreed with the IT department	FCMB direction, ACBA (BI building owner), NBK direction; ENEDIS (DSO)	All the buildings	Absence of company's EVs; Need of multiple EVs ; Limitation for use of EVs by staffs	
	Heat production systems of FCMB	Temporary decrease of ambient temperature set-point during the winter	Incentive, Price signal; Local Weather signal	To be agreed with the occupants and building manager in order to have the ambient comfort conditions maintained.	FCMB direction	FCMB building		Annual Gas demand reduction (from the national network)

Self-consumption of local energy production inside the demonstration site area	PV panels	Self-consumption of local production during the workdays by the building producing energy	Local Solar irradiation; Price signal	Number of working days (about 250 days)	ACBA (BI building owner); ENGIE (BI utility); EDF (National energy network)	Implemented at BI building	Need to be contractualized between utility and consumer; Areas for new plants are limited or not available	Annual Electrical demand reduction (from the grid)
		Exchange of electricity locally produced between loads of the buildings belonging to the BOB considered	Prices of purchase from the grid/selling of energy to the grid	During HPH (TOU tariff) of NBK building		Not feasible, virtual solution	The electrical distribution systems of buildings need to be interconnected	

Where (P_{PEAK} - $P_{MIN\_NIGHT\_TIME}$) is a Reduction of difference between Peak Power demand P_{PEAK} and min power night time demand.

At the FCMB building one energy optimisation action could be implemented during the DR-BOB project; it concerns the implementation of automatically toggling between the woodchips boiler and the gas-fire boiler. It would allow additional reduction of the gas demand from national gas network for the FCMB direction.

Based on the DR programs above and on the interviews held with stakeholders, some rules have been defined to be applied during the demonstration of these DR programs:

- All settings/operations of these DR programs will be configured/carried out manually by a dedicated person into each building.
- No control signals will be sent to service points. The Dispatch Mode will be selected as Notification Only.
- The notifications should be sent to the Facilities Managers 1 day before by email.
- Automated DR notification must be opted if they can be enacted by the Facilities Manager.
- DR programs could be short with durations ranging from 30 minutes to 2 hours and distributed over the time during some days.
- Short DR programs could be repeated several times per day to have more of impact.
- The duration of the DR events is to be agreed with the occupants in order to have the ambient comfort conditions maintained.
- Maximum expected impact could be reached by shifting of event targets or switching them to storage.
- The number of DR events per year is to be defined later, according to the maximum expected impact of the each DR event. Should not be less than 10 per year.

Based on the rules above the following demonstration scenarios have been defined.

Scenario 1 – Electric demand reduction

Event:

Start time: 10:00, 13:00 and 17:00

Duration: up to 1 hour and half

Signal: Tempo Red days, Tempo White days

Opt Behaviour: OptIn/OptOut

Event targets: NBK heat pump, BI heat pump, NBK cooling heat pump for server room, BI cooling heat pump for server room, NBK laptops, FCMB laptops, BI laptops

Maximum expected impact, kWh: to be evaluated

Number of Events per year: 22 for Red days signal, 43 for White days signal

Report: required

Scenario 2 – Electric demand reduction

Event:

Start time: 10:00, 13:00 and 17:00

Duration: 1 hour

Signal: Electricity prices on the wholesale market

Opt Behaviour: not required

Event targets: NBK heat pump, BI heat pump, NBK cooling heat pump for server room, BI cooling heat pump for server room, NBK laptops, FCMB laptops, BI laptops

Maximum expected impact, kWh: to be evaluated

Number of Events per year: to be defined

Report: not required

Scenario 3 – Gas demand reduction

Event:

Start time: in function of local weather

Duration: up to 1 hour and half

Signal: local weather forecast

Opt Behaviour: OptIn/OptOut

Event targets: FCMB gas boiler

Maximum expected impact, kWh: to be evaluated

Number of Events per year: to be defined later

Report: required

Scenario 4 –Electric Peak power demand reduction

Event:

Start time: in function of local weather

Duration: 1 hour

Signal: local weather forecast

Opt Behaviour: OptIn/OptOut

Event targets: NBK heat pump, BI heat pump, NBK cooling heat pump for server room, BI cooling heat pump for server room, NBK laptops, FCMB laptops, BI laptops

Maximum expected impact, kWh: to be evaluated

Number of Events per year: to be defined in function of local weather

Report: required

Scenario 5 – Virtual microgrid or Selling of electric energy inside the demonstration site area

Event:

Start time: 8:00

Duration: 10 hours

Signal: occupancy (holidays, weekend), ToU HPH (full hours winter) of NBK building

Opt Behaviour: OptIn/OptOut

Event targets: PV production

Maximum expected impact, kWh: to be evaluated

Number of Events per year: to be defined

Report: not required

3.1.3 ITALIAN PILOT SITE

The Demand Response scenarios for the Italian pilot site are described in the following table.

It should be noticed that the project will mainly target implicit DR so it will not be based on direct signal but indirect (lower price), so it is always an option for savings. However, the current electricity contract of FPH has just a flat constant tariff.

DR program	Building assets to be targeted by the DR program	DR program's description	Type of DR signal	Duration of DR event	Number of DR event days per year	Beneficiary (type of benefits/ opportunity)	Feasibility of DR action at BOB or building's scale	Barriers
Load shedding program	Lighting	Dimming or turning off lights in non-critical areas (limited to some small areas)	Energy spot price or DR incentive.	Up to 8 hours in the night and even more during weekends	365	Energy saving plus a benefit for a dedicated DR program (if implemented in the future)	Different areas across multiple buildings	Safety issues related to not lighted areas. The BMS doesn't allow a single lamp control.
	Cooling and heating assets	Modify temp. setpoint in unoccupied areas. Switch cooling/heating system	Energy spot price or DR incentive.	Up to 8 hours in the night and even more during weekends	365	Energy saving plus a benefit for a dedicated DR program (if implemented in the future)	Different areas across multiple buildings (Research Centre and week surgery)	User comfort during start up time
	Ventilation	Dynamic ventilation control according to the occupancy	Energy spot price or DR incentive.	Depending on occupancy	365	Energy saving plus a benefit for a dedicated DR program (if implemented in the future)	Different areas across multiple buildings (no the ones dedicated to the operating rooms)	CO2 sensors required an VSD on AHU fans

	Non Critical Appliances: Laptops go on battery	Turn off appliances that can be disconnected without functional risk – (i.e. automatic PC hibernation after 30min of unused)	Energy spot price or DR incentive.	Up to 8 hours in the night and even more during weekends	365	Energy saving	Almost all personal computers. No the ones for electromedicals equipment	Users resistance to change.
	Water distribution pumps	Regulate flow rate based on actual demand with VSD	Energy spot price or DR incentive.	Continuous flow modulation	365	Energy saving	All the hydronic circuits	Need to buy and install VSD to the pumps and implement a system regulation.
Load shifting	food preparation	Warming up food for patients can be shifted in case of necessary for a small period of time (30min)	Energy spot price or DR incentive.	30 minutes	365	benefit for a dedicated DR program (if implemented in the future)	Kitchen	Part of the activities of the personnel must be reschedule

	Cooling/Heating	Pre or post cooling or heating areas	Energy spot price or DR incentive.	2 hours	365	benefit for a dedicated DR program (if implemented in the future)	All the cooling/heating generation assets	Risk of discomfort for a limited period of time.
	Ventilation	Over ventilate areas prior to an event	Energy spot price or DR incentive.	15 minutes	365	benefit for a dedicated DR program (if implemented in the future)	All the AHU generation assets controlled by BMS	Risk of discomfort for a limited period of time.
	Mobility, electric vehicles, Electric storages	During off peak, electric vehicles can be recharged.	Energy spot price or DR incentive.	As required	365	benefit for a dedicated DR program (if implemented in the future)		Risk of delay in charging the vehicles
Self-consumption from CHP system	Electric energy, thermal energy, refrigeration	Use the electric energy and the thermal for the most time possible. Never sell electric energy to the grid. Use absorption chillers or electric ones as convenience	Electric and thermal loads, electric energy price, natural gas price	Continuous	More days possible apart from the maintenance period	Economic benefit from CHP production, and National incentives from high efficiency CHP.		None

Even is not properly part of the Demand Response program, to help reducing the peak power demand, some energy efficiency project are being carrying on in the hospital. These are for example the revamping of the lighting system in the outside parking area of the hospital with LED lamps and a similar project for inside lighting to all the hospital.

Investments in variable speed drive on water pumps and HVAC fans are being also evaluated in order to reduce their energy consumption when not required of for the DR- program.

Based on the DR programs above and on the interviews with stakeholders we have defined some rules to be applied during the demonstration of these DR programs:

- ✓ At first all changes in the today settings need to be implemented manually. After a positive feedback from the first experimentation it can be integrated in the automation (BMS) and extend in all the not-critical Areas.
- ✓ Critical areas can't be part of the project (emergency room, surgery rooms and delivery rooms)
- ✓ No access and control can be made on the BMS from the outside of the hospital. A manual action of the team in the control room is required in case of an outside signal of the DR program.
- ✓ The energy consumption data collected from the local energy monitoring system can be available for the Local Energy Manager but the frequency and the way they exchanges data needs to be defined.
- ✓ DR programs should be short with durations ranging from 15 minutes up to 2 hours and distributed over the time during some days.
- ✓ Short DR programs could be repeated as many times as required as far as comfort and safety are guaranteed for people and machines.
- ✓ The duration of the DR events is to be agreed with the occupants in order to have the ambient comfort conditions maintained.
- ✓ Maximum expected impact could be attended by shifting of event targets or switching them off.

Based on the rules above the next demonstration scenarios have been defined.

<u>Scenario 1 - Load curtailment or shedding of HVAC and chillers loads</u>

Event:

Start time: 06:00, 12:00 and 22:00.

Duration: 1 hour.

Signal: FPH Peak Power Demand Period and electric energy price

Opt Behaviour: OptIn/OptOut.

Event targets: chillers, ventilation units (HVAC)

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: to be defined.

Report: required.

DR programme: Virtual

Demonstration Scenario 1 aims to temporally reduce peak power demand for the upcoming day by shifting / rescheduling the working hours of chillers, ventilations units and water pumping systems. This Scenario assumes a temporally reduction (changing set points) of the cooling systems up to 2 hours during peak power demand period, if it is necessary a precooling of the building will be done to maintain occupants comfort level; after a period of experimentation (manual operations) with positive results and without discomfort for patients or personnel it could be implemented on the BSM for the chillers which are controlled remotely.

Scenario 2 - Load shedding of small loads

Event:

Start time: 12:00 and 13.00.

Duration: 45 minutes.

Signal: FPH Peak Power Demand Period and electric energy price.

Opt Behaviour: OptIn/OptOut.

Event targets: Ask staff to put in stand by equipment, PC's and turning off lights during lunch time (same time as the peak power demand in Poliambulanza).

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: working days.

Report: required.

DR programme: Virtual

Demonstration Scenario 2 aims to reduce peak power demand by turning off equipment not strictly requires for their work during the day peak power hours. To reach this target a dissemination program using the intranet and mail could be used.

Scenario 3 - Load shifting of important loads

Event:

Start time: 11:00, 17:00

Duration: 30 minutes.

Signal: FPH Peak Power Demand Period and electric energy price.

Opt Behaviour: OptIn/OptOut.

Event targets: food warmer carts used to serve food to patients

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: during lunch and dinner time.

Report: required.

DR programme: Virtual

Demonstration Scenario 3 aims to reduce the peak power consumption during lunch when electric food warmers cart are charged to keep food at a constant temperature before delivery. The general idea is to shift the loads taking advantages from the inertia of the karts and their good insulation.

Scenario 4 - Self-consumption and heat recovery from CHP power plant

Event:

Start time: to be defined.

Duration: as required.

Signal: FPH Peak Power Demand Period and electric energy price

Opt Behaviour: OptIn/OptOut.

Event targets: CHP power plant and adsorption chiller.

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: to be defined.

Report: required.

DR programme: Virtual

Demonstration Scenario 4 aims to reduce electric energy consumption by switching the cooling capacity from the electric chillers to the adsorption chiller installed in the CHP power plant. The hospital uses cooling capacity all year long so this can be done whenever is convenient or required depending on energy process or DR programs.

3.1.4 ROMANIAN PILOT SITE

It is considered the all the 12 buildings from the 4 different locations will act as one virtual block of buildings. Demand Response scenarios for the Romanian pilot site, the aggregated are described in the following table.

Table 31. Demand response programs for the Romanian pilot site

DR-BOB project DR program	Building assets to be targeted by the DR program	DR program's description	Type of DR signal	Number of DR event days per year	Beneficiary (type of benefits/ opportunity)	Feasibility of DR action at BOB or building's scale	Barriers	Expected Impact Target
Time-of-Use tariff (virtual solution for the moment)	All or most of the electricity powered equipment	Shifting of the important loads from peak hours to normal usage hours	Price Signal	365 days	- TUCN management	All the TUCN buildings	No such tariff program for public entities in Romania yet. A contract has to be signed between supplier and consumer	Annual Electrical demand reduction (from the grid); P_{PEAK}-P_{MIN_TIME}
Load curtailment or shedding of important loads	Heat production systems of Buildings used for Teaching and Management	Temporary decrease or increase of ambient temperature set-point during the winter. Different temperature set-points for workday, weekend, daytime and night-time periods. Different set-points around the building according to rooms/ classrooms usage.	To be agreed with the building managers and system maintenance team	Winter Period	- TUCN management - Building managers	Location 01, 02 & 04	Limitations of Control Systems	Annual Gas demand reduction; Partial Electrical demand reduction; P_{PEAK}-P_{MIN_TIME}
	Heat production systems of Dormitories	Temporary decrease or increase of ambient temperature set-point during the winter.	To be agreed with the building managers and system	Winter Period	- TUCN management - Building managers	Location 03 Buildings 09 & 10	Limitations of Control Systems	Annual Gas demand reduction;

		Shifting the work period of the heating system out of peak power demand period	maintenance team					Partial Electrical demand reduction; $P_{PEAK}-P_{MIN\_TIME}$
	Cooling systems (Chillers)	Temporary decrease or increase of ambient temperature set-point during the summer. Shifting the work period of the chillers out of peak power demand periods	To be agreed with the building managers and system maintenance team	Summer Period	- TUCN management - Building managers	Buildings B01&B02, B07, B11	Limitations of Control Systems	Annual Electrical demand reduction; $P_{PEAK}-P_{MIN\_TIME}$
	Data Centre, Data Centre Cooling System	Temporary decrease work load of data centre servers, Temporary increase of ambient temperature set-point	TUCN Peak Power Usage periods	To be agreed with the IT department	- TUCN management	Building B01	To be agreed with the IT department	$P_{PEAK}-P_{MIN\_TIME}$
	Washing machines and Dishwashers	Rescheduling of using of washing machines and dishwashers outside of peak power demand periods and towards night time	Electrical Energy Price	Whole Year (workdays in case of student restaurants)	- TUCN management	Location 03 Student Dormitories and Restaurant	Possible nuisance for the students affecting willingness	$P_{PEAK}-P_{MIN\_TIME}$
	Student Dormitories Electrical Equipment	Reduce for a short period of time the students electricity usage Reward students if a consumption target is reached	Electrical Energy Price	5/10 per year	- TUCN management - Building managers - Students	Location 03 Student Dormitories (Building 09 & 10)	Possible nuisance for the students affecting willingness	$P_{PEAK}-P_{MIN\_TIME}$

	Swimming pool water treatment and heating equipment	Rescheduling of equipment work hours outside of peak power demand periods	Electrical Energy Price	Whole Year	- TUCN management - Building managers			$P_{PEAK}-P_{MIN\_TIME}$
Self-consumption of local energy production inside the pilot site locations	PV production	Self-consumption of local PV production during the workdays by the building producing energy and by the buildings belonging to the same BOB	Local Solar irradiation, Weather forecast, Electrical Energy Price	Whole Year except for the period when laboratory tests are carried out on the PV production equipment	- TUCN management - Professors & Students (as practical experiments)	Only at *Location 1*: "G. Baritiu", No. 26-28	Low production capability; Not available when special laboratory experiments are carried out on the PV Panels;	Annual Electrical demand reduction (from the grid)
	Storage unit of PV production system	Fully charge from the grid batteries of the PV production system during normal or low power demand periods; Totally discharge the batteries into the local building network during peak power demand periods	Electrical Energy Price	Up to 5 times per year	- TUCN management	*Only at Location 01: "G. Baritiu", No. 26-28*	Willingness of the associated research laboratory staff	$P_{PEAK}-P_{MIN\_TIME}$

Where

$P_{PEAK}-P_{MIN\_TIME}$ is Reduction of the difference between Peak Power demand P_{PEAK} and normal or min power time demand P_{MIN_TIME}.

Some energy efficiency actions at the scale of all the TUCN buildings are also planned to be implemented during DR-BOB project. It includes:

- Replacing old ineffective lightning equipment with new more efficient LED equipment and implementing human presence and natural lighting sensors on hallways, classrooms and toilets;
- TUCN staff behaviour change action: rise of awareness about the standby mode consumption of computers and other hardware equipment, and shutting down of this equipment during night-time or day-time if they are not used for longer periods.

Based on the DR programs above and on the interviews with stakeholders we have defined some rules to be applied during the demonstration of these DR programs:

- ✓ All settings/operations of these DR programs will be configured/carried out manually by a dedicated person, or by integrated automation system into each building or group of buildings in the same site.
- ✓ Some control signals will be sent to service points. The Dispatch Mode will be selected as Notification or Intervention.
- ✓ The notifications should be sent to the Local Energy Manager and to the Facilities Managers 1 day before, by email.
- ✓ Automated DR notification must be opted if they can be enacted by the Local Energy Manager and/or Facilities Manager.
- ✓ DR programs could be short with durations ranging from 15 minutes up to 1 hour and distributed over the time during some days.
- ✓ Short DR programs could be repeated at least two times per day to have more of impact.
- ✓ The duration of the DR events is to be agreed with the occupants in order to have the ambient comfort conditions maintained.
- ✓ Maximum expected impact could be reached by shifting of event targets or switching them off.
- ✓ The number of DR events per year is to be defined later, according to the maximum expected impact of each DR event.

Based on the rules above the following demonstration scenarios have been defined.

Scenario 1 - Load curtailment or shedding of important loads

Event:

Start time: 08:00, 11:00 and 16:00.

Duration: 1 hour.

Signal: TUCN Peak Power Demand Period.

Opt Behaviour: OptIn/OptOut.

Event targets: chillers, ventilation units, PC and auxiliary equipment, laboratory equipment, etc.

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: 20.

Report: required.

DR programme: Virtual ToU (GVT)

Demonstration Scenario 1 aims to temporally reduce peak power demand for the upcoming day by shifting / rescheduling the working hours of chillers, ventilations units, computers and laboratory equipment outside the TUCN and/or regional/national peak power demand periods.

This Scenario assumes to temporally interrupt the cooling systems for 1 hour during peak power demand period, if it is necessary a precooling of the building will be done to maintain occupants comfort level; to ask one day prior the event the TUCN staff to reschedule their activity in order to reduce building electrical energy demand during the DR event.

Scenario 2 - Load curtailment or shedding of important loads

Event:

Start time: 11:00.

Duration: 2 hours.

Signal: TUCN Peak Power Demand Period.

Opt Behaviour: OptIn/OptOut.

Event targets: Ask the Laboratories not to plan and use the high power equipment.

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: during semesters.

Report: required.

DR programme: Virtual ToU (GVT)

Demonstration Scenario 2 aims to permanently reduce TUCN teaching buildings peak power demand by rescheduling high power equipment Laboratory works. Before the start of the academic year high power equipment laboratory staff will be asked to plan their teaching laboratory works for the entire semester outside the local / regional peak power demand periods, introducing a break in their schedule for this periods.

Scenario 3 - Load curtailment or shedding of important loads

Event:

Start time: 08:00, 11:00 and 16:00

Duration: 1 hour.

Signal: TUCN Peak Power Demand Period.

Opt Behaviour: OptIn/OptOut.

Event targets: washing machines, dishwashers in the dormitories and Student Restaurants.

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: during semesters.

Report: required.

DR programme: Virtual ToU (GVT)

Demonstration Scenario 3 aims to permanently reduce Student Dormitories and Restaurant peak power demand by planning a break in the work flow of washing machines and dishwashers. The allowed working hours of washing machines form Students Dormitories will be moved outside peak power demand periods towards night-time.

Scenario 4 – Demand Reduction in Student Dormitories

Event:

Start time: in function of local weather during semesters, during day or evening peak.

Duration: 1 hour.

Signal: Electrical Peak Power Demand Period.

Opt Behaviour: OptIn/OptOut.

Event targets: PC computers belonging to students and academics, personal appliances.

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: to be defined in function of local weather during semesters.

Report: required.

DR programme: Virtual ToU (GVT)

Demonstration Scenario 4 aims to temporally reduce Students Dormitories electrical energy consumption. Through the online monitoring system that will be implemented at the Romanian pilot site, even the students will be able to see the real time electrical energy consumption of Student Dormitories. The Romanian DR-BOB team plan to implement a student rewarding system if the can keep their electrical energy consumption under a previously imposed level when they are asked.

Scenario 5 - Self-consumption of local energy production inside the demonstration site area

Event:

Start time: 8:00.

Duration: 10 hours.

Signal: occupancy (holidays, weekends).

Opt Behaviour: OptIn/OptOut.

Event targets: PV production, Energy storage system

Maximum expected impact, kWh: to be evaluated.

Number of Events per year: to be defined.

Report: not required.

DR programme: Virtual ToU (GVT)

Demonstration Scenario 5 aims to permanently reduce Romanian pilot site Location 01 electrical energy consumption during daytime by connecting to the local building network the PV production unit form Building 05. This way the electrical energy consumption of Location 01 buildings will be partially compensated by the PV unit according to local weather conditions.

3.2 MANAGEMENT TOOLS

The above mentioned demonstration scenarios will be implemented through the deployment of the tools shortly described hereafter. For a more detailed description of these tools, the reader can refer to the deliverable D2.3 'System requirements and technological specifications'.

3.2.1 MARKET EMULATOR (ME)

This sub-system is a proxy for the energy market that each demo site is situated within. It will allow the project to model and simulate existing and new demand response incentives. The primary focus of the DR market in most countries is on electricity. This is not to say that heat or gas is not considered, but they are secondary to electricity, without direct DR incentives.

Where a market exists then the ME will act as the interface to that market, taking the actual events as inputs. These signals may be acted upon immediately or held until such time as best suits the project experiments. The ME can hold the signal as there will be no responses returned to the market signal originator.

In addition to real markets the ME will generate new simulated signals based on market pricing, distribution network constraints and other relevant events. By creating these signals the project can test new possibilities for the DR-BOB solution and identify the opportunities where it can contribute most to the energy system.

3.2.2 VIRTUAL ENERGY PLANT (VEP)

The DR-BOB Virtual Energy Plant (VEP) will be based on the Siemens Demand Response Management System (DRMS) product. This component will focus primarily on electricity and its DR markets and schemes. From a DRMS perspective a DR Programme is a way of associating a single market [or local] type of event with a customer and a set of assets. Each customer, in our case single site, block of buildings or single building within that site (if there are multiple owners), can have multiple programmes assigned to it. In these cases DRMS balances the benefits of these against each other to ensure that the optimal programme is invoked for that site. DRMS has many rules that allow this optimised decision to be made, for instance; is there a contractual requirement, am I already participating in another programme etc.? DRMS will also ensure fair balancing between customers so that one customer or site is not always favoured over the others. However, this may not be necessary in the UK, Italy and Romania as they only have single customers per country, but it may be possible to try this feature in France as there are multiple customers at the site.

3.2.3 LOCAL ENERGY MANAGER (LEM)

The purpose of the Local Energy Manager (LEM) is the efficient management of local energy production, consumption and storage. The LEM consists of a prediction and an optimisation module. The input to the LEM is the forecast of various factors effecting energy consumption and renewable energy production over the next horizon (typical 24 hours but adjustable). These include energy buying and selling price forecast (available from energy markets), energy demand forecast (generated by the prediction algorithm using energy demand and temperature data for the last calendar week), weather forecast (cloudiness, temperature, wind speed), solar PV energy generation forecast (from cloudiness forecast and Solar Irradiation simulation model), wind turbine energy generation forecast (from wind speed forecast and Wind turbine simulation model).

The LEM, as part of its operations, will collect data in near real-time and will make that data available to other components of the DR-BOB solution and users by pushing it to an external data store.

The optimisation model can be tuned for a trade-off between maximum profit and minimising CO_2 emissions. The output of the optimisation model is the decision information for each hour over the next horizon.

In addition to providing decision support to energy managers, the LEM will also perform control of local assets, directly or via a BMS across a number of protocols. The LEM will also allow DRMS to send DR signals over OpenADR which the LEM will handle.

3.2.4 CONSUMER PORTAL (CP)

The consumer engagement will be mainly led by the Consumer Portal (CP). This consumer portal will have an important role to present relevant information of the Demand Response in a simple, clear and engaging form using a User Interface.

The interaction between the User Interface and consumer can be represented as follows:

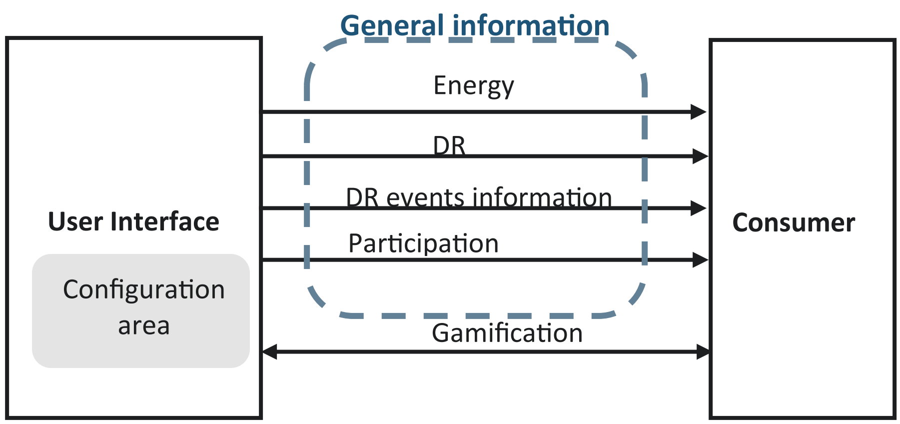

Figure 43: Overview of the University of Teesside

General information:

Consumer needs to be notified and informed about a coming DR event and energy usage of its building.

Demand response events are characterized by different parameters such as start time, duration, nature and amount of energy to be saved, and must be forwarded to the Consumer.

Results that will be displayed should highlight financial benefit of participation. They should also show energy and pollution savings, and the impact on the environment.

Configuration area:

On the User Interface [18], the building manager should have a dedicated environment (Configuration area). This environment will enable him to configure the site's DR participation. The configuration begins with an OptIn or OptOut action to confirm or not the participation to

[18] The User Interface should be accessible through several platforms: desktop web browsers, mobile web browsers, public screens.

DR, and thereafter allows to define (areas of) buildings taking part to the event and sets relevant parameters.

Gamification:

To keep Consumers involved, competitions between different buildings could be organised. The Consumer Portal will be used to animate and display information related to these competitions. They could be rewarded differently according to the efforts afforded. An important point to be taken into account in these competitions is the representation of the results.

4 CONCLUSIONS

This deliverable introduces the four pilot sites and the demonstration scenarios of the DR technologies that could be implemented within the project for each pilot site. The four demonstration sites of the project are composed by buildings and assets of:

- University of Teesside located in Middlesbrough (United Kingdom). It includes one block of building with four buildings which are equipped with one gas fired CHP, one BMS, ~20 chillers and two diesel backup generators;
- Technology Park Montaury located in Anglet (France). It includes one block of buildings with three buildings which are equipped with two PV systems, two heat pumps, three BMS, one woodchip boiler, one gas boiler and battery backup for server rooms;
- Private hospital located in Brescia (Italy). It includes one block of buildings with four buildings which are equipped with heating plant, a PV system, CCHP, BMS, chillers and air conditioning systems;
- Technical University of Cluj-Napoca located in Cluj-Napoca (Romania). It includes seven blocks of buildings with 28 buildings distributed over the whole city. These buildings are equipped with one CHP, one PV system, multiple gas boilers and chillers.

The table below summarises the main characteristics of the four pilot sites.

Table 32. Main characteristics of the four pilot sites

Pilot site	Number of buildings	Location	Main Function/ uses	Governed by	Energy sources	Energy demand	Generation systems
UK	4	Located closely	Teaching and research	Single owner	Electricity, gas, diesel	High	PV, CHP, backup generators
FR	3	Located closely	Offices and workrooms	Multiple owners	Electricity, gas, wood	Low	PV, Heat pump, Boilers, battery backup
IT	4	Located closely	Medical and health care	Single owner	Electricity, gas, district heating	High	PV, CCHP, backup generators
RO	12	Distributed over the city	Teaching, research, dwellings	Single owner	Electricity, gas	High	PV, CHP, boilers

These blocks of buildings (BOB) allow testing different scenarios to access the electricity market, the main barrier for it being a limited number of DR programs available for consumers in Europe. Even if such DR programs exist, the participation is open to large industrial or aggregated BOB consumers.

For the four pilot sites of the project, the demonstration scenarios have been developed taking into account the local context and the main findings collected from interviews and workshops conducted with local stakeholders. These scenarios will be trialled first but may be updated or supplemented during the implementation of the project as additional information or ideas are identified by stakeholders or local market opportunities change. The main parameters of DR events such as duration, event targets, opt behaviour, requirement of report have been accurately defined based on existing DR programs and the Demand Response Program Implementation Guide 2.0 (OpenADR Alliance); some parameters such as maximum expected impact or signal need to be evaluated or clarified later because of absence of required test conditions, metering system or local DR market.

5 REFERENCES

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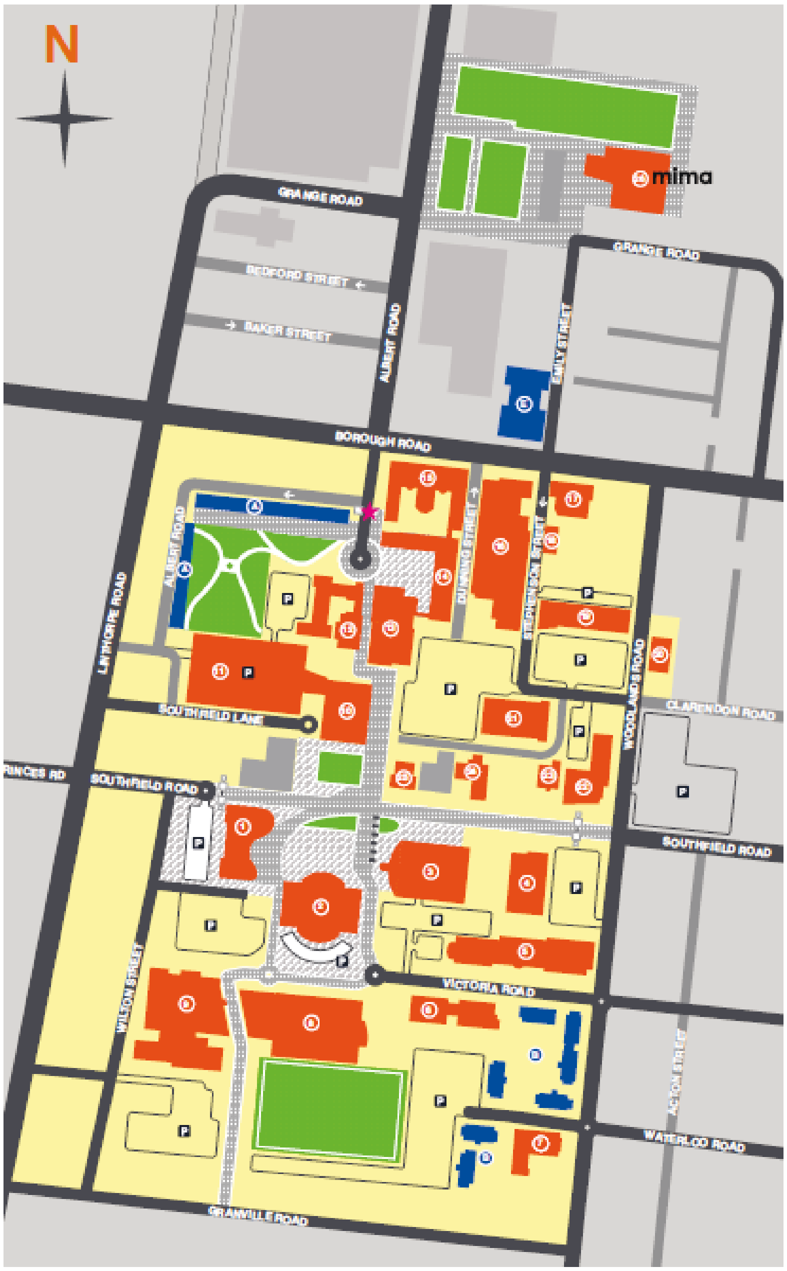
6 APPENDICES

6.1 APPENDIX A. UK DEMONSTRATION SITE

6.1.1 OVERVIEW OF THE UNIVERSITY OF TEESSIDE



Key to University Buildings:

1 The Curve

2 Library

3 Students' Union

4 Greig Building

5 Europa Building

6 Victoria Building

7 Mercuria Building

8 Olympia Building

9 Centuria Building

10 Students Centre

11 Clarendon Building

12 Waterhouse Building

13 Brittan Building

14 Middlesbrough Tower

15 Constantine Building

16 Stephenson Building

17 Cook Building

18 Foster Building

19 Phoenix Building

20 Education House

21 Orion Building

22 Athena Building

23 University House

24 Aurora Building

25 Centre House

26 MIMA

Figure 44: Overview of the University of Teesside

6.1.2 BUILDINGS' OCCUPANCY

Table 33: Buildings' occupancy

Buildings	Max occupancy	Average occupancy, % from maximum occupancy						
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Stephenson	TBC	Variable, but take as 100%	Variable but take as 100%	Variable, but take as 100%	Variable, but take as 100%	Variable, but take as 100%	5-10 %	5-10 %
Constantine	TBC	Variable, but take as 100%	Variable but take as 100%	Variable, but take as 100%	Variable, but take as 100%	Variable, but take as 100%	<5%	<5%
Brittan	TBC	Variable, but take as 100%	Variable but take as 100%	Variable, but take as 100%	Variable, but take as 100%	Variable, but take as 100%	<5%	<5%
Tower	TBC	Variable, but take as 100%	Variable but take as 100%	Variable, but take as 100%	Variable, but take as 100%	Variable, but take as 100%	5-10 %	5-10 %

6.1.3 UK ELECTRICITY MARKET MECHANISMS

At present, the UK System Operator, National Grid, has a number of active approaches to system balancing that pay customers able to offer demand response, as well as the Transmission Network Use of System (TNUoS, or "Triad") charge which incentivises demand response and the Distribution Use of System (DUoS or red-zone) charge which is time dependent.

Frequency response services act quickly to help National Grid maintain the system frequency at 50Hz +/- 1%. Firm Frequency Response (FFR) is a scheme where participants able to provide 10MW of generation or demand reduction within 30 seconds of a frequency deviation are paid an availability payment to be on standby. Typically there are 10 activations per year. This service has been challenging for DR providers to access because of the high power threshold. Recognising this, the FFR Bridging scheme has been recently launched allowing access to participants from 1MW with incentives to increase their contribution through aggregation.

If a customer is able to reduce demand within 2 seconds, through automation, then they can participate in Frequency Control by Demand Management (FCDM). There is a 3MW power threshold which must be able to be sustained for 30 minutes. Once again, aggregation is possible provided other technical requirements are met and there are typically 10 activations per year.

FFR and FCDM are post-fault services, however, National Grid is also developing an Enhanced Frequency Response scheme (EFR) for battery storage owners who are able to provide response frequently and at less than one second notice as a pre-fault service to the system.

Similarly, the reserve services are called upon frequently to balance the system within scheduled time periods. The Short Term Operating Reserve (STOR) is the largest market and a minimum of 3MW response is required for participation. For DR this is often achieved through aggregation. The response time of between 20 and 240 minutes is individually contracted but must be maintained for at least two hours. Similar to FFR Bridging, the STOR Runway lowers the bar to entry to 1MW with a commitment to reaching 3MW over a defined period. The Fast Reserve (FR) requires a minimum of 50MW participation so is the preserve of pumped storage hydro and part loaded Combined Cycle Gas Turbines (CCGT).

The Demand Side Balancing Reserve (DSBR) is a programme introduced in the winter of 2014/15 for a two-year period; however, this may be extended in the future. It provides attractive availability payments of up to £16,000/MW to businesses who can reduce demand by 1MW for a period of 2 hours between 4PM and 8PM on winter weekdays. A similar temporary arrangement, although over a much longer period, is the Capacity Market. This series of auctions is intended to increase the availability of capacity in the period four years ahead of the auction. This will offer long term confidence for National Grid and a continuous long term source of payments to generators.

Another novel scheme is Demand Turn Up whereby businesses are paid an availability fee and a utilisation fee to consume more power at times of high non-dispatchable generation, typically overnight and at weekends 13:00 to 16:00. The 1MW minimum may be achieved by aggregation and participants will be notified several hours ahead of time. This is currently being trialled in one region, with Western Power Distribution (WPD), but may be rolled out elsewhere as the penetration of renewables increases.

6.2 APPENDIX B. FRENCH PILOT SITE

6.2.1 MAIN CHARACTERISTICS OF THE BUILDINGS

Table 34. Main characteristics of the buildings

Building	Specifications								
	Main current functions	Year Of construction	Number of levels	Height (m)	Net floor area (m²)	Occupancy	EUI (kWh/m²/yr) [19]	Peak power demand (W/m²) [20]	Min night time demand (W/m²) 20
Training centre FCMB	Office, Classroom, Workroom	2012	3 levels: Basement + ground floor + 2	8.9	3850	50	28.7		
Technology centre Nobatek	Office	2009	3 levels: Basement + ground floor + 2	15	843	35	55.1	26	2
Business Incubator	Office, Workroom	2016	3 levels: Basement+ ground floor + 2	10	1810	40	26.2 (evaluated)	82 (according to the electricity supply contract)	0.3 (estimated value))

6.2.2 THE PURCHASE PRICES FROM WIND TURBINES INSTALLATIONS IN 2007 IN FRANCE

The purchase prices from wind turbines installations at 2007 were as follows[21]:

- ✓ For wind turbines functioning annually 2400 hours and less, the purchase energy price for 10 first years is equal to 8,2 c€/kWh and 8,2 c€/kWh for the last 5 years.
- ✓ For wind turbines functioning annually between 2400 and 2800 hours, the purchase energy price for 10 first years is equal to 8,2 c€/kWh and linear interpolated during the last 5 years.
- ✓ For wind turbines functioning annually 2800 hours, the purchase energy price for 10 first years is equal to 8,2 c€/kWh and 6,8 c€/kWh for the last 5 years.
- ✓ For wind turbines functioning annually between 2800 and 3600 hours, the purchase energy price for 10 first years is equal to 8,2 c€/kWh and linear interpolated during the last 5 years.
- ✓ For wind turbines functioning annually 3600 hours and more, the purchase energy price for 10 first years is equal to 8,2 c€/kWh and 2,8 c€/kWh for the last 5 years.

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[19] EUI = Energy Use Intensity, average annual energy demand per net floor area square meter

[20] Peak and minimum (electric) power demand calculated as a building net floor area average over 30 minute interval. This period is generally used by EU electric utility companies to represent a highest and lowest point of customer electricity consumption. Considering shorter intervals would imply the installation and use of proprietary technology solutions, which would impede the wider applicability and impacts of the project results.

[21] Source : Le Service Public de la Diffusion de Droit https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000029167875&dateTexte=&categorieLien=id

6.2.3 FRENCH ELECTRICITY MARKET MECHANISMS

6.2.3.1 Balancing mechanism

The French TSO RTE proposes a Balancing Mechanism in the form of a permanent and transparent system of calls for tender. The system is open to everyone and provides a real-time reserve of power that can be used for balancing either upward (increase in production, decrease in consumption or imports) or downward (decrease in production, increase in consumption or exports). If necessary, RTE activates these offers in order, based on economic precedence and their usage conditions, taking into account system operating conditions. Offers are remunerated pay-as-bid. This mechanism, for each half-hour period, gives a reference price applicable for settling the imbalances based upon the Average Weighted Prices of upward (AWPu) and downward (AWPd) balancing offers, or on the basis of the Epex spot price.

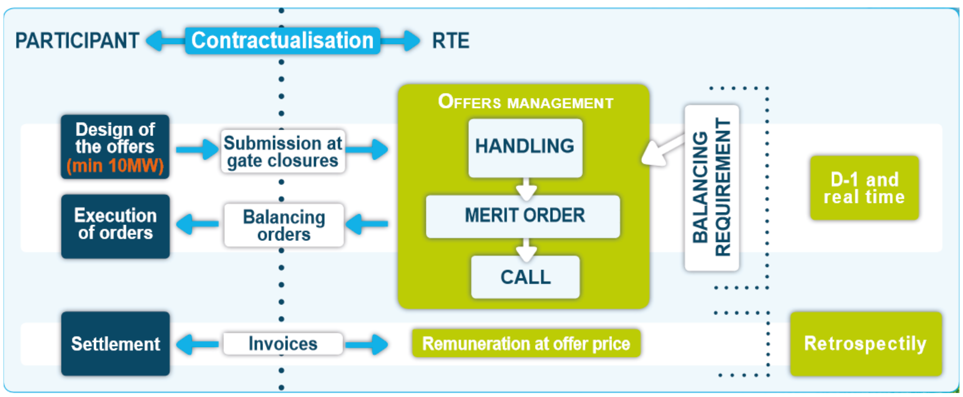

Figure 45: Principle of function of French Balancing mechanism

6.2.3.2 Capacity Mechanism

Starting in 2016, French grid TSO RTE will start asking the country's power suppliers, i.e. power plant owners, to offer capacity certificates to qualified parties on an over-the-counter market (Jeff St. John, 2015). Out of France's entire 90 to 100-gigawatt wintertime peak load, about 6 gigawatts of capacity is expected to be needed to fill in gaps that can't be met by the country's nuclear and fossil fuel-fired generator fleet, "and that's obviously where demand response can compete". Competitors in this market are Actility, Voltalis, and Energy Pool, the demand response aggregator majority-owned by French grid giant Schneider Electric, which is largely present in the existing capacity programs France.

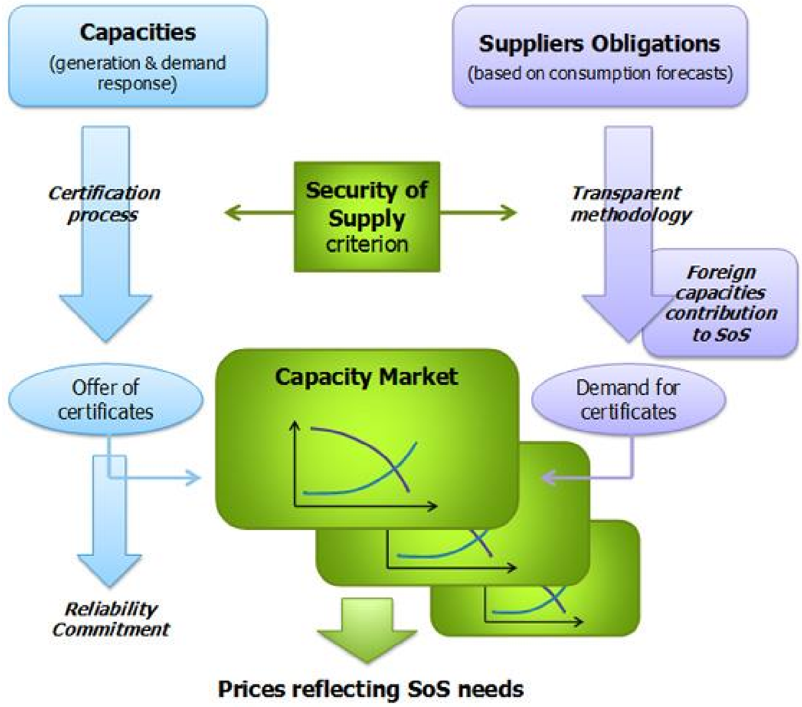

Figure 46: Principle of function of French capacity mechanism

6.2.3.3 NEBEF (Block Exchange Notification of Demand Response) mechanism

The NEBEF project has been initiated in the DSM frame and enables any consumer in mainland France to use its electricity demand reductions on the energy markets, either directly by itself becoming a Demand Side Management Operator (DSMO), or indirectly through a third party that is a DSMO. However, as a transitory arrangement, only those consumers connected to Distribution System Operators applying a generalised flow adjustment system (i.e. generalised profiling) can participate at the present stage of the mechanism (RTE, 2013)[22]. Nowadays there is a 100 kW power reduction threshold that should be attended during a half-hour; this fact opens the door for BOBs participation into the market.

[22] Source: Deliverable 2.3. Generalized business models. 2014/11/21, FP7 project IDEAS: Intelligent NeighbourhooD Energy Allocation & Supervision.

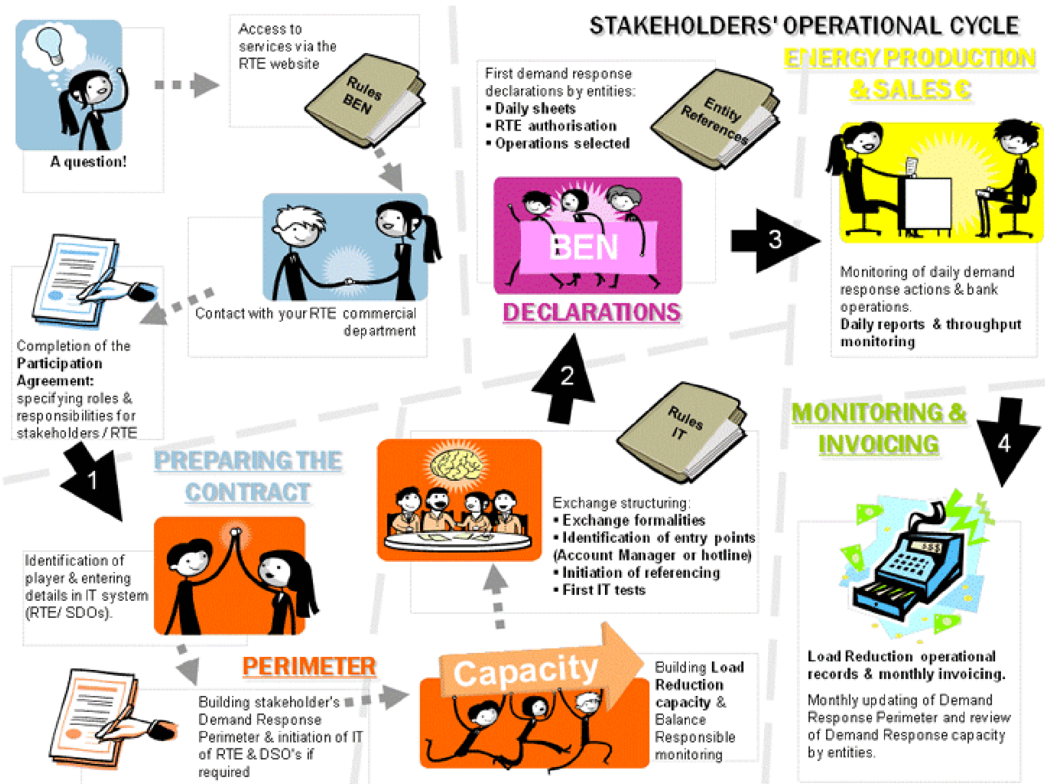

Figure 47: Schema of operation of stakeholders involved in electricity load reduction procedures, NEBEF mechanism

6.3 APPENDIX C. ITALIAN DEMONSTRATION SITE

6.3.1 COMPONENTS OF THE BUILDINGS AND OCCUPANCY PER ROOM

Table 35: Components of the Main Building and occupancy per room

MAIN BUILDING		
Floor	**Department**	**Std. Activity working time/ occupancy**
Basement Floor	Warehouse	7:00-17:00 Monday-Friday
	Carpenters room	8:00-17:00 Monday-Friday
	Laundry	7:00-16:00 Monday -Saturday
	Pharmacy warehouse	7:00-17:00 Monday-Friday
	Pharmacy	7:00-16:00 Monday-Friday + Saturday 7:00-12:00
	General warehouse	7:00-17:00 Monday-Friday
	Morgue	8:00-18:00 Monday -Sunday
	Electrophysiology/hemodynamic dep.	7:30-17:00 Monday-Friday
	Angiography	7:00-19:30 Monday-Friday
	Service rooms	-
	Radiology	6:30-17:00 Monday-Friday
	CSSD	7:00-22:00 Monday-Friday
	Technical workshop	7:00-17:00 Monday-Friday
	Mammography	7:00-17:00 Monday-Friday
	Looker rooms	24/7
	Medical records warehouse	8:00-17:00 Monday-Friday
	Kitchen	5:00-22:00 Monday-Sunday
	cafeteria	11:00-15:00 + 18:00-21:00 Monday – Saturday
	Rehabilitation gym	6:30-13:00 Monday-Friday
Ground Floor	ER	24/7
	Intensive care	24/7
	Outpatient clinics	7:00-18:00 Monday-Friday
	Operating rooms	8:00-20:00 Monday-Friday
	Cardiovascular intensive care	24/7
	Operating rooms low complexity	8:00-16:00 Monday-Friday
	Test lab	7:00-16:00 Monday-Friday
	Pathological anatomy	7:00-16:00 Monday-Friday
	Cashier	6:00-17:00 Monday-Friday
	Ophthalmology operating rooms	7:00-18:00 Monday-Friday
	Conference room	-
	Bank	8:00-17:00 Monday-Friday

	Cafe	6:00-21:00 Monday -Saturday + 9-21 Sunday
	chapel	24/7
	Technical direction offices	7:00-21:00 Monday-Friday
First floor	ICT offices	7:00-20:00 Monday-Saturday
	General direction offices	7:00-21:00 Monday-Friday
	Health direction offices	7:00-18:00 Monday-Friday
	HR offices	7:00-18:00 Monday-Friday
	Preventive medicine offices	7:00-18:00 Monday-Friday
	HSE office	8:00-18:00 Monday-Friday
	Administrative direction offices	7:00-21:00 Monday-Friday
	Pediatric unit	24/7
	Oncology unit	6:30-17:00 Monday-Friday
Second Floor	Cardiology unit	24/7
	General medicine unit	24/7
Third floor	Neurology and stroke unit	24/7
	Week surgery	24/7
	Cardiac and vascular surgery unit	24/7
Fourth floor	Sub-acute care unit	24/7
	Urology surgery unit	24/7
	Week surgery unit	24/7

Table 36: Components of the Inpatient Building and occupancy per room

INPATIENT BUILDING		
Floor	**Area**	**Std. Activity working time**
Basement Floor	Nuclear medicine	6:30-17 Monday-Friday
	Radiotherapy	6:30-17 Monday-Friday
	Service room	-
Ground Floor	Endoscopy	7-13 Monday-Friday
	Blood test area	7-13 Monday-Friday
	Outpatient clinics	6:30-18:30 Monday-Friday
First floor	Puerperium / nest	24/7
Second Floor	Geriatric unit	24/7
Third floor	Orthopedic unit	24/7
Fourth floor	Surgery unit7 gynecology unit	24/7
Fifth floor	Rehabilitation unit	24/7

Table 37: Components of the Multifunctional Building and occupancy per room

MULTIFUNCTIONAL BUILDING		
Floor	**Area**	**Std. Activity working time**
Basement Floor	New CSSD	7:00-22:00 Monday-Friday
	New morgue	8:00-18:00 Monday –Sunday
	New Pathological anatomy	7:00-16:00 Monday -Friday
Ground Floor	Operating rooms	8:00-20:00 Monday - Friday
	Intensive care	24/7
First floor	Delivery rooms	24/7
	Operating rooms	8:00-20:00 Monday - Friday
Second Floor	Technical room for HVAC	-

Table 38: Components of the CREM Building and occupancy per room

CREM Building		
Floor	**Area**	**Std. Activity working time**
Ground Floor	Lab	Monday - Friday 8:00-19:00
	telephone exchange	Monday - Friday 8:00-18:00
	Researchers offices	Monday - Friday 8:00-19:00
	Technical room for HVAC an heat exchangers	Service room – 24/7
First floor	Classrooms	Monday - Friday 8:00-18:00
	offices	Monday - Friday 8:00-19:00

6.3.2 ITALIAN ELECTRICITY MARKET MECHANISMS

In the Italian market, there are few available DR programs, none with free access for the customers, but through bidding or pilot programs. *The Smart Energy Demand Coalition (SEDC)* has drafted an interesting report called "*Mapping Demand Response in Europe Today (2015)*"[23] that shows the progress of Member States in enabling explicit Demand Response programs. It shows a smart outline for the Italian market and analysed the DR situation thought the customer's accessibility, the participation in agreement and the readiness of legislations. There are three potential markets for DR in Italy: Interruptible Contracts, Capacity Market, Wholesale market. In addition to those, there are the Balancing Market and the Reserve market that cannot be defined DR. Table 39 summarizes the situation.

[23] Smart Energy Demand Coalition is the European industry association dedicated to making the demand side a smart and interactive part of the energy value chain (http://www.smartenergydemand.eu/)
Mapping Demand Response in Europe Today (2015) - http://www.smartenergydemand.eu/?p=6533

TABLE 39. LIST OF BALANCING MARKET PRODUCTS (SOURCE: MAPPING DEMAND RESPONSE IN EUROPE TODAY (2015))

ENTSO-E's terminology	TERNA's terminology		Market Size	Load Access & Participation	Aggregated Load Accepted
FCR	Primary Frequency Control		1,5% of the total installed power	✗	✗
FRR	Secondary Frequency Control		4,77 TWh	✗	✗
RR	Tertiary Reserve		8,99 TWh	✗	✗
	Interruptible (Mainland)	Fast	3.300 MW	✓ 3.300 MW	✗
		Emergency	0 MW	✓ 0 MW	✗
	Interruptible (Islands)	Fast	389 MW Sicily 372 MW Sardinia	✓ 389 MW Sicily 372 MW Sardinia	✗
	Capacity Market		Not yet defined	✓	Not yet defined

Balancing market

The balancing market is an ancillary service or system service necessary required by Terna (TSO) to all the non-intermitted energy production facilities able to participate to the Electrical market with a nominal power greater than 10 MVA. The service regards adjustment of primary and secondary frequency and the power, in order to safely manage the Italian electrical system, and to ensure, at the same time, an adequate level of quality of service.

Terna has established non-discriminatory rules that identify the minimum technical requirements for participation. The production units capable to deliver such service are listed in a specific registry called RUP (Registro delle Unità di Produzione). Into the RUP the production units with a self-certification document declare all characteristics data and performance for the power plant.

Interruptible Programme

The interruptible programme is also known as Interruptible Contracts and is an integral part of the defense system of the national network and is one of the tools that Terna has to ensure safety of the electrical system and in particular in order to mitigate the risk of outages in different operating conditions. The service is regulated by the directive AEEG 187/10.

It can be considered a DR programme, but given the stringent requirements, the customers must participate in an auction until the entire available power share is assigned. The enrolment of interruptible loads is currently about 3.300 MW (reduced for the period 2015-2017), with a minimum size of 1 MW for each site to participate and do not allowed for aggregation. The customers that accept the contract must provide the availability for an interruptible load in exchange for payments based on €/MW/years.

Each interruptible load should be remotely measurable and controlled in real time by one or more dedicated signals requiring its disconnection without any advance notifications. There are two types of possibility of interruption:

- Instantly interruptible (interruption within 200 milliseconds of the signal sending);

- Interruptible emergency (interruption within 5 seconds of the signal sending).

Table 40. Description of programme requirements (source: Mapping Demand Response in Europe Today 2015)

Programme		Minimum Size (MW)	Notification Time	Activation	Triggered
Interruptible contract (Mainland)	Fast	1 MW	200 ms	After TSO request	No limit
	Emergency	1 MW	5 s	After TSO request	No limit
Interruptible contract (Islands)	Fast	1 MW	200 ms	After TSO request	No limit

The allocation is done through bidding, starting from a base of 150.000 €/MW/year for instantly interruptible resources and 100.000 €/MW/year for emergency resources. These values represent the annual bonus paid to all the selected power, defined according to the principle of the marginal price. If the offer is less than the demand, the whole supply is selected and remunerated at the base price auction (and this is the case occurred in most of the time so far). At this remuneration is added a bonus/malus mechanism that assign a payment based on the selected power multiplied by 3.000 €/MW and the difference between the number of interruptions that occurred during the year and a standard value of 10. The providers can get out of the contract even temporarily, but they have to pay a fee to Terna that was forced to find alternative resources at a higher price. In 2013 the total interruptible power contracted was 4.318 MW. In order to define the quantity needed Terna makes an estimation of the average annual interruptible power it needs for a period of 3 years.

The interruptible programme and some security service for the National Grid are realized with the application of ICT in parallel to the electrical network and is in responsibility not only of the TSO, but also in charge of the DSO. An example of DSO level programme is the **Load Shedding** that today can be applied in a very modern way thanks to the new available technologies. Thanks to the communication between the TSO central intelligence (Centralized Computer for automatic Load shedding, called EDA) and DSO peripherals, the loads are monitored in real time to have the real value of the power available for disconnection. The system may reduce generation or disconnected some power plants, following a system fault to relieve localized network overloads, to maintain system stability, to manage system voltages and to avoid the so called "Black outs". In this direction, TERNA developed in collaboration with Proteco Consortium[24] a modern Load shedding application (called BME). ENEL Distribuzione, that is the main Italian DSO, played a consistent role in the project as far as system integration is concerned. Participants in Load Shedding programmes will be compensated according to a non-market price defined in regulation. The size of available power is of 10 MW for programmes without notice and 3 MW for programmes with notice.

[24] Proteco Consortium: http://www.protecogroup.it/en/ Proteco has been engaged in the implementation and evolutionary maintenance of the central system management of Load Shedding and Electricity Network Defence system. Load Shedding - http://www.protecogroup.it/en/products/load-shedding/

The argument was also defined by the AEEGSI in a recent deliberation called 79/2015/R/eel[25] that is applied to the wind plants and photovoltaic plants with nominal power from 100 kW and connected in medium voltage.
The deliberation established that *the DSO having at last one primary station must implement a centralized system able to send the necessary signals to activate the remote interruption to plants powered by wind energy or solar photovoltaics, connected to the medium voltage networks*. Before this deliberation, the system was necessary only for the primary station connected with the national transmission network. Therefore, the current obligation extend to the distribution companies that have at least one primary station not directly connected to the national transmission network, ensuring that they also receive the signals aimed at remote detachment directly by Terna.

Capacity Market

The Capacity Market is a programme in development since 2003 (with decree n.379) and its growth has followed the progress of the liberalization of the Italian electric market and the development of the renewable production systems. The object of the Capacity Market is to coordinate the investment decisions of different actors, including the TSO and the regulator AEEGSI. Under the Capacity Market, Terna will auction reliability call options on an annual basis, which will translate into payments linked to available capacity of plants rather than their actual electricity output. The rules and guidelines of the market were approved in summer 2014, but the programme is not yet active and the prevision of payment is not expected before 2019.
In the rules proposed until now, there is no role for DR in line with the conditions set on the reserves markets and there are also some not clear issues regarding for instance how the system was set to support struggling gas fired plants that have been squeezed out by the increase of RES subsidies.
AEEGSI proposed a 2017 adoption of the new market under simplified rules. These would include a reduction in the number of auction bids each production unit can submit from 10 to 5, an increase in the minimum price reduction from the auction base price from 5% to 10%, and a reduction of auction sessions from 21 to 11. Restrictions on the type of collateral needed to take part in the auctions would also be eased.

In field of electric energy market, in the Italian regulation there is the possibility to have access at the **Wholesale Market**. The flexible consumers can access the spot market, in a single or aggregated form (as dispatching user), with demand bids with indication of price. The participation is still low but has risen slightly.

The CESI study concludes that the Italian DR technical and economic potential ranges between 1.6 and 4.2% in relation to peak power.

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[25] 79/2015/R/eel - http://www.autorita.energia.it/it/docs/15/079-15.htm

6.4 APPENDIX D. ROMANIAN DEMONSTRATION SITE

6.4.1 LOCATION AND NET USEFUL SURFACE OF BUILDINGS

Table 41: Location and net useful surface of each building (F = Floor; G = Ground Floor; B = Basement; A = Attic, M = Mezamin)

Building	Address	Ground footprint [m²]	Total net useful surface [m²]	Levels	No. of Levels
Appendix B	"G. Baritiu", No. 26-28	435	1,175	G+1F+A	3
Secondary Building	"G. Baritiu", No. 26-28	1,518	2,468	B+G+1F+A	4
Main Building	"G. Baritiu", No. 26-28	1,321	3,682	B+G+1F+A	4
Appendix D	"G. Baritiu", No. 26-28	174	1,356	B+G+2F+A	5
Appendix S	"G. Baritiu", No. 26-28	172	866	G+3F+A	5
Appendix H	"G. Baritiu", No. 26-28	228	878	G+3F+A	5
Main building	"21 Decembrie 1989", No. 128-130	1,881	4,973	G+3F+A	5
Secondary building	"21 Decembrie 1989", No. 128-130	304	500	G+A	2
Student Dormitory 1F	*"Fabricii de Zahar"*, No. 58	870	6,137	B+G+9F	11
Student Dormitory 2B	*"Fabricii de Zahar"*, No. 58	1,290	7,000	B+G+9F	11
Student Restaurant	*"Fabricii de Zahar"*, No. 58	1,276	3,149	B+G+1E	3
Swimming Pool	"Splaiul Independentei"	1,880	5,280	B+G+2F	4

6.4.2 LIST OF MAIN ASSETS

Table 42. List of Main Assets for Pilot Site Buildings

General					Capacity	
Name	Type	Make & Model	Location	Owner	Power Range	Heat Range
AC	Chiller	BICOLD - WBA-E 1138	G. Baritiu No. 26-28, located near the N façade between the Main Building and Appendix D **(Building B04)**	TUCN	44.4 kW	138.6 KW
PV	PV	SMA SB3000-TL	G. Baritiu No. 26-28, located on the roof of Appendix H	TUCN	0 - 3 kW	N/A

General					Capacity	
Name	**Type**	**Make & Model**	**Location**	**Owner**	**Power Range**	**Heat Range**
			(Building B06)			
AC	Chiller	Lennox FGM 100 H	21 Decembrie 1989 No.128-130, located on the roof of amphiteatre of the Main Building **(Building B07)**	TUCN	80.9 kW	169.4 kW
H	Boiler	FERROLI PEGASUS, FN3	G. Baritiu No. 26-28, located inside the old Boiler Room **(Building B03)**	TUCN	N/A	2×289 kW
H	Boiler	FERROLI PEGASUS, F2 N102 2S	G. Baritiu No. 26-28, located in the Attic of the Main Building **(Building B01)**	TUCN	N/A	102 kW
H	Boiler	VIESSMANN/ VITODENS 200 , MODEL:WB2B	G. Baritiu No. 26-28, the Secondary Building **(Building B02)**	TUCN	N/A	66 kW
H	Boiler	LAMBORGHINI, MEGAPREX N-120	G. Baritiu No. 26-28, Appendix H **(Building B06)**	TUCN	N/A	120 kW
H	Boiler	VIESSMANN/ VITODENS 200 , MODEL:WB2B	G. Baritiu No. 26-28, Appendix D **(Building B04)**	TUCN	N/A	2×66 kW
H	Boiler	BOSCH GMBH, MODEL: ZBR65-2	G. Baritiu No. 26-28, Appendix S **(Building B05)**	TUCN	N/A	2×65 kW
AC	Chiller	LENNOX, FLEXY II, 1X FGM 170 S	Splaiul Independentei, located on the Rooftop of the Swimming Pool Complex **(Building B12)**	TUCN	80.9 kW	169.4 kW
H	Boiler	LOSS, TIP:UT, MODEL:1900	Splaiul Independentei, located inside the Basement of the Swimming Pool Complex **(Building B12)**	TUCN	N/A	2×1600 kW
H	Boiler	VIESSMANN/ PAROMAT ND	Fabricii de Zahar, No. 2 **(Building B10)**	TUCN	N/A	170 kW
H	Boiler	VIESSMANN/ PAROMAT SIMPLEX PS175	Fabricii de Zahar, No. 2 **(Building B09)**	TUCN	N/A	2×1750 kW
H	Boiler	VIESSMANN/ PAROMAT SIMPLEX PS112	Fabricii de Zahar, No. 2 **(Building B10)**	TUCN	N/A	1120 kW
H	Boiler	VIESSMANN/ VITOPLEX200 , MODEL:SX2	21 Decembrie 1989 No. 128-130, located in the Secondary Building **(Building B08)**	TUCN	N/A	270 kW

General					Capacity	
Name	Type	Make & Model	Location	Owner	Power Range	Heat Range
H	Boiler	VIESSMANN/ B11 BS/VITOCROSAL 300, MODEL: CT3	21 Decembrie 1989 No. 128-130, located in the Secondary Building **(Building B08)**	TUCN	N/A	285 kW
L	Lighting	TFL/CFL/ Incadescent	G. Baritiu No. 26-28, the Main Building **(Building B01)**	TUCN	5×0.018 kW; 118×0.036 kW; 27×0.058 kW; 1×0.1 kW	N/A
L	Lighting	TFL	G. Baritiu No. 26-28, the Secondry Building **(Building B02)**	TUCN	18×0.018 kW; 146×0.036 kW; 12×0.058 kW;	N/A
L	Lighting	TFL/CFL	Splaiul Independentei **(Building B12)**	TUCN	30×0.011 kW; 24×0.018 kW; 53×0.036 kW; 5×0.058 kW; 83×0.072 kW; 38×0.12 kW; 49×0.4 kW;	N/A
L	Lighting	TFL	G. Baritiu, No. 26-28, Appendix D **(Building B04)**	TUCN	109×0.018 kW; 86×0.036 kW; 8×0.058 kW;	N/A
L	Lighting	TFL/CFL	G. Baritiu, No. 26-28, Appendix H **(Building B06)**	TUCN	300×0.018 kW; 98×0.018 kW; 7×0.036 kW; 2×0.058 kW;	N/A
L	Lighting	TFL	G. Baritiu, No. 26-28, Appendix B **(Building B03)**	TUCN	105×0.018 kW; 250×0.036 kW;	N/A
L	Lighting	TFL/CFL	G. Baritiu, No. 26-28, Appendix S **(Building B05)**	TUCN	277×0.018 kW; 13×0.018 kW; 120×0.036 kW; 5×0.058 kW;	N/A
L	Lighting	TFL/ Incandescent	Fabricii de Zahar, No. 58 Student Restaurant **(Building B11)**	TUCN	376×0.036 kW; 26×0.06 kW; 24×1 kW	N/A

6.4.3 UTILITY COSTS 2013

Table 43. Utility Costs for TUCN buildings according to 2013

Location	Useful Surface [sqm]	Electricity Bill [Eur]	Gas Bill [Eur]	Water Bill [Eur]	Total Billed 2013 [Eur/year]	Specific Cost [Eur/sqm/year]

“G. Baritiu”, No. 26-28	10,565	124,675	67,752	6,511	198,939	18.83
“21 Decembrie. 1989”, No. 128-130	5,725	14,554	25,802	1,660	42,018	7.34
“Fabricii de Zahar” No. 58	17,376	134,333	171,988	75,491	381,813	21.97
“Splaiul Independentei”	6,616	45,136	73,021	32,395	150,554	22.76
TOTAL TUCN Pilot Site	**40,282**	**318,698**	**338,565**	**116,058**	**773,323**	**70.90**

6.5 APPENDIX E. MAIN OUTCOMES COLLECTED DURING INTERVIEWS AND WORKSHOPS WITH LOCAL STAKEHOLDERS AND OTHER RELEVANT ACTORS INTERVIEWED AS PART OF TASK 2.2

The following table synthetises the interviews and workshops conducted in the frame of Task2.2.

Table 44. List of the interviews and workshops conducted in the frame of Task2.2

Pilot site	Type of event	Date of event	Role of the interlocutor	Section describing the main outcomes of the event
UK pilot site	Interview	07/06/2016	Estates management	6.5.1
	Interview	07/06/2016	Estates administration	
	Interview	09/06/2016	Estates management	
	Interview	12/07/2016	Technical staff in academic school	
	Interview	13/07/2016	Academic staff in in academic school	
	Interview	14/07/2016	Technical staff related to estates	
	Interview	14/07/2016	Estates administration	
	Workshop	18/07/2016	Estates technical, Estates administration, Academic School technical	
French pilot site	Workshop	23/06/2016	FCMB Director, FCMB deputy director, maintenance staff and trainee at the FCMB	6.5.2
	Workshop	23/06/2016	ACBA staff (decision makers for the area)	
	Interview	08/07/2016	Maintenance company	
Italian pilot site	Interviews	11/02/2016 17/03/2016 22/03/2016 24/03/2016 05/04/2016 07/04/2016 12/04/2016 27/04/2016 03/05/2016 04/05/2016 05/05/2016 10/05/2016	Departments coordinators (11 people)	6.5.3
	Interview	04/08/2016	Maintenance responsible and his technical staff	
Romanian pilot site	Interview	May-July 2016	TUCN Rector, Vice Rector with Research, General Director of TUCN	6.5.4
	Workshop	01/07/2016	Building Managers	

6.5.1 UK PILOT SITE

6.5.1.1 Individual discussions:

Table 45. Individual discussion schedule

Role	Department	Date
Management	Estates	07/06/2016
Administration	Estates	07/06/2016
Management	Estates	09/06/2016
Technical	Academic School	12/07/2016
Academic	Academic School	13/07/2016
Technical	Estates	14/07/2016
Administration	Estates	14/07/2016

6.5.1.2 Use Case Workshop – 18/07/2016

Attending: Tracey Crosbie, Michael Short, John Broderick (all DR-BOB team), Jon Bird (Energy Expert Group, EEG), 1x Estates technical, 1x Estates administration, 1x Academic School technical.

Apologies: 2x Estates management, 1x Estates technical, 1x Estates administration

- Jon Bird, EEG, formerly Northern Powergrid, introduced the strategic case for demand response in terms of energy costs and carbon reduction.
- Meeting opened with Michael presenting ideas for demand response use cases that will be investigated or simulated on the TU site. These included self-consumption of CHP power, modification of chiller and HVAC schedules, shifting of EV charging and high load computing off peaks, fast frequency response via IT UPS + generator.
- Discussion followed, noting the promise of the TU site (diversity of buildings and technologies, similarity to other public and commercial buildings) but also existing concerns on ambient conditions in Stephenson labs (heating still on in July?) and the wear & tear arising from activating IT backup systems. However, it was broadly felt this use case was worth investigating, noting the frequency of events matching existing testing. There was a question of whether the business case was valid; do availability payments for frequency response warrant the set-up costs? MS will investigate.
- IT policy on powering down PCs out of hours was not fully known. JB will contact names suggested in IT department.
- Scheduling: Semesterisation process will restrict flexibility in laboratory and teaching scheduling. No large, flexible loads e.g. research equipment, were identified. Shifting 24/7 availability of library, lab and computer resources may have implications, positive and negative e.g. on baseline, on total consumption.

- Jon Bird, suggested contacting innovation and network planning team at Northern Powergrid to identify and local distribution network congestion and/or schemes to alleviate it. JB to follow up.
- Aggregation is most likely required to access national DR schemes for payment. Smallest identified is 1MW for FFR Bridging programme. JB to investigate if aggregating requires a supply contract. MS/JB will contact Power Responsive
- DUoS/Triad charges more promising source of (apparent) revenue. Jon Bird will forward a paper on distribution charges, JB will investigate half hourly profiles and DUoS/Triad exposure with Estates administration.
- TC presented the DR-BOB video and leaflet for internal and external communication. JB noted that we are not seeking to engage the entire user base at this stage, project profile will focus on staff with a direct interest.

6.5.2 FRENCH PILOT SITE

Two workshops and one interview have been organised in order to collect the expectations, requirements and questions from the local stakeholders of the French pilot site.

6.5.2.1 Workshop with FCMB

Date: 23 of June 2016

Attending: Igor PEREVOZCHIKOV (NOBATEK), Denis ROUAULT (FCMB, deputy director), Jean René Dithurbide (FCMB, director), Guillaume BERNON (FCMB, member of the building maintenance staff), and Géraldine (trainee in the FCMB).

The project has been briefly introduced by I. PEREVOZCHIKOV and the objectives of the interview and discussions have been described. The preliminary draft of DR scenarios for the French pilot site has also been introduced in order to make the possibilities offered by the DR-BOB project more concrete.

- FCMB is an organisation with a local director and a deputy director taking in charge the whole management of the building including all the energy aspects (decision making process at local level). Even if the local organisation depends on a more global organisation, there is no directive and subvention coming from this general organisation. Therefore, the local direction staff is the main decision making body and the teaching staff and trainees are engaged in energy efficiency and energy management of the site.
- Some information about the occupancy of the building has been provided. The number of occupants ranges from 80 people up to 100 people (85% of trainees and 15% of trainers). Some 25 people are present every two Saturdays during which the workshops and machines are functioning and therefore are consuming). The site is completely unoccupied (closed) during 15 days in August and 15 days in December and beginning of January for Christmas holidays.
- There is a single energy provider for both electricity and gas (ENGIE). Even if the maintenance is realised by external maintenance companies (boiler: BOBION JOANIN,

electricity: ARRAMBIDE), some internal technical people are in charge of the building and BMS maintenance.

- Concerning the temperature set point, it can be adjusted by the Director and Deputy Director only. There is no possibility for the teaching staff and trainees to tune the regulation parameters. An "eco mode" (18°C) is used between 22:00 and 05:00 in the morning and a "comfort mode" is used from 06:30 until 17:00 (21°C). An automated regulation of the heating system is practicable and this should be investigated.
- In terms of energy consumption optimisation, brightness detectors are present in the offices and classrooms. There is no brightness detector in the workshops leading to wasted energy consumption in these areas. The lighting system is turned on manually in the morning and piloted by the trainers. Therefore, the end users of the site are already aware of energy management requirements but this seems insufficient. Another area of improvement deals with the functioning of the machines (electric saws, chipper) used in the workshops. These machines are functioning according to the following schedule:

Table 46. Functioning periods of the machines located in the workshops

Day	Functioning period
Monday	09:00 – 12:00 13:00 – 17:00
From Tuesday till Thursday	08:00 – 12:00 13:00 – 17:00
Friday	08:00 – 12:00

On Tuesday morning, 40% of trainees are attending courses in the classrooms. Nevertheless, the machines are still powered on and some of them are still functioning or they are in standby mode but not completely shut off.

The electricity is completely shut off during the nights and the week-ends (from 18:00 till 06:30 from Monday to Thursday, from 12:30 on Friday till 07:30 on Saturday and from 12:30 on Saturday till 7:30 on Monday morning).

- In terms of electricity usage, the administrative staff works with desktop computers whereas the teaching staff uses laptops in the classrooms (60 computers are used and 40 among them are turned on permanently for CAD activities). It's potentially feasible to switch the laptops power supply to batteries power during some 1 hour or 2 hours per day.
- There is no electrical vehicle for the FCMB personal (not planned) even if they are travelling a lot in the department by car. One issue is the lack of charging stations available in the department preventing or slowing down the use of electrical vehicles. Some charging stations are planned to be installed in the vicinity of the pilot site in 2017. Some people working or studying at the FCMB have individual hybrid vehicles.

- The wood chip boiler is the primary source of heating for the building and it often breaks down. Moreover, people complain about the heat produced by the wood chip boiler which is not felt as comfortable as the heat produced by the gas boiler. The local maintenance manager decides himself when the gas boiler needs to be launched to supply heat to the building. It should be highlighted that the building benefits from a large amount of solar irradiation and that there is no heating in the workshops.

6.5.2.2 Workshop with ACBA

Date: 23 of June 2016

Attending: Igor PEREVOZCHIKOV (NOBATEK), Maxime RENAUD (ACBA, energy project officer), Delphine MATHOU (ACBA, officer in charge of Ocean and Sustainable construction projects), Henry ANGIER (ACBA, one of ACBA directors).

The DR-BOB project has been briefly introduced by I. PEREVOZCHIKOV and the objectives of the interview and discussions have been described. The preliminary draft of DR scenarios for the French pilot site has also been introduced in order to make the possibilities offered by the DR-BOB project more concrete.

- The BI building is almost finished and is planned to be occupied by September 2016. The PV system is connected and is currently functioning. The implementation of the heating systems is not completely achieved. The building will be occupied continuously with some small periods of activity decrease. A large screen displaying the PV production of the PV installation will be installed in the entrance hall.
- Three companies will occupy the building in September 2016. There won't be any energy sub-metering associated to the zones occupied by each company. The rental costs will be calculated according to the surface occupied by each company.
- The subscribed power is currently 96kVA and will be increased up to 250 kVA when the companies will be installed in the building.
- Doors and windows opening sensors will be used to shut off the fan coils. There is no cooling system in the building except for the server room.
- Some electrical plugs will be available for the charging of the electrical vehicle that will be present on site, but there is no electrical charging station planned.
- Some discussions are currently in progress to discuss with the company TOTAL[26] the possibility to buy a SAFT-brand electrical storage battery.
- A person in charge of the incubator animation will be engaged in September but he won't be able to handle the role of interlocutor for the DR actions. Another person should be designated for this activity (for instance the person or the company in charge of the maintenance).
- It should be highlighted that the area where the BI is located has a large program to be launched in the future years and related to the implementation of common energy

[26] http://www.total.com/en/media/news/press-releases/joint-press-release-proposed-acquisition-saft-group-total

production systems , common energy storage systems and a common transport system in the frame of a sustainable approach. In that frame, ACBA is currently investigating the regional Smart grids demonstrators such as the one located in Toulouse which has been developed as part of the project Smart ZAE[27] (project launched in February 2012 and supported by ADEME). ACBA is highly interested by the tools developed as part of the DR-BOB project and would like to keep them installed after the end of the project.

6.5.2.3 Interview with Arrambide Maintenance

Date: 8 of July 2016

Attending: Igor PEREVOZCHIKOV (NOBATEK), Sebastien BIREPINTE (ARRAMBIDE, maintenance manager).

The DR-BOB project has been briefly introduced by I. PEREVOZCHIKOV and the objectives of the interview and discussions have been described. The preliminary draft of DR scenarios for the French pilot site has also been introduced in order to make the possibilities offered by the DR-BOB project more concrete.

To keep the equipment operating at peak performance, 3 types of contracts offered by Arrambide:

- P1 contract: energy supply or management of primary energies. This contract understands that maintenance society became unique energy supplier for all the energies for a consumer. Sometimes it is offered as “Maintaining comfort conditions” with fixed monthly price not depending from real energy consumption. In this case the DR management could be beneficial for Arrambide maintenance.
- P2 contract: preventive and corrective maintenance.
- P3 contract: full warranty and replacement of equipment (heavy maintenance). It includes P2 contract.

6.5.3 ITALIAN PILOT SITE

6.5.3.1 Interview with departments coordinators

Since the energy uses in the hospital are mainly to provide comfort and medicals tests to the patients, it was necessary to interview the departments coordinators who know better what are the needs of each area of the hospital.

Before starting the single interview program, a presentation of energy use, aims and future Poliambulanza’s goals was presented to all the departments’ coordinators. This was to involve people in the program and make them understand the importance and the benefits of a smart energy management.

After an introduction to the DR-BOB project, an on the field energy audit was conducted to understand when and what uses of energy could be reduced in case of need for a Demand Response program. The result was that lighting and air conditioning / heating can be reduced according to the occupancy of people in the areas of interest and according also with the schedule of the cleaning services of the building.

[27] http://www.scle-sfe.fr/en/Smart-ZAE/33_5_17/

In the following table the list of people interviewed.

Table 47 List of persons interviewed during the interviews

Hospital Department	Date of interview
Analysis LAB	11/02/2016
Surgery rooms area	17/03/2016
Emergency room	22/03/2016
Intensive Care	24/03/2016
Obstetrics department	05/04/2016
Hemodynamics department	07/04/2016
Cardiology	12/04/2016
radiotherapy and nuclear medicine	27/04/2016
Inpatient surgery area	03/05/2016
Radiology	04/05/2016
Day hospital and oncology	05/05/2016
rehabilitation gymnasium	10/05/2016

6.5.3.2 Interview with maintenance responsible and his technical staff

To better understand how energy is produced and distributed around the hospital it was required to also interview the people who actually manage and control the assets of the hospital.

The people involved for this interview were:

- Mr. Luigi Grossi – maintenance responsible
- Mr. Andrea Marelli – mechanical assets coordinator

The aim of the interview was to understand the real feasibility of shedding and shifting energy loads according with the assets installed in the Hospital.

Obviously, the electromedicals equipment can't be part of the Demand Response program, but all the services of the buildings, like HVAC, lighting and water pumps.

Since there is not a dedicated energy storage in the Hospital the main idea is using its thermal inertia to be able to use it like an energy storage and shift loads whenever is required according with external inputs (energy price or incentive).

To guarantee the comfort of the patients and employees HVAC and chillers cannot be turned off, but what can be done is use the BMS to change their set points in order to reduce their energy consumption or increase it in off-peak periods to store energy.

In 2017 will start running a trigeneration power plant (CHP) that will help on shifting loads from electric grid supply to locally produced electric energy supply. Both the engine and the adsorption chiller power can be continuously regulated to follow energy demand of the hospital.

6.5.4 ROMANIAN PILOT SITE

6.5.4.1 On site visits and individual discussions

Period: May - July 2016

DR-BOB Project members: Dan Doru MICU, Andrei CECLAN, Levente CZUMBIL (Romanian pilot site management team)

Individual discussions were carried out with:

Table 48. List of persons interviewed during the interviews

Name	Role
***Prof. Dr. Ing.* Vasile TOPA**	TUCN Rector
***Prof. Dr. Ing.* Sergiu NEDEVSCHI**	Vice Rector with Research
***Ec.* Cornel MURESAN**	General Director of TUCN

The Romanian local DR-BOB team has performed several on-site visits on each individual building, so as to get to know the Administrators, the structure of the buildings and associated HVAC and lighting installations.

The team has also met the Rector and the General Director of TUCN, to whom they presented the project concept, the preparations needed to implement DR-BOB project and the expected results.

As our TUCN Rector is an Electrical Engineering Professor, he was content with the project outcome and offered full support in the implementation.

6.5.4.2 Workshop with Building Managers

Date: 1st of July 2016

Attending from the DR-BOB Project: *Dan Doru MICU*, *Andrei CECLAN*, *Levente CZUMBIL* (Romanian pilot site management team)

Attending from TUCN Management:

Table 49. List of attendants during the Workshop with Building Managers

Name	Role / Department
Danuț SINCRAIAN	Technical Workshop 3 “Marasti”
Bianca INDREI	Building Administrator: “21 Decembrie 1989” street, No. 128-130 and “Dorbanților” street, No. 71-73
Adrian BODEA	Head of Administrative Service
Florin OLT	Building Administrator: “Muncii” street, No. 103-105
Florin GIURGIU	Technical Workshop 2 “Observator”
Marcel CRISTE	Building Administrator: Student Restaurant, Campus Marasti
Adrian BARAIAN	Technical Workshop 1 “Centru”
Marcela MURESAN	Building Administrator: “Observatorului” street, No. 72.
Ana-Maria MARGINEAN	Building Administrator: “Observatorului” street, No. 2.
Emilia CIOBAN	Building Administrator: “C. Daicoviciu” street, No. 15.
Diana MATEI	DTA (Technical and Administrative Department)

The team has organized a presentation and training session for all building Administrators and Technical Department, in order to briefly describe the project, the current energy status of the TUCN buildings, their energy optimisation potential and the expected involvement of the technical and administrative staff. The animated video of the DR-BOB project was presented as a start-up for the discussions.

The preliminary extracted conclusions were that in the current moment, the Administrators are no longer monitoring the energy use in their buildings, as in 2015 a decision from the Rectorate moved this activity to a centralized level at the Technical Department of TUCN.

After the organized presentation of the TUCN current energy status, the Technical Director decided to keep the centralized monitoring in the Technical Department and in the same time, to put in charge each individual Administrator to keep track of the monthly energy use in their buildings.

Building Managers were interested in the online energy monitoring system the will be implemented in the buildings of the DR-BOB Project Romanian pilot site.

As most of the Administrators are non-technical professionals, they were not motivated to understand the energy use, up to the moment when we presented the whole picture, the energy costs and the potential to increase energy efficiency and to have a better control in the energy load curve, through Demand Response.

The short presentation acted as a training course also for the Administrators.

Some information about the occupancy of the TUCN building was provided by Building Manager. The main electrical energy consumer equipment was identified at each location with their working periods. It was agreed that the Building Managers will provide a list of main assets for each building. They were interested to identify the energy consumption of each building.

Different measures and work plans form the Building Management side, in order to reduce the energy consumption of their buildings, were discussed (for example changing the lightning equipment in new energy efficient LED ones). The need of replacing the entire electrical system in some of the buildings was mentioned by the technical service department personal.