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DR-BOB

DEMAND RESPONSE IN BLOCKS OF BUILDINGS DELIVERABLE: D5.1 MONITORING AND VALIDATION STRATEGIES

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Unrestricted Project Consortium



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DoA	<p>Task 5.1 Developing the monitoring and validation strategies for the demonstrations.</p> <p>This task will develop strategies and data collection instruments (i.e. surveys and interview schedules) for evaluating and validating the demonstrations. The approach adopted will integrate the collection and analysis of energy monitoring data and qualitative data concerning everyday energy consuming routines and behaviours. It will use the information supplied in T4.1 to identify the KPIs that will be used to measure the impact of the demonstrations in terms of energy and CO2 reduction, as well as consumer' engagement, through the willingness and capability of consumers to participate in demonstrated solutions and the response to DR solicitations. However this task will also build on the information gained in T2.2 to develop KPIs and data capture strategies.</p> <p>This deliverable report will present the strategies developed for monitoring the case study demonstrations to be undertaken as part of WP4. The strategies presented will include both methods for quantitative validation, including data capture and relevant KPIs, and those catering for more qualitative evaluation using aspects such as contextual interviews, self-observations, and/or questionnaires.</p>		
Contribution of partners	<p>CSTB was responsible for the overall structure of the document and more particularly of the following sections: §1 introduction; §2 KPI; §3.1, §3.2, §3.3, §3.5 in the chapter Methods for quantitative evaluation; §5 Adaptation of evaluation strategies to the scenarios (with the exception of the sections listed below for which the other partners contributed); §6 implementation of evaluation strategies.</p> <p>DuneWorks contributed to the chapter 4 Methods for qualitative evaluation.</p> <p>Siemens was responsible for section 3.4 corresponding to the Baseline.</p> <p>Teesside University was responsible for sections 3.5.6.5 (Financial rewards in UK pilot site), 5.2.1.x.1 (short descriptions of the scenarios, x=1 to 5), 5.2.2.1.3 (Energy prices and DR rates). Teesside University also contributed to the section 3.4 (Baseline).</p> <p>Nobatek was responsible for sections 3.5.6.6 (Financial rewards in FR pilot site), 5.3.1.x.1 (short descriptions of the scenarios, x=1 to 4).</p>		

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	<p>R2M and with Fondazione Poliambulanza was responsible for sections 5.4.1.x.1 (short descriptions of the scenarios, x=1 to 4), 5.4.2.1.2 (temperature readings), 5.4.2.1.3 (Energy prices). Technical University of Cluj-Napoca was responsible for sections 5.5.1.x.1 (short descriptions of the scenarios, x=1 to 3).</p> <p>The pilot partners, responsible for a demonstration site (Teesside University, Nobatek, Fondazione Poliambulanza accompanied by R2M, Technical University of Cluj-Napoca accompanied by Servelect) contributed the chapter 5 by completing some information and validating the synthesis of collected data (in meter readings, temperatures and energy prices sections).</p> <p>The technical partners responsible for DRBOB solutions (Siemens, Teesside University, Nobatek, GridPocket) were involved in particular in the development of requirements for evaluation and analysis. Specifically, it was a matter of agreeing on the availability of measures coming from the technologies (LEM, DEMS, CP, ME) and their export for the WP5 data collection during the evaluation period.</p>	
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EXECUTIVE SUMMARY

Purpose:

The Deliverable 5.1 constitutes the output of Task 5.1 aiming at developing the monitoring and validation strategies for the demonstrations.

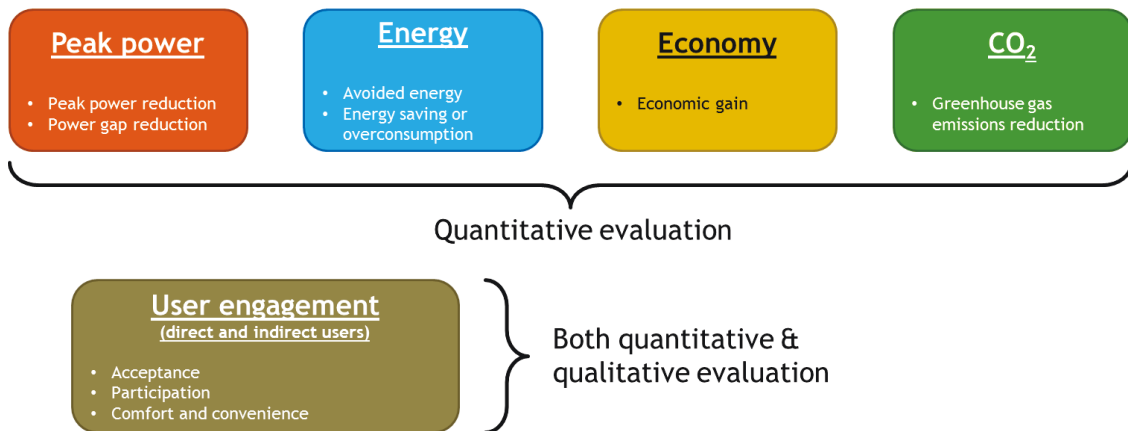
The strategies presented include both methods for quantitative validation, including data capture and relevant KPIs, and those catering for more qualitative evaluation using aspects such as contextual interviews, self-observations and questionnaires.

The approach adopted integrate the collection and analysis of energy monitoring data and qualitative data. Key Performance Indicators (KPIs) have been defined and will be used to measure the impact of the demonstrations in terms of energy saving, peak power shaving, CO₂ reduction, economy, as well as user engagement, through the willingness and capability of consumers to participate in demonstrated solutions and the response to DR solicitations.

The strategies and data collection instruments for evaluating and validating the demonstrations have been adapted to each DR scenario in each pilot site in order to be sure to measure the right impacts of the demonstrations and to have relevant analysis.

Methodology:

To provide a more extensive evaluation of the DR-BOB solution, 5 categories of KPIs are defined in the following, with both quantitative and qualitative evaluation:



- **Peak power KPIs:** related to the peak shaving of electricity load
 - Reduction between peak power and minimum night time demand
 - Reduction of peak power demand
- **Energy KPIs:** related to the volumes of energy involved
 - Avoided electricity volume: reduction of electricity demand during shedding
 - Electricity demand savings: reduction of electricity demand due to DR (including both shedding and shift periods)
 - Energy demand savings: reduction of primary energy consumption (related to electricity and fuel demand) due to the DR

- **Economic KPI:** related to the economic benefit
 - Direct economic gain from the DR scenarios, due to the energy savings (electricity and fuels), the shedding during peak periods where the electricity tariff is high, and eventually the financial rewards of the related DR programs (utilisation and availability payments).
- **CO₂ KPI:** related to the environmental benefit in terms of greenhouse gas emissions
 - Reduction of greenhouse gas emissions (in equivalent CO₂ kg), due to the energy savings (electricity and fuel) and the shedding during peak periods where the emission factor of the electricity mix is high (due to the starting of fossil fuel power plants to meet the grid demand)
- **User engagement KPIs** related to people reaction :
 - Evaluation of participation of consumers (number, percentage and qualitative evaluation)
 - Acceptation and satisfaction of consumers (qualitative evaluation)
 - Thermal comforts quantitative KPIs
 - Discomfort time variation due to the DR events (in h) that could be generated from the shedding on heating and cooling equipment (pre-heating, pre-cooling, free-floating) or the shift of the heat & cold generation asset.
 - Maximal thermal deviation gap from the comfort temperatures band (in K)

Methods for quantitative evaluation

In order to make a relevant evaluation of the DR-BOB potential in each pilot site, the evaluation of the quantitative KPIs will be done for each DR event, and globally for all the evaluation period. The segmentation of the DR events will provide some statistics that could be helpful to evaluate the robustness and the potential of the different proposed scenarios in all pilot sites. The global indicators on all the evaluation period (compared with historical data) will also allow to incorporate the effect of the energy investments, the awareness and the changing routines of the occupants through the project progress (in addition to the DR events).

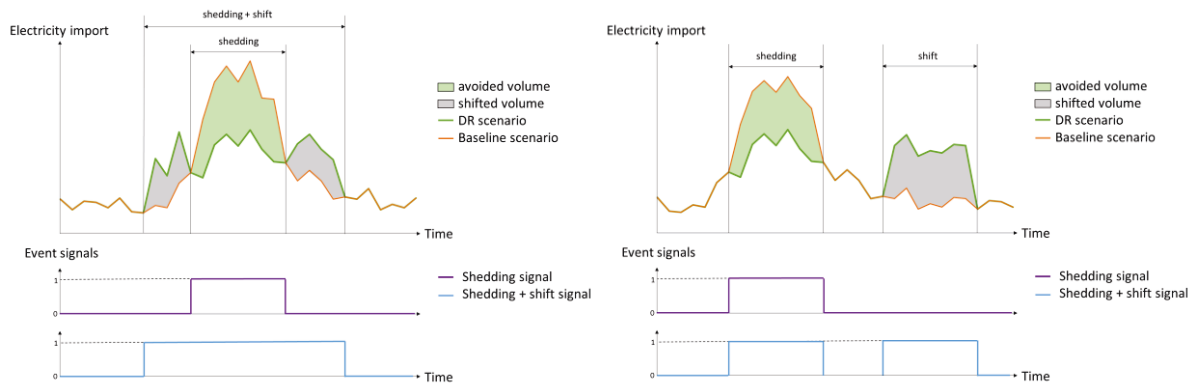
For each DR event, two different periods will be considered to calculate the KPIs:

- Shedding period
- Shedding + shifting periods

The shedding period is the period where electricity consumption is lower than the baseline scenario (assets are turned off, or electricity production is increased). In this perimeter, the energy savings are equal to the avoided energy.

The shifting period is the period where the electricity consumption is reported and thus is higher than the baseline scenario. This period can occur:

- Just before the shedding period (ex: pre-cooling or pre-heating)
- Just after the shedding period (ex: post-heating or post-cooling)
- Staggered from the shedding period during the day (ex: shifted charge of computers, electric vehicle, shifted time schedules for kitchen or wash machines)



As well as for the time perimeter, two spatial perimeters will be considered:

- Set of involved assets (for controlled assets)
- Block of Building level (for involved buildings)

Nevertheless, the involved assets level will not be always available, as some of them will not be able to be submetered (manually controlled small power assets in particular). In this case, only the BoB level will be considered.

Baseline

Baseline, in the context of this section of the document, is relevant to any data that is measured by quantitative methods. A baseline is required for the Monitoring and Evaluation in order that it is possible to determine the impact of running the Demonstration Scenario.

Concretely, a baseline corresponds to the evolution of a physical variable (temperature, electricity consumption or import) if a DR event did not take place. Thus it is not possible to measure this quantity, it can only be estimated, by means of prediction techniques.

Baselines are created by two of the systems that are part of the Technical Solution, the LEM and DEMS. But the baseline for Monitoring and Evaluation must be calculated independently of the Technical Solution in order that impartiality is maintained. The aim is to ensure that the method is easily understood and as transparent as possible.

The approach for creating the baseline is agreed with all parties before development of the calculation is undertaken. The approach is an average adjustment method which will be informed by the 'International Performance Measurement and Verification Protocol'. The method uses the following elements: historic data, any related data set anticipated to be a driver for energy consumption (such as external temperature), details of what the meter supplies and operational hours of the site/equipment supplied, details of any historic events which would alter energy consumption (such as, previous demand side events or operational changes).

Methods for qualitative evaluation

As for the qualitative evaluation regarding the consumers' engagement, addressing thermal comfort, consumer participation and acceptance of the DR interventions, an explorative yet pragmatic and feasible approach has been set up.

The DR-BoB project is focused on the demonstration of different technologies in real life contexts, implying that the users of those BoBs will be affected or even actively engaged. The owners of these BoBs can be regarded as customers of the DR-BoB solution and their building managers are the direct users of the solution. In addition in each BoB there is a large group of

‘indirect users’ i.e. the *building occupants*. As these ‘indirect users’ do not bear the cost (of energy) or have a direct role in decision-making they often simply ‘fall out of sight’ when thinking about DR for medium scale users. Hence we address both the direct and the indirect users in the qualitative evaluation to learn how the solutions match with the everyday practices and routines of the users of these buildings.

The different DR scenarios all affect building occupants differently, but we can identify similarities in how the building occupants are affected. Taking a closer look at the scenarios, we can observe that some of the demonstration scenarios will have no impact at all on users (these are scenarios where only the source of energy is temporarily changed). However, for other scenarios, occupants will be affected and we can in fact distinguish three levels of expected impact or involvement:

- A. Occupants will hardly notice anything
- B. Occupants (or some of them) are actively involved and asked to turn off or unplug appliances during peak hours
- C. Occupants (or some of them) are actively involved and are asked to shift their activities to another moment

		Impact on occupants				
		occupants are passive		occupants are active		
		no impact	impact on comfort (changes in setpoints)	participation in loads shedding (no change in activities)	participation in loads shifting (changes in behaviour and routines)	
UK site	Scenario 1	Electric demand reduction		YES		
	Scenario 2	Electric demand increase	YES			
	Scenario 3a	Electric peak demand reduction			YES	
	Scenario 3b	Electric peak demand reduction				YES
	Scenario 4	Frequency regulation / emergency load shedding	YES			
FR site	Scenario 1	Capacity Market		YES	YES	
	Scenario 3	Reduction of gas consumption		YES		
	Scenario 4	Reduction of Peak power consumption		YES	YES	
	Scenario 5	Virtual microgrid	YES			
IT site	Scenario 1	Load curtailment or shedding of HVAC and chillers loads	YES			
	Scenario 2	Load shedding of small loads			YES	
	Scenario 3	Load shifting of important loads				YES
	Scenario 4	Self-consumption and heat recovery from CHP power plant	YES			
RO site	Scenario 1	Critical peak pricing with automated control		YES	YES	
	Scenario 4	Explicit demand reduction in student Dormitories			YES	YES
	Scenario 5	Virtual ToU tariff with schedules response			YES	YES

As for the qualitative evaluation, the plan is threefold:

1. **Qualitative comparison of the implementation with the original ideas:** assess what has actually been implemented (compared to baseline scenario plans) and compare actual involvement of users and occupants with expected involvement
2. Have pilot partners conduct **interviews with the direct users** (i.e. building -, energy-, facility manager and their team) to collect their feedback on the DR intervention, the communication, the response options, how participation in DR events has affected their daily working routines and practices
3. Set up consumer panels with occupants (**occupant panels**) to collect feedback on the interventions, the communication, the response options and how it has affected comfort and daily routines

The occupant panels do not refer to any technology. Taken from the field of product testing, the term ‘user panel’ refers to a group of users that is asked to give their opinion and/or advice about a product or service. People can give feedback individually and/or in a group setting; they can give feedback once or several times so a user panel can be organised using a diversity of methods

(workshop, focus group, surveys, group discussions, online platforms, etc.) at set moments in time.

So while small surveys may be held among the occupants, a choice has been made to have a more explorative approach allowing for unexpected feedback. A survey with closed questions would not allow for that. Moreover, closed questions don't tell us anything about why and how people responded. In addition, setting up occupant panels involves a more active engagement with these occupants (e.g. through workshop meetings) which increases the chance of getting feedback in comparison with a rather anonymous survey approach where response rates are often disappointing.

The aim is not to have a test among a representative group but rather to gather as much as feedback as possible considering limited time and resources. All building occupants affected by a DR intervention are eligible to participate in such a panel, except for the building-, energy- and facilities managers – because they will be interviewed separately.

Occupant panels allow for occupants to bring up issues that the pilot manager may not yet have considered as being of relevance. Since DR in these context is a new phenomenon, it is useful to learn about all issues that may affect occupants' engagement and acceptance.

The set-up and organisation of these occupant panels is done by the pilot site managers. A template has been developed to support the pilot managers in this. The aim is that the template will help also in gathering feedback that the pilot managers have collected and translated, at set moments during and after the implementation of the scenarios.

It should be noted that there may be overlaps between the communication strategy that the pilot sites have developed and the qualitative evaluation. The pilot managers are aware that once they start communicating about DR BoB to building occupants, they also need to consider inviting building occupants to take part in a panel (or announce already that they will invite the occupants at a later moment).

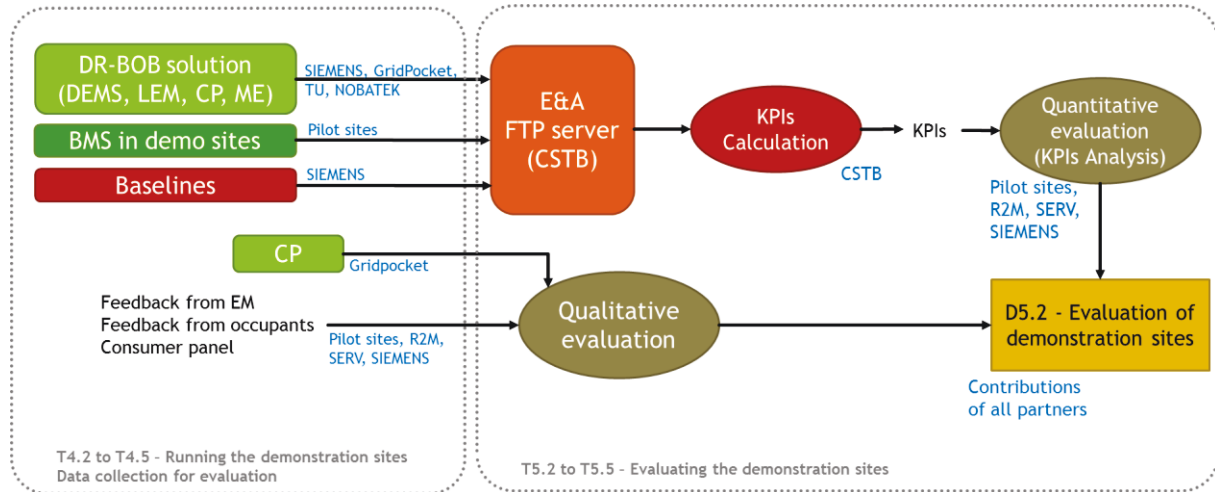
Key Findings and Conclusions:

The development of the global methodology for evaluation the impact of Demand Response has shown that the methods and indicators needed to be adapted to the context of the project. It was necessary to adapt the KPIs and the evaluation to the DR scenarios and pilot sites. Indeed Key Performance Indicators and evaluation methods are generic and not all indicators are relevant for all DR programs.

The right KPIs have been adapted to each DR scenario and calculation schemes have been drawn for the evaluation of quantitative indicators. These schemes allow to identify the necessary input data. This deliverable presents the synthesis of required data for each pilot site. It concerns mainly high frequency time series data for energy consumption, temperatures, energy prices, CO₂ and DR event data. All the measurement data come from different sources (DRBOB implemented technologies, BMS...) that have been specified.

The results contained in this report will serve as the evaluation methodology and be used by the pilot partners to conduct the implementation of the evaluation strategies in tasks 5.2 to 5.5 and present the results of the impacts of the DR programs and of the technical solutions.

The implementation scheme for evaluation of demonstration sites is described below.



The evaluation period for the pilot sites will begin in October 2017 and will last 1 year. All these results will contribute to the writing of the Deliverable D5.2 “Evaluation of demonstration sites”.

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ACRONYMS AND ABBREVIATIONS

All acronyms and abbreviations used in the report should be listed in alphabetical order in the table below (other than symbols for units of measurement) in the following way:

BI	Business Incubator
BMS	Building Management System
BoB	Blocks of Buildings
CCHP	Combined Cooling, Heat and Power also known as trigeneration
CHP	Combined Heat and Power, also known as cogeneration
CP	Consumer Portal
CSV	Comma Separated Variable
#DEMS	Distributed Energy Management System
DNO	Distribution Network Operator
DR	Demand Response
DR-BoB	Demand Response in Blocks of Buildings
DTU	Demand Turn Up
EMS	Energy Management System
ESCo	Energy Service Company
EV	Electric Vehicle
FCDM	Frequency Control by Demand Management
FCMB	Fédération Compagnonique des Métiers du Bâtiment
FTP	File Transfer Protocol
KPI	Key Performance Indicator
LEM	Local Energy Manager
ME	Market Emulator
NBK	NOBATEK
STOR	Short-Term Operating Reserve
TOU	Time-Of-Use
TSO	Transmission System Operator
TU	Teesside University
TUCN	Universitatea Tehnica din Cluj-Napoca
WP	Work Package

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 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.

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

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 counties is a competitive market.

Energy Suppliers buy electricity and /or gas in bulk and sells 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,

Local renewable energy sources includes 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.

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

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 5.1 constitutes the output of Task 5.1 aiming at developing the monitoring and validation strategies for the demonstrations.

The strategies presented include both methods for quantitative validation, including data capture and relevant KPIs, and those catering for more qualitative evaluation using aspects such as contextual interviews, self-observations and questionnaires.

The approach adopted integrate the collection and analysis of energy monitoring data and qualitative data. Key Performance Indicators (KPIs) have been defined and will be used to measure the impact of the demonstrations in terms of energy and CO2 reduction, as well as consumer' engagement, through the willingness and capability of consumers to participate in demonstrated solutions and the response to DR solicitations.

The strategies and data collection instruments for evaluating and validating the demonstrations have been adapted to each DR scenario in each pilot site in order to be sure to measure the right impacts of the demonstrations and to have relevant analysis.

The results contained in this report will serve as the evaluation methodology and be used by the pilot partners to conduct the implementation of the evaluation strategies in tasks 5.2 to 5.5 and present the results of the impacts of the DR programs and of the technical solutions.

1.2 RELATIONS TO OTHER ACTIVITIES IN THE PROJECT

The diagram in Figure 1 illustrates the relationship that T5.1 has with other Work Packages and Tasks.

Into the Work Package 5, T5.1 defines the evaluation strategies that will be used in the following tasks T5.2, T5.3, T5.4 and T5.5 during the 12 months evaluation period. And an overall comparative analysis of the results from the 4 pilots will be realized in Task 5.6 in order to draw lessons learnt and suggest guidelines for future pilots.

For the development of the monitoring and validation strategies, T5.1 relied on task 2.2 which defines the demonstration scenarios and task 4.1 which defines the implementation strategies.

An important connection exists between WP5 and WP4 'Implementation' as the data collection required for the evaluation is conducted in tasks 4.2 to 4.5 (running of the demonstration scenarios) in the four pilot sites. Indeed Tasks 5.2 to 5.5 will analyse the qualitative and quantitative data provided by T4.2 to T4.5 following the monitoring and evaluation strategy developed in this deliverable. An important input for WP5 is the deliverable D4.3 - Evaluation data, due to month 31, which will be the data both qualitative (i.e. completed surveys) and quantitative (i.e. detailed energy monitoring data) results as specified in D5.1 for the evaluation of the solutions implemented.

Another connection with WP2 can be mentioned: the results of the evaluation that will be reported in D5.3 (T5.6) will inform business models (T2.4) and exploitation plan (T2.5).

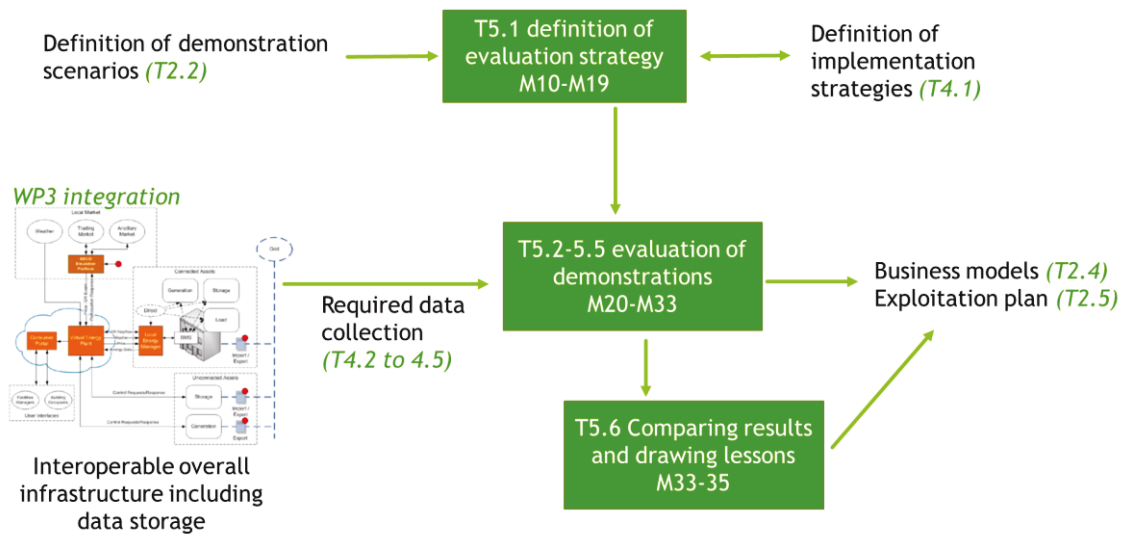


Figure 1: Relations of D5.1 to other activities in DRBOB Project

1.3 REPORT STRUCTURE

The introduction of D5.1 (Chapter 1) sets the main content of Task 5.1 and explains how the work conducted in Task 5.1 is connected to the work being conducted in the other tasks and WPs of the project.

Chapter 2 of the document is dedicated to the definition of the Key Performance Indicators (KPIs). The KPIs will be calculated during the evaluation period in order to assess the impacts of the demonstrations. There are specific expectations in terms of results in the project contract that should be achieved and need to be evaluated.

Chapters 3 and 4 describe respectively the methods for the quantitative evaluation and for the qualitative evaluation. The methods developed are used for evaluating the KPIs. Calculation algorithms for the quantitative evaluation are presented in section 3.5.

Not all indicators are relevant for all scenarios. It is therefore necessary to adapt the indicators and evaluation methods according to the demonstration sites and the DR programs. Chapter 5 presents these adaptations.

Finally, Chapter 6 introduces how the evaluation and validation strategies of the demonstrations will be applied in the next steps of the WP5. The application framework is described with the role of each partner and the specifications for data collection.

2 KEY PERFORMANCE INDICATORS

This section defines the Key Performance Indicators developed for the DR-BOB Project to evaluate the DR scenario in the demonstration sites.

The first paragraph recalls the expected contractual outcomes that are specified in the DR BOB Description of Actions

2.1 EXPECTED CONTRACTUAL FINDINGS

To achieve its aim the DR-BOB project have to realize:

- up to 11% saving in energy demand,
- up to 35% saving in electricity demand and
- a 30% reduction in the difference between peak power demand and minimum night time demand for building owners and facilities managers at the demonstration.
- at least 25% consumers involved in the project

As no time scale is associated to these objectives, they will be defined and justified in section 3.3.2.

2.2 KEY PERFORMANCE INDICATORS

2.2.1 OVERVIEW

To provide a more extensive evaluation of the DR-BOB solution, 5 categories of KPIs are defined in the following, with both quantitative and qualitative evaluation:

- Peak power KPI's: related to the peak shaving of electricity load
- Energy KPI's: related to the volumes of energy involved
- Economic KPI: related to the economic benefit
- CO₂ KPI: related to the environmental benefit in terms of greenhouse gas emissions
- User engagement KPI's: related to people reaction (participation, acceptance, comfort, etc.)

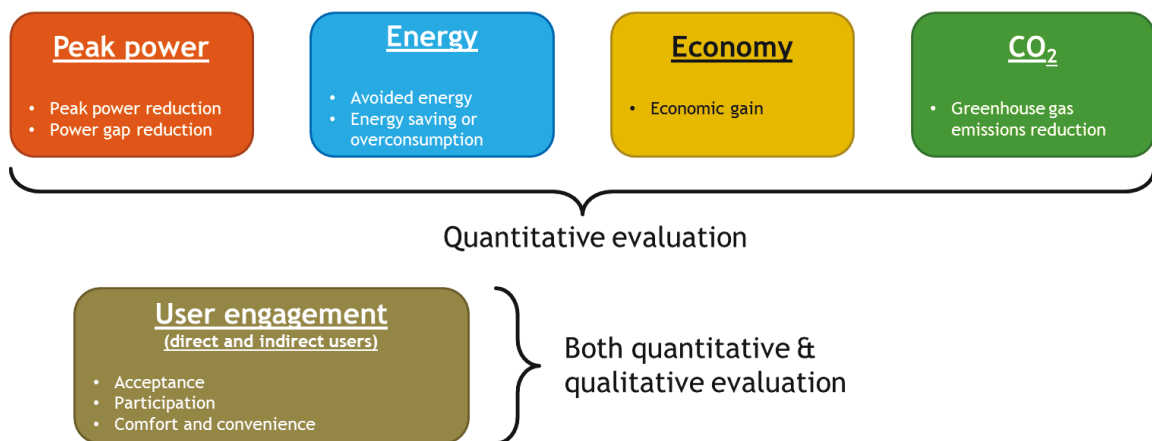


Figure 2: KPIs overview: thematics and evaluation type

The most relevant KPIs for each target actors are suggested in Figure 3.

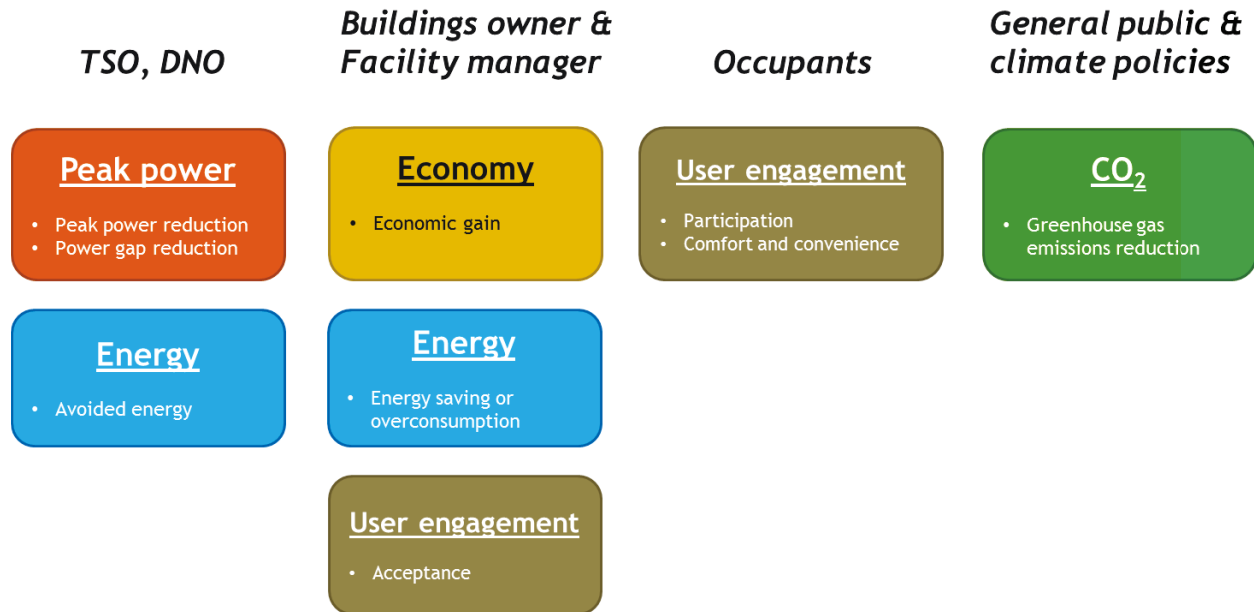


Figure 3: Relevancy of different KPIs depending on the target actors

All different KPIs will be described in the following paragraphs. Their calculations can be found in Section 3.5.

2.2.2 ENERGY

The following KPIs will be considered:

- Avoided electricity volume: reduction of electricity demand during shedding (does not take into account the shifted energy after or before shedding)
- Electricity demand savings: reduction of electricity demand due to DR (including both shedding and shift periods)
- Energy demand savings: reduction of primary energy consumption (related to electricity and fuel demand) due to the DR (including both shedding and shift period)

Both absolute values (in kWh) and relative values (in %) will be considered. The spatial and temporal perimeters will be stated in section 3.

2.2.3 PEAK POWER

The following KPIs will be considered:

- Reduction between peak power and minimum night time demand
- Reduction of peak power demand

Similarly, the absolute values (in kW) and relative values (in %) will be considered, and the spatial and temporal perimeters will be stated in the following.

2.2.4 CO₂

The only selected KPI will be the **reduction of greenhouse gas emissions** (in equivalent CO₂ kg), due to the energy savings (electricity and fuel) and the shedding during peak periods where the emission factor of the electricity mix is high (due to the starting of fossil fuel power plants to meet the grid demand). The CO₂ implied by DR-BoB deployment will not be counted for, as it may be very difficult to evaluate it precisely.

2.2.5 ECONOMY

The only considered economic KPI will be the direct **economic gain** from the DR scenarios, due to the energy savings (electricity and fuels), the shedding during peak periods where the electricity tariff is high, and eventually the financial rewards of the related DR programs (utilisation and availability payments).

As the DR-BOB solution is not currently a full operational technology, implementation costs and investment payback cannot be evaluated precisely for now. However, the results on the cost KPI and a future costing study (based on the lessons learned from the project) could provide such an evaluation.

2.2.6 USER ENGAGEMENT

The following KPIs will be considered:

- Evaluation of participation of consumers (number, percentage and qualitative evaluation)
- Acceptation and satisfaction of consumers (qualitative evaluation)
- Thermal comforts quantitative KPIs
- Discomfort time variation due to the DR events (in h) that could be generated from the shedding on heating and cooling equipment (pre-heating, pre-cooling, free-floating) or the shift of the heat & cold generation asset.
- Maximal thermal deviation gap from the comfort temperatures band (in K)

The strategies to evaluate the two first KPIs will be described in section 4. The calculation methods of the quantitative KPIs related to thermal comfort will be stated in section 3.

3 METHODS FOR QUANTITATIVE EVALUATION

3.1 INTRODUCTION

In order to make a relevant evaluation of the DR-BOB potential in each pilot site, the evaluation of the KPIs will be done:

- For each DR event
- Globally for all the evaluation period
 - With cumulative KPI results of individual DR scenarios events
 - At once, regardless DR scenarios

Indeed, the DR scenarios are mainly intended to limit the consumption (and therefore the electrical power demand) during the peak periods. This implies a transfer of the unused energy to another time called the shifting period (ex: re-heating, deferral of the use of domestic appliances by the occupants, etc.).

For this reason, Demand-Response does not necessarily realize energy savings overall.

Nevertheless increasing awareness of occupants and optimizing energy use with respect to costs (taking into account implicit DR) can generate savings. In this perspective, the total energy consumption of the buildings measured after the implementation of the DRBOB solutions will be compared with the consumption of the previous year, in addition to the KPIs evaluation during events (with some adjustments on weather condition and occupation).

At the end of the evaluation period, the partners will verify whether or not the expected contractual findings are being met and for what reasons.

3.2 STATE OF THE ART

Evaluation of demand response scenarios, in particular for block of building is a very new subject. Therefore, no very many existing –and even less standardized– methodologies are currently referenced.

Most studies are focused on energy management at the building level (Favre and Peuportier, 2014), or on flexibility loads assessment (Patteeuw, et al., 2016; Saker, 2013; Da Silva, 2012). Demand-response events are generally simulated virtually and are not implemented in reality.

In S3C project (S3C, 2017a), some recommendations can be found concerning energy KPIs (S3C, 2017b) and user-centred KPIs (S3C, 2017c) for determining the effect of the smart grid environment. Some others have been proposed and adapted to residential and commercial buildings (Minou, et al., 2014).

In the Smart Electric Lyon project (SEL, 2017), a variety of different KPIs has been proposed to evaluate the impact of tariff based heating load control in residential and heating buildings (Agapoff, et al., 2017). These indicators also involve thermal comfort, energy, peak power and CO₂ aspects.

Most of the proposed methods and KPIs will be adapted from these projects, while considering the specifications of DR-BoB pilot sites and business scenarios.

The economic aspects of demand-response in schools, offices and healthcare facilities, with some specific European cost and rewards models will be explored in DR-BoB project, in particular when implementing such DR scenarios in reality.

For global energy enhancements evaluation (regardless DR events), many standardized methods are already existing (Kelly, et al., 2013), such as the often cited International Performance Measurement and Verification Protocol (IPMVP).

3.3 TIME & SPACE PERIMETERS

3.3.1 TIME PERIMETER

The KPIs will be calculated during periods when demands for load shedding occur (DR events).

For each DR event, two different periods will be considered to calculate the KPIs:

- Shedding period
- Shedding + shifting periods

During shedding period, electricity consumption is lower than the baseline scenario (assets are turned off, or electricity production is increased). In this perimeter, the energy savings are equal to the avoided energy (filled in green in Figure 4).

During shifting period, electricity consumption is reported and thus is higher than the baseline scenario. This period can occur:

- Just before the shedding period (ex: pre-cooling or pre-heating)
- Just after the shedding period (ex: post-heating or post-cooling)
- Staggered from the shedding period during the day (ex: shifted charge of computers, electric vehicle, shifted time schedules for kitchen or wash machines), see Figure 5

The methodology to identify the shedding and shifting periods is the following:

- Shedding schedules will be sent for all events by the Consumer Portal (by mean of json event files, see section 6.2)
- Shifting periods will be identified when the electricity import will be significantly higher than the baseline. The “significance level” will depend on the baseline accuracy, which needs to be assessed during the evaluation period (see section 3.4)

These informations will be translated into binary events signals (illustrated in Figure 4 and Figure 5) in order to calculate the KPIs.

Both individual and cumulative values of KPIs will be considered when performing the results analysis, in order to appreciate the different scenarios potentials and robustness.

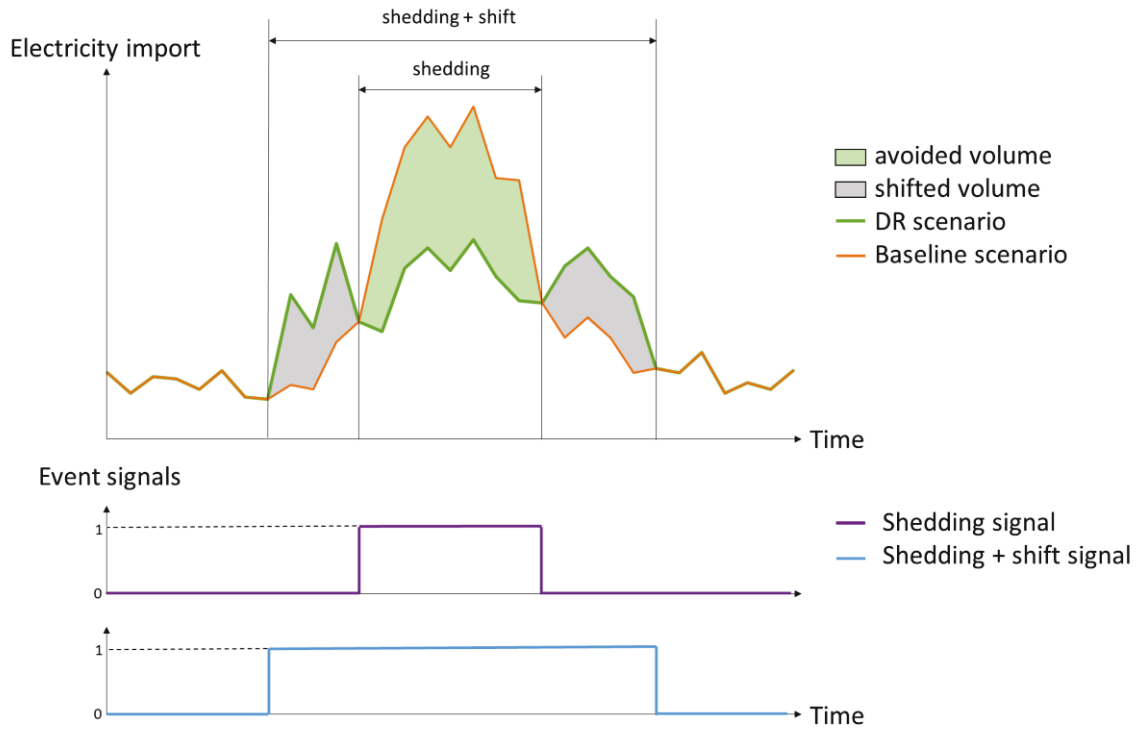


Figure 4: Illustration of energy volumes and expected event signal for a continuous DR scenario

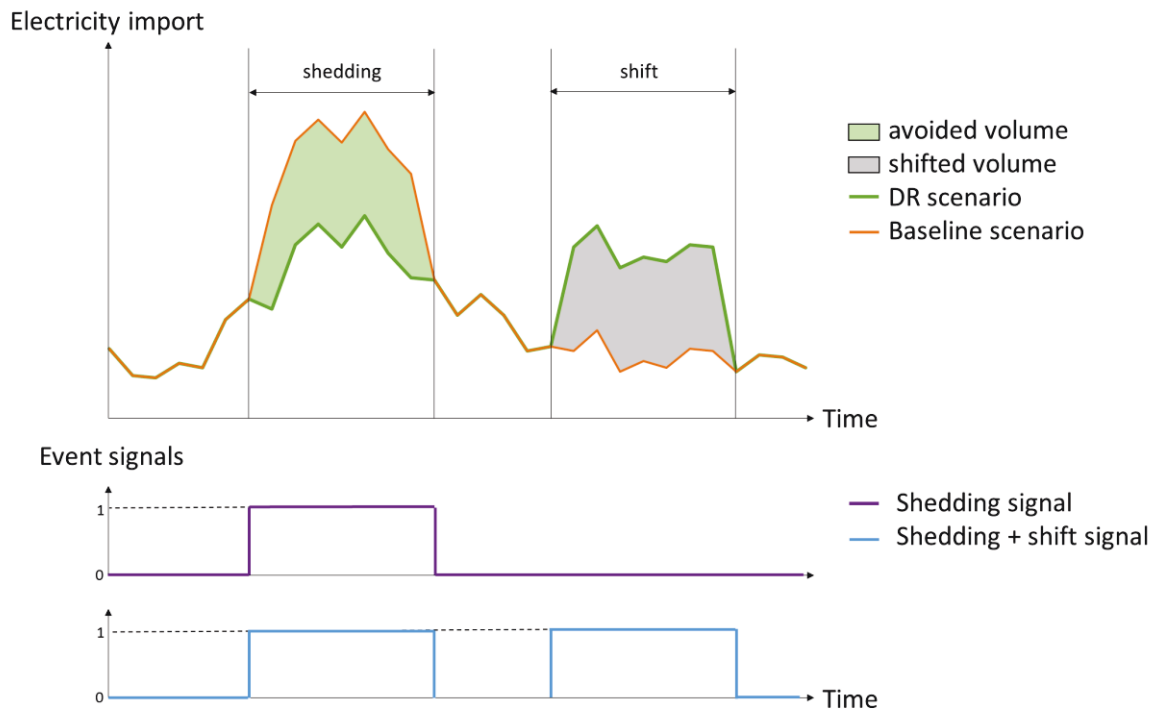


Figure 5: Illustration of energy volumes and expected event signal for a discontinuous DR scenario

3.3.2 TIME SCALE

Data acquisition frequency is an important issue. Indeed, if the time step is longer than the duration of the shedding periods, KPI calculation will not be relevant (as non-shedding periods will be integrated).

Therefore, the time step has to be as small as possible. All the data providers will export the meter data with the highest acquisition frequency available, by considering their respective operational constraints (15 minutes for most cases).

In case of insufficient acquisition frequency (time step longer than shedding periods), the calculations will be skipped to a larger time perimeter (shedding + shifting periods).

3.3.3 SPATIAL PERIMETER

As well as for the time perimeter, two spatial perimeters will be considered:

- Set of involved assets (for controlled assets)
- Block of Building level (for involved buildings)

Nevertheless, the involved assets level will not be always available, as some of them will not be able to be submetered (manually controlled small power assets in particular). In this case, only the BoB level will be considered.

This point will be discussed in the section 5 regarding the adaptation to the scenarios in demo sites.

3.4 BASELINE

In the last 25 years a number of approaches and methodologies to establish the baselines in energy measurement have led to guidelines, but the way to measure and establish the baseline for Demand Response actions has not been agreed nor standardized as yet. Several approaches to this have occurred (Johnson controls, Christensen...).

Baseline, in the context of this section of the document, is relevant to any data that is measured by quantitative methods. It aims at establishing both the framework for evaluation of the system and action success and performance, referring to the KPIs. It also provides an overview of the measuring methodologies as a whole, and builds on to create an evaluation standard for Demand Response in Europe.

3.4.1 PRINCIPLE

As referring to quantitative assessment of the whole system, a consistent assessment methodology is required across the different sites and scenarios. As well, a verifiable approach is due in order to obtain comparable and repeatable experiments and results.

A baseline is required for the Monitoring and Evaluation Work Package (WP5) in order that it is possible to determine the impact of running the Demonstration Scenario.

Baselines are created by two of the systems that are part of the Technical Solution, the LEM and DEMS (see D3.2 LEM and Energy Management Systems and D3.1 VEP and Interoperable IT Infrastructure, respectively). The purpose of the baselines and the way that they are calculated is described in section 3.4.2, below.

The baseline for Monitoring and Evaluation must be calculated independently of the Technical Solution in order that impartiality is maintained. The method proposed for the creation of the baseline is described in section 3.4.4, below

3.4.2 LEM/DEMS BASELINES

3.4.2.1 LEM

The LEM establishes a baseline for specific assets' demand focusing on short-term forecasting of both heat and electrical loads, along with unit commitment scheduling and economic dispatch optimisation. As part of this, the baseline establishes an accurate prediction strategy based on historic values, utilisation patterns and weather functions. This forecast is more accurate as the window horizon shortens, i.e. for one day ahead forecast, the baseline has typically a 5% Mean Absolute Prediction Error (MAPE) with real demand of each asset in the LEM algorithm but this algorithm loses accuracy as the rolling horizon expands (Short et al. 2016). The approach adopted builds on recent research employing Mixed Integer Linear Programming (MILP) models and non-linear boiler efficiency curves, and extends this work into a rolling horizon context.

The 24 h rolling horizon is consistent with most of the requests for Demand Response actions to be taken, and so, this baseline would be convenient to be established as a way to examine the effectiveness of the DR actions in lowering, shedding or shifting demand across assets within Blocks of Buildings. Part of the benefits of the E&A WP is discerning the best approach to determine the effectiveness of the baselines in DR programmes.

3.4.2.2 DEMS

The baseline generation process used by DEMS is a highly parameterised algorithm. The algorithm uses predominantly historic data to calculate the baseline, and can also take into account the weather, although weather has not been deemed necessary for the DR-BoB solution. The parameterisation provides a considerable amount of tuning which can be applied during the execution of the algorithm. For example, to ensure that a suitable set of data is used then a number of parameters can be set: the standard number of days to look back over the historic data; a maximum number of days which is used instead of the standard look back if there is not enough historic during the standard days to make a good estimate; the types of day, e.g. weekday, weekends, national holidays, or bespoke day groups, perhaps there are periods of time when a building is less used, for example during organisational closedown, particularly in educational establishments, as this effects the consumption; and if normalisation should be applied, which means removing particularly high or low consumption days as they might skew the baseline.

The purpose of the baseline is to allow the participation in a DR event to be calculated, therefore to achieve this it is necessary to calculate what would have been expected to be consumed during the period of the event and then find the delta with what was actually consumed. To make the baseline more accurate adjustment parameters can be taken into account, these include the number of hours before an event where load may to be shifted to enable the event to be more effective, but may uncharacteristically increase the consumption during the time period before the event occurs.

3.4.3 BIBLIOGRAPHY, REFERENCES

International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings. Volume 1. EVO 10000 – 1:2012

Prepared by Efficiency Valuation Organization, January 2012

Guideline How to create a Consumption Baseline S3C www.smartgrid-engagement-toolkit.eu.

3.4.4 PROPOSED METHOD

3.4.4.1 *Baseline Scope and Stages*

Baseline calculations will be created for the purposes of demand response element of the project. Any baselines created for the purposes of overall consumption reduction and night load reduction are considered out of scope. The baselines will be in consumption units and conversion to financial measures is not within scope. Any potential interactive effects between the targets have not been considered, but this should be minimal for any DR baseline using a recent rolling period. In the first instance only electricity import will be within scope. The Project is currently assessing the role of other meters and baseline requirements.

Bank Holidays and other types of non-standard days may not be applicable for the application of the baseline calculations provided. This is only an issue if DR savings are going to be calculated. The Project may need to consider this further and evaluate options as to how this is dealt with. The baseline calculations set during this process will exclude such days.

This proposal outlines how the Bureau will approach creating the baseline calculations, what will be handed over to the project and the estimated resource requirements to do so. The document *S3C Guideline How to Create a Consumption Baseline* provided by the consortium lead will be used as framework.

The main stages will be:

- Data will be collated and supplied by the project to the Siemens Bureau
- Assess the data and detail any assumptions, observations and exceptions which have been made
- Establish the proposed baseline approach and provide a supporting rationale
- Provide the actual baselines and narrative as to its use for each meter.

The following sections provide more detail around each stage of the process.

3.4.4.2 *Information requirements*

The proposal assumes that meter information and interval data is made available. Certain elements will only be necessary where complex baseline calculation methods are required.

Table 1: Required data from the Project to enable base line setting

Data requirement	Purpose	Criticality
Details of the meters requiring a baseline and a description of the load it supplies	To understand the nature of the load, shift times, trading hours etc. to establish energy drivers and to inform the baseline method choice.	Essential

Interval data for a recent period where current operational conditions have been in force. Up to two years of data where it is available. The interval, time slot and unit of measure should be clearly marked and the maximum period is an hour. Shorter periods are acceptable but baselines will be set in hourly frequency.	Where there are no varying energy drivers, a shorter period can be used. Data is required for a minimum of ten occurrences of each day type (meaning that if the meter displays one consumption pattern on weekdays and another on weekends we would expect at least five weeks of data). A full history of two years will help to establish if seasonality is pronounced.	Essential
Holidays or national events that would have fallen in the data window supplied.	This will help identify anomalies to be removed from the base lining assessment, especially if regression is required.	Useful
Details of any significant changes in operation, previous DR events, projects which had impacted during the data window supplied.	This will help identify anomalies to be removed from the base lining assessment, especially if regression is required.	Useful
Any known data problems (phase failures, power outages etc.).	This will help identify anomalies to be removed from the base lining assessment, especially if regression is required.	Useful
Data for driving factors over the same period (often temperatures or degree days).	If there are known factors that influence energy consumption then these would be need for regression. The time period needs to be the same as the interval data and ideally in the same interval.	Useful
Magnitude of the DR event expected (in kW).	If provided this can be used to provide an opinion of whether the DR event will be readily recognisable given the context.	Optional

Where information is not available, it will mean that an assumption will be made and documented and may rule out a regression based approach.

3.4.4.3 Baseline Approach

The following approach will be used in creating the baseline calculations. At each stage the variance between the baseline and actual profile will be assessed. Where statistical tests demonstrate a close correlation further stages will not be explored.

For clarity, the output will be a baseline calculation (for example, rolling mean average of the last ten weekdays), rather than a baseline in absolute figures.

Table 2: Baseline calculation setting stages

Stage	Activity
Quality assurance of the data	To ensure that the base data is sound and query any concerns
Assess data for patterns	To understand whether the profiles respond to the cycles expected such as weekday/weekend and seasonality
Ten rolling days approach	Apply the calculation of a baseline based on the ten previous occurrences of the same day type. If this predicts the profile accurately through application of shifting or scaling then the baseline will be accepted
Averaging method excluding outliers	Apply approach which excludes certain high and/or low instances thereby excluding non-operational or abnormal periods. If this predicts the profile accurately through application of shifting or scaling then the baseline will be accepted
Create regression models	Apply linear regression by interval using a relevant historic period. If this predicts the profile accurately then the baseline will be accepted. Shifting and scaling is not considered appropriate to this method
Baseline Rejection	Where no acceptable baseline can be created (due to extreme volatility or the absence of enough applicable data) a statement will be included as to recommended next steps. This may be to record further data before calculating or additional metering to remove unrelated loads

3.4.4.4 Further Considerations

When conducting the analysis the following will be taken into account:

- Baselines for an individual meter may use varying calculations by day and type.
- Where scaling or shifting is applied it will be stated which yielded the better results in testing and this will be stated alongside the baseline calculation.
- Where scaling or shifting is necessary it will be applied to the average of the two data points just prior to the DR event. However, where information is made available about the nature of the DR event planned, the baseline calculation may include a statement to move this reference period further away from the event to create a more accurate saving calculation.
- To establish the accuracy of the model, the proposed calculation will be carried out to predict recent periods. The quality of the match achieved will then be quantified by the variance from the actual. The variance can be used to establish the viability of recording DR savings. Where the variance per period is more the 50% of the anticipated saving per period, it would be unadvisable to claim savings.

3.4.4.5 Constraints

When using the baseline for the evaluation of the data it is important that the constraints are understood. This will ensure that they can be accounted for, or explained in the analysis results.

Constraints that impact the creation of the baseline are as follows:

- Availability of historic metered data, the longer the period for which the data is available the more accurate the baseline that can be created
- Availability of historic event data
- Metering installed for the assets that are included in the scenario, if a meter serves more than one asset the baseline will be less accurate than if there were a one to one relationship

3.5 KPIS CALCULATION METHODS

This section describes the calculation methods for the defined Key Performance Indicators, in terms of inputs and outputs variables and equations.

3.5.1 ENERGY: AVOIDED ENERGY

3.5.1.1 Description

The avoided energy corresponds to the reduction of energy consumption in kWh during the shedding period of a DR event.

3.5.1.2 Inputs

The data required for the calculation are:

- δ_{shed} : DR event trigger ($\delta_{shed} = 1$ during shedding events, and 0 elsewhere)
- $P_{DR}(t)$: asset real energy consumptions (for each energy vector) during DR event, in kW
- $P_{baseline}(t)$: asset baseline energy consumptions (for each energy vector) without DR event, in kW

3.5.1.3 Outputs

The calculated data will be:

- $E_{avoided}$: Avoided energy volume
- In kWh of primary energy
- In % for all considered time and space perimeters (see Section 3.3)
- $E_{avoided,elec}$: Avoided electricity volume
- in kWh of final energy
- in % for all considered time and space perimeters

3.5.1.4 Calculation method

The avoided electricity volume is calculated as the gap between DR scenario consumption and baseline consumption during shedding event:

$$E_{avoided,elec}(\Delta t) = \int_{\Delta t} (P_{baseline,elec}(t) - P_{DR,elec}(t)) \cdot \delta_{shed}(t) \cdot dt$$

When working with discontinuous values, the approximation becomes:

$$E_{avoided,elec}(\Delta t) \approx \sum_{t \in \Delta t} (\bar{P}_{baseline,elec}(t) - \bar{P}_{DR,elec}(t)) \cdot \delta_{shed}(t)$$

Where $\bar{P}_{DR}(t)$ and $\bar{P}_{baseline}(t)$ refer to the mean electricity power consumption during the time sample.

The avoided energy volumes for all other energy vectors (fuels, district heating) will be calculated in the same way.

Finally, the global avoided primary energy volume will be:

$$E_{avoided}(\Delta t) = \sum_{\forall ev} E_{avoided, ev}(\Delta t)$$

Where ev refer to the related energy vectors. All the avoided energies need to be converted in kWh of primary energy (kWh_p). This conversion will be done by considering:

- National electricity conversion factors (in kWh_p/kWh_{elec})
- Local district heating conversion factor (in kWh_p/kWh_{heat})
- Lower calorific value of different fuels (in kWh/m³)

In order to convert the avoided energy and electricity in percent, these volumes will be divided by the baseline energy demand for the considered space perimeter (see section 3.3.2)

$$E_{avoided}[\%] = 100 \frac{E_{avoided}[kWh_p]}{E_{demand,baseline}[kWh_p]}$$

With:

$$E_{demand,baseline}(\Delta t) = \sum_{\forall ev} \left(\int_{\Delta t} P_{baseline, ev}(t) \cdot dt \right) \approx \sum_{\forall ev} \sum_{t \in \Delta t} P_{baseline, ev}(t)$$

3.5.2 ENERGY: ENERGY SAVINGS OR OVERCONSUMPTION

3.5.2.1 Description

The energy savings (or overconsumption) corresponds to the reduction (or increase) of energy consumption in kWh during a whole DR event.

3.5.2.2 Inputs

The data required for the calculation are:

- $\delta_{shed+shift}$: DR event trigger ($\delta_{shed+shift} = 1$ during shedding and shift periods, and 0 elsewhere)
- $P_{DR}(t)$: asset real energy consumptions (for each energy vector) during DR event, in kW
- $P_{baseline}(t)$: asset baseline energy consumptions (for each energy vector) without DR event, in kW

3.5.2.3 Outputs

The calculated data will be:

- $E_{savings}$: Energy savings (negative in case of overconsumption)
- In kWh of primary energy
- In % for all considered time and space perimeters (see Section 3.3)
- $E_{savings,elec}$: Electricity savings (negative in case of overconsumption)

- in kWh of final energy
- in % for all considered time and space perimeters

3.5.2.4 Calculation method

The electricity savings are calculated as the difference between the avoided energy volume (during shedding period) and the shifted energy volume (during shift period).

$$E_{savings,elec}(\Delta t) = E_{avoided,elec}(\Delta t) - E_{shifted,elec}(\Delta t)$$

In a simpler manner, it can also be calculated as the gap between DR scenario consumption and baseline consumption during both shedding and shift periods:

$$E_{savings,elec}(\Delta t) = \int_{t \in \Delta t} (P_{baseline,elec}(t) - P_{DR,elec}(t)) \cdot \delta_{shed+shift}(t) \cdot dt$$

When working with discontinuous values, the approximation becomes:

$$E_{savings,elec}(\Delta t) \approx \sum_{t \in \Delta t} (\bar{P}_{baseline,elec}(t) - \bar{P}_{DR,elec}(t)) \cdot \delta_{shed+shift}(t)$$

The energy savings for all other energy vectors (fuels, district heating) will be calculated in the same way.

Finally, the global primary energy savings (or overconsumption) will be:

$$E_{savings}(\Delta t) = \sum_{ev} E_{savings,ev}(\Delta t)$$

Where *ev* refer to the related energy vectors.

As for the avoided energy calculation method, all savings need to be converted in kWh of primary energy (kWh_p). Likewise, the conversion in percent will be done by dividing the absolute value by the baseline energy demand for the considered space perimeter.

3.5.3 POWER: PEAK POWER REDUCTION

3.5.3.1 Description

This indicator corresponds to the reduction of the maximum electricity power demand.

3.5.3.2 Inputs

The needed measures are:

- $D_{elec,DR}(t)$: asset real electricity demand during DR event, in kW
- $D_{elec,baseline}(t)$: asset baseline electricity demand without DR event, in kW

3.5.3.3 Outputs

The calculated data will be:

- $D_{elec,peakreduction}(\Delta t)$: average peak power reduction
- In kW of final energy

- In % for all considered time and space perimeters (see Section 3.3)

3.5.3.4 Calculation method

This reduction is calculated as the difference between both maximums of DR and baseline electricity power demand:

$$D_{elec,peakreduction}(\Delta t) = \max_{t \in \Delta t}(D_{elec,baseline}) - \max_{t \in \Delta t}(D_{elec,DR})$$

The conversion in percent is realized by dividing by the baseline electricity peak power demand regarding the considered space perimeter (see section 3.3.2):

$$D_{elec,peakreduction}[\%] = 100 \frac{D_{elec,peakreduction}[kW]}{\max_{t \in \Delta t}(D_{elec,baseline}[kW])}$$

NB: When working with energy metering, the instant values of energy demand are generally unavailable: only an average power is provided. For this reason, the evaluation of peak power reduction could be underestimated due to the averaging near the peak power demands.

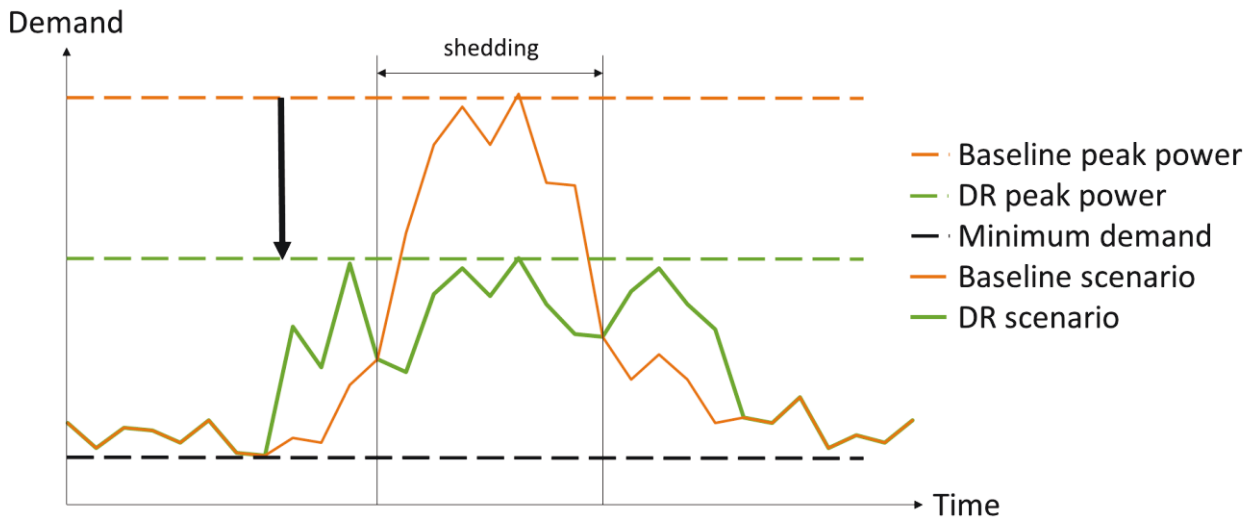


Figure 6: Illustration of power demand reduction by performing a DR scenario

3.5.4 POWER: PEAK POWER GAP REDUCTION

3.5.4.1 Description

This indicator corresponds to the reduction between peak power and minimum night time demand.

3.5.4.2 Inputs

The needed measures are:

- $D_{elec,DR}(t)$: asset real electricity demand during DR event, in kW
- $D_{elec,baseline}(t)$: asset baseline electricity demand without DR event, in kW

3.5.4.3 Outputs

The calculated data will be:

- $\Delta D_{elec,peakreduction}(\Delta t)$: average peak power reduction
- In kW of final energy
- In % for all considered time and space perimeters (see Section 3.3)

3.5.4.4 Calculation method

This reduction is calculated as the difference between maximum and minimum electricity power demands:

$$\Delta D_{elec,peakreduction}(\Delta t) = \Delta D_{elec,baseline}(\Delta t) - \Delta D_{elec,DR}(\Delta t)$$

With:

$$\Delta D_{elec,baseline}(\Delta t) = \max_{t \in \Delta t}(D_{elec,baseline}) - \min_{t \in \Delta t}(D_{elec,baseline})$$

$$\Delta D_{elec,DR}(\Delta t) = \max_{t \in \Delta t}(D_{elec,DR}) - \min_{t \in \Delta t}(D_{elec,DR})$$

The conversion in percent is realized by dividing by the baseline electricity peak power gap demand regarding the considered space perimeter (see section 3.3.2):

$$\Delta D_{elec,peakreduction}[\%] = 100 \frac{\Delta D_{elec,peakreduction}[kW]}{\Delta D_{elec,baseline}[kW]}$$

NB: As well as the peak power reduction calculation, the evaluation of peak power gap reduction could be underestimated due to the averaging near the peak power demands in collected power data.

3.5.5 CO₂: REDUCTION OF GREENHOUSE GASES EMISSIONS

3.5.5.1 Description

This indicator corresponds to the reduction of equivalent CO₂ emissions in kgCO_{2eq} due to the DR implementation.

3.5.5.2 Inputs

The needed measures and informations are:

- $D_{DR}(t)$: asset real energy demand during DR event, in kW
- $D_{baseline}(t)$: asset baseline energy demand without DR event, in kW
- $C_{DR,fuel}(t)$: asset real fuel consumption (for each type of fuel) during DR event, in kg/h
- $C_{baseline,fuel}(t)$: asset baseline fuel consumption (for each type of fuel) without DR event, in kg/h
- $MIX_{source}(t)$: proportions of the national electricity mix (index source corresponding to the production sources, as diesel, gas, coal, nuclear, hydropower, wind, solar, etc.)
- EF_{source} : emission factors of national production sources and district heating supplier, in kgCO_{2eq}/kWh
- EF_{fuel} : emission factors of locally consumed fuel (for all different fuels), in kgCO₂/kg

3.5.5.3 Output

The only output data will be:

- $I_{CO_2, reduction}(\Delta t)$: Reduction of greenhouse gases emission (negative in case of emission increase), in kgCO₂

3.5.5.4 Calculation method

The reduction of CO₂ emissions is taking into account the fuel, district heating and electrical consumptions separately:

$$I_{CO_2, reduction}(\Delta t) = \sum_{t \in \Delta t} \Delta I_{CO_2}(t)$$

With:

$$\begin{aligned} \Delta I_{CO_2}(t) = & \sum_{source \in \{sources\}} \left(D_{DR,elec}(t) - D_{baseline,elec}(t) \right) MIX_{source}(t) EF_{source} \\ & + \sum_{fuel \in \{fuels\}} \left(C_{DR,fuel}(t) - C_{baseline,fuel}(t) \right) EF_{fuel} \\ & + \left(D_{DR,distr\ heating}(t) - D_{baseline,distr\ heating}(t) \right) EF_{distr\ heating} \end{aligned}$$

Index “source” correspond to the national production sources of electricity (for instance: diesel, gaz, coal, nuclear, wind, solar, etc.), whose proportions MIX_i are time varying.

The emissions factors EF for electricity sources are reported in kgCO_{2,eq}/kWh_{elec} and will be based on Life Cycle Analysis of the production sources (except for emissions due to infrastructure, whose quantification is still at the research stage). They are extracted from the ecoinvent database (ECONVENT, 2017) which is not only taking into account the production type of electricity but also the national context of this production (ex: difference between French and Romanian nuclear power technologies).

The electricity MIX for all countries can be gathered from the ENTSOE-E database (ENTSOE-E, 2017).

Both emission factors and electricity mixes are reported in Annex (Table 39).

Index “fuel” correspond to the different fuels involved in the DR event (ex: gas, diesel, wood, etc.). The related emission factors are related in annex (Table 38).

Index “distr heating” correspond to the district heating energy factor. The related emission factor will be specified in the adaptation to the Italian pilot site (section 5.4).

3.5.6 COST: ECONOMIC GAIN

3.5.6.1 Description

The economic gain corresponds to the overall benefit in national currency (£, €, RON) due to the DR implementation.

3.5.6.2 Inputs

The needed measures and information are:

- $D_{DR}(t)$: asset real energy demand during DR event, in kW

- $D_{baseline}(t)$: asset baseline energy demand without DR event, in kW
- $S_{DR,elec}(t)$: electricity selling during DR event, in kW
- $S_{baseline,elec}(t)$: electricity selling baseline without DR event, in kW
- $C_{DR,fuel}(t)$: asset real fuel consumption (for each type of fuel) during DR event, in m³/h
- $C_{baseline,fuel}(t)$: asset baseline fuel consumption (for each type of fuel) without DR event, in m³/h
- $Pr_{elec}(t)$: electricity sales tariff (bought from the grid), in national currency per kWh
- $Pr_{elec,feedin}(t)$: electricity feed-in tariff (sold to the grid), in national currency per kWh
- Pr_{fuel} : fuel tariff (for each type of fuel), in national currency per m³
- $Pr_{distr\ heating}$: district heating tariff, in national currency per kWh
- $FR_{DR,util}$: Utilization payment of related DR program (see paragraphs 3.5.6.5 and 3.5.6.6), in national currency or national currency per kW per hour
- $FR_{DR,avail}$: Availability payment of related DR program (see paragraphs 3.5.6.5 and 3.5.6.6), in national currency

3.5.6.3 Output

The only output data will be:

- $EG(\Delta t)$: Economic gain from DR scenario, in national currency

3.5.6.4 Calculation method

The economic gain is calculated by summing the financial rewards and the energy and fuel expenses variations:

$$EG(\Delta t) = \Delta FR(\Delta t) + \sum_{t \in \Delta t} \Delta Ex(t)$$

ΔEx corresponds to the energy expenses variations (electricity, fuels and district heating):

$$\begin{aligned} \Delta Ex(t) = & \left(D_{baseline,distr\ heating}(t) - D_{DR,distr\ heating}(t) \right) Pr_{distr\ heating} \\ & + \left(D_{baseline,elec}(t) - D_{DR,elec}(t) \right) Pr_{elec}(t) + \sum_{fuel \in \{fuels\}} \left(C_{baseline,fuel}(t) \right. \\ & \left. - C_{DR,fuel}(t) \right) Pr_{fuel} \end{aligned}$$

ΔFR correspond to the financial rewards variations, including electricity selling and specific incentives from the demand response programs (only for UK and FR pilot sites):

$$\Delta FR(\Delta t) = FR_{DR,util} + FR_{DR,avail} + \sum_{t \in \Delta t} \left(S_{DR,elec}(t) - S_{baseline,elec}(t) \right) Pr_{elec,feedin}$$

3.5.6.5 Financial rewards in UK pilot site

3.5.6.5.1 STOR

In the current standard of Demand Response (DR) in the UK, the Transmission Systems Operator (TSO) provides a signal that creates DR events for large industrial users. This signal is sent to these users by an aggregator. The Teesside demo-site is too small to really participate in this scheme and therefore the Short-Term Operating Reserve (STOR) signal will be simulated based upon data on previous year's STOR events.

The frequency and timetable of these signals is not set, but signals typically occur during afternoon peaks with an alert time of 20 minutes for response. The DR events last from half an hour to two hours, during which electric demand is to be reduced. The short notice only makes possible to coordinate manually activated actions to reduce demand.

In terms of the benefits, decrease in electricity consumption is expected during the DR events, resulting in financial savings because energy is more expensive during these periods. Moreover, this DR market, the Short-Term Operating Reserve (STOR), is the largest one in the UK. STOR has two daily operating windows (from 7:00-14:00 and 16:00 to 22:00) and a minimum demand peak capacity reduction from 150 KW and year, as shown in Figure 7.

UK DR Market - Market Size & Returns



- Market size and returns summary

Programme	Overall Capacity Per Year (MW)	DR Capacity Per Year (MW)	Procurement Method	Returns Per Year, Per MW
FFR - Primary	200-700	Unknown	Tender	£15,000 to £20,000
FFR - Secondary	700-1400	Unknown	Tender	£30,000 to £40,000
FCDM	150-200	150-200	Bilateral	£30,000 to £40,000
STOR	2500-3500	200-700	Tender	£20,000 to £30,000

- FFR and FCDM run 24/7; returns are based on an hourly availability payment
- STOR has two daily operational windows (~07:00-14:00 & ~16:00-22:00); returns are based on an availability payment and a utilisation payment
- STOR DR capacity is provided via 150-250MW of Load Reduction and 300-500MW from Load Replacement (using backup generators, CHP etc.)

Figure 7: UK DR Market size and returns

In the UK, the STOR DR program benefits the user in two different payments on a monthly basis: availability payment (KW/h) and utilisation payment (actual assets participating during the events in KWh). As not qualifying to be participating in this program in terms of capacity, the financial assessment will be emulated according to the current contract types. This means that there are no *real* financial rewards during the demonstration.

3.5.6.5.2 DTU

In this scenario, the DR request is to *increase* the use of electricity from the grid. For this the Demand Turn Up signal is used (NATIONALGRID, 2017a). In summer, when there is an excess of renewable electricity locally, a request will be sent asking to *increase* electricity consumption from the grid.

The Demand Turn Up is expressed in the price attractiveness of the electricity unit price versus the gas unit price.

3.5.6.5.3 FCDM

Frequency Control by Demand Management (FCDM) requires rapid automated response (around 2 seconds), so is suitable for only a small number of loads.

3.5.6.6 Financial rewards in FR pilot site

For the French pilot site, the financial rewards are not applicable into in the case of the French demonstration scenarios. But we can speak about financial benefits ensuing from savings of energy during peak periods PP1 where electricity is more expensive in the context of the scenario 1 Capacity mechanism. The scenarios 3 and 4 don't have any rewarding system as are based on simulated signals (depending from local weather conditions). The scenario 5 is focused on energy sharing between neighbour buildings and also don't natively integrate any rewards.

In fact, the Capacity mechanism launched in France by RTE on the 1st of January 2017 is based on certification of capacities of power generators for keeping sufficient generation capacity available and demand response aggregators for reducing power demand during peak periods at the national level. In the case the power generators provide declared capacities available as well as demand response aggregators declared energy reductions during peak period, these both are rewarded by energy fund managed by RTE. From other side, there are also obliged market actors (mainly electricity suppliers), which need to certify their capacities to provide enough of energy to their consumers during peak periods. It is made by purchasing certificates of capacities from: power generators (capacities of energy production) helping the last ones to maintain these power capacities (or increase them by constructing new power plants) or from demand response operators (capacities of short term energy reduction of their clients) or from one tierce actor trading it on a spot market (type EPEX SPOT in France). These additional charges due by electricity suppliers will be transposed on their consumers as added costs on their electricity bills. In function of contract subscribed these added costs could be:

- In €/MWh constant during the whole year. This option is proposed to consumers of C5 – Bleu tariff (Tarif Bleu) and C4 – ex Yellow tariff (Tarif Jaune). In this case the consumers don't have any lever to reduce this added cost;
- Applied only during Peak Periods in the winter. This option is proposed to consumers of C4 – ex Yellow tariff (Tarif Jaune) and C3 – ex Green tariff (Tarif Vert). In this case the consumers can reduce this added cost by reducing their demand during Peak Periods;
- On regularization at the end of the year. This option is mainly proposed to “big” consumers having contracts C2 – ex Green tariff (Tarif Vert) having profiled load curve. In this case, the consumers have also a possibility to reduce this added cost by reducing their electricity demand during Peak Periods (OPERA-ENERGIE, 2017).

The capacities provided by the 3 buildings of the French pilot site don't allow a real participation into this market as tierce actor on EPEX SPOT (one guarantee of capacity is equal to 0,1 MW which is much more important than maximum capacities provided by the pilot site) nor as demand response operator without be aggregated with other buildings. Thereby, none reward could be available in this context.

As far as all the 3 buildings have C4 contracts for electricity supply, building owners can reduce their electricity demands during Peak Periods to pay less and thus obtain financial benefits. Taking into consideration only PP1 days in the scenario 1, these reductions of electricity demand are expected to occur during 10-15 PP1 days at the cold period (November-March).

It is actually difficult to evaluate what will be these added costs billed by suppliers to consumers, because this information is still not available (some evaluations existent <https://opera-energie.com/eclairages/fiches-pratiques/mecanisme-de-capacite/>, but there is no guarantee that the added costs showed will be really applied by suppliers). That's why in the DR-BOB project

we are proposing to use a simulated added cost of 3 c€/kWh combined with peak and off-peak real prices contracted by buildings of the French pilot site (see table below).

Table 3: Simulated electricity purchasing prices proposed to be used into the scenario 1 at the French pilot site

Band	Price c/kWh	Days of Week	Start	End
	NBK: 0,1118; FCMB: 0,07295; BI: 0,03855	PP1 days	00:00:00	06:00:00
	NBK: 0,1233; FCMB: 0,09856; BI: 0,03855	PP1 days	06:01:00	06:59:00
Price/peak	NBK: 0,1533; FCMB: 0,12856; BI: 0,06855	PP1 days	07:00:00	07:59:00
Price/peak	NBK: 0,1533; FCMB: 0,12856; BI: 0,08248	PP1 days	08:00:00	14:59:00
	NBK: 0,1233; FCMB: 0,09856; BI: 0,05248	PP1 days	15:00:00	17:59:00
Price/peak	NBK: 0,1533; FCMB: 0,12856; BI: 0,08248	PP1 days	18:00:00	20:00:00
	NBK: 0,1233; FCMB: 0,09856; BI: 0,03855	PP1 days	20:01:00	22:00:00
	NBK: 0,1118; FCMB: 0,07295; BI: 0,03855	PP1 days	22:01:00	23:59:00

We can suppose that the buildings of the French pilot site are aggregated with other buildings within a demand response operator. In this context, according to the demand response capacities of their customers, the demand response operator will request a number of certificates to be assigned to him through certification process. After winter, the scheduled availability declared during the certification process will be compared to that actually observed during peak periods. A financial settlement will be calculated for the resulting differences (RTE, 2017a).

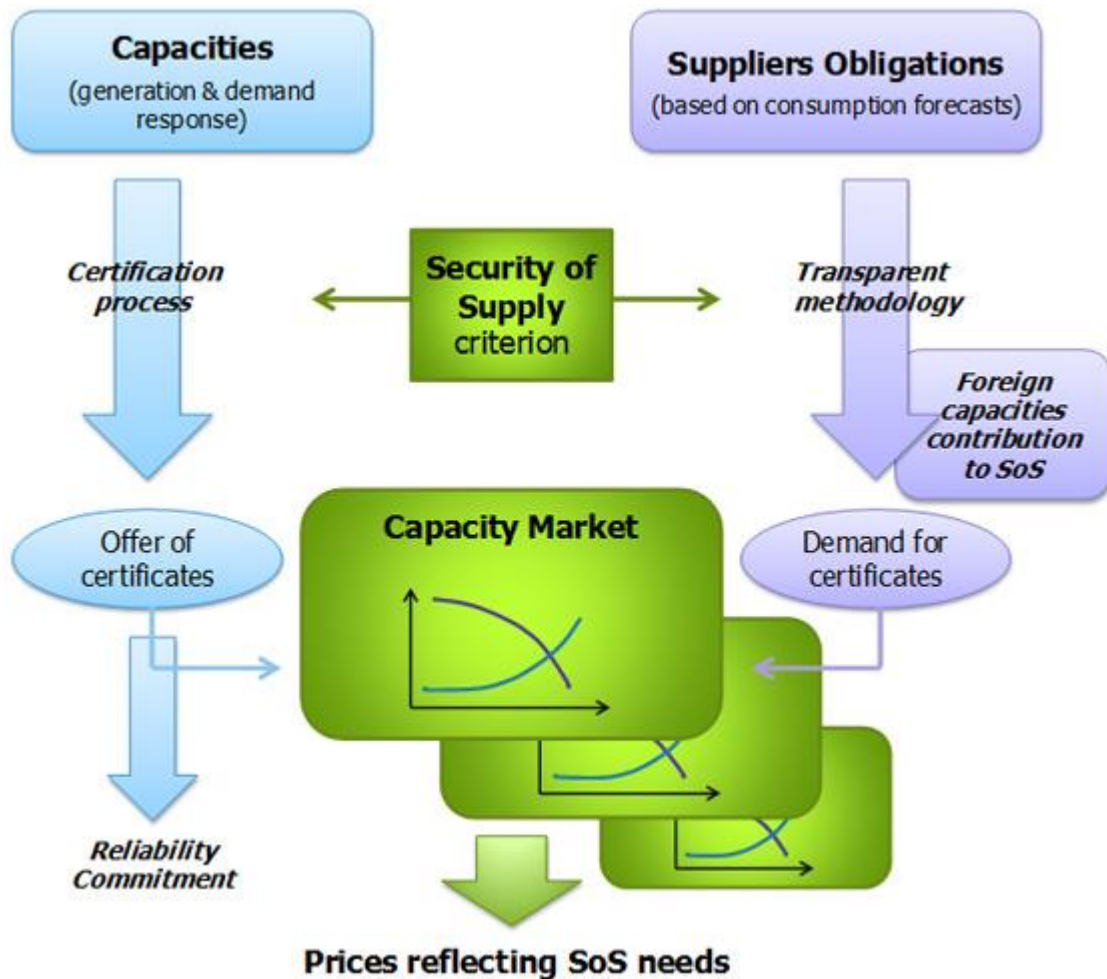


Figure 8: General organizational framework of the French capacity mechanism

Demand response operators can choose between certification of demand response as capacity and reduction of consumption as supplier obligations.

The formula applied in calculating the settlement to capacity portfolio managers/demand response operators can be written as follows:

Settlement = $-Volume_{\text{imbalance}} \times Price_{\text{unit}}$, where

$Volume_{\text{imbalance}}$ is the difference between total effective capacity and total certified capacity within its portfolio;

$Price_{\text{unit}}$ is the unit price for the settlement which vary between the situations when security of supply is at risk and not;

Capacity portfolio managers with negative imbalances pay into the settlement fund for capacity portfolio manager imbalances the amount corresponding to their imbalances, multiplied by the negative imbalance settlement price, plus the cost associated with rebalancing.

Capacity portfolio managers with positive imbalances receive from the settlement fund for capacity portfolio manager imbalances the amount corresponding to their imbalances, multiplied by the positive imbalance settlement price, plus the cost associated with rebalancing. They may

receive less if the balance in the account is too low to compensate all stakeholders with positive imbalances. In this case, they will receive settlements proportionate to their imbalances.

It is not planned to rebalance available capacities during the demonstration year for the French site.

3.5.7 THERMAL COMFORT: MAXIMAL THERMAL DEVIATION GAP

3.5.7.1 Description

The indicator correspond to the difference of the maximal amplitude between baseline and effective temperature respect to the comfort limit bands.

3.5.7.2 Inputs

The needed measures and information are:

- $T_{DR,zone}(t)$ Temperatures of impacted zones during DR event, in °C
- $T_{baseline,zone}(t)$ Baseline temperatures of impacted zones without DR event, in °C
- $T_{limit,max}$ Comfort or recommended upper limit, in °C
- $T_{limit,min}$ Comfort or recommended lower limit, in °C

3.5.7.3 Output

The only output data will be:

- $\Delta T_{max,diff}(\Delta t)$: maximal thermal deviation gap, in K

3.5.7.4 Calculation method

The maximal thermal deviation for one zone is calculated as the maximal amplitude between the indoor temperature and the comfort limit bands. As illustrated in Figure 9, both DR and baseline scenarios can be concerned, as the temperature variations are not exclusively caused by DR events:

$$\Delta T_{max,diff,zone}(\Delta t) = \Delta T_{max,DR,zone}(\Delta t) - \Delta T_{max,baseline,zone}(\Delta t)$$

$\Delta T_{max,DR,zone}$ reflects the maximal thermal deviation during the DR scenario for the related zone, while $\Delta T_{max,baseline,zone}$ refers to the maximal thermal deviation during the baseline scenario.

$$\Delta T_{max,DR,zone}(\Delta t) = \max_{t \in \Delta t} (0; T_{DR,zone}(t) - T_{limit,max}; T_{limit,min} - T_{DR,zone}(t))$$

$$\Delta T_{max,baseline,zone}(\Delta t) = \max_{t \in \Delta t} (0; T_{baseline,zone}(t) - T_{limit,max}; T_{limit,min} - T_{baseline,zone}(t))$$

All temperature deviations are calculated for every impacted zones. Then, the maximal value is given:

$$\Delta T_{max,diff}(\Delta t) = \max_{zone \in zones} (\Delta T_{max,diff,zone}(\Delta t))$$

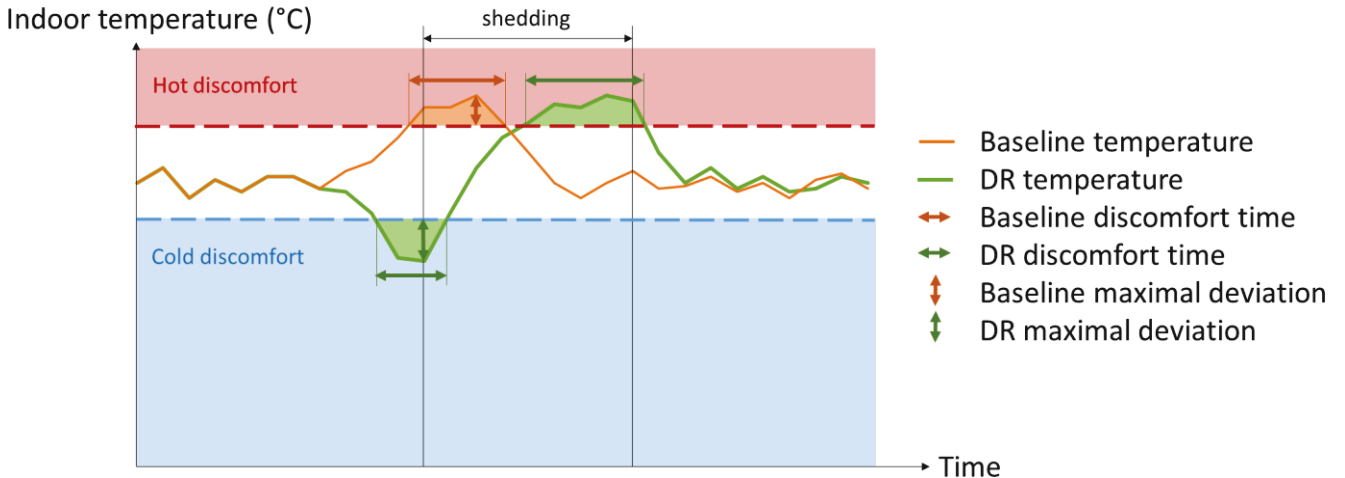


Figure 9: Illustration for thermal comfort KPIs calculation in a DR event involving pre-cooling and free-floating

3.5.8 THERMAL COMFORT: MAXIMAL DISCOMFORT TIME VARIATION

3.5.8.1 Description

The indicator correspond to the maximal variation of the duration from which temperature exceeds comfort temperature ranges of neutral feeling, due to DR event (only for temperature-related scenarios).

As “neutral feeling” depend on occupant characteristics and activity, the weakest impacted user will be considered (ex: inpatient, senior) depending on scenario (see part 5). Then, a heat balance on this user will be conducted (using reference publications and standards hypothesis) to define the neutral feeling temperature band.

3.5.8.2 Inputs

The needed measures and information are:

- $T_{DR,zone}(t)$ Temperatures of impacted zones during DR event, in °C
- $T_{baseline,zone}(t)$ Baseline temperatures of impacted zones without DR event, in °C
- $T_{limit,max}$ Comfort or recommended upper limit, in °C
- $T_{limit,min}$ Comfort or recommended lower limit, in °C

3.5.8.3 Output

The only output data will be:

- $\Delta DT_{max}(\Delta t)$: Maximal discomfort time variation, in hours.

3.5.8.4 Calculation method

The discomfort time is calculated as the amount of time where the temperature exceeds the comfort or recommended limits. As illustrated in Figure 9, both DR and baseline scenarios can be concerned, as the temperature variations are not exclusively caused by DR events:

$$\Delta DT_{zone}(\Delta t) = DT_{DR,zone}(\Delta t) - DT_{baseline,zone}(\Delta t)$$

$DT_{DR,zone}$ reflects the discomfort time during the DR scenario, while $DT_{baseline,zone}$ refers to the discomfort time during the baseline scenario.

$$DT_{DR,zone}(\Delta t) = \int_{\Delta t} \delta_{disc,DR}(t) \cdot dt$$

$$DT_{baseline,zone}(\Delta t) = \int_{\Delta t} \delta_{disc,baseline}(t) \cdot dt$$

Where:

$$\delta_{disc,DR}(t) = \begin{cases} 1 & \text{if } T_{DR,zone}(t) \notin [T_{limit,min}; T_{limit,max}] \\ 0 & \text{elsewhere} \end{cases}$$

$$\delta_{disc,baseline}(t) = \begin{cases} 1 & \text{if } T_{baseline,zone}(t) \notin [T_{limit,min}; T_{limit,max}] \\ 0 & \text{elsewhere} \end{cases}$$

When working with discontinuous values (with “timestep” time interval), the approximation becomes:

$$DT_{DR,zone}(\Delta t) \approx \sum_{t \in \Delta t} \delta_{disc,DR}(t) \cdot timestep$$

$$DT_{baseline,zone}(\Delta t) \approx \sum_{t \in \Delta t} \delta_{disc,baseline}(t) \cdot timestep$$

All discomfort durations are calculated for every impacted zones. Then, the maximal value is given:

$$\Delta DT_{max}(\Delta t) = \max(\Delta DT_{zone}(\Delta t))$$

4 METHODS FOR QUALITATIVE EVALUATION

As for the qualitative evaluation regarding the consumers' engagement, addressing thermal comfort, consumer participation and acceptance of the DR interventions, an explorative yet pragmatic and feasible approach has been set up.

The DR-BoB project is focused on the demonstration of different technologies in real life contexts, implying that the users of those BoBs will be affected or even actively engaged. Rather than consumers, we see customers and users of the DR BoB solutions. The owners of these BoBs can be regarded as customers of the DR-BoB solution and their building managers are the direct users of the solution. In addition in each BoB there is a large group of 'indirect users' i.e. the *building occupants*. As these 'indirect users' do not bear the cost (of energy) or have a direct role in decision-making they often simply 'fall out of sight' when thinking about DR for medium scale users. Hence we address both the direct and the indirect users in the qualitative evaluation to learn how the solutions match with the everyday practices and routines of the users of these buildings.

4.1 QUALITATIVE EVALUATION: A THREEFOLD APPROACH

As for the qualitative evaluation, the plan is threefold:

4. **Qualitative comparison of the implementation with the original ideas:** assess what has actually been implemented (compared to baseline scenario plans) and compare actual involvement of users and occupants with expected involvement (reported in D5.3)
5. Have pilot partners conduct **interviews with the direct users** (i.e. building -, energy-, facility manager and their team) to collect their feedback on the DR intervention, the communication, the response options, how participation in DR events has affected their daily working routines and practices (reported in D5.2 and used for D5.3)
6. Set up consumer panels with occupants (**occupant panels**) to collect feedback on the interventions, the communication, the response options and how it has affected comfort and daily routines (reported in D5.2 and used for D5.3)

4.1.1 QUALITATIVE COMPARISON OF THE IMPLEMENTATION WITH THE ORIGINAL IDEAS

As part of the qualitative evaluation, we have written up the baseline scenarios in non-technical terms and these descriptions will function as a kind of qualitative 'baselines'. In addition to this empirical material (scenario descriptions), data was collected from over 30 respondents that participated in interviews and/or workshops at each pilot site in 2016/7, with interviewees including facility-, building- and energy managers, technical staff, as well as users and the pilot site managers (see 9.1 Appendix A). The baseline scenario descriptions and the information gathered from the respondents reveal certain expectations about the direct and indirect users in terms of how they will respond to the various scenarios and based on the feedback collected from users during and after implementation we can assess if these expectations match the real-life contexts and practices (to be reported on in D5.3). During and after implementation we can contrast developments at each pilot site with the original ideas as written down in these baselines.

4.1.2 INTERVIEWS WITH THE DIRECT USERS

Because the pilot site managers already have regular contact with the building -, energy- and/or facility managers, having brief (informal) interviews with them at set times will allow for a better understanding on how these users appreciate the DR BoB intervention. A template will be developed to gather feedback in a systematic manner, addressing;

- Communication: about the DR events; response options; use of the Consumer Portal and feedback options
- DR events themselves
- Response options
- Impact or potential impact on their daily routines and practices
- Other issues that come to the fore (e.g. suggestions for improvement)

4.1.3 BUILDING OCCUPANT PANELS: GROUPS OF OCCUPANTS GIVE FEEDBACK ON THE DR INTERVENTIONS

First of all, the term user panel should not lead to any confusion with the Consumer Panel that is being developed by GridPocket. The occupant panels do not refer to any technology. Taken from the field of product testing, the term ‘user panel’ refers to a group of users that is asked to give their opinion and/or advice about a product or service. The users, as members of the user panel, are invited to evaluate various aspects of these products – e.g. in case of a new food product they could be asked give feedback on aspects like taste, structure, appearance, colour, smell, price, similarity to existing products etc. User panels are especially relevant when it concerns a new product or service whereby it is not yet clear how users will appreciate it. People can give feedback individually and/or in a group setting; they can give feedback once or several times so a user panel can be organised using a diversity of methods (workshop, focus group, surveys, group discussions, online platforms, etc.) at set moments in time.

So while small surveys may be held among the occupants, a choice has been made to have a more explorative approach allowing for unexpected feedback. A survey with closed questions would not allow for that. Moreover, closed questions don’t tell us anything about why and how people responded. In addition, setting up occupant panels involves a more active engagement with these occupants (e.g. through workshop meetings) which increases the chance of getting feedback in comparison with a rather anonymous survey approach where response rates are often disappointing.

Occupant panels allow for occupants to bring up issues that the pilot manager may not yet have considered as being of relevance. Since DR in these context is a new phenomenon, it is useful to learn about all issues that may affect occupants’ engagement and acceptance.

To conclude, the aim is not to have a test among a representative group but rather to gather as much as feedback as possible considering limited time and resources. All building occupants affected by a DR intervention are eligible to participate in such a panel, except for the building-, energy- and facilities managers – because they will be interviewed separately.

The set-up and organisation of these occupant panels is done by the pilot site managers. In the following section, we elaborate the different types or segments of occupants that can be distinguished (based on the level of and type of engagement in a DR intervention). After that, we explain how the pilot manager subsequently can develop an approach to set up occupant panels for each segment. A template has been developed to support the pilot managers in this, which has been introduced and discussed during a Skype conference call on July 13th and 20th. Next, a

word template was developed that the pilot managers have started to fill in. These were then again discussed during a Skype conference call on August 23rd.

The aim is that the template will help also in gathering feedback that the pilot managers have collected and translated, at set moments during and after the implementation of the scenarios, so that this feedback can contribute to the comparison of implementations at the four sites and lessons can be drawn for future DR interventions with regard to the engagement of building occupants (D5.3).

4.2 THREE SEGMENTS OF BUILDING OCCUPANTS

The different DR scenarios all affect building occupants differently, but we can identify similarities in how the building occupants are affected. Table 4 below summarises the scenarios as originally developed in spring 2017 for each demonstration site.

Table 4: Demand Response demonstration scenarios for each site

Pilot site	Scenarios	Occupants directly affected/ involved?
Teesside University Campus UK	S1 Electric Demand Reduction	Changing set-points heating/cooling, so that rooms are pre-heated/pre-cooled
	S2 Electric Demand Increase	Same energy provided with another source (decrease use of self-generated electricity; increase electricity from grid)
	S3a Electricity Peak Demand Reduction	Cascading messages from Facility Manager to team leader to laboratory staff members to decrease demand during critical peaks
	S3b Electricity Peak Demand Reduction: EV charging	EV users asked not to charge during a DR event
	S4 Fully automated DR	Same energy provided by different resource
Business Park France	S1 Electric Demand Reduction (Nov – April)	Changing set-points or request occupants to manually disconnect/unplug equipment
	S2 Electric Demand Reduction (throughout the year)	Changing set-points
	S3 Optimisation only	Same energy provided with local woodchip burner
	S4 Electricity peak power demand Reduction	Changing set-points or request occupants to manually disconnect/unplug equipment
	S5 Virtual micro grid or selling electric energy inside the demonstration area	Changing set-points or request occupants to charge laptops etc. or locally sell the surplus of local energy
Private Hospital Italy	S1 Load curtailment or shedding of HVAC and chiller loads	Set-point changes: lowering the temperature of cooling water

	S2 Load shedding of small loads	Staff members are requested to decrease their energy consumption during DR Event
	S3 Load shifting of important loads	Shifting the schedules for cooking outside peak hours
	S4 Self-consumption and heat recovery from CHP	Same energy from different source
Cluj Napoca University Campus Romania	S1 Load curtailment or shedding important loads	Change set-points and request staff to change setting to pre-cool their room and to turn off equipment that is not used during peak hours
	S2 Load curtailment or shedding important loads based on virtual ToU tariffs	Students requested to change the schedules for washing. And: altering schedules for pumping and ventilation in swimming pools
	S3 Demand reduction in student dormitories	Energy manager requests students to lower energy consumption during peak hours (using reward system and/or competition)

Taking a closer look at the scenarios, we can observe that some of the demonstration scenarios will have no impact at all on users (these are scenarios where only the source of energy is temporarily changed).¹ However, for other scenarios, occupants will be affected and we can in fact distinguish three levels of expected impact or involvement:

- A. Occupants will hardly notice anything
- B. Occupants (or some of them) are actively involved and asked to turn off or unplug appliances during peak hours
- C. Occupants (or some of them) are actively involved and are asked to shift their activities to another moment

4.3 TOWARDS SETTING UP OCCUPANTS' PANELS FOR EACH SEGMENT

Based on the level of expected impact, we now have identified three segments: A, B and C. Next, when we now assess which scenarios fit with which segment, we can further specify the (implicit) expectation about the occupants in terms of the impact they will notice, or their active response. This all is formulated from the viewpoint of the DR Solution provider (see tables below). However, the implementation of the scenarios will help us find out about the responses of the real building occupants and the extent to which they will respond as expected and how the interventions are being appreciated. That will be investigated using the building occupants panels.

¹ UK S2 – same service but switch from electricity from CHP to electricity from the Grid; UK S4 – same service but with back-up generator; FR S3 and S5 – using own energy generated – idem; ITA S4 – using the tri-generation plant).

Table 5: Segment A: scenario, actions and expectations

Scenario:	Entails what actions?	Expectation with regard to occupants
Teesside University Campus UK S1	The FM* is asked to change set-points for heating and cooling to shift demand during the peak moment (20 min- 2hrs) (opt out possible)	No impact on occupants expected because rooms are pre-heated or – cooled and temp is not allowed to move outside of the set band-widths.
Business Park France S1; S2	BM** is asked to change settings of various assets for cooling and heating (can opt out)	No impact on occupants expected because rooms are pre-heated or – cooled and temp is not allowed to move outside of the set band-widths.
Private Hospital Italy S1;	BM is asked to change settings of chillers (can opt out) (Overall the energy consumption may rise)	Lowering the temp of the cooling water may affect indoor temperature at the start
Cluj Napoca University Campus Romania S1	EM asked to change settings manually (can opt out)	No /little impact on occupants as if considered too great EM can opt out

(*FM: facilities manager; ** BM: building manager; ***EM: energy manager)

Table 6: Segment B: scenario, actions and expectations

Scenario	Entails what actions?	Expectation with regard to occupants
Teesside University Campus UK S3a	Via FM, team leaders are asked to ask staff to do a more extensive shutdown of equipment (opt-out = not responding)	Occupants are expected to (really) turn off non-used equipment when receiving such a request from team leaders (manual adaptations and perhaps shifting activities)
Business Park France S1; S2; S4	Occupants asked via mail to disconnect equipment (e.g. laptops) (opt-out is possible)	Occupants are expected to unplug equipment on batteries when receiving such a request (manual adaptations and perhaps shifting activities)
Private Hospital Italy S2	Occupants asked via mail to turn off unused equipment or disconnect laptops (opt-out is possible)	Occupants are expected to unplug or turn off equipment when receiving such a request (manual adaptations and perhaps shifting activities)
Cluj Napoca University Campus Romania S1; S2	Occupants asked to manually shut down equipment and pre-cool their offices	Occupants are expected to unplug or turn off equipment when receiving such a request (manual adaptations and perhaps shifting activities)
Cluj Napoca University Campus	Demand reduction in student dormitories	Occupants are expected to unplug or turn off equipment when receiving such a request (manual adaptations and perhaps shifting activities)

Romania S3		
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Table 7: Segment C: scenario, actions and expectations

Scenario	Entails what actions?	Expectation with regard to occupants
Teesside University Campus UK S3B	Request to EV users via de FM to not charge the car (opt-out = not responding)	Expectation that in future this may provide DR potential (currently not many EV users)
Private Hospital Italy S3	Request to change the use of cooking equipment outside peak hours	Expectation that canteen staff can and is willing to do this
Cluj Napoca University Campus Romania S2	Changed washing schedules	Expectations that students are flexible and are able to wash their clothes outside peak hours

As the tables show, the expectations about the level and type of involvement of the building occupants differ for each segment. At set moments during and after implementation, the pilot managers can ask occupants panels for feedback. The approach and the sort of questions asked are likely to differ according to the manner in which and extent to which building occupants are involved. Therefore it makes sense to set up different occupant panels (using different approaches) for each segment A, B and C.

Next, for each segment and panel, the pilot managers can develop an approach (see Appendix A) addressing the following issues:

- Communication
- DR events
- Response options
- Impact or potential impact on their behaviors
- Influence of context on ability and willingness to participate

Table 8 shows (in a non-exhaustive manner) what sort of information would be interesting to collect, to get feedback on. It also shows that not all issues are equally relevant for each segment (e.g. segment A is not actively involved so it makes little sense to ask questions about the DR events or response options). For the questions formulated, specific questions addressing the building occupants directly still would need to be formulated.

Table 8: Feedback solicited from the different occupant segments

Topics on which feedback is solicited	Segments	Examples of questions for building occupants to give feedback on?
Communication	A, B, C	How did occupants find the means, messages, frequencies of the communication about DR (events and/or overall program)?
DR Events (e.g. timing)	B, C	What do occupants feel about the DR events in terms of timing, (ir)regularity, and how long in advance they are being informed?
Response options	B, C	How do the occupants feel about the response options? Are these feasible? Is it a lot of effort? Is it interrupting their work? Is it intrusive?
Impact or potential impact on their behaviors	B, C	How and to what extent have they responded? What sort of actions were required? How often? What changes in their behavior did it entail?
Influence of context on ability and willingness to participate	B, C	<p>What was their motivation to participate? Is it clear what the 'whats-in-it-for-me' is for themselves and others working in this building?</p> <p>What is/could affect their willingness to participate? (e.g. existing satisfaction with the building, indoor climate, the organization, etc.)</p>

The Appendix A sets out in detail steps taken to further develop the occupant panel strategy for each demo site, finding out for each segment things like:

- how many building occupants to recruit, whom, when, how often
- what exactly to ask them (with regard to communication, DR event, response options, impact, influence of context)
- using what instruments or tools (e.g. group meeting/workshop; brief interviews; surveys; inviting feedback in other ways)
- Planning of feedback rounds
- Time resources and competences needed

It should be noted that there may be overlaps between the communication strategy that the pilot sites have developed and the qualitative evaluation. The pilot managers are aware that once they start communicating about DR BoB to building occupants, they also need to consider inviting building occupants to take part in a panel (or announce already that they will invite the occupants at a later moment).

4.4 COLLECTING FEEDBACK

DuneWorks will collect the feedback in several rounds:

- August: consumer panel set-up is collected from each demo site and these will be further discussed and compared
- At set moments in time, DuneWorks will ask the demo site partners to report back based on the collected feedback

This feedback, together with the feedback collected from the interviews with the building-, facility- and energy managers, will be used for an assessment regarding the user-related dimensions of the design and implementation of the DR solutions (reported on in D5.2 and D5.3).

5 ADAPTATION OF EVALUATION STRATEGIES TO THE SCENARIOS IN DEMO SITES

5.1 GENERAL OVERVIEW

Key Performance Indicators and evaluation methods are generic. The direct application of these indicators to each DR scenario is certainly not relevant depending on the nature of DR programs. It was indeed important to specify which indicators were relevant for each scenario and a fortiori to adapt the evaluation strategies to each scenario at each pilot site. Table 9 presents the quantitative indicators that are relevant for each scenario at each pilot site.

Table 9: Adaptation of quantitative KPIs to the scenarios

KPIs			Peak power		Energy		Cost	CO2	Consumers' engagement
			Peak power reduction	Power gap reduction	Avoided energy	Energy saving or overconsumption	Economic gain	GHG emissions reduction	Thermal Comfort
UK site	Scenario 1	Electric demand reduction	YES	YES	YES	YES	YES	YES	YES
	Scenario 2	Electric demand increase	NO	NO	YES	YES	YES	YES	NO
	Scenario 3a	Electric peak demand reduction	YES	YES	YES	YES	YES	YES	YES
	Scenario 3b	Electric peak demand reduction	YES	YES	YES	YES	YES	YES	NO
Scenario 4	Frequency regulation / emergency load shedding	YES	YES	YES	YES	YES	YES	NO	
FR site	Scenario 1	Capacity Market	YES	YES	YES	YES	YES	YES	YES
	Scenario 3	Reduction of gas consumption	NO	NO	YES	YES	YES	YES	YES
	Scenario 4	Reduction of Peak power consumption	YES	YES	YES	YES	YES	YES	YES
	Scenario 5	Virtual microgrid	YES	YES	YES	YES	YES	YES	NO
IT site	Scenario 1	Load curtailment or shedding of HVAC and chillers loads	YES	YES	YES	YES	YES	YES	YES
	Scenario 2	Load shedding of small loads	YES	YES	YES	YES	YES	YES	NO
	Scenario 3	Load shifting of important loads	YES	YES	YES	YES	YES	YES	NO
	Scenario 4	Self-consumption and heat recovery from CHP power plant	YES	YES	YES	YES	YES	YES	YES
RO site	Scenario 1	Critical peak pricing with automated control	YES	YES	YES	YES	YES	YES	YES
	Scenario 4	Explicit demand reduction in student Dormitories	YES	YES	YES	YES	YES	YES	YES
	Scenario 5	Virtual ToU tariff with schedules response	YES	YES	YES	YES	YES	YES	YES

For the qualitative assessment, the approach depends on the impact on users of the DR scenario. As defined in paragraph 4.2, several segments have been identified to describe how users are involved in DR events. Table 10 presents the types of impacts on occupants by scenario according to this segmentation.

Table 10: Definition of the different levels of impact on occupants for each scenario

			Impact on occupants			
			occupants are passive		occupants are active	
			no impact	impact on comfort (changes in setpoints)	participation in loads shedding (no change in activities)	participation in loads shifting (changes in behaviour and routines)
UK site	Scenario 1	Electric demand reduction		YES		
	Scenario 2	Electric demand increase	YES			
	Scenario 3a	Electric peak demand reduction			YES	
	Scenario 3b	Electric peak demand reduction				YES
Scenario 4	Frequency regulation / emergency load shedding	YES				
FR site	Scenario 1	Capacity Market		YES	YES	
	Scenario 3	Reduction of gas consumption		YES		
	Scenario 4	Reduction of Peak power consumption		YES	YES	
	Scenario 5	Virtual microgrid	YES			
IT site	Scenario 1	Load curtailment or shedding of HVAC and chillers loads	YES			
	Scenario 2	Load shedding of small loads			YES	
	Scenario 3	Load shifting of important loads				YES
	Scenario 4	Self-consumption and heat recovery from CHP power plant	YES			
RO site	Scenario 1	Critical peak pricing with automated control		YES	YES	
	Scenario 4	Explicit demand reduction in student Dormitories			YES	YES
	Scenario 5	Virtual ToU tariff with schedules response			YES	YES

The following paragraphs present for each pilot site: a description of each scenario, the calculation schemes for quantitative indicators for each scenario and the synthesis of required data for this quantitative evaluation (time series for consumption, temperatures, etc.)

5.2 UK

5.2.1 ADAPTATION OF KPIS TO THE SCENARIOS

5.2.1.1 UK - Scenario 1

5.2.1.1.1 Short description

Scenario 1 works with the Short-Term Operating Reserve (STOR) signal (described in section 3.5.6.5.1), that will be simulated based upon data on previous year's STOR events.

The frequency and timetable of these signals is not set, but signals typically occur during afternoon peaks with an alert time of 20 minutes for response. The DR events last from half an hour to two hours, during which electric demand is to be reduced. The short notice only makes 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. The maximum power capacity to participate in this scenario is 400KW (200 KW in Clarendon building).

Using the previous year's STOR events a table will be created that the ME will use to generate the event. The ME will make use of a statistical algorithm to determine the appropriate time to generate the event based on the table.

In response to such signals, a notification email is sent to the Facility manager (Energy Manager), who is asked to opt in/out for the assets (by changing automatically the set-points for heating and cooling) in order to reduce energy demand. Only the Clarendon building and the Constantine building will be able participate in this scenario, for which several BMS modifications have been needed. Temperature set-points of the assets that are opted-in will be altered automatically by the Local Energy Manager (LEM). This alteration is based upon predictions on weather, a number of indoor temperature sensor data and outside temperatures.

The Facility Manager can, through the consumer portal, choose to opt out different rooms, buildings or assets (i.e. HVAC and Chillers) for the upcoming DR event. Through the consumer portal the Facility Manager can also adapt the default settings that describe which assets and rooms take part in future DR events, so that he does not have to go through this every time. The DR-BoB systems control the various assets through the Building Management System (BMS) that is also controlled by the Facility Manager.

The decision to exclude from DR assets or rooms will depend on activities in the building on that day, prior occupants' experiences during DR events in the various rooms, indoor temperatures and thermal inertia of the building. Reason to opt out could be: high number of complaints because of changed settings, identified risks (e.g. overheating or malfunctioning assets), or activities like a seminar that require a certain level of indoor temperatures. For the building occupants, the expectation is that it can be done that they will not really notice anything. This is because rooms will be pre-heated or cooled, if necessary, and because there is a limit set-point, i.e. the temperatures should not exceed temperature level thresholds above the regulatory

established (EN15251-2008) acceptable ratios. The implicit assumption seems to be that building occupants consider the current temperatures and indoor climate acceptable.

The indoor temperature is one of the factors considered to make a decision whether to opt in/out for the DR event. The LEM will determine the temperatures forecast (outside and inside the building) and show the relevant values to the Facility Manager. The thermal comfort will be assessed in terms of past events to ascertain whether the DR has had a noticeable effect on the users comfort in the affected areas. As this scenario implies heating and cooling devices, thermal comfort of occupants (students, academic & non-academic staff) will be evaluated through occupant panels and user surveillance (direct through engaged users and indirect through complaints to FM services).

The temperature points in the building take in consideration more than 60 individual temperature points and establish the highest, average and lowest temperature point for each of the four building quadrants per floor (there are 2 floors considered).

Expected findings

In terms of the benefits, decrease in electricity consumption is expected during the DR events, resulting in financial savings because energy is more expensive during these periods. Moreover, this DR market, the Short-Term Operating Reserve (STOR), is the largest one in the UK.

Demand electricity peak will be calculated on the basis of the participating assets. This will be extrapolated to the whole campus in order to obtain a general value if the complete campus was operated accordingly. This approach will be followed as well to calculate the CO₂ equivalent avoided emissions. A similar approach will be done for the financial aspects.

According to the expectations of TU, the results of the DR scenario participation would produce the benefits shown Table 11.

Table 11: Expected benefits for UK site / Scenario 1

STOR scenario 1	Availability Payment					Utilisation Benefit			Energy Savings			Lost benefit of heat rejected	Poten- tial	Actual
	Revenue status	Asset Power /kW	hr per day	days	Fee /£/kW per hr*	Payment /£	Utili- sation /h	Fee /£/k Wh*	Be- nefit /£	Ho- urs /h	Cost /£/k Wh		Be- nefit /£	Total £
Not enrolled, emulated	200	13	365	0,005	4745	40	0,13	1040	40	0,0738	295		6080	295

*fee per KW/hr is taken from mean values in the actual historic market.

5.2.1.1.2 Evaluation scheme:

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 10.

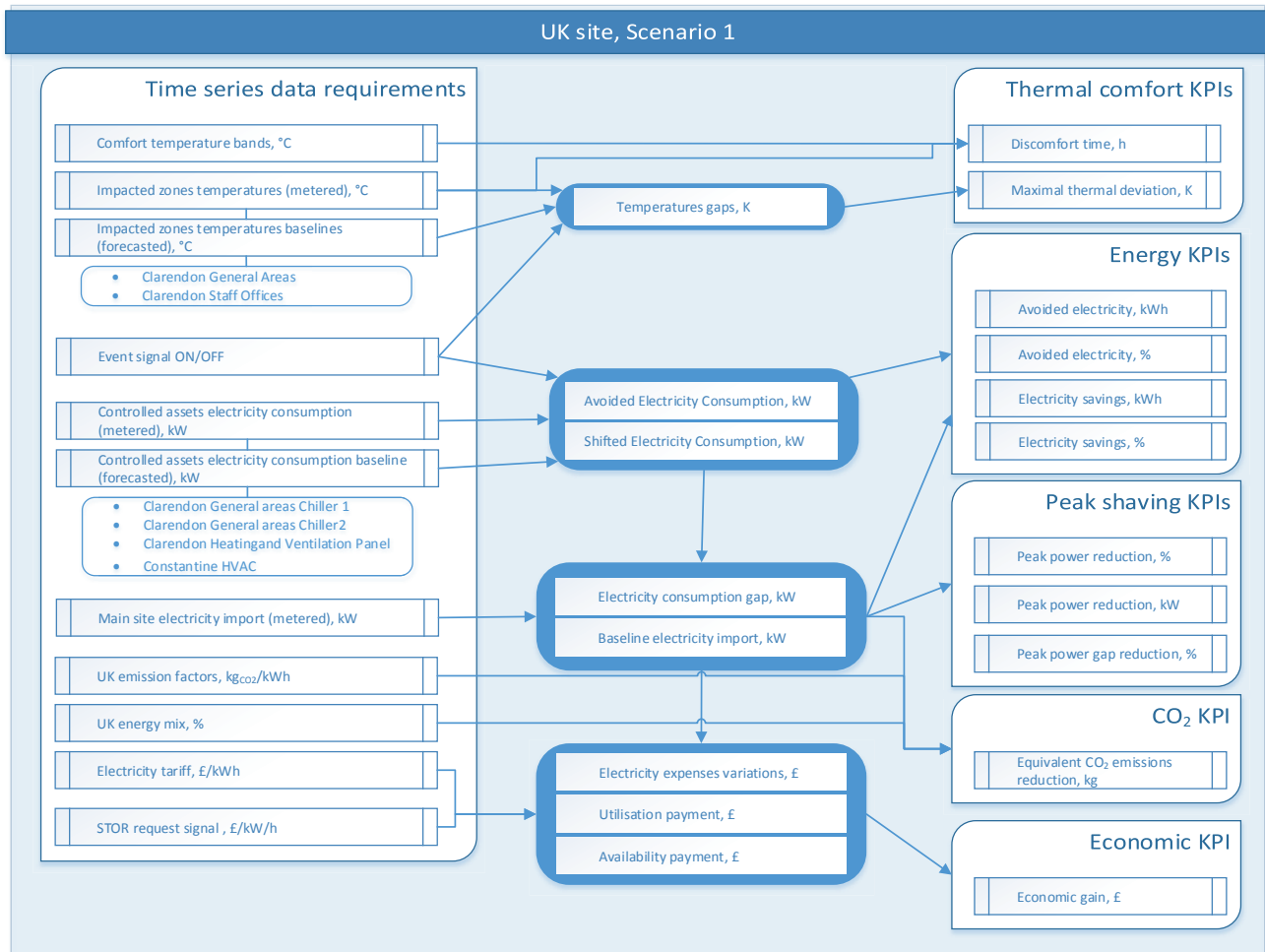


Figure 10: UK site / Scenario 1 scheme for quantitative evaluation

5.2.1.2 UK - Scenario 2

5.2.1.2.1 Short description

In this scenario, the DR request is to *increase* the use of electricity from the grid. For this the Demand Turn Up signal is used (see section 3.5.6.5.2). In summer, when there is an excess of renewable electricity locally, a request will be sent asking to *increase* electricity consumption from the grid, which means that the CHP in the tower building will be deactivated so that the amount of self-generated electricity consumption can decrease and more electricity is drawn from the grid. This typically takes place during off-peak hours when demand for heat is low – e.g. overnight and in weekends in the summer period (27th March to 28th October).

There will be 24 events every year of which the timing will depend on when the generation of electricity outruns the demand. The signal is simulated by the Market Emulator, and is based on forecast for weather, temperature set points, temperature sensor data and outside temperature. Notification will be at least of 10 minutes, but more likely a day ahead and each event lasts 1 to 2 hours.

In response to the signals the Facility Manager can opt-out for the DR event. In case of opt-in, the CHP plant will be turned off automatically by the Local Energy Manager (LEM). However, the current plan for Scenario 2 appears to be to simulate the CHP (at least until such point as the benefit of shutting down the CHP in response to a Demand Turn-Up (DTU) event is demonstrated). If this scenario would be executed instead of being simulated, this would mean that an external company (Ener-G) would need to participate as well, since they are responsible for controlling, managing and maintaining the CHP plant. Or instead, the contract would have to be changed so that the Facility Managers at TU will become responsible for controlling the CHP plant in the case of a DR event.

Reasons to opt-out could be: the university has demand for heat which makes it more beneficial to make use of the CHP which produces both heat and electricity, malfunctioning of the CHP plant, large effort needed to turn off/on the CHP plant, risks regarding the functioning of the CHP plant.

For the building occupants, the events will have no noticeable effect at all, since the same service is provided but using a different source of energy.

Expected findings

The scenario will focus on the Demand Turn Up, expressed in the price attractiveness of the electricity unit price versus the gas unit price. In terms of financial reward and attractiveness, the expectation is a lower price for the electricity drawn from the grid compared to the cost of generating the same amount with the CHP during the events. However, the capacity (220 kW) is not large enough to enter the market (minimal threshold of 1 MW, which can be aggregated from 0.1 MW and larger). Thus, in the demonstration there are no real financial benefits in this scenario. It is possible that in the future also sites with smaller capacities can be aggregated. The expected results are shown in Table 12.

The expectation of TU is a lower price for the electricity drawn from the grid compared to the cost of generating the same amount with the CHP during the events. However, the capacity (220 kW) is not large enough to enter the market (minimal threshold of 1 MW, which can be aggregated from 0.1 MW and larger). Thus, in the demonstration there are no real financial benefits in this scenario. It is possible that in the future also sites with smaller capacities can be aggregated. The expected results are shown in Table 12.

Table 12: Expected benefits for UK site / Scenario 2

DTU scenario 2	Availability Payment					Utilisation Benefit			Energy Savings			Lost benefit of heat rejected	Potential	Actual
	Revenue status	Asset Power /kW	hr per day	days	Fee /£/kW per hr*	Payment /£	Utilisation /h	Fee /£/ kWh*	Benefit /£	Hours/h	Cost /£/ kWh		Benefit /£	Total £
Simulation	229	12	153	0,0015	6307	116	0,06	1590	116	0,0289	768	-665	6464	NA

5.2.1.2.2 Evaluation scheme:

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 11.

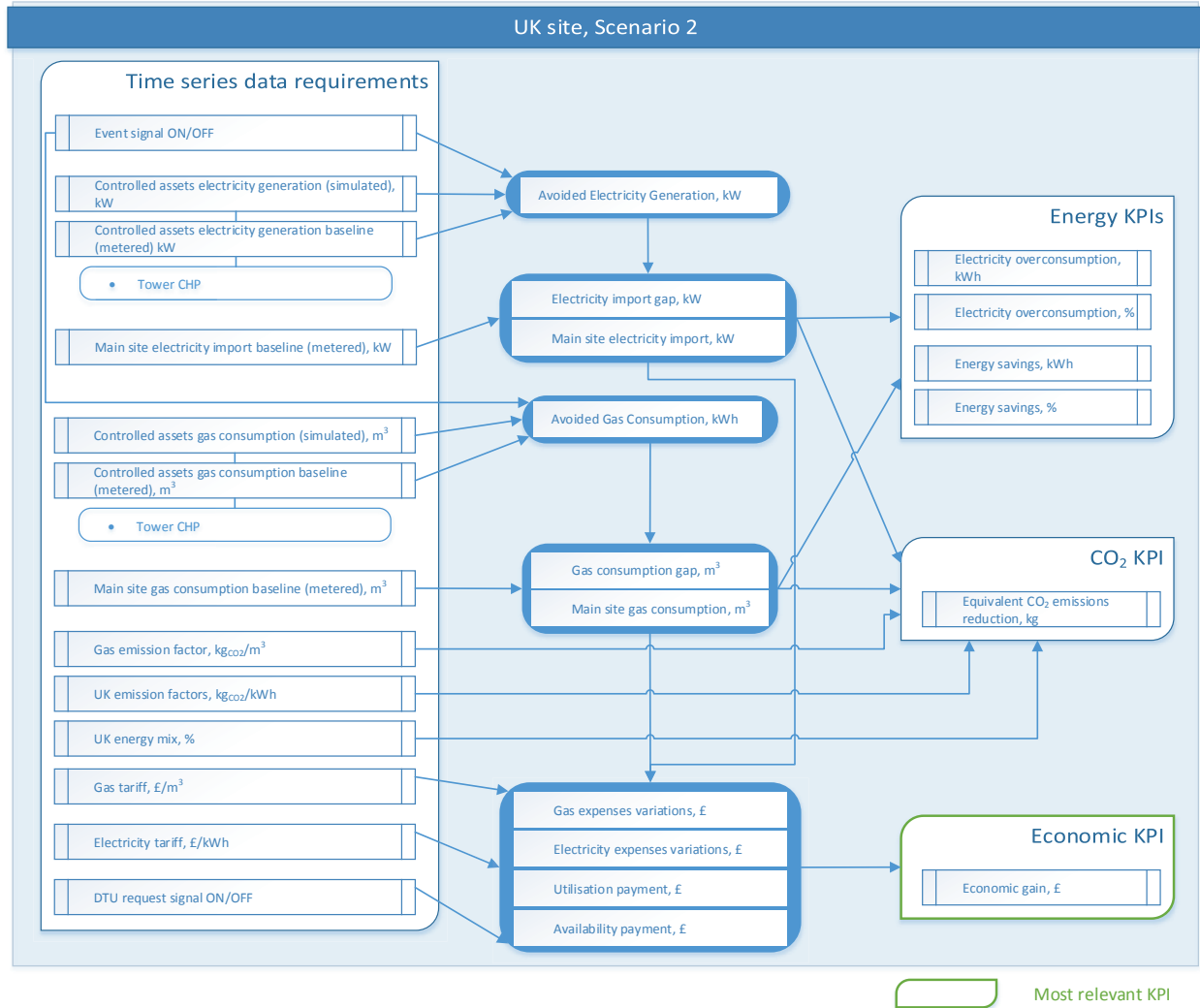


Figure 11: UK site / Scenario 2 scheme for quantitative evaluation

5.2.1.3 UK - Scenario 3a

5.2.1.3.1 Short description

Around 3 times a year, a half-hour period of Critical Peak Pricing -called TRIAD events in the UK- will occur and this is during peak hours: during this period the price of electricity will be very high – e.g. in winter in the late afternoon. The duration of the event may be between 30 minutes and three hours. The difference with Critical Peak Pricing however is that the exact occurrence is not certain: occurrences will be predicted (approximately 20 times a year) with a notification time of at least 4 hours but more likely 1 day in advance, but only at the end of the winter it will be clear which three (out of 20) predictions were right.

The Triad refers to the three half-hour settlement periods with highest system demand between November and February, separated by at least ten clear days. 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.

This scenario will generate the Triad Warning following the process: the LEM's forecast algorithm and the Rolling System Demand (ELEXON, 2017) from National Grid to predict when a Triad period is likely. The event will be activated in DEMS via REST API. The ME will gather Rolling System Demand data, pass this to forecasting routine (implemented as the Critical Peak Pricing Black Box, CPPBB) and create any predicted events in the VEP.

The current market process is for the Triad warning to be generated by the customer's Supplier (or possibly aggregator/ESCo) based on the rules of the Triad and other factors. The warning often comes in the form of an email (as is the case of Teesside). Each customer appoints its own Supplier, and therefore this differs from customer to customer. There is no standard for formatting each of the warning emails. We must also consider that to automate such a process will require the customer have access to the DEMS system via a web service, which may not be owned by either the customer or Supplier depending on the Business Model in place.

The daily window for the events to happen during winter (November to February) from 16:30 to 19:00, It will be manually operated mostly and last for 2.5 hours and will have at least 4 hours warning.

The scenario will monitor a number of assets in the Middlesbrough Tower (laboratories and PCs electricity), the Stephenson Building (users' electricity), the Clarendon Building (chillers and users' electricity), the Constantine Building (users' electricity use), the Tower Car Park (EV charging points), and the Phoenix Building (electricity use at offices).

Expected findings

The scenario will focus on demand reduction during the assets and stakeholders involved. The expected financial data from the scenario are shown in the Table 13.

Table 13: Expected benefits for UK site / Scenario 3a

Scenario 3a	Asset Power /kW	Utilisation Benefit			Energy Saving			Lost benefit of heat rejected	Poten-	Actu-
		Utilisation /h	Fee /£/kWh	Benefit /£	Hours /h	Cost /£/kWh	Benefit /£		tial	al
Revenue status									Total /£	Total /£
Actual	10	1	40	400	20	0,0738	15		415	415
Actual	100	1	40	4000	20	0,0738	148		4148	

5.2.1.3.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in

Figure 12.

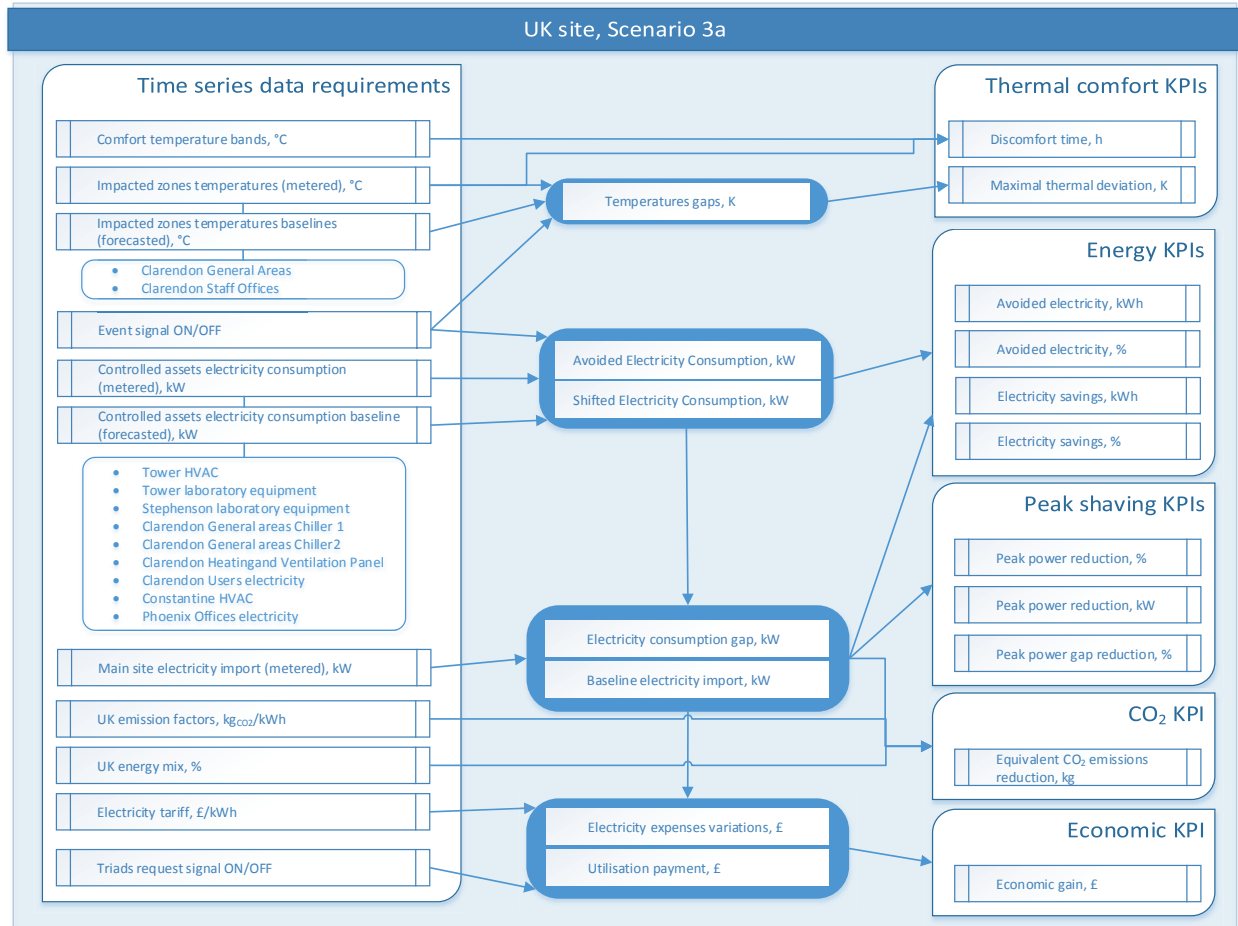


Figure 12: UK site / Scenario 3a scheme for quantitative evaluation

5.2.1.4 UK - Scenario 3b

5.2.1.4.1 Short description

This scenario simulates the DUoS (Distribution Use of System) charges in UK market. As an implicit DR it is not necessary to generate an event, however, the DUoS schedule will be set up in DEMS as ToU time-bands, these will be accessed by the LEM so it can account for the in its optimisation, and by the CP so they can be displayed to the Facilities Manager.

The idea here is that EV users will not charge during peak hours (between 4-7 PM) in the same type of events described in 3a. However, there are only a few EV users (of which one is part of the DRBOB team) and they usually charge directly after arrival. Since only a few people make use of the EV chargers, the use and availability is managed through an email group in which they can tell the others when a charging post becomes available. This email group contains the email addresses that will be used to send notifications about upcoming DR events in which they are asked not to charge their EV during peak hours. The tariffs applied in this scenario are shown in Table 14.

Table 14: UK DUoS tariffs description

UK						
Scenario	3b	3b				
Name	DUoS					
		Band	Price p/kWh	Days of Week	Start	End
		Green	7,038	Mon-Fri	00:00:00	08:00:00
		Amber	7,374	Mon-Fri	08:00:00	16:00:00
		Red	14,839	Mon-Fri	16:00:00	19:30:00
		Amber	7,374	Mon-Fri	19:30:00	22:00:00
		Green	7,038	Mon-Fri	22:00:00	23:59:00
		Green	7,038	Sat-Sun	00:00:00	23:59:00
		Commodity	7,000	All		

The FM knows the DUoS schedule in advance and communicates with EV users (staff using private vehicles, staff using TU owned vehicles) periodically.

TU owned vehicles represent 7% of energy drawn at the EV charging points and public users another 7%. TU staff driving private EVs are responsible for the bulk of the energy consumed and are offered a preferential tariff over public EV users, with an agreement that they will move their EV after a 2 hour charging session. They are also members of a mailing list which can be used to communicate requests to end charging at peak times. This could be dynamic in the case of Triad or to establish a routine in the case of DUoS.

5.2.1.4.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in

Figure 13.

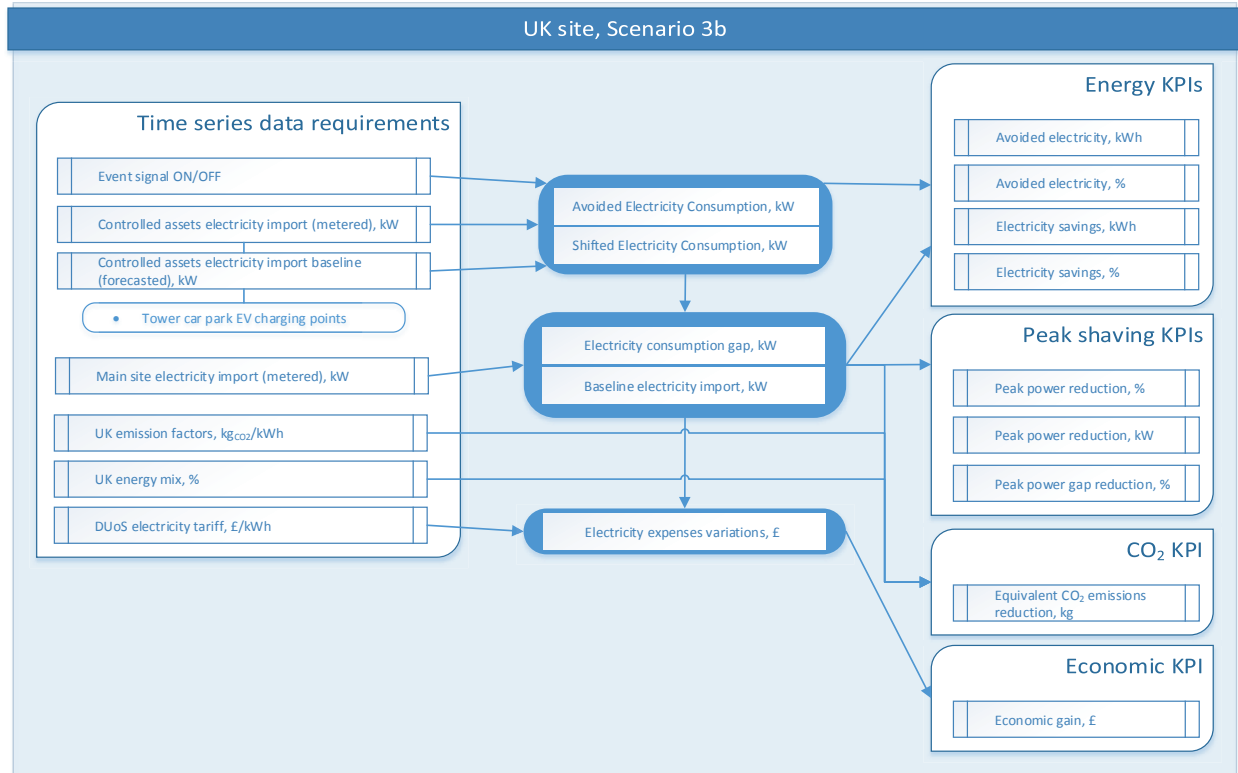


Figure 13: UK site / Scenario 3b scheme for quantitative evaluation

5.2.1.5 UK - Scenario 4

5.2.1.5.1 Short description

This scenario will be fully automatic because frequency regulation requires rapid automated response (around 2 seconds), 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 Building Management System (BMS). Thus, the Local Energy Manager (LEM), which takes care of the automatic actions, plays an important role here.

The local low frequency measurement will be made by the FCDM device and notify the LEM to act. These signals will be sent at random (Poisson) moments during the year, there will be around 10 events a year. The events last for half an hour.

The assets involved in this scenario are the UPS and backup generators for the IT servers at the Middlesbrough Tower building (175 KW).

Expected findings

The scenario will focus on instantaneous demand response triggered by grid frequency signals (FFR program in the UK). The expected benefits produced by this program will be as shown in Table 15.

Table 15: Expected benefits for UK site / Scenario 4

FFR - Secondary		Availability Payment				Energy Savings/replacement			Potential	Actual
Revenue status	Asset Power /kW	hr per day	days	Fee /£/kW per hr*	Payment /£	Hours /h	Cost /£/kWh	Benefit /£	Total£	Total £
Simulation	175	24	365	0,004	6125	3	-0,35	-185	5940	

5.2.1.5.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 14.

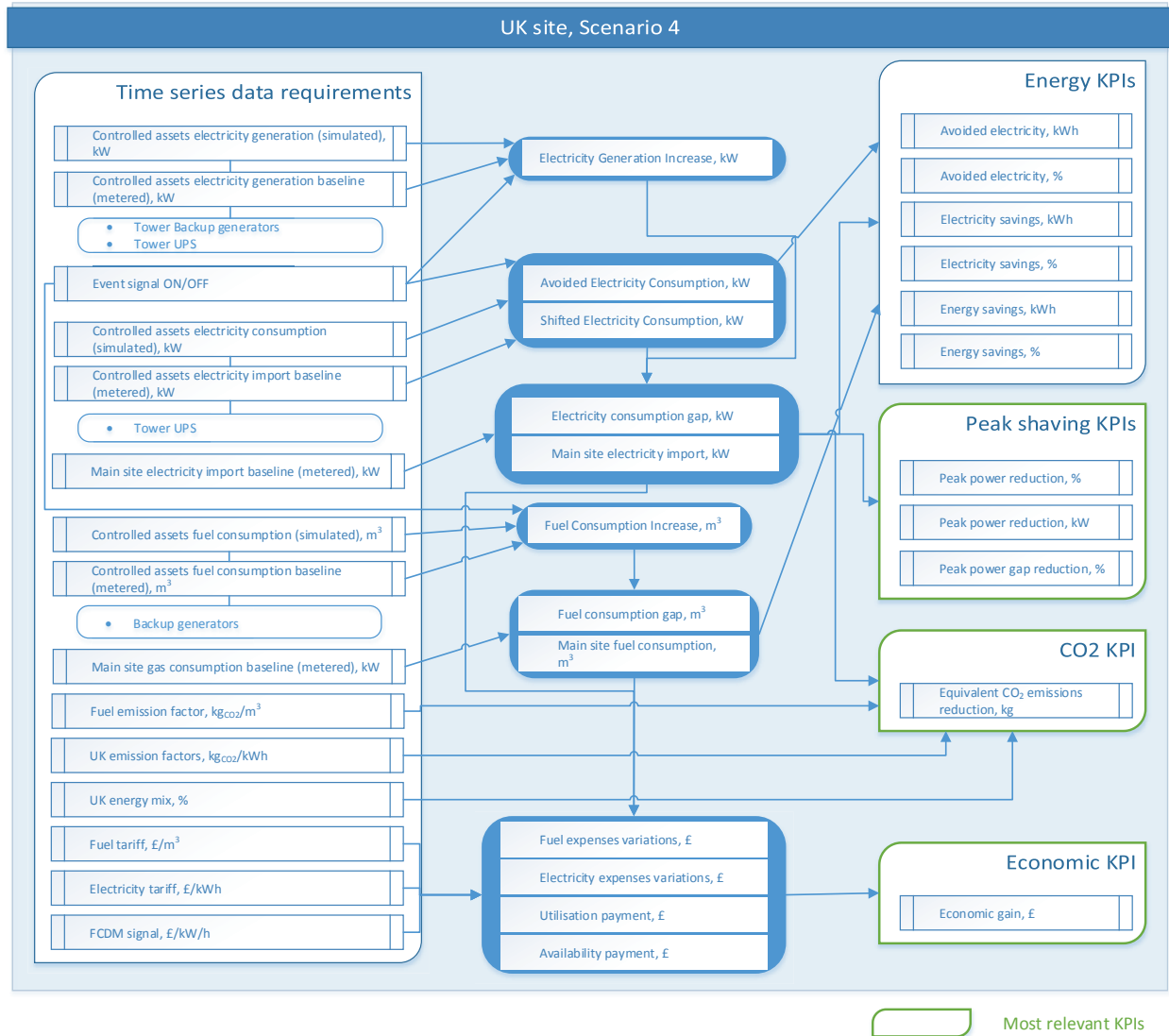


Figure 14: UK site / Scenario 4 scheme for quantitative evaluation

5.2.2 SYNTHESIS OF REQUIRED DATA FOR QUANTITATIVE EVALUATION

5.2.2.1 Time series data

5.2.2.1.1 Meter readings (energy consumption)

The list of all required meter readings for quantitative evaluation is presented in Table 16.

Most of the data can be provided directly from the DEMS. Some other data will have to be provided directly from the pilot site. And finally, a few readings will not be available (due to technical limitations) and impact the evaluation strategies.

Here, the lack of sub metering for HVAC and laboratory equipment electricity consumption will affect the precision of the evaluation for scenarios 1 and 3a, which will be done through the use of electricity consumption at the building level (including other assets not under the DR-BoB scope) and completed by the qualitative evaluation. This problem may present a risk for the results consistency, as we are not able to evaluate the impact only on the involved assets.

The baselines will be calculated and provided separately (see section 3.4). The simulation of backup generators fuel consumption will also be necessary.

Table 16: List of required meter readings from UK pilot site for quantitative evaluation

Thematics	Building	Asset	Unit	Baseline need	Data provider	Time step	Scenario
Gas consumption	Middlesbrough	CHP	m ³	✓	DEMS	15 min	2
Fuel consumption	Middlesbrough	Backup generators	m ³	X	UK pilot site	15 min	4
Electricity generation	Middlesbrough	CHP	kWh	✓	DEMS	15 min	2
		Backup generator	kWh	X	DEMS	15 min	4
Electricity consumption	TU Block of Buildings	-	kWh	X	DEMS	15 min	all
	Middlesbrough	entire building	kWh	✓	DEMS	15 min	2, 3a, 4
		UPS	kWh	✓	DEMS	15 min	4
		all HVAC	kWh	✓	unavailable		1, 3a
		laboratory equipment	kWh	✓	unavailable		3a
	Clarendon	entire building	kWh	✓	DEMS	15 min	1, 3a
		all HVAC Electricity	kWh	✓	DEMS	15 min	1, 3a
		General Areas Chiller 1	kWh	✓	DEMS	15 min	1, 3a
		General Areas Chiller 2	kWh	✓	DEMS	1 min	1, 3a
		Heating and Ventilation Panel	kWh	✓	DEMS	1 min	1, 3a
Lecture Theatre Chillers	kWh	✓	DEMS	1 min	1, 3a		

		Users Electricity	kWh	✓	DEMS	15 min	3a
	Stephenson	entire building	kWh	✓	DEMS	15 min	1, 3a
		all HVAC	kWh	✓	unavailable		1, 3a
		laboratory equipment	kWh	✓	unavailable		3a
	Constantine	entire building	kWh	✓	DEMS	15 min	1, 3a
		all HVAC	kWh	✓	unavailable		1, 3a
	Phoenix	entire building	kWh	✓	DEMS	15 min	3a
		RIS office DB Business 3+4	kWh	✓	DEMS	15 min	3a
	Tower Car Park	All EV charging points	kWh	✓	DEMS	15 min	3a,3b

5.2.2.1.2 Temperature readings

A large panel of temperatures in the impacted zones for the DR events (scenarios 1 and 3a) are reported in Table 17. All the readings will be provided by the LEM.

The baselines will be calculated and provided separately (see section 3.4).

Table 17: UK site – description of temperature readings

Building	Level	Quad rant	Number of sensors	Setpoint(s) (°C)	Surface (m ²)	Needed time series	Baseline need	Time step
Clarendon	1	NW	35	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
		SW	25	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
		NE	12	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
		SE	40	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
	2	NW	35	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
meters lowest						✓	15 min	
SW		25	21/24	336	meters highest	✓	15 min	
					meters average	✓	15 min	

				Override settings: 18/26		meters lowest	✓	15 min
		NE	12	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
		SE	40	21/24 Override settings: 18/26	336	meters highest	✓	15 min
						meters average	✓	15 min
						meters lowest	✓	15 min
Outdoor		1	-	-	-	meter	X	15 min

Comfort temperatures will be set at 20-24°C in winter and 23-26°C in summer as specified in the EN 15251 Annex A3 (Category II related to offices and spaces with similar activity - single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms-)

5.2.2.1.3 Energy prices and DR rates

In the UK the energy prices are regulated by a dynamic market structure. The bodies in charge of monitoring and setting the rules are the UK Department of Energy and Climate Change (DECC) for industrial energy prices and by the UK the Department for Business, Energy & Industrial Strategy home energy prices for domestic energy prices.

Monitoring UK industrial energy prices are an important part of the DECC's work. They are widely used within government - in briefing, to assist in developing and monitoring policies, to assess price trends, to highlight (and therefore help to prevent) price discrimination, and to monitor the effects of liberalising energy markets. They are also used extensively by industry, e.g. as price escalators in fuel purchasing contracts and as evidence in contract negotiations.

DECC produces industrial energy price statistics tables on a quarterly and annual basis (GOV-UK, 2017). In addition, a monthly survey of industrial energy prices is conducted by DECC as part of the Producer Price Index (PPI). The aim is to produce statistically representative price for all the fuel types, via the Quarterly Fuels Inquiry (QFI)² and the Non-domestic Price Transparency (PT) Survey³.

The domestic energy market is arbitrated by Ofgem, which stands for Office of Gas and Electricity Markets. This independent body is governed by the Gas and Electricity Markets Authority (GEMA). On a monthly basis, the domestic component of the Consumer Price Index for the UK is published.

The domestic gas market was opened to competition in stages between 1996 and 1998; whilst the domestic electricity market was opened up to competition over eight months between 1998 and 1999. The home supplier for any area is the original supplier in that area prior to the opening of the domestic energy market to competition. For gas, the home supplier is British Gas Trading. For electricity, the home

² From a panel of approximately 600 manufacturing industry sites. Coverage reaches up to around 25% of UK industrial sales.

³ Required by Eurostat under Directive 90/377/EEC. The survey gathers data from 8 gas and 6 electricity suppliers in the UK

supplier is the former public electricity suppliers (PES) within their own distribution area or that of their parent company.

5.2.2.1.3.1 GRID BALANCING MECHANISMS- THE CAPACITY MARKET

National Grid UK, a partially publicly owned enterprise, maintain the high-voltage electricity transmission network in England and Wales (Scotland has its own networks), balancing supply with demand on a minute-by-minute basis. The network carries electricity from the generators to substations where the voltage is lowered ready for distribution. Most of the network is overhead lines, underground cables and substations. It is responsible for balancing the system and managing generation output to make sure that it matches demand throughout the day, and that voltage and frequency are kept within acceptable limits. (UK national grid Website, 2017). Hence the need to establish mechanisms to balance and secure electricity supply in a self-regulated electricity market. The UK government, through EMR introduces two key mechanisms to provide incentives for the investment required in the energy infrastructure.

- **Contracts for Difference (CFD)** provides long-term price stabilisation to low carbon plants, allowing investment to come forward at a lower cost of capital and therefore at a lower cost to consumers.
- **The Capacity Market** provides a regular retainer payment to reliable forms of capacity (both demand and supply side), in return for such capacity being available when the system is tight.

5.2.2.1.3.2 TARIFFS AND PROGRAMS INVOLVING DEMAND RESPONSE (DR) IN THE UK

The Capacity Market ensures security of electricity supply by providing a payment for reliable sources of capacity, alongside their electricity revenues, to ensure they deliver energy when needed. Basically the different aspects to differentiate the schemes relate to: the intention of the program; the minimum capacity available to qualify for the program; the availability payments; and the utilisation payments. The different tariffs available to large electricity consumers to qualify for DR tariffs are:

5.2.2.1.3.2.1 SHORT TERM OPERATING RESERVE (STOR);

The UK National Grid requires extra power in the form of generation or demand reduction during certain periods of the day to maintain balance in the event that actual demand is greater than forecasted demand, or an unforeseen generation unavailability occurs. National Grid procures Short Term Operating Reserve (STOR) to help meet this reserve requirement. STOR is a contracted balancing service whereby the Service Provider delivers a contracted level of power (within pre-agreed parameters) when instructed by National Grid. Payments are done for availability during specified windows and actual utilisation during the billing period. Payments for availability are paid in terms of £/MW/h. These are settled on a monthly basis using the availability for the capacity unit. The minimum capacity availability to qualify for this contract are:

- to have a connection to the Electricity Transmission/Distribution Network
- to offer a minimum of 3MW generation or steady demand reduction (this can be aggregated);
- maximum Response Time for delivery of 240 minutes following instruction from National Grid, although we typically contract for 20 minutes or less;
- ability to deliver the Contracted MW for a continuous period of not less than 2 hours;
- to have a Recovery Period after provision of Reserve of not more than 1200 minutes;
- to be able to deliver at least 3 times per week.

STOR is procured via competitive tender processes with three tender rounds per year, with one or more contracted seasons (there are 6 STOR seasons per year) up to a contracted period of two years. Exact Availability windows for the current season, can be found on the Tender Sheets on the STOR page of

National Grid’s website. Each year providers have the opportunity to make their unit/site available for a maximum of 3800 hours. STOR prices are shown in the graph below.

STOR prices depend on accepted tenders. The figure below shows the last years applied incentives for the different tenders.

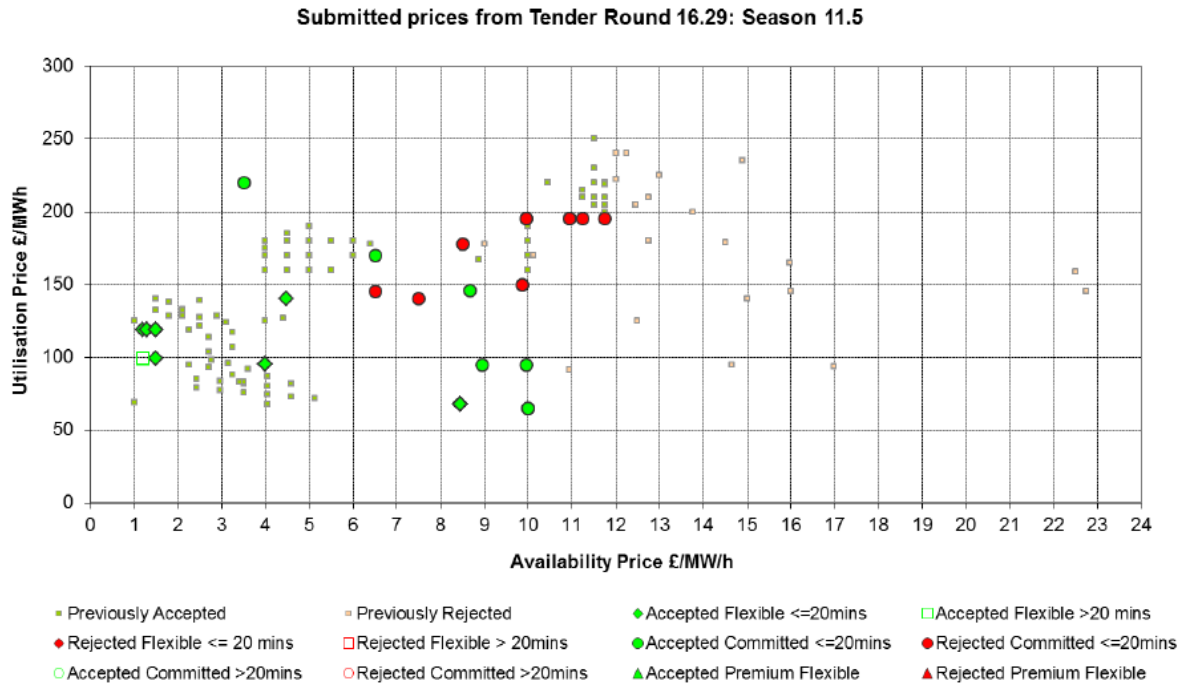


Figure 15: Applied STOR incentives for the different tenders during the last years

5.2.2.1.3.2.2 DEMAND TURN UP (DTU)

Demand Turn Up incentivises the use of power from the grid by compensating the price of generating the demanded power locally when there is an unbalanced surplus of energy in the grid, usually generated by RES. The structure of payments to customers is similar to that of other balancing services, and includes an availability payment and a utilisation or benefit, which in this case, would be the incremented use of power from the grid at a lower price than the one that would be used instead by local (diesel or other fuel type) or grid (in the case of natural gas) power sources.

Table 18: Availability and utilisation payment used for DTU

Availability payment	1.50£/MW/h to 1.75£/MW/h
Utilisation payment	60£/MWh to 97£/MWh

It also has an operability window or service window. The payments in the accepted 2017 fixed DTU tenders (NATIONALGRID, 2017a) are also based on the minimum (30 to 120) and maximum (300 to 9999), as well as in the response time (5 to 85 minutes). The service windows vary from a week day to weekend, and is shown in the figure below. The prices are established as follows:

Table 19: Service windows used for DTU

	Overnight period Monday – Sunday (window 1)	Weekend afternoon period Saturday, Sunday & bank holidays (window 2)
May and September	23:30 – 08:30	13:00 – 16:00
June, July, August	23:30 – 09:00	13:00 – 16:00

5.2.2.1.3.2.3 FREQUENCY RESPONSE

Balancing every second the UK national grid needs ahead resource allocation, which could be referred as STOR, DTU and TNUoS, but also refers to the immediate response to the grid frequency signals in real time. This scheme has limited scope in terms of power availability but can mean a significant push to the success in grid balancing. There are two schemes available in the UK market. One important factor that differentiates this balancing resource is that for it there is no forecast or prevision, but instead a real time response that cannot be done but automatically and relying on BMS.

In the UK the National Grid (National Grid, 2017) is mandated to deliver a service that maintains mains frequency within statutory (49.5 Hz to 50.5 Hz) and operational limits (49.8 Hz to 50.2 Hz). Traditionally, control strategies are triggered when a frequency measurement exceeds a set threshold (Dehghanpour et al 2015; Lakshmanan et al, 2016). Supply companies and larger loads may be contracted to receive DR signals to aid the process of frequency restoration, by altering their energy consumption for set time periods usually for a financial reward.

- **Firm Frequency Response (FFR)** “provides firm provision of Dynamic (continually matching) or Non-Dynamic Response (set points) to changes in Frequency” Firm Frequency Response is procured to counter the same incidents as Mandatory Frequency Response – but is open to any consuming or generating plant that can meet the service requirements.

FFR is procured through a monthly tender. Once service providers succeed in the pre-qualification assessment and sign onto a framework agreement, they can participate in the tender process. They can tender in for a single or multiple months. Having considered the quality, quantity and the nature of the services, National Grid will accept the most economical tender. This then becomes contractually binding.

Payment:

FFR has a multi-part payment structure. However, most providers only tender in for availability and nomination:

Availability Fee (£/hr) – the number of hours of availability from a provider

Nomination Fee (£/hr) – for each hour utilised

Optional fees

- Window Initiation Free (£/window) – for each FFR window that the provider has been instructed under.
 - Tendered Window Revision fee (£/hr) - National Grid notifies providers of window nominations in advance and, if the provider allows, this payment is payable if National Grid subsequently revises this nomination.
 - Response Energy Fee (£/MWh) – this is for non-BM providers only and is based upon the actual response energy provided in the nominated window.
- **Frequency Control by Demand Management (FCDM)** “provides frequency response through interruption of demand customers. The electricity demand is automatically interrupted when the system frequency transgresses the low frequency relay setting on site”.

It just deactivates loads when required by the grid’s frequency signal. In the case of UK-SC4, TU is going to perform this scheme of DR action, basing on real time signal reading from the grid and reacting to these in a simulated approach through the LEM, automating the UPS of the IT servers activation in the Middlesbrough tower building.

5.2.2.1.3.2.4 OTHER ALTERNATIVES TO CAPACITY MARKET. CUSTOMER DEMAND MANAGEMENT

There are alternative ways other than to qualify for the capacity market. These are the “TRIAD avoidance” or TNUoS, and the DUoS, i.e. incentivising load reduction and load-shifting to a cheaper price off-peak time band respectively.

5.2.2.1.3.2.5 TNUoS

Stands for Transmission Network Use of Services and applies prices per consumption during specific not predefined half-hour periods to all the customers in their bills. These periods are called Triads. The Triads are the three half-hour settlement periods with highest system demand and are used by National Grid to determine charges for demand customers with half-hour metering and payments to licence exempt distributed generation. They can occur in any half-hour on any day between November to February inclusive but are separated from each other by at least 10 full days. There are two tariffs: HH to clients metered half hourly (as Teesside University), which are charged the average (£/kW) triad tariff; and the NHH (Non Half Hourly metered users), which are charged p/kWh from 4 to 7 PM. P results of the forecasted NHH metered daily consumption from 4 to 7 PM and divided by the quantity (£m) to cover with this payment, which is a residual of what is paid through HH users. The TNUoS tariffs for 2017/18 and are now fixed (NATIONALGRID, 2017b) with a demand HH established cost of 39.22 £/kW, and the previous year’s tariffs (NATIONALGRID, 2017c) show a demand HH established cost of 42.93£/kW for the Northern zone, which is the applicable zone for Teesside University. TNUoS will be applied within the scenario 3a involving the assets including laboratories and office demand as well as chillers and ventilation.

5.2.2.1.3.2.6 DUoS

Stands for Distribution Use of System. The DUoS Distribution use of System is the recovering of the cost of distributing electricity across the national network. It defines different charging bands for the tariff paid (£/kW), charged by one of the 6 DNOs in the UK. These bands are red, amber and green, as shown in the table below these lines. The different final prices applied by the TU supplier in 2017/2018 per band are found in the table below. Within the DR-BOB project, in scenario 3a, TU intends to avoid the periods of highest distribution network costs, commonly known as ‘red-zones’.

Table 20: Time bands for Half Hourly metered assets

Time Bands for Half Hourly Metered Properties			
Time periods	Red Time Band	Amber Time Band	Green Time Band
Monday to Friday (Including Bank Holidays) All Year	16:00 to 19:30	08:00 to 16:00 19:30 to 22:00	00:00 to 08:00 22:00 to 24:00
Saturday and Sunday All Year			00:00 to 24:00
Notes	All the above times are in UK Clock time		

Table 21: Sample bill from Teesside University campus

	p/kWh	Total/hr excluding VAT
SSE Commodity rate	7.168	
DUoS Red	7.556	14.724
DUoS Amber	0.364	7.532
DUoS Green	0.036	7.592

The charges are published once a year by each DNO in February for the period 1st April- 31st March.

The time series data related to the energy prices that will be collected are related in Table 22. The signals and tariffs will be provided both by the LEM and ME. For constant prices, the 15 min time step is not necessary and a single value will be provided.

Table 22: UK site – description of variable energy prices

Energy	Unit	Name	Data provider	Time step
Electricity	£/kWh	basic tariff	LEM	15 min
	£/kWh	DUoS tariff	LEM	
	£/kW/h	STOR signal	ME	
	£/kW/h	FCDM signal	LEM	
	-	DTU signal	ME	
	-	Triads signal	ME	
Gas	£/m ³	tariff	LEM	
Fuel	£/m ³	tariff	LEM	

5.2.2.1.4 CO₂

The time series data related to CO₂ KPI that will be collected are the national energy mix for electricity production, which should be collected from the ENTSOE-E database.

The emission factors related to electricity will be collected from the ecoinvent database, and linked to the generation sources by using the weightings described in annex (Table 39).

The emission factors related to fuel combustion (natural gas, diesel) are reported in annex (Table 38).

5.2.2.2 Data related to DR events

All data related to the DR events (Time and duration of the events, participating assets, financial reward, feedback gathered from users, participation results available) will be gathered from the Consumer Portal following the common communication strategy that will be described in Section 6.

5.3 FRANCE

5.3.1 ADAPTATION OF KPIS TO THE SCENARIOS

5.3.1.1 FRANCE - Scenario 1 – Electric demand reduction

5.3.1.1.1 Short description

The scenario 1 is based on PP1 (Peak Period 1) signals from the French Capacity Market mechanism active from the 1st of January 2017. These signals are generated by the French national TSO RTE and collected by the Market Emulator (ME) from RTE website each day.

As defined in the rules of the French Capacity Market mechanism (RTE, 2017a), the PP1 period:

- Targets periods of national high consumption (French national electricity demand depends a lot from weather conditions);
- Covers a time period that is consistent with the typical duration of shortfall episodes, enabling peak load reductions to be rewarded in proportion to their contribution to reducing the shortfall risk.

The PP1 period corresponds to the time slots [07:00; 15:00[and [18:00; 20:00[(i.e. ten hours per day) on days notified by RTE. The days notified are not selected before the delivery period. However, they will always be working days in the months between November and March, minus the period corresponding to the Christmas school holidays. PP1 days are notified on D-1 at 10:30am. Notification is based on a demand criterion. The number of PP1 days notified varies between 10 and 15.

On the reception of an acknowledgement that tomorrow will be a PP1 day, the ME will generate an event and send it to the DEMS. Immediately after reception of such an event, the Building managers of the 3 buildings will be notified by e-mail and asked to opt in/out for the next actions on the assets of their respective buildings:

- BI building: manually raise temperature set point of Heat Pump by 2 degrees before the event and return back to a normal during the event, manually reduce ambient temperature setpoints by changing mode of all the fan coils to economy mode during the event, manually switch-off Air Handling Units (AHU) for 1 hour several times during the event, manually increase ambient temperature setpoint of cooling heat pump for server room during the event, ask the occupants to switch power of their laptops from the grid source to integrated batteries at the beginning of the working day. All these actions will be made manually by the BI building manager through the BMS system or control hardware interface for non-controlled assets. These actions will be scheduled to be active at the moment when the occupants arrive at building in the morning.
- NBK building: automatically reduce temperature set point for heat pump during the event, manually switch ambient temperature set points for heating floor from mode comfort to economical mode during the event, manually switch-off AHU for 1 hour several times during the event, manually switch-off cooling heat pump for server room for the whole duration of event, manually switch power supply of servers from the grid to the UPS backup power batteries during 20 minutes at the beginning of the event, ask the occupants to switch power of their laptops from the grid source to integrated batteries at the beginning of the working day. All these actions will be made by the NBK building manager and through the BMS system or control hardware interface for non-

controlled assets. These actions will be scheduled to be active at the moment when the occupants arrive at the building in the morning.

- FCMB building: ask the occupants to switch power of their laptops from the grid source to integrated batteries 2 times per day (at the beginning of the working day when the occupants arrive at the building and after noon once laptops' batteries are charged).

All the assets opted in by building managers could be opted out up to the beginning of DR event. The decision to opt out some assets depends from the activities in the building expected for this day.

5.3.1.1.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in

Figure 16.

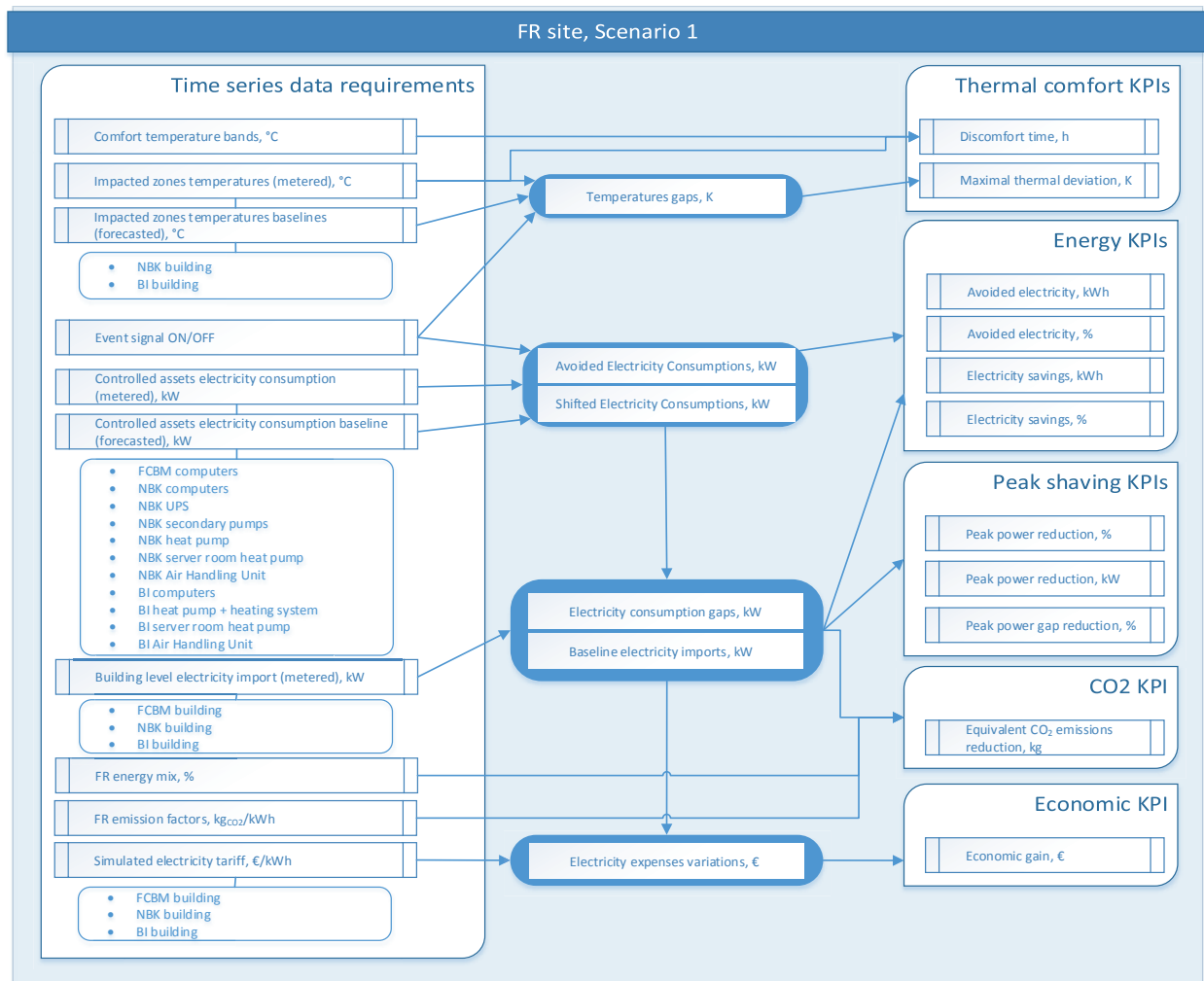


Figure 16: French site / Scenario 1 scheme for quantitative evaluation

5.3.1.2 FRANCE - Scenario 3 – Gas demand reduction

5.3.1.2.1 Short description

Forecasting heat demand is a necessary functionality of an energy management solution. The main factors affecting heat demand are:

- Time of day effect;
- Weekend/weekday effect;
- Time varying volatility;
- Local weather conditions;
- Correlation between heat demand and external temperature or thermal inertia of buildings.

In this scenario, the heat demand of FCMB building is forecasted on the basis of predictions of local weather conditions. The peaks of FCMB heat demand trigger the actions on heating systems inside the FCMB building.

The heating installation inside the FCMB building is supplied by 2 sources: 1 gas-fired boiler supplied by the gas of the city of Anglet and 1 woodchips boiler supplied locally by woodchips issued from practical works of apprentices. FCMB building owner would like to reduce gas demand for the heating of his building by switching from the gas-fired boiler to the woodchips boiler which is a by-product of apprentices' activities.

The typical heating period during a year for FCMB building lasts from 1st of November to 15th of April. During this period, the LEM will forecast average building heat demand for the D+1 day based on correlation between overall FCMB building heat demand and outdoor temperature expressed into heating degree days (HDD) with 18°C basis (see the diagram below). If a peak of heat energy demand is detected, the LEM will generate an event and present it to FCMB building manager (BM) through the Consumer Portal. To help the FCMB building manager to take a decision the LEM will also provide to the Consumer Portal availability of woodchips into the tank (collected by a dedicated woodchips level sensor installed especially for the DR-BOB project). This event will be accompanied by one of the following recommendations:

1. "Use the woodchip boiler during the peak period" if there is enough of woodchips into the tank to meet the heat energy demand during the event.
2. "Use woodchips boiler with high ambient temperature set point during one hour before the event and switch to the gas boiler at the beginning of the event" if there is not enough of woodchips into the tank to meet the heat energy demand during the whole event.

Based on that information and also on the state of the woodchips boiler (broken or not broken) the FCMB BM will manually select the heating energy source for the before the event and during the event. If FCMB BM opts in with recommendation 1 selected, so he will call a technical person to go to the boiler room and manually change a heat energy source at the beginning of the event period and one more time to make an inverse switching after the end of the event (up to him to decide about keep heating on woodchips energy or on gas energy after the end of the event). If FCMB BM opts in with recommendation 2 selected, he manually increases temperature set points before the event and reduce temperature set points on the BMS during the event.

The events will be generated between 10 and 15 times during the heating period and will start at the morning when the occupants arrive at building (between 7:30 and 8:30). The duration of event will be of 1 hour during the first 2 months and will increase up to 2-3 hours during the following months if this action doesn't impact the comfort of occupants.

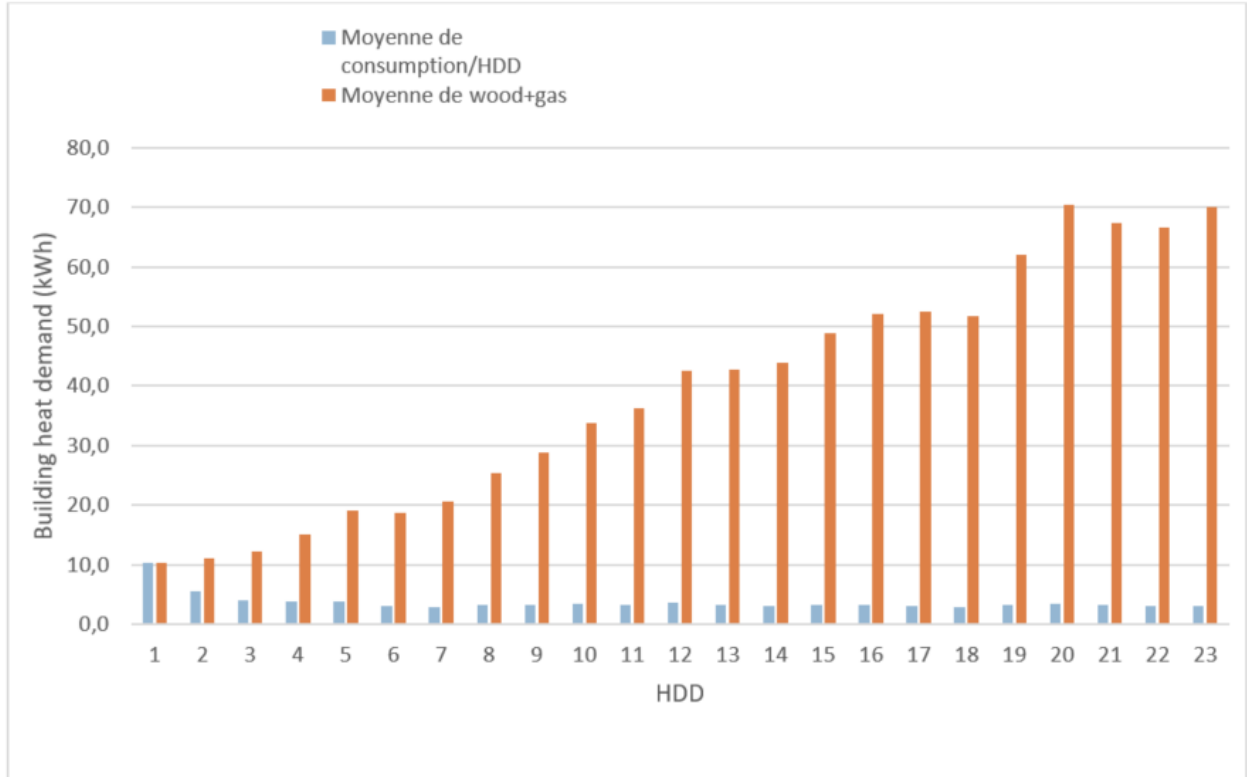


Figure 17: Relation between FCMB building heat demand and HDD basis 18°C

5.3.1.2.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in

Figure 18.

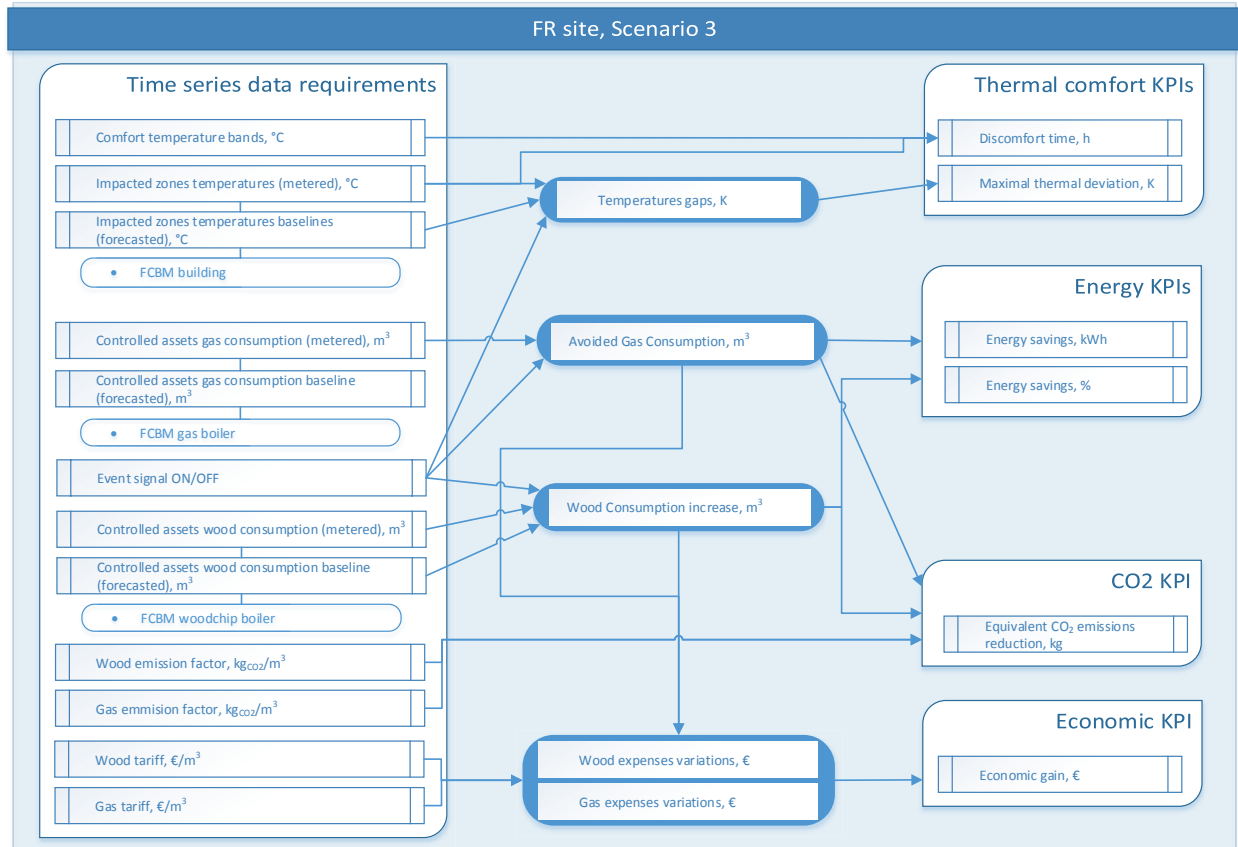


Figure 18: French site / Scenario 3 scheme for quantitative evaluation

5.3.1.3 FRANCE - Scenario 4 – Electric peak-power demand reduction

5.3.1.3.1 Short description

The sensitivity to cold weather is very relevant in France due to the high use of electric domestic heating – despite a declining trend noted in recent years, as building energy performance regulations RT2012 have favored the use of gas heating in new homes. France accounts for half of Europe's demand-sensitivity to cold temperatures. Consequently, cold spells have a particularly significant impact on the French electricity system.

Daily consumption of electricity is characterized by two peaks in demand: a surge between 8am and 1pm, and an evening peak at 7pm (RTE, 2017b). The morning surge is due to the starting of working day at private enterprises and public organizations, the evening peak at 7pm is due to the peoples coming back to home after work and running electricity devices (heating, cooking, multimedia).

In this scenario, the DR events will be triggered on simulated signals depending from the cold winter peaks of local weather conditions correlated with the morning peaks when the peoples start to work. The ME will collect a forecast of minimal and average daily temperatures for the

next day, and will create an event if the forecast of an average temp for tomorrow is less than 7 degrees Celsius and the tomorrow's minimum is less than average minimum for previous week (see Figure 19). The 7 degrees threshold has been selected to have between 10 and 15 events during the winter period.

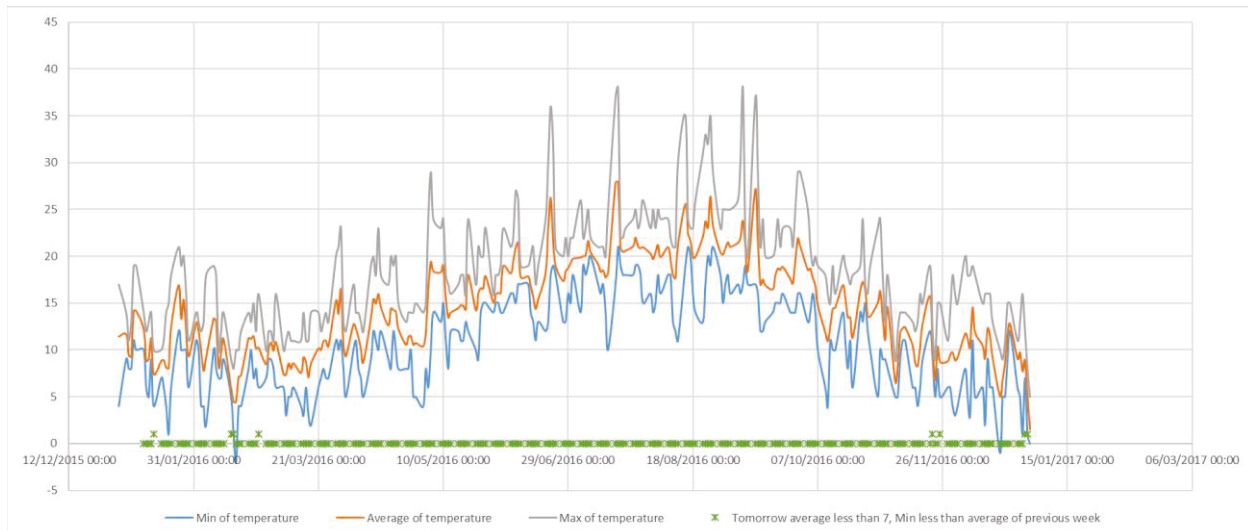


Figure 19: Representation of the algorithm of selection of cold weather peaks in Anglet

To cover almost the whole period of next day' morning peak the abovementioned algorithm will be run at 12PM. If there will be a peak, a DR event will be created into the DEMS at the same time. Immediately after reception of such a DR event, the Building managers of the 3 buildings will be notified by e-mail and asked to opt in/out for actions on the assets of their respective buildings. In the case of opt in response the actions to be made by the BMs are similar to the actions listed in the scenario 1. All the assets opted in by building managers could be opted out up to the beginning of DR event. The decision to opt out some assets depends from indoor ambient temperatures and the activities in the building expected for this day. As the events will be triggered on local cold winter peaks, the indoor ambient temperatures will be the more important factor to take a decision regarding involvement of heating assets (heat pumps, Air Handling Units (AHU), fan coils). The thermal comfort of occupants will be assessed through requests of feedback after the end of each DR event.

This scenario is based on implicit simulated signal, thus none rewarding system or financial incentive other than energy savings associated to morning peak-power reduction due to extreme outdoor temperatures are not planned. The expected impact of this scenario is the shift of buildings' electricity demand on cold days in response to morning change of grid demand.

It will be surely some situations when the Peak Periods PP1 of scenario 1 depending from average French weather conditions will coincide with the DR events of scenario 4 depending from local cold peaks. In this case, the financial evaluation from scenario 1 will be also applied to the event period of scenario 4.

5.3.1.3.2 Evaluation scheme

The evaluation scheme for scenario 4 will be the same as for scenario 1 (see

Figure 16), except that the Direct Load Curtailment electricity tariff will be considered for the economic KPI.

5.3.1.4 FRANCE - Scenario 5 - Virtual microgrid or Sharing of electric energy inside the demonstration site area

5.3.1.4.1 Short description

In February 2017 France adopted new law on self-consumption and collective self-consumption of renewable energy. The law n° 2017-227 of 24 February 2017 defines collective self-consumption as “the supply of electricity produced by one or more generators to one or more consumers, linked by a common legal entity and situated on the same low voltage feeder” (extended to all feeders on the same substation). Implementation uses virtual metering managed by distribution network operators, with the algorithm for the allocation of kWh supplied by the common legal entity.

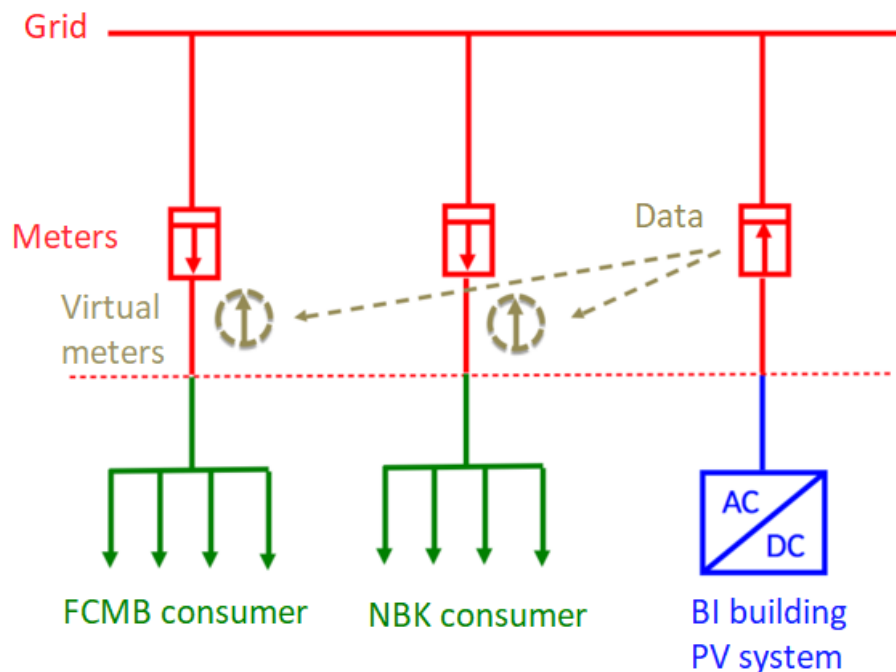


Figure 20. Scheme of collective self-consumption in France at the example of the French pilot site. Source: www.photovoltaique.info

The term Virtual microgrid introduced in the name of this scenario is based on the concept of Collective self-consumption combined with Community Microgrid concept. Community Microgrid is a coordinated local grid area served by one or more distribution substations and supported by high penetrations of local renewables and other distributed energy resources (DER) such as energy storage and demand response. Community Microgrids represent a new approach for designing and operating the electric grid, relying heavily on DER to achieve a more sustainable, secure, and cost-effective energy system while generally providing renewables-driven power backup for prioritized loads over indefinite durations (CLEANCOALITION, 2017).

In the context of the scenario 5 the term Virtual Microgrid is adapted for block of 3 buildings located closely with DREG and without storage systems. One of these buildings (BI) has been developed as Positive Energy Building which produces more of energy than it consumes. The energy generated is firstly self-consumed inside the building and the excess of energy is sold to the national electricity supplier EDF with a fixed contractual price 13,25 c€/kWh.

This scenario focuses on a new use for this excess of energy: instead to be sold to the grid this over energy will be proposed to be absorbed into the building host and to be virtually absorbed

into neighbor buildings. When an excess of energy will be forecasted by the Local Energy Manager (LEM) for the next 24 hours, an event will be created and a notification will be sent to the building manager of the BI building. The last one will have to make a choice between 3 options:

1. Locally absorb the excess generated, which could be associated with the DTU signal in the UK. It will be the first opt in option;
2. Sell excess to neighbor buildings with fixed prices which will be also a second opt in option;
3. Sell excess of energy to the grid which will be the equivalent of opt out answer.

The selling prices will not be displayed to the BMs, this aspect will be affected during interviews with the BMs of the 3 buildings. Each option will be accompanied by recommendations about actions on the building assets to be made. If the BI BM will choose the first option, she will be recommended to increase the electricity demand of the BI building by rescheduling the use of 3D printer and Electric Vehicle (EV) at the manner to run and charge it at the beginning of event. If the BI BM will choose the second option, the NBK and FCMB BMs will be notified by e-mail and asked to buy this excess of energy. If one of them or the both opt in to buy this energy, they will be recommended to increase the electricity demand of their corresponding buildings. This could be achieved by:

- rescheduling the use of woodchips chipper into the FCMB building to run it at the beginning of event;
- reducing ambient temperature setpoints for the heat pump and the server room cooling heat pump into the NBK building at the beginning of event.

The BMs could opt out the participation into the actions recommended because of the assets involved are not planned to be used or not charged or broken.

The events will be created during a hot period between May and October 2018 when there is a lot of solar energy in the Basque country. During this period between 10 and 15 events will be created.

As mentioned into the D2.2 the selling prices per kWh to the grid at feed-in tariffs are decreasing each year and are already almost equal to the purchasing prices from the grid. In few years the selling prices to the grid will be lower purchasing prices from the grid which will stimulate consumers to consume differently (privilege local self-consumption, sharing of energy) and will allow other business models (consumers with multiple electricity suppliers).

Expected impact: increase of building's electricity demand to absorb the bigger part of excess of energy produced by PV system of the BI building. It could be considered as a kind of local electricity market at block of buildings scale.

5.3.1.4.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in

Figure 21.

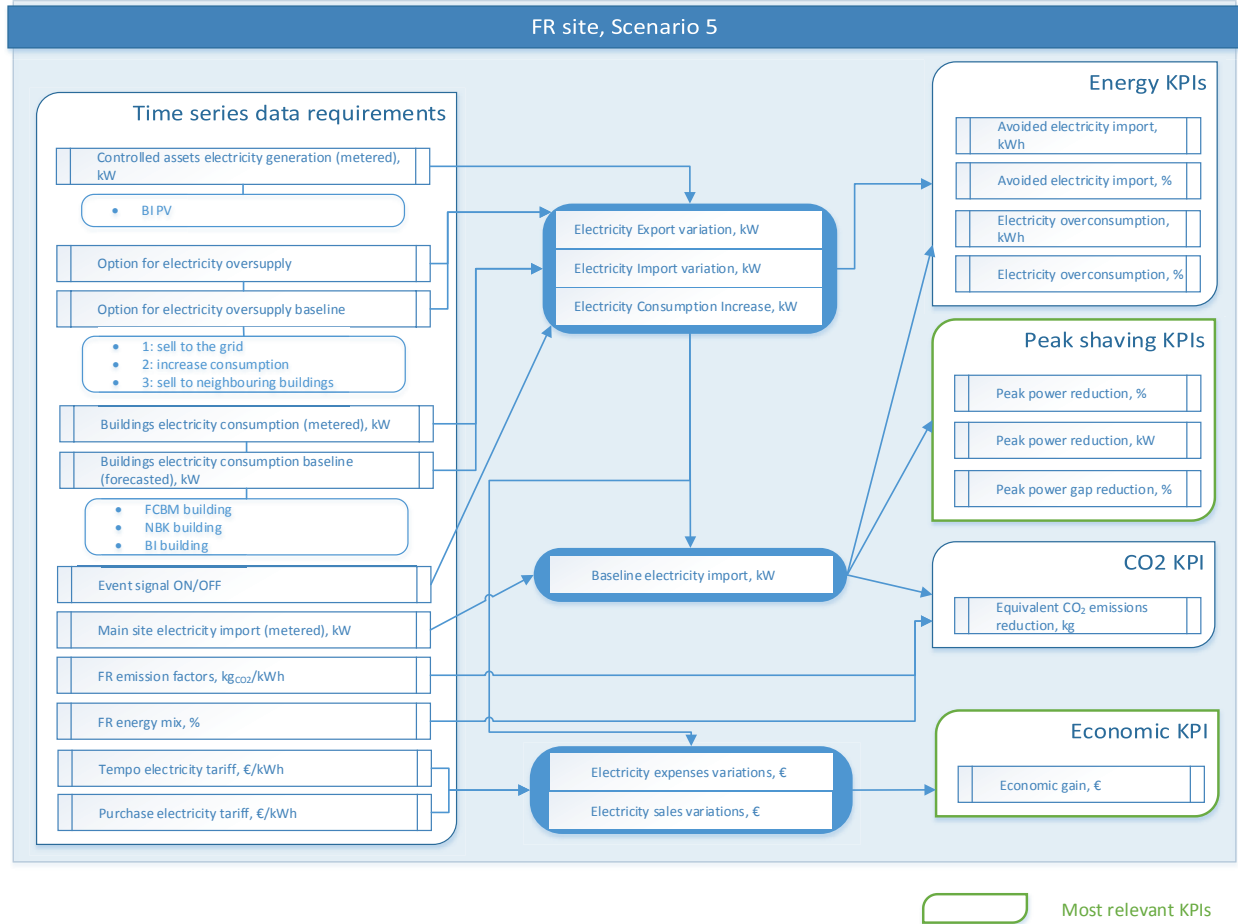


Figure 21: French site / Scenario 5 scheme for quantitative evaluation

5.3.2 SYNTHESIS OF REQUIRED DATA FOR QUANTITATIVE EVALUATION

5.3.2.1 Time series data

5.3.2.1.1 Meter readings (energy consumption)

The list of all required meter readings for quantitative evaluation is presented in Table 23.

Most of the data can be provided directly from the DEMS. Some other data will have to be provided directly from the BMS through an intermediate FTP server. And finally, a few readings will not be available (due to technical limitations) and impact the evaluation strategies.

Here, the lack of individual meters for laptops, NBK secondary pumps, NBK heat pump 2, and BI cooling heat pump will affect the evaluation for scenarios 1 and 4, which will be done through the use of electricity consumption at the level of floors or building level (including other assets not under the DR-BoB scope) and completed by a qualitative evaluation. This problem may present a risk for the results consistency, as we are not able to evaluate the impact only on the involved assets.

The important time step of the FCBM building (1h) can also limit the evaluation precision for the same scenarios.

Also, the lack of meter for the FCMB Gas boiler consumption can slightly impact the evaluation for scenario 3, which will be done through the use of its heat production measurement and overall system efficiency.

The baselines will be calculated and provided separately (see section 3.4). The estimations of electricity consumptions for Nobatek Secondary pumps and cooling heat pump (n°2) will also be uploaded separately as feedbacks or reports from corresponding building managers.

Table 23: List of required meter readings from FR pilot site for quantitative evaluation

Thematics	Building	Asset	Unit	Baseline need	Data provider	Time step	Scenario
Gas consumption	FCBM	Gas boiler	kWh	✓	unavailable		3
Heat production	FCBM	Gas boiler	kWh	✓	DEMS	1 h	3
Woodchip level	FCBM	Woodchip boiler	cm	✓	DEMS	1 h	3
Electricity generation	BI	PV	kWh	X	DEMS	5 min	5
Electricity consumption	FCBM	entire building	kWh	✓	BMS	1 h	1,4,5
		laptops	kWh	✓	unavailable		1,4
	NOBATEK	entire building	kWh	✓	DEMS	5 min	1,4,5
		air handling unit	kWh	✓	DEMS	5 min	1,4
		secondary pumps	kWh	✓	unavailable		1,4
		heat pump 1	kWh	✓	DEMS	5 min	1,4
heat pump 2	kWh	✓	unavailable		1,4		

		laptops	kWh	✓	unavailable		1,4
		UPS	kWh	✓	DEMS	5 min	1,4
	BI	entire building	kWh	✓	BMS	5 min	1,4,5
		air handling unit	kWh	✓	DEMS	5 min	1,4
		heating system	kWh	✓	DEMS	5 min	1,4
		Machines (3D printer and others)	kWh	✓	DEMS	5 min	1,4
		cooling heat pump	kWh	✓	unavailable		1,4
		laptops	kWh	✓	unavailable		1,4

5.3.2.1.2 Temperature readings

All temperatures in the impacted zones for the DR events (scenarios 1, 3 and 4) are reported in Table 24. As the site scale is quite limited, all temperature readings will be provided by the BMS.

The baselines will be calculated and provided separately (see section 3.4).

Table 24: FR site – description of temperature readings

Building	Type of zone	Baseline need	Surface (m ²)	Temperature set points (°C)		Nb of sensors	Data provider	Time step	Scenarios
				Winter	Summer				
Nobatek	Open Space R+1	✓	195	22	24	1	BMS (NBK)	5 min	1, 4, 5
	Open Space Ground	✓	190	22	24	2	BMS (NBK)	5 min	1, 4, 5
	Workspaces /meeting rooms R+1	✓	76	21	24	3	BMS (NBK)	5 min	1, 4, 5
	Offices Ground floor	✓	78	21	24	6	BMS (NBK)	5 min	1, 4, 5
	Meeting room	✓	70	21	24	1	BMS (NBK)	5 min	1, 4, 5
Business Incubator	Average of Offices/meeting rooms/Open Space/Work room 3D Ground floor and R+1	✓	616	20	N/A	20	BMS (NBK)	5 min	1, 4
FCMB	Management/direction	✓	1283	20	N/A	1	BMS (NBK)	1 h	3
	Examen room	✓		20	N/A	1	BMS (NBK)	1 h	3
	Mock-up	✓	Not known	20	N/A	1	BMS (NBK)	1 h	3

Outdoor	-	X	-	-	-	1	BMS (NBK)	5 min	all
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Comfort temperatures will be set at 19-24°C in winter and 23-26°C in summer in extension to the values specified in the EN 15251 Annex A3 (Category II related to offices and spaces with similar activity - single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms-). The winter lower band has been lowered due to:

- The 20°C setpoint in BI and FCBM buildings (in order to avoid excessive baseline discomfort time).
- To be in correspondence with the French thermal regulation (RT)

5.3.2.1.3 Energy prices and incentives

The time series data related to the energy prices that will be collected are related in Table 25. The signals and tariffs will be provided both by the LEM and ME.

Table 25: FR site – description of variable energy prices

Type of energy	Unit	Needed time series	Data provider	Time step
Electricity	€/kWh	basic tariff	LEM	15 min
	€/kWh	purchase tariff	LEM	
	-	PP1 signal	ME	
	-	PP2 signal	ME	
	€/kW/h	DLC signal	LEM	
	-	Option choice for electricity oversupply (BI)	LEM	
Gas	€/m ³	tariff	LEM	

More details on these prices can be found in Table 26. As before, for constant prices, the 15 min time step is not necessary and a single value will be provided.

Table 26. FR site –energy prices details

Name	Building	Energy	Financial flow	Real or virtual (source)	Price, € VAT included/kWh				Frequency of measurement acquisition
					HCE	HPE	HCH	HPH	
ToU tariff	NBK	Electricity	Purchase (consumption)	Real	0,117	0,12372	0,13452	0,14856	1 year
	FCMB	Electricity	Purchase (consumption)	Real	0,0561	0,07673	0,08754	0,11827	1 year
	BI	Electricity	Purchase (consumption)	Real	0,0341	0,0479	0,04626	0,06298	1 year
	FCMB	Gas	Purchase (consumption)	Real	0,05254				1 year
	FCMB	Wood	Purchase (consumption)	Real					
	FCMB	Electricity	Sale to the grid (production)	Real	0,2746				20 years
	BI	Electricity	Sale to the grid (production)	Real	0,1325				20 years
	BI	Electricity	Sale to neighbours (production)	Virtual					

5.3.2.1.4 CO₂

The time series data related to CO₂ KPI that will be collected are the national energy mix for electricity production, which should be collected from the ENTSOE-E database.

The emission factors related to electricity will be collected from the Ecoinvent database, and linked to the generation sources by using the weightings described in annex (Table 39).

The emission factor related to the gas combustion is reported in annex (Table 38).

The wood fuel for FR site is supposed to be coming from waste, so the related emissions should be negligible (the combustion process belongs to the “short” carbon cycle, as long as the burnt biomass is rapidly balanced by the other biomass growth).

5.3.2.2 Data related to DR events

All data related to the DR events (Time and duration of the events, participating assets, financial reward, feedback gathered from users, participation results available) will be gathered from the Consumer Portal following the common communication strategy that will be described in Section 6.

5.4 ITALY

5.4.1 ADAPTATION OF KPIS TO THE SCENARIOS

5.4.1.1 ITALY - Scenario 1

5.4.1.1.1 Short description

The scope of the DR action in scenario 1 is to reduce load as much as possible during a given interval of time which is expected to be a CPP interval.

This will be done by reducing the set-point of the chilled water (i.e. by increasing use of chillers) 15-30 minutes before the time of the DR event and then moving it back to the nominal value, which translates into a load shifting. The action will use the inertia of the cooling circuit to minimise impact on occupants' comfort (i.e. there will be no modification in the set-points of the areas served by the chillers).

5.4.1.1.2 Evaluation scheme

All the time series data requirements, related KPIS with intermediate calculations are summarized in Figure 22.

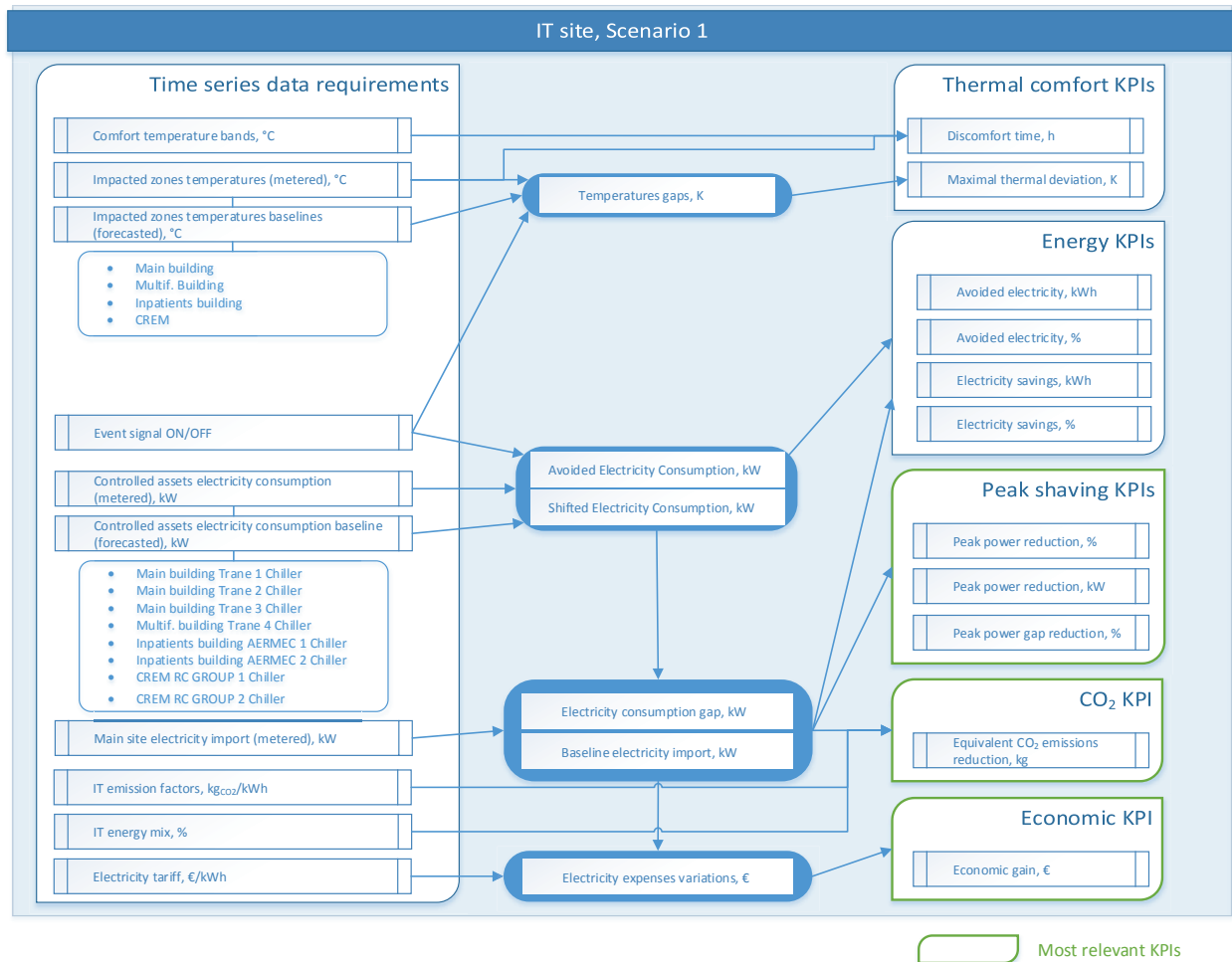


Figure 22: Italian site / Scenario 1 scheme for quantitative evaluation

5.4.1.2 ITALY - Scenario 2

5.4.1.2.1 Short description

In this scenario, members of the administration staff and personnel with access to a personal computer are asked to reduce small power consumption at a given time, i.e. by unplugging the laptop, turning off printers and monitors, etc. The rationale of this DR action is load shedding based on dynamic energy pricing (as a function of ToU tariff and generation availability from the CCHP). Members of the administration staff will receive emails with requests and reminders and will be also asked to provide feedbacks about their participation.

5.4.1.2.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 23.

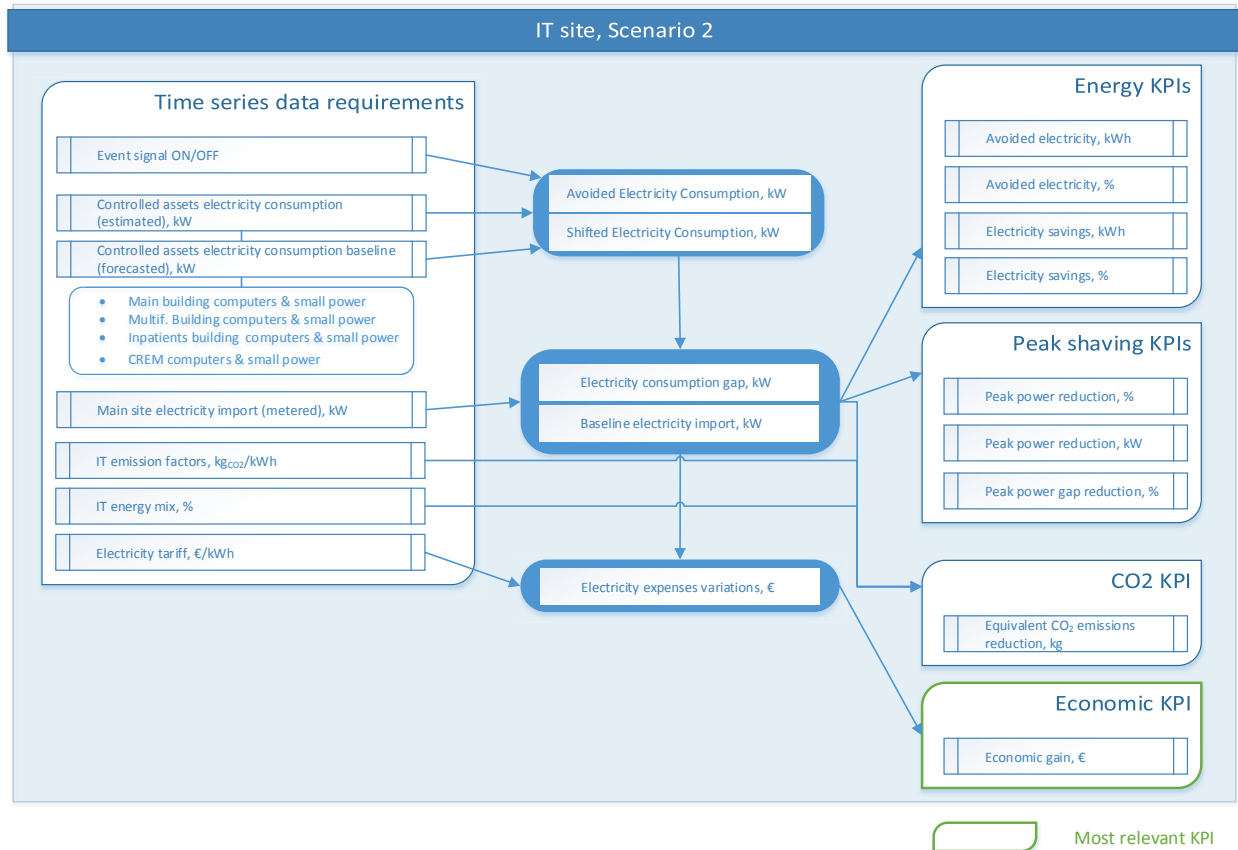


Figure 23: Italian site / Scenario 2 scheme for quantitative evaluation

5.4.1.3 ITALY - Scenario 3

5.4.1.3.1 Short description

Scenario 3 is similar to Scenario 2 for it is triggered by the same dynamic pricing opportunities. However in this case the scenario is focused on shifting the use of food-carts by delaying/anticipating the whole cooking and delivery process by 30 minutes. The canteen staff currently follows a well-defined schedule for this. The ideas is to anticipate or delay this time-schedule of 30 minutes based on internal DR request.

5.4.1.3.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 24.

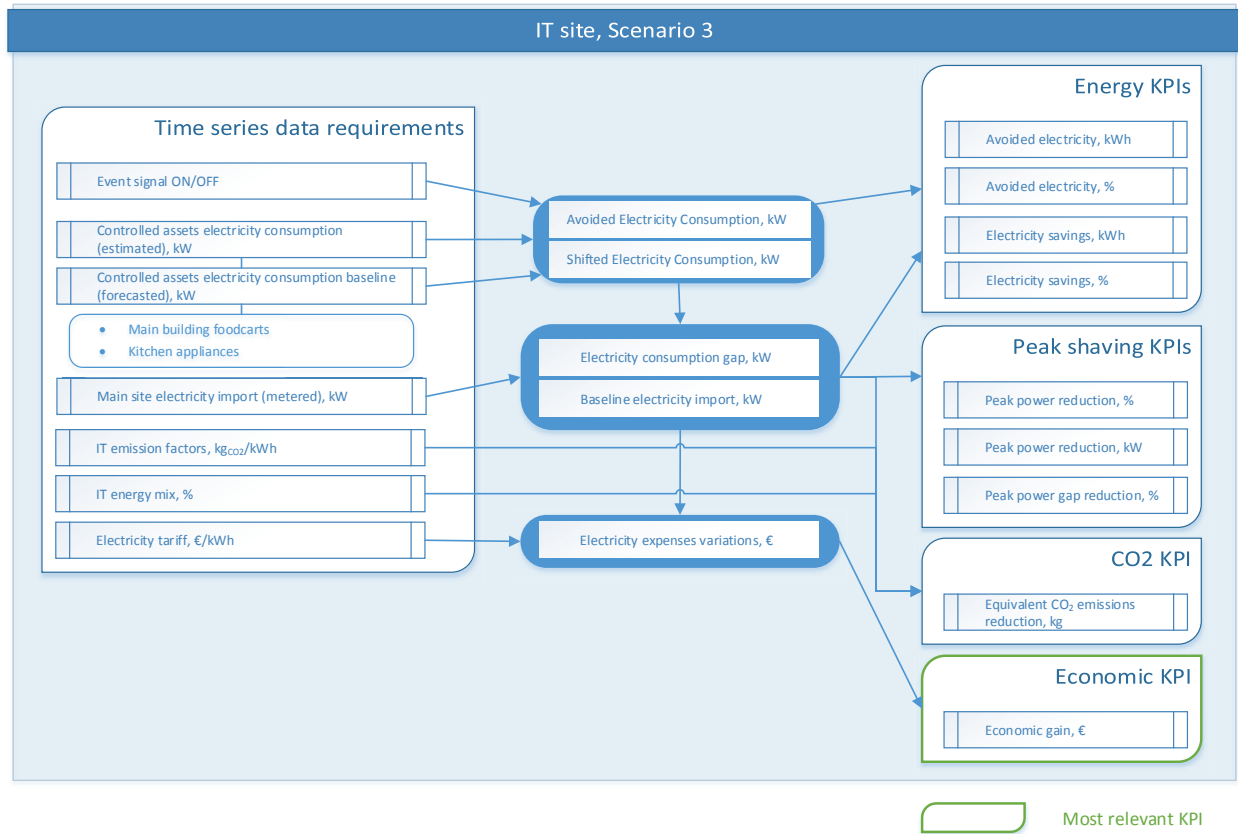


Figure 24: Italian site / Scenario 3 scheme for quantitative evaluation

5.4.1.4 ITALY - Scenario 4

5.4.1.4.1 Short description

Scope to this scenario is to optimise the use of the generation assets of the hospital in order to minimise energy cost. This involves all energy vectors (electricity, heat, cool, gas, steam - see image below) and is done on a daily basis. The outcome is a set of recommendations/useful information that allows the building EM to schedule the use of generation assets in the most cost-optimal way for the next 24 hours. The comparison is to be done with the default schedule for the day.

5.4.1.4.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 25.

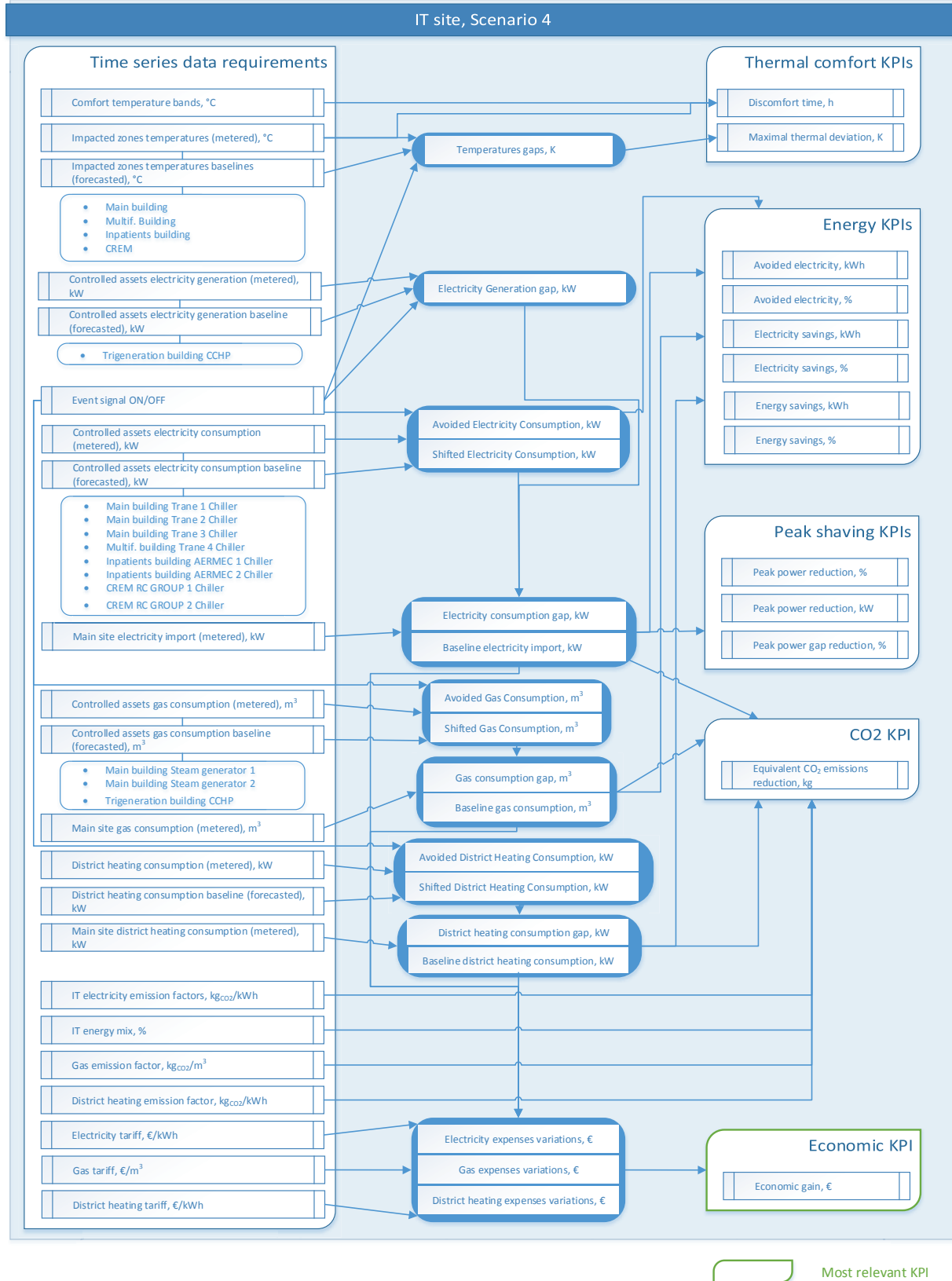


Figure 25: Italian site / Scenario 4 scheme for quantitative evaluation

5.4.2 SYNTHESIS OF REQUIRED DATA

5.4.2.1 Time series data

5.4.2.1.1 Meter readings (energy consumption)

The list of all required meter readings for quantitative evaluation is presented in Table 27.

Most of the data can be provided directly from the DEMS. It could also be possible to transfer the data from the local FTP server (supplied by Zucchetti).

Some other data will have to be provided directly from the pilot site. And finally, a few readings will not be available (due to technical limitations) and impact the evaluation strategies.

Here, the lack of individual meters for food warmers, personal computers & small power will affect the evaluation for scenario 2 and 3, which will be done through the use of electricity consumption at the BoB level (including other assets not under the DR-BoB scope) and completed by the qualitative evaluation. This problem may present a risk for the results consistency, as we are not able to evaluate the impact only on the involved assets.

The baselines will be calculated and provided separately (see section 3.4). The RC GROUP Chillers electricity consumption will also be provided separately by the BMS (Desigo).

Table 27: List of required meter readings from IT pilot site for quantitative evaluation

Thematics	Building	Asset	Unit	Baseline need	Data provider	Time step	Scenario
Gas consumption	Trigeneration building	CCHP	m ³	✓	DEMS	15 min	4
	Main building	kitchen	m ³	✓	DEMS	15 min	3
		Steam generator 1	m ³	✓	DEMS	15 min	4
		Steam generator 2	m ³	✓	DEMS	15 min	4
District heating consumption	Main building	District heat exchanger	kWh	✓	DEMS	15 min	4
Electricity generation	Trigeneration building	CCHP	kWh	✓	DEMS	15 min	4
	FP	PV	kWh	X	DEMS	15 min	4
Electricity consumption	FP Block of Buildings	-	kWh	✓	DEMS	15 min	all
	Main building	personal computers & small power	kWh	✓	unavailable		2
		Trane 1 chiller	kWh	✓	DEMS	15 min	1
		Trane 2 chiller	kWh	✓	DEMS	15 min	1
		Trane 3 chiller	kWh	✓	DEMS	15 min	1
		Food warmers	kWh	✓	unavailable		3

	Inpatients building	personal computers & small power	kWh	✓	unavailable		2
		AERMEC 1 chiller	kWh	✓	DEMS	15 min	1
		AERMEC 2 chiller	kWh	✓	DEMS	15 min	1
	CREM	personal computers & small power	kWh	✓	unavailable		2
		RC GROUP 1 chiller	kWh	✓	BMS	15 min	1
		RC GROUP 2 chiller	kWh	✓	BMS	15 min	1
	Multif. Building	personal computers & small power	kWh	✓	unavailable		2
		Trane 4 chiller	kWh	✓	DEMS	15 min	1

5.4.2.1.2 Temperature readings

No temperature of the potentially impacted zones for the DR events (scenarios 1 and 4) can be collected at now, as the connection with the local FTP is not fully operative (which could be before the beginning of the summer of the evaluation period).

As there are hundreds of temperatures sensors in the FP Block of Buildings, a similar approach to that adopted by TU will be adopted, but with usage segmentation (patient rooms/surgery rooms depending) instead of spatial segmentation (by building levels quadrants, see paragraph 5.2.2.1.2), because of the plurality of comfort temperature bands depending on the type of room. The exact corresponding measured temperatures will be stated during the evaluation period.

This may not impact the evaluation of scenario 1, as events will be run in summer. Nevertheless, the evaluation of thermal comfort KPIs for scenario 4 could be delayed, although there should normally be no impact. Indeed, there will not be set-point modification or control strategy. The hospital is already using different heat sources (the district heating and the steam generators) and these are coupled to make sure the water set point is always met. The CCHP will be integrated in the existing system with the same rational. The secondary circuit of both heat and cool will work exactly the same as before.

Other useful temperatures to collect are the chillers outlet set points (involved in scenario 1) and the outdoor temperature.

The baselines will be calculated and provided separately (see section 3.4).

In terms of thermal comfort, the EN 15251 defines hospitals as Category I, but does not specify recommended temperature bands (as it depends on the room type -as surgery rooms, patient rooms- and the type of service –specific diseases, newborns, etc. -).

By analogy with other sedentary uses, the standard considered temperatures bands will be 20-21°C in winter and 24-25°C in summer. Typical setpoints in the hospital are 20-24 °C with 40-60% of relative humidity. For surgery rooms, the range is stricter and lower and varies depending on the type of operating room. More precisions on related temperature comfort bands will be provided in the following deliverable D5.2.

5.4.2.1.3 Energy prices

The time series data related to the energy prices that will be collected are related in Table 28. The signals and tariffs will be provided both by the LEM and ME.

Table 28: IT site – description of variable energy prices

Energy	Unit	Name	Data provider	Time step
Electricity	€/kWh	ToU tariff	LEM or ME	15 min
	€/kWh	Virtual CPP tariff		
Gas	€/m ³	tariff		
District heating	€/kWh	tariff		

More details on these prices can be found in Table 29. As before, for constant prices, the 15 min time step is not necessary and a single value will be provided. Gas and district heating are characterised by a fixed price, i.e. a price that does not change during the day. In particular, for gas, the price is composed by an energy component (i.e. the cost of the gas itself) and a fixed component that accounts for the distribution network. For the district heating, there is only a fixed component (that includes both energy and distribution).

Table 29: IT site –energy prices details

Commodity	Unit	Fixed component	Energy component			VAT	Total		
			F1	F2	F3		F1	F2	F3
Gas Commodity Price	€/Sm3	0.0340	0.1780			22%	0.2586		
ToU Commony Price	€/kWh	0.0750	0.0480	0.0480	0.0398	22%	0.1501	0.1501	0.1401
District Heating Price	€/kWh	0.0607				22%	0.0740		

The electricity price is instead a Time of Use tariff, i.e. a tariff that changes during the day and also according to the day of the week (see Table 30).

This concerns only the energy component, i.e. the cost of electricity. In Italy there are three time bands (F1, F2, F3), as reported in the following table and graphical representation in Table 31.

Table 30: IT site – electricity ToU tariff time bands

Time band	Starting time	Ending time	Days
F1 (Peak)	08:00	19:00	M to F without bank holidays
F2 (Intermediate)	07:00	08:00	M to F without bank holidays
F2 (Intermediate)	19:00	23:00	M to F without bank holidays
F2 (Intermediate)	07:00	23:00	Saturday without bank holidays
F3 (Off-peak)	23:00	07:00	Monday to Saturday
F3 (Off-peak)	00:00	24:00:00	Sunday and bank holidays

Table 31: IT site – electricity ToU tariff time bands (graphical representation)

Ore del giorno	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
lunedì	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
martedì	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
mercoledì	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
giovedì	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
venerdì	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
sabato	F3	F3	F3	F3	F3	F3	F3	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F2	F3
domenica	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3	F3

In addition to the energy component there is also a fixed component (that is based on the contractual demand of the hospital) and that accounts for transmission, distribution and other fixed components.

5.4.2.1.4 CO₂

The time series data related to CO₂ KPI that will be collected are the national energy mix for electricity production, which should be collected from the ENTSOE-E database.

The emission factors related to electricity will be collected from the ecoinvent database, and linked to the generation sources by using the weightings described in annex (Table 39).

The emission factor related to the gas combustion is reported in annex (Table 38).

The emission factor related to the district heating is estimated to 0.173 kg_{CO2}/kWh_{heat}, based on the ecoinvent database version 2.2 (the values and related weightings are defined in Table 32).

The heat production sources of the hospital district heating is 40% from waste incineration, and the rest from CHP and boilers (using mainly gaz).

Table 32: Considered emission factors for Italian site district heating [source: ecoinvent 2.2, world values, 2015]

Source type	Emission factor (kg _{CO2} /kWh _{heat})	Weighting
Biomass (waste)	0.118	40%
CHP natural gas	0.144	30%
Natural gas	0.274	30%

5.4.2.2 Data related to DR events

All data related to the DR events (Time and duration of the events, participating assets, financial reward, feedback gathered from users, participation results available) will be gathered from the Consumer Portal following the common communication strategy that will be described in Section 6.

5.5 ROMANIA

5.5.1 ADAPTATION OF KPIS TO THE SCENARIOS

5.5.1.1 ROMANIA - Scenario 1

5.5.1.1.1 Short description

Demonstration Scenario 1 aims to temporally reduce TUCN peak power demand for the upcoming day by shifting / rescheduling the working hours of chillers, ventilations units, etc away from national peak power demand periods. This scenario assumes temporary interruptions to cooling 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.

5.5.1.1.2 Evaluation scheme

All the time series data requirements, related KPIS with intermediate calculations are summarized in

Figure 26.

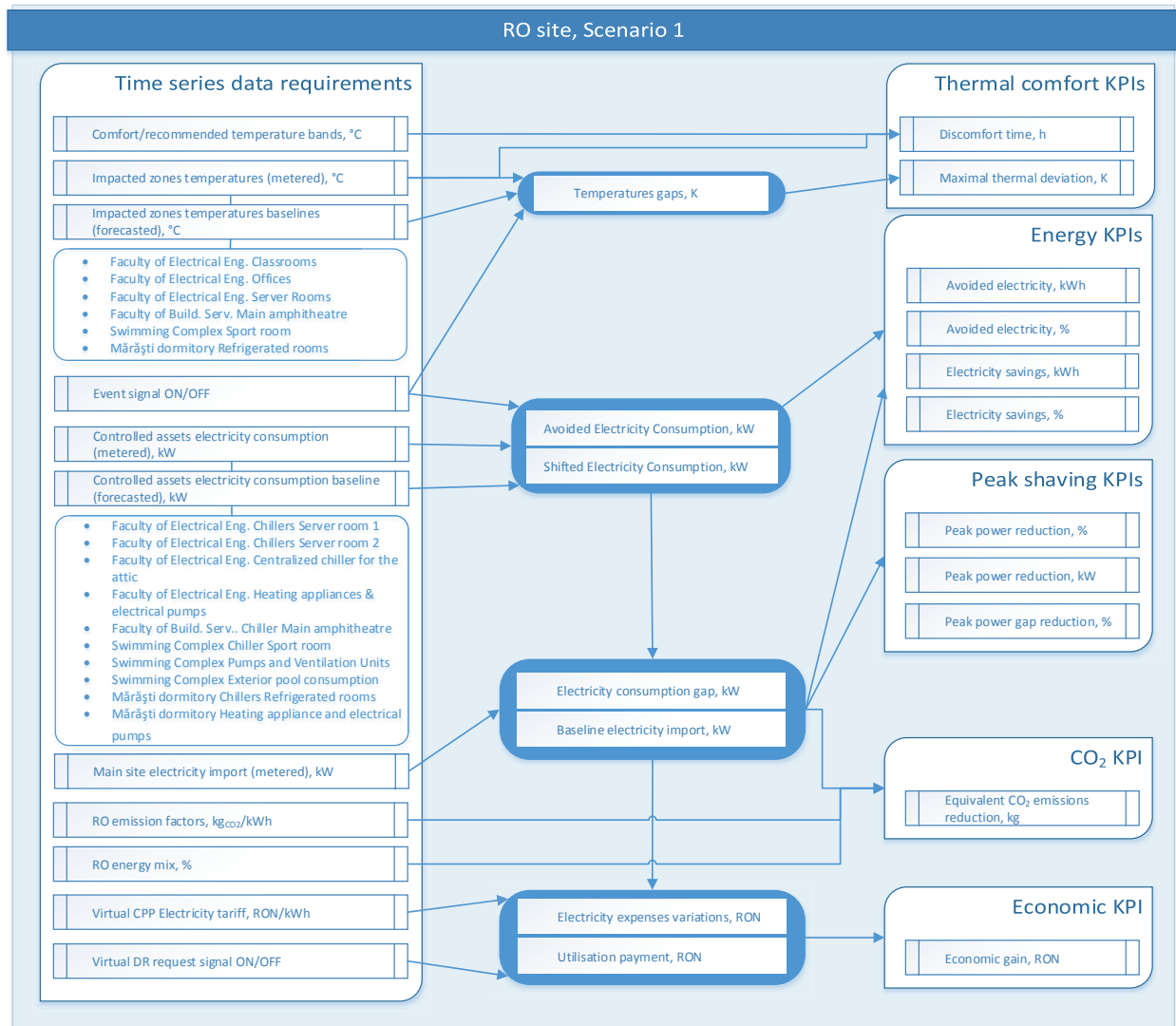


Figure 26: Romanian site / Scenario 1 scheme for quantitative evaluation

5.5.1.2 ROMANIA - Scenario 4

5.5.1.2.1 Short description

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.

5.5.1.2.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 27.

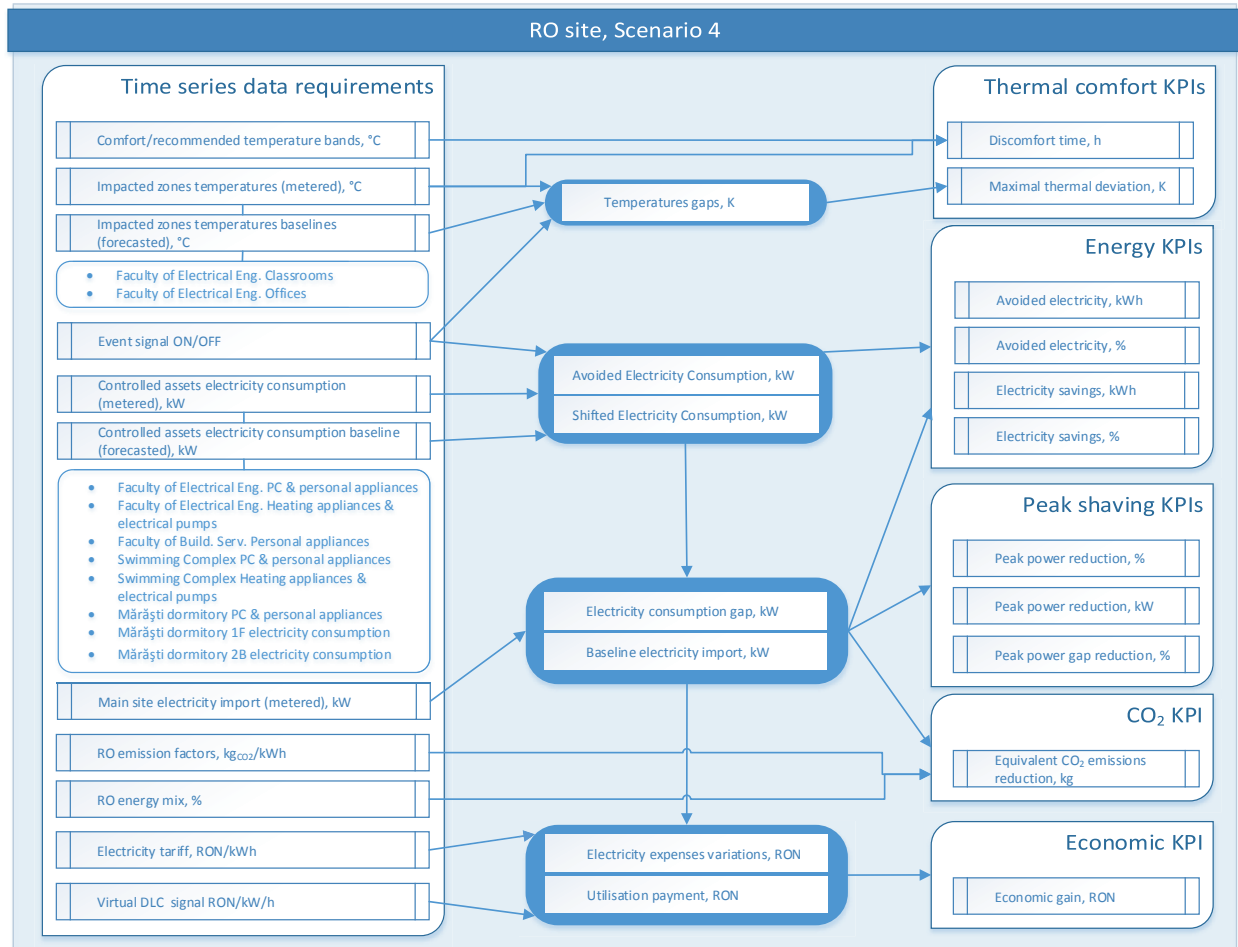


Figure 27: Romanian site / Scenario 4 scheme for quantitative evaluation

5.5.1.3 ROMANIA - Scenario 5

5.5.1.3.1 Short description

Demonstration Scenario 5 aims to permanently reduce TUCN buildings' peak power demand by rescheduling the use of high power equipment. Before the start of the academic year high power equipment staff will be asked to plan their work for the entire semester outside national peak power demand periods, introducing a break in their schedule for this period. The potential shift will be quantified as if a Time of Use tariff was charged.

5.5.1.3.2 Evaluation scheme

All the time series data requirements, related KPIs with intermediate calculations are summarized in Figure 28.

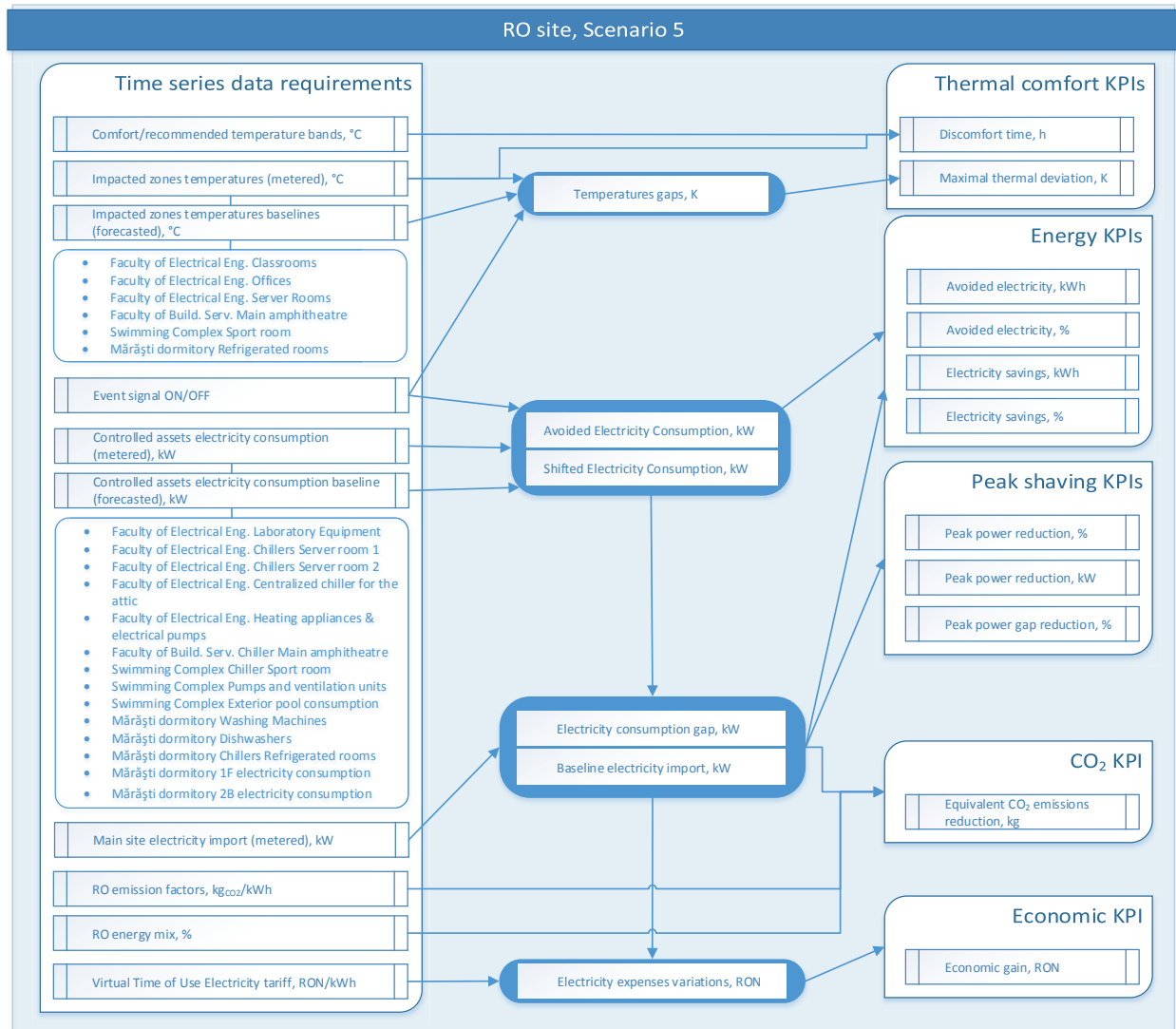


Figure 28: Romanian site / Scenario 5 scheme for quantitative evaluation

5.5.2 SYNTHESIS OF COLLECTED DATA

5.5.2.1 Time series data

5.5.2.1.1 Meter readings (energy consumption)

The list of all required meter readings for quantitative evaluation is presented in Table 33.

Most of the data can be provided directly from the DEMS. Some other data will not be available (due to technical limitations) and impact the evaluation strategies.

Here, the lack of sub metering for PC, personal appliances, laboratory equipment, washing machines, dishwashers, and specific appliances at the Swimming pool complex will affect the precision of the evaluation for all scenarios, that will be done through the use of electricity consumption at the building level (including other assets not under the DR-BoB scope) and completed by a qualitative evaluation. This problem may present a risk for the results consistency, as we are not able to evaluate the impact only on the involved assets.

The baselines will be calculated and provided separately (see section 3.4).

Table 33: List of required meter readings from RO pilot site for quantitative evaluation

Thematics	Location	Asset	Unit	Baseline need	Data provider	Time step	Scenario
Electricity consumption	Electrical engineering (B1-6)	general	kWh	✓	DEMS	15 min	all
		Heating appliances and electrical pumps	kWh	✓	DEMS	15 min	all
		Centralized chiller attic	kWh	✓	DEMS	15 min	1,5
		Chillers server room 1	kWh	✓	DEMS	15 min	1,5
		Chillers server room 2	kWh	✓	DEMS	15 min	1,5
		PC & personal appliances	kWh	✓	not available		4
		laboratory equipment	kWh	✓	not available		5
	Faculty of Building Services (B7-8)	general	kWh	✓	DEMS	15 min	all
		Chiller main amphitheatre	kWh	✓	DEMS	15 min	1,5
		personal appliances	kWh	✓	not available		4
	Dormitories (B9-10) + Student Restaurant (B11)	general	kWh	✓	DEMS	15 min	all
		Dormitory 1F	kWh	✓	DEMS	15 min	4,5
		Dormitory 2B	kWh	✓	DEMS	15 min	4,5
		PC and personal appliances	kWh	✓	not available		4

		washing machines	kWh	✓	not available		5
		dishwashers	kWh	✓	not available		5
		refrigerated rooms chiller	kWh	✓	DEMS	15 min	1,5
		Heating appliances and electrical pumps	kWh	✓	DEMS	15 min	1
	Swimming pool (B12-13)	general	kWh	✓	DEMS	15 min	all
		exterior pool	kWh	✓	DEMS	15 min	1,5
		Pumps and ventilation units	kWh	✓	not available		1,5
		PC and personal appliances	kWh	✓	not available		4
		Heating appliances and electrical pumps	kWh	✓	not available		4
		Chiller Sport room	kWh	✓	DEMS	15 min	1,5

5.5.2.1.2 Temperature readings

Apart from the Restaurant refrigerated room temperatures, all temperatures readings will be provided by the BEMS.

The potentially impacted zones have already been identified.

At the Electrical Engineering Office, 1 sensor in one office representing the most unfavourable comfort conditions in the Attic has been selected (where the main chiller provides cooling). The 2 sensors in the server rooms (inside the server cores, with a temperature setpoint of 24°C) will be recorded. As there will be no cooling or controlled assets providing cooling in Classrooms, there will not be recordings in these areas.

At the Faculty of Building Services, the sensor inside the Main Amphitheatre will be recorded.

At the Student restaurant, 1 sensor inside the refrigerated rooms will be recorded.

At the Swimming pool, 1 sensor inside the Sport Room will be recorded. The temperature set point is 25°C.

The list of temperatures in the impacted zones for the DR events are reported in Table 34.

The baselines will be calculated and provided separately (see section 3.4).

Table 34: RO site – description of temperature readings

Location	Zone or room	Baseline need	Number of sensors	Setpoint	Comfort temperatures		Data provider	Time step	Scenario
					Winter	Summer			
Electrical engineering (B1-6)	Offices	✓	1	20-26°C	20-24°C	23-26°C	BEMS	15 min	all
	Classrooms	X	0	-	-	-	BEMS	15 min	all
	Server rooms	✓	2	24°C	16-40°C	16-40°C	BEMS	15 min	1,5
B7 - Faculty of Building Services, Main building	Main amphitheater	✓	1	20-26°C	20-24°C	23-26°C	BEMS	15 min	1,5
B11 - Student Restaurant	Refrigerated rooms	✓	1	unknown	unknown	unknown	DEMS	15 min	1,5
B12 - Indoor Swimming pool	Sport room	✓	1	25°C	24-26°C	24-26°C	BEMS	15 min	1,5
Outdoor		X	1	-	-	-	BEMS	15 min	all

In the offices and main amphitheatre, comfort temperatures will be set at 20-24°C in winter and 23-26°C in summer as specified in the EN 15251 Annex A3 (Category II related to offices and spaces with similar activity - single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms-)

In the server room, temperature bands will be set at 16-40°C as recommended by the IT service. Set point and temperature limits for the refrigerated rooms will be defined in D5.2 deliverable.

In the sport room, temperature bands will be set at 24-26°C during all year as the indoor temperature has a continuous set point of 25°C.

5.5.2.1.3 Energy prices

The time series data related to the energy prices that will be collected are related in Table 35. **These prices may change throughout the project and may be redefined in the D5.2 deliverable, with further description of these tariffs.**

The signals and tariffs will be provided both by the LEM and ME. As before, for constant prices, the 15 min time step is not necessary and a single value will be provided.

Table 35: RO site – description of variable energy prices

Energy	Unit	Name	Data provider	Time step
Electricity	RON/kWh	basic tariff	LEM	15 min
	RON/kWh	Virtual CPP tariff	ME	
	RON/kWh	Virtual ToU tariff	LEM	
	RON/kWh	Virtual DLC signal	LEM	

The basic electricity tariff is of 8,0625 c€/kWh (~0.4 RON/kWh).

5.5.2.1.4 CO₂

The time series data related to CO₂ KPI that will be collected are the national energy mix for electricity production, which should be collected from the ENTSOE-E database.

The emission factors related to electricity will be collected from the ecoinvent database, and linked to the generation sources by using the weightings described in annex (Table 39).

5.5.2.2 Data related to DR events

All data related to the DR events (Time and duration of the events, participating assets, financial reward, feedback gathered from users, participation results available) will be gathered from the Consumer Portal following the common communication strategy that will be described in Section 6.

6 IMPLEMENTATION OF EVALUATION STRATEGIES

6.1 FRAMEWORK FOR APPLICATION OF EVALUATION STRATEGIES

KPIs and calculation methods has been defines in the previous sections. This section is used to show how the evaluation methods will be implemented. The evaluation of the demonstration sites corresponds to tasks T5.2, T5.3, T5.4 and T5.5 (for the 4 sites). These tasks involve analysing the qualitative and quantitative data (provided by tasks 4.2 to 4.5) using the methodology developed in this deliverable (Task 5.1). The evaluation period for the pilot sites will begin in October 2017 and will last 1 year.

The partners involved in tasks 4.2 to 4.5 will collect the required data for the analysis. These data has been defined and validated by the partners.

The data for the quantitative evaluation will come from the DRBOB technical solution mainly (i.e. the DEMS, the LEM, the CP and the ME) and from the demo sites (e.g. some data as temperatures coming from the BMS of pilot sites or energy prices). Moreover the baseline data will be provided by Siemens outside of the DRBOB solution.

The data for the qualitative evaluation will be provided by the pilot partners in application of the qualitative evaluation, using questionnaires as defined in the consumer panels (see §4) or using the Consumer Portal of GridPocket.

In order to gather all the data needed for evaluation, a centralized FTP server has been supported by CSTB.

CSTB will be in charge to calculate the KPIs applying the algorithms defined in section 3.5 of this document.

Then the analysis of both quantitative and qualitative evaluation (including the contextual explanations of the findings) will be managed by the national partners leading the tasks 5.2 to 5.5 with the support of Siemens.

All these results will contribute to the writing of the Deliverable D5.2 “Evaluation of demonstration sites”.

The implementation scheme for evaluation of demonstration sites is described in Figure 29. And the details of data collection is described in Figure 30.

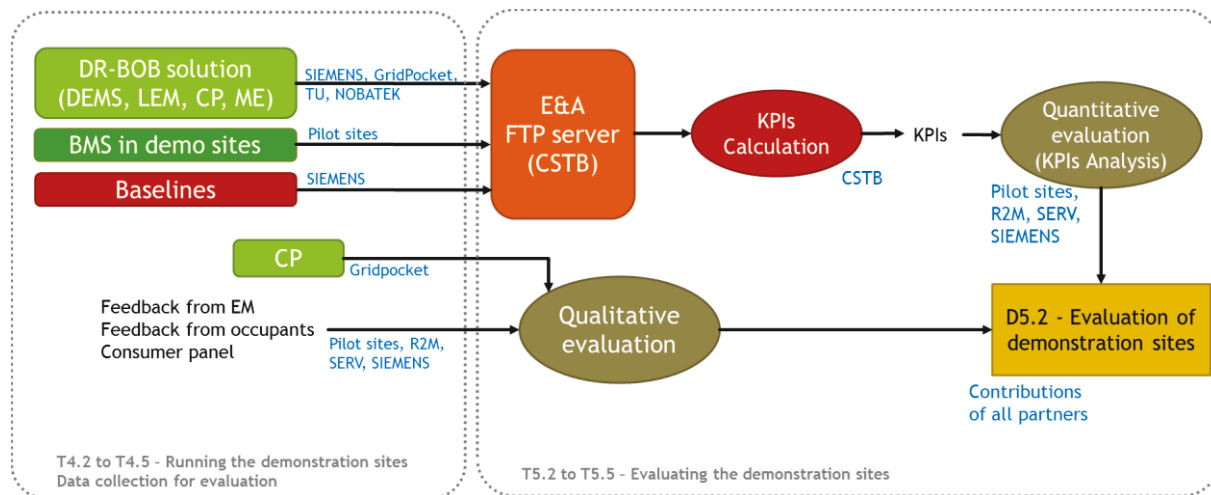


Figure 29: Implementation scheme for evaluation of demonstration sites

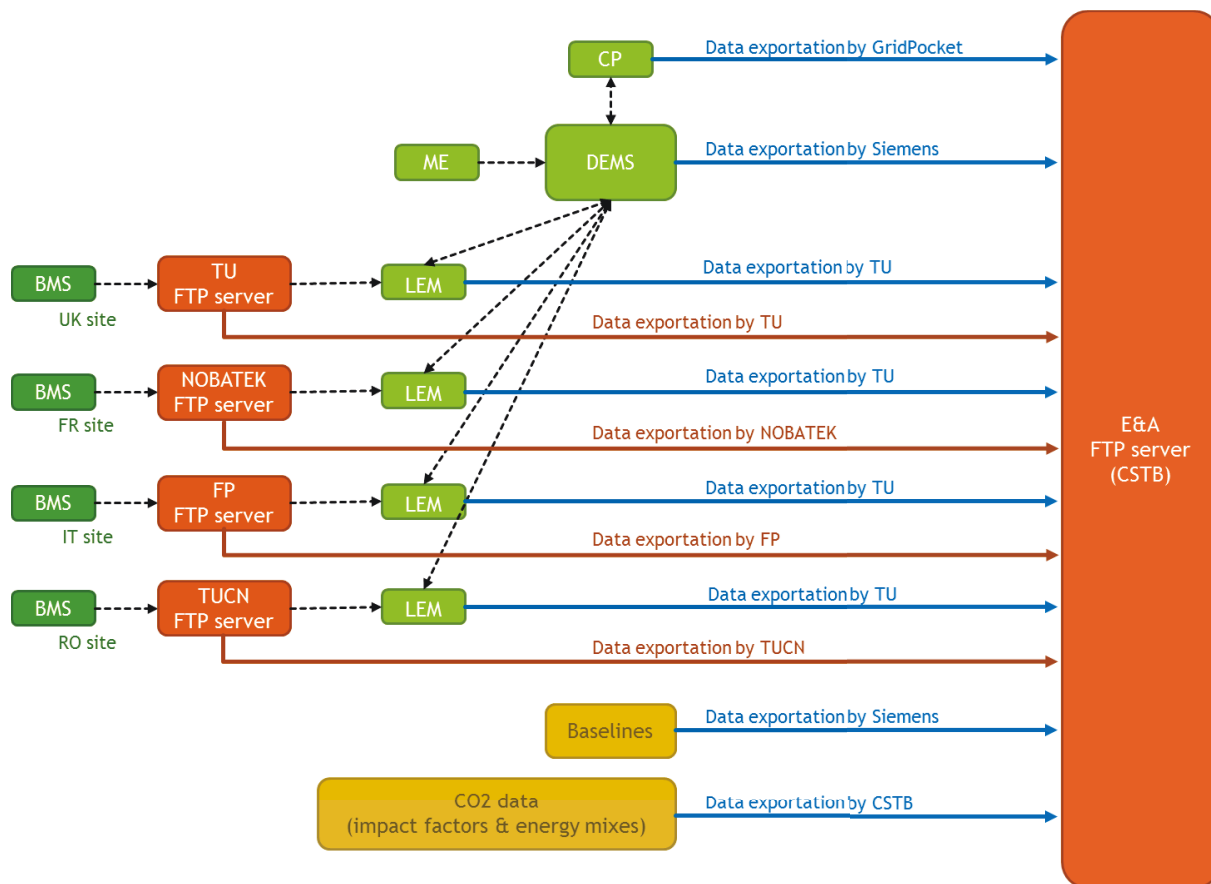


Figure 30: Data collection scheme for evaluation of demonstration sites

6.2 DATA COLLECTION SPECIFICATIONS FOR EVALUATION AND ANALYTICS

In order to gather all the data needed for evaluation, a centralized FTP server has been supported by CSTB. The structure and specifications asked to data providers are described in Appendix C. The expected contribution and upload frequency are summarized in the following.

6.2.1 EXPECTED CONTRIBUTIONS OF PARTNERS

All contributions are summarized in Table 36.

Table 36: Summary of expected contributions in Dr-BoB partners to the data collection

Contributor(s)	Expected action(s)
CSTB	Collect CO ₂ data (CO ₂ impact factors, energy mixes)
Siemens	Upload DEMS data on the FTP server: <ul style="list-style-type: none"> All requested energy time series (.csv) All requested temperature time series (.csv) All csv column headers descriptions (.json)
	Collect the time series where the baseline is needed on the FTP
	Calculate and upload the baselines time series on the FTP server: <ul style="list-style-type: none"> All requested energy time series (.csv) All requested temperature time series (.csv) All csv column headers descriptions (.json)
Teesside University	Upload to the FTP server: <ul style="list-style-type: none"> requested LEM data <ul style="list-style-type: none"> UK site temperature time series (.csv) requested prices time series (.csv) simulated backup generators fuel consumption (.csv) All csv column headers descriptions except prices (.json)
Gridpocket	Upload events to the FTP server: <ul style="list-style-type: none"> Events data (.json) Feedback gathered from users (free format) Participation results available (free format)
Nobatek	Upload to the FTP server: <ul style="list-style-type: none"> requested ME data <ul style="list-style-type: none"> requested prices time series (.csv) All BMSs rooms temperatures (.csv) All BMSs csv column headers descriptions (.json)
FP, R2M	Upload to the FTP server: <ul style="list-style-type: none"> CREM RC GROUP Chillers electrical consumptions (.csv) Temperatures averages, min and max as stated (.csv) Chillers outlets set points (.csv) All csv column headers descriptions (.json)
TUCN, Servelect	Upload all requested BEMS data to the FTP server : <ul style="list-style-type: none"> All requested temperature time series (.csv) All csv column headers descriptions (.json)

6.2.2 UPLOAD FREQUENCY

Table 37 indicates the upload frequency to the FTP server depending on the type of data and the data provider.

Table 37: Upload frequency for different types of data and data provider

Type of data	Data provider	Upload frequency
Prices time series data	All	Ad-hoc
Time series description metadata	All	
Feedback gathered from users	CP	
Participation results available	CP	
Event metadata	CP	60 days
Baselines	Siemens	
Temperature metering	BMS, Other	
Energy metering		
Temperature metering	DEMS	Everyday - automatically
Energy metering		
Temperature metering	LEM	Everyday - automatically
Energy metering		

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8 CONCLUSIONS

Deliverable D5.1 introduced Key Performance Indicators into 5 categories, which reflect the expected impacts defined in the project's DoA, in terms of Energy saving, Peak Power shaving, CO2 emissions reduction, Economy and User engagement.

The definition of the indicators highlighted some essential methodological elements: in particular the determination of the baseline which serves as a reference for evaluating the impacts, the spatial and temporal perimeter for the analysis.

It was chosen to calculate indicators for each DR event to be able to make a statistic analysis and compare it according to different contextual factors (climatic season, day of the week, moment in the day, duration of DR, and other parameters). The aggregate impacts for the entire 1-year evaluation period will also be calculated to measure the cumulative benefits of the implemented Demand-Respond programs.

For the baseline, the consortium preferred to develop a new method rather than using the predictions available in the LEM and DEMS technologies for reasons of integrity and credibility. This new approach, to be developed by SIEMENS, will be based on the 'average method' with adjustments, for which reference publications were identified.

The algorithms for the calculation of quantitative KPIs has been written and will have to be coded in computer to analyse the measurement data that will be collected in each demo site.

As for the qualitative evaluation regarding the consumers' engagement, addressing thermal comfort, consumer participation and acceptance of the DR interventions, an explorative yet pragmatic and feasible approach has been set up.

The DR-BoB project is focused on the demonstration of different technologies in real life contexts, implying that the users of those BoBs will be affected or even actively engaged. The owners of these BoBs can be regarded as customers of the DR-BoB solution and their building managers are the direct users of the solution. In addition in each BoB there is a large group of 'indirect users' i.e. the building occupants. Hence we address both the direct and the indirect users in the qualitative evaluation to learn how the solutions match with the everyday practices and routines of the users of these buildings.

Taking a closer look at the scenarios, we can observe that some of the demonstration scenarios will have no impact at all on users (these are scenarios where only the source of energy is temporarily changed). However, for other scenarios, occupants will be affected and we can in fact distinguish three levels of expected impact or involvement:

- Occupants will hardly notice anything
- Occupants are actively involved and asked to turn off or unplug appliances during peak hours
- Occupants are actively involved and are asked to shift their activities to another moment

As for the qualitative evaluation, the plan is threefold:

- Qualitative comparison of the implementation with the original ideas: assess what has actually been implemented (compared to baseline scenario plans) and compare actual involvement of users and occupants with expected involvement
- Have pilot partners conduct interviews with the direct users (i.e. building -, energy-, facility manager and their team) to collect their feedback on the DR intervention, the communication, the response options, how participation in DR events has affected their daily working routines and practices
- Set up consumer panels with occupants (occupant panels) to collect feedback on the interventions, the communication, the response options and how it has affected comfort and daily routines

The templates for these consumer panels has been developed and should be adapted thereafter to each case.

An important part of the work was to adapt the KPIs and the evaluation to the DR scenarios and pilot sites. Indeed Key Performance Indicators and evaluation methods are generic and not all indicators are relevant for all DR programs.

The adapted KPIs have been selected for each DR scenario and calculation schemes for the evaluation of quantitative indicators have been drawn. These schemes allow to identify the necessary input data. This deliverable presents the synthesis of required data for each pilot site. It concerns mainly high frequency time series data for energy consumption, temperatures, energy prices, CO2 and DR event data. All the measurement data come from different sources (DRBOB implemented technologies, BMS...) that have been specified.

The last chapter presents how the evaluation and validation strategies of the demonstrations will be applied in the next steps of the work in WP5. The application framework is described with the role of each partner and the specifications for data collection.

9 APPENDICES

9.1 APPENDIX A. TEMPLATE QUALITATIVE EVALUATION

9.1.1 INTRODUCTION

9.1.1.1 *Aims and objectives*

This template has been developed by DuneWorks in order to support the demo site partners in setting up a qualitative evaluation approach. In addition, it provides clarity on what sort of information and feedback is sought in order to be able to make a comparison between the demosites. In order to be able to do that, the collected feedback will need to be translated in English and shared with DuneWorks.

9.1.1.2 *Background considerations*

A distinction is made between on the one hand the direct users of the DR BoB solutions, which are the building -, facility -, energy managers, and on the other hand the indirect users which are the building occupants and can be staff, students, visitors, patients, etc.

9.1.2 DIRECT USERS: ENERGY -, FACILITY -, BUILDING MANAGERS

Due to the limited number of direct users and the already existing direct contacts the DR BoB pilot managers have with them, providing an interview template to be used for interviews before, during and after the demonstration is suitable. The pilot partners can conduct these interviews at the start of, during and after the demonstration, whereby questions are asked about the communication of the DR events (and the use of the CP), the DR events themselves, the response options, how participation affects their daily working routines and behaviours and questions about how they appreciate this participation. A template for this will be provided in September 2017.

9.1.3 INDIRECT USERS: DIVERSE TYPES OF BUILDING OCCUPANTS

The indirect users are the building occupants, e.g. staff members, students, visitors, patients, service providers in the BoBs, etc.

9.1.4 CONSUMER PANELS AS A LEARNING TOOL

For the evaluation among indirect users, at each demosite a ‘consumer panel’ will be set up. Dedicated consumer/user panels are commonly used in product evaluations whereby a group of dedicated users is asked to provide feedback at set points in time – e.g. via group discussions, workshops, individual interviews, surveys, etc. The aim of such user panels is to collect as much and as diverse feedback as possible, which is very important when the product or service introduced is new and when – for that reason – little experience with how users appreciate it has been gathered so far. It allows for the provider to learn to what extent their expectations regarding user experiences match the their real-life experiences of real users. Next, identified mismatches can be addresses to improve the service or product provided.

In analogy to these types of user panels, we will gather feedback through ‘occupant’ panels at the DR BoB demosites. The following section presents a template to help devise the approach for the qualitative evaluation at each site using occupant panels.

9.1.5 TEMPLATE FOR EACH DEMO SITE (TO BE FILLED IN BY THE DEMOSITE PARTNERS)

Three segments of occupants can be distinguished (considering that we do not include occupant that experience no impact at all because only in the source of energy is changed (for further explanation of segment A-C we refer to our ppt or our paper)

- A. Occupants will hardly notice anything: set-point changes of heating and cooling installations are done by the building manager
- B. Occupants (or some of them) are actively involved: they are asked to manually turn off or unplug appliances during peak hours in case of a DR event.
- C. Occupants (or some of them) are actively involved: in case of a DR event, they are asked to shift practices in time: e.g. to charge their Electrical Vehicle (UK) on a different moment; to shift use of washing machines in student dorms (RU); to shift cooking schedules (IT)

Filing in the tables below for segment A, B and C will allow the demosite partners to develop a tailored evaluation approach for the different segments and scenarios.

9.1.6 SEGMENT A TEMPLATE

1. Scenario and segment:

	Scenario number (e.g. UK S2)	
	Scenario entails what DR intervention:	
	Segment A, B or C and brief explanation:	
	How is your communication about this scenario towards the occupants planned and/or conducted (e.g. see your communication plans):	

2. Feedback wished for (first inventory)

	What feedback would you like to get from the occupants on (the impacts of this) scenario? And what would you like to learn from them:
	<ul style="list-style-type: none"> - Communication (e.g. how did the occupants appreciate the communication, the means used, frequency, messaging; was it understandable; did it appeal to them (why?); did they use the CP and if so, how did they like the public portal (visual appeal; messages; clarity; etc). Other remarks:)
	<ul style="list-style-type: none"> - Response options (mainly relevant for segments B and C) (e.g. how did occupant appreciate the response options? Did it make sense to them, did it raise questions, and if so which ones? Other remarks:)

	<ul style="list-style-type: none"> - Impact of DR event and response option on occupants' behaviours, activities and on comfort, convenience, well-being (mainly relevant for segments B and C) (e.g. how did the response affect their usual routines and behaviours? Did they have to make a change and if so how did they find that (e.g. annoying, no problem at all, - and why?) What if response options like these would become part-and-parcel of their working here in these buildings (not just during the demo but thereafter as well), how would they appreciate that? Why?) ? Other remarks:)
	<ul style="list-style-type: none"> - Influence of the context on ability to change or to accept the change (e.g. do you know who initiated the DR events? What would you need to be able to participate or accept the change? Other remarks:)
	<ul style="list-style-type: none"> - Influence of context on willingness to change or to accept the change (e.g. do you know who initiated the DR events? If it is your employer who asks you to accept or participate in the DR events, how do you feel about that? If you would participate, why would you do so? Other remarks:)

3. How would the occupant panel look like?

	<ul style="list-style-type: none"> - How many occupants will be affected by this scenario?
	<ul style="list-style-type: none"> - What is the running time? Number of events?
	4. What is the expected impact from the point of view of the DR solution provider?
	5. How many people to recruit for feedback on this scenario?
	<ul style="list-style-type: none"> • How to recruit? (e.g. via personal contacts; advertisement; ask team leaders; student leaders; others to help out)? • Will you any rewards (like e.g. free lunch or some gadget)
	<ul style="list-style-type: none"> • When to recruit? (when did/do you start, when does it stop)
	<ul style="list-style-type: none"> • Which forms do you intend to use and in what order? (e.g. first group meetings/workshops; then brief email surveys to the same people; followed by brief interviews and a final group meeting etc), and what is the timing and how will that ensure

	you that you collect feedback at the beginning, during the demonstration and afterwards)?
	<ul style="list-style-type: none"> • Is there an overlap of this group of occupants with occupants involved in other scenarios?
	<ul style="list-style-type: none"> • How will you use the overall communication strategy to recruit and inform occupants about the occupant panels?
	<ul style="list-style-type: none"> • Your time resources and competences

Depending on the sort of occupants panels and manner of interactions (e.g. survey, focus groups, timing of feedback rounds) and depending on your scenario, you can start formulating more specific questions that you would like to see answered with regard to the topics, when the above template is filled in for each segment.

9.1.7 SEGMENT B TEMPLATE

6. Scenario and segment:

	Scenario number (e.g. UK S2)	
	Scenario entails what DR intervention:	
	Segment A, B or C and brief explanation:	
	How is your communication about this scenario towards the occupants planned and/or conducted (e.g. see your communication plans):	

7. Feedback wished for (first inventory)

	What feedback would you like to get from the occupants on (the impacts of this) scenario? And what would you like to learn from them:
	<ul style="list-style-type: none"> - Communication (e.g. how did the occupants appreciate the communication, the means used, frequency, messaging; was it understandable; did it appeal to them (why?); did they use the CP and if so, how did they like the public portal (visual appeal; messages; clarity; etc). Other remarks:)

	<ul style="list-style-type: none"> - Response options (mainly relevant for segments B and C) (e.g. how did occupant appreciate the response options? Did it make sense to them, did it raise questions, and if so which ones? Other remarks:)
	<ul style="list-style-type: none"> - Impact of DR event and response option on occupants' behaviours, activities and on comfort, convenience, well-being (mainly relevant for segments B and C) (e.g. how did the response affect their usual routines and behaviours? Did they have to make a change and if so how did they find that (e.g. annoying, no problem at all, - and why?) What if response options like these would become part-and-parcel of their working here in these buildings (not just during the demo but thereafter as well), how would they appreciate that? Why?) ? Other remarks:)
	<ul style="list-style-type: none"> - Influence of the context on ability to change or to accept the change (e.g. do you know who initiated the DR events? What would you need to be able to participate or accept the change? Other remarks:)
	<ul style="list-style-type: none"> - Influence of context on willingness to change or to accept the change (e.g. do you know who initiated the DR events? If it is your employer who asks you to accept or participate in the DR events, how do you feel about that? If you would participate, why would you do so? Other remarks:)

8. How would the occupant panel look like?

	<ul style="list-style-type: none"> - How many occupants will be affected by this scenario?
	<ul style="list-style-type: none"> - What is the running time? Number of events?
	9. What is the expected impact from the point of view of the DR solution provider?
	10. How many people to recruit for feedback on this scenario?
	<ul style="list-style-type: none"> • How to recruit? (e.g. via personal contacts; advertisement; ask team leaders; student leaders; others to help out)? • Will you any rewards (like e.g. free lunch or some gadget)
	<ul style="list-style-type: none"> • When to recruit? (when did/do you start, when does it stop)

	<ul style="list-style-type: none"> • Which forms do you intend to use and in what order? (e.g. first group meetings/workshops; then brief email surveys to the same people; followed by brief interviews and a final group meeting etc), and what is the timing and how will that ensure you that you collect feedback at the beginning, during the demonstration and afterwards)?
	<ul style="list-style-type: none"> • Is there an overlap of this group of occupants with occupants involved in other scenarios?
	<ul style="list-style-type: none"> • How will you use the overall communication strategy to recruit and inform occupants about the occupant panels?
	<ul style="list-style-type: none"> • Your time resources and competences

Depending on the sort of occupants panels and manner of interactions (e.g. survey, focus groups, timing of feedback rounds) and depending on your scenario, you can start formulating more specific questions that you would like to see answered with regard to the topics, when the above template is filled in for each segment.

9.1.8 SEGMENT C TEMPLATE

11. Scenario and segment:

	Scenario number (e.g. UK S2)	
	Scenario entails what DR intervention:	
	Segment A, B or C and brief explanation:	
	How is your communication about this scenario towards the occupants planned and/or conducted (e.g. see your communication plans):	

12. Feedback wished for (first inventory)

	What feedback would you like to get from the occupants on (the impacts of this) scenario? And what would you like to learn from them:
	<ul style="list-style-type: none"> - Communication (e.g. how did the occupants appreciate the communication, the means used, frequency, messaging; was it understandable; did it appeal to them (why?); did

	they use the CP and if so, how did they like the public portal (visual appeal; messages; clarity; etc). Other remarks:)
	- Response options (mainly relevant for segments B and C) (e.g. how did occupant appreciate the response options? Did it make sense to them, did it raise questions, and if so which ones? Other remarks:)
	- Impact of DR event and response option on occupants' behaviours, activities and on comfort, convenience, well-being (mainly relevant for segments B and C) (e.g. how did the response affect their usual routines and behaviours? Did they have to make a change and if so how did they find that (e.g. annoying, no problem at all, - and why?) What if response options like these would become part-and-parcel of their working here in these buildings (not just during the demo but thereafter as well), how would they appreciate that? Why?) ? Other remarks:)
	- Influence of the context on ability to change or to accept the change (e.g. do you know who initiated the DR events? What would you need to be able to participate or accept the change? Other remarks:)
	- Influence of context on willingness to change or to accept the change (e.g. do you know who initiated the DR events? If it is your employer who asks you to accept or participate in the DR events, how do you feel about that? If you would participate, why would you do so? Other remarks:)

13. How would the occupant panel look like?

	- How many occupants will be affected by this scenario?
	- What is the running time? Number of events?
	14. What is the expected impact from the point of view of the DR solution provider?
	15. How many people to recruit for feedback on this scenario?
	<ul style="list-style-type: none"> • How to recruit? (e.g. via personal contacts; advertisement; ask team leaders; student leaders; others to help out)? • Will you any rewards (like e.g. free lunch or some gadget)

	<ul style="list-style-type: none"> • When to recruit? (when did/do you start, when does it stop)
	<ul style="list-style-type: none"> • Which forms do you intend to use and in what order? (e.g. first group meetings/workshops; then brief email surveys to the same people; followed by brief interviews and a final group meeting etc), and what is the timing and how will that ensure you that you collect feedback at the beginning, during the demonstration and afterwards)?
	<ul style="list-style-type: none"> • Is there an overlap of this group of occupants with occupants involved in other scenarios?
	<ul style="list-style-type: none"> • How will you use the overall communication strategy to recruit and inform occupants about the occupant panels?
	<ul style="list-style-type: none"> • Your time resources and competences

Depending on the sort of occupants panels and manner of interactions (e.g. survey, focus groups, timing of feedback rounds) and depending on your scenario, you can start formulating more specific questions that you would like to see answered with regard to the topics, when the above template is filled in for each segment.

Plan provision of feedback to DuneWorks

For D5.3, DuneWorks needs your feedback from the building occupants that has been collected during several moments in time.

In addition, we would also like to get an overview of the more specific questions that you will address in the (various forms you use in the) occupant panels (for segment A, B, C).

We want to be able to collect and compare the feedback from the diverse occupant segments at each site for D5.3. That means that we also need to develop templates with questions that will be asked at the demonstration sites – which will reveal an overlap at least.

We need to further plan that the coming months.

9.2 APPENDIX B. CO₂ EMISSION FACTORS (ELECTRICITY AND FUELS)

9.2.1 EMISSION FACTORS FOR FUELS COMBUSTION

Table 38: Considered fuels properties and emission factors for the project

		ICP		Density		EF	
Type of fuel	Concerned countries	GJ/T	source	kg/m ³	source	kg _{CO2} /kWh _{ICP}	source
Natural gas	UK, FR, IT	48	Decision 2007/589/CE	654	Directive 1999/100/CE (at 15°C)	0,239	ADEME carbon database (europe)
Diesel	UK	43	Directive 2009/28 CE	845	Circular n°9501 of 28/12/2004	0,323	
Wood	FR			-		negligible	

The considered values of the emission factors consider the upstream (extraction and transit) and the combustion processes. More details can be found on the AMEDE carbon database report (ADEME, 2017).

The wood fuel for FR site is supposed to be coming from waste, so the related emissions should be negligible (the combustion process belongs to the “short” carbon cycle, as long as the burnt biomass is rapidly balanced by the other biomass growth).

9.2.2 EMISSION FACTORS WEIGHTING FOR ELECTRICITY

As the granularity is more precise for the ecoinvent emission factors than for the ENTSOE-E generation sources, the following hypothesis will be made for weighting:

- When the type of technology is not expected in the country (ex: nuclear power, alpine hydropower) or if the data is not available in the databases (ex: geothermal power, offshore wind power), the corresponding weighting of the emission factor is zero
- For all other emission factors of the corresponding production source, the weighting corresponds to the ratio of the related installed power (when the information is available)
- When the installed power is not precise enough (ex: fossil fuel installed power, hydro power, nuclear power), the weighting is set as uniform

All related weightings are reported in Table 39. The specified installed power corresponds to the ENTSOE-E inventory of generation 2016.

The numerical values of emission factors (in kg_{CO2}/kWh_{elec}) will be extracted from the ecoinvent database (ECOINVENT, 2017).

Table 39: Emission factors weightings related to electricity production sources, installed power and available informations

MIX production source [ENTSOE-E]	Corresponding emission factor(s) [ECOINVENT]	UK		France		Italy		Romania	
		Installed power (MW) [ENTSOE-E]	Weighting	Installed power (MW) [ENTSOE-E]	Weighting	Installed power (MW) [ENTSOE-E]	Weighting	Installed power (MW) [ENTSOE-E]	Weightings
Biomass	heat and power co-generation, biogas, gas engine	Not Expected	-	390	20%	809	26%	Not Expected	-
	heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014	1377	100%	656	34%	1920	63%	118	100%
Coal	electricity, from municipal waste incineration to generic market for electricity, medium voltage	Not Expected	-	881	46%	324	11%	Not Expected	-
	electricity production, lignite	Not Expected	-	Not Expected	-	Not Expected	50%	Not Expected	100%
Oil	electricity production, hard coal	Not Expected	100%	Not Expected	100%	Not Expected	50%	Not Expected	0%*
	electricity production, oil	Not Expected	50%	Not Expected	50%	Not Expected	50%	Not Expected	50%
Gas	heat and power co-generation, natural gas, at conventional power plant	46930	25%	21806	33%	66534	25%	8185	33%
	heat and power co-generation, natural gas, conventional power plant, 100MW electrical		25%		33%		25%		33%
	electricity production, natural gas, combined cycle power plant		25%		33%		25%		33%
	heat and power co-generation, natural gas, combined cycle power plant, 400MW		25%		0%		25%		-
Geothermal	electricity production, deep geothermal	Not Expected	-	Not Available	0%	961	100%	Not Available	0%
	electricity production, hydro, reservoir, alpine region	Not Expected	-	25091	33%	25801	33%	Not Expected	-
Hydro	electricity production, hydro, pumped storage	3920	50%	25091	33%	25801	33%	6405	50%
	electricity production, hydro, run-of-river	Not Expected	50%	25091	33%	25801	33%	6405	50%
Nuclear	electricity production, nuclear, boiling water reactor, heavy water moderated	Not Expected	-	Not Expected	-	Not Expected	-	1300	50%
	electricity production, nuclear, pressure water reactor	9230	50%	63130	100%	Not Expected	-	1300	50%
Solar	electricity production, nuclear, boiling water reactor	Not Expected	50%	Not Expected	-	Not Expected	-	Not Expected	-
	electricity production, photovoltaic, 3kW/p slanted-roof installation, multi-Si, panel, mounted	Not Expected	-	1087	8%	Not Expected	-	1301	50%
Wind	electricity production, photovoltaic, 3kW/p slanted-roof installation, single-Si, panel, mounted	Not Expected	-	1087	8%	Not Expected	-	1301	50%
	electricity production, photovoltaic, 570kW/p open ground installation, multi-Si	11500	100%	5685	84%	4249	100%	Not Expected	-
Wind	electricity production, wind, <1MW turbine, onshore	Not Expected	-	14	0%	Not Expected	-	6	0%
	electricity production, wind, >3MW turbine, onshore	10000	33%	11748	50%	9087	50%	2959	50%
	electricity production, wind, 1-3MW turbine, onshore	10000	33%	11748	50%	9087	50%	2959	50%
	electricity production, wind, 1-3MW turbine, offshore	5000	33%	Not Available	0%	Not Expected	-	Not Expected	-

9.3 APPENDIX C: FTP SERVER STRUCTURE AND REQUIREMENTS

9.3.1 LEVEL 1: HISTORICAL DATA / DATA COLLECTION

The FTP server is actually containing 2 folders:

- **Historical_data**: data concerning the period before evaluation (already gathered by all pilot sites), in order to provide annual comparisons
- **Data_collection**: specific data to be gathered during the evaluation period

9.3.2 LEVEL 2 (FROM DATA_COLLECTION): PILOT SITES FOLDERS

The folder is divided in 4 sub-folders (1 per pilot site: **UK, FR, IT, RO**).

9.3.3 LEVEL 3: DATA SOURCE FOLDERS

Each site folder will contain 7 new sub-folders (1 per data source: **DEMS, LEM, ME, CP, BMS, Baselines, Other**)

The involved DR-BoB partners are indicated in Table 40.

Table 40: DR-BOB data providers

Data folder	Data provider
DEMS	Siemens
LEM	Teesside University
ME	Nobatek
CP	Gridpocket
BMS	UK: Teesside University FR: Nobatek IT: Fondazione Poliambulanza along with R2M RO: Technical University of Cluj-Napoca along with Servelect
Baselines	Siemens
Other	Any partner

“Other” data folder can be provided by anyone (for other important additional information such as logs, feedback from occupants, EM reports, etc). The data format and names can be defined by the data provider)

9.3.4 LEVEL 4: THEME FOLDERS

Each data source folder will contain different subfolders depending on provided data:

- **TEMP subfolder** (if convenient for the data provider), in order to upload data properly: the files can be put here and then moved the other directories when finished. This stops any problems with other applications trying to read the file before the transfer has finished. The data provider is in charge of the upload and moving process.

- **Energy_Time_Series** subfolder (if provided data)
- **Temperature_Time_Series** subfolder (if provided data)
- **Prices Time_Series** subfolder (if provided data)
- **Event_Data** subfolder (if provided data)

9.3.5 TIME SERIES AND METADATA FILES

The **Time_series** folders will contain the **time series data** with CSV format and the metadata description file with JSON format (except for prices).

The number of csv files inside each folder will depend on the type of data and the data provider.

Basically:

- The DEMS and LEM data should provide about 350 csv files (1 csv per day)
- The B(E)MS and Baseline data should provide about 6 csv files (1 every 2 months)
- Prices time series can be provided in a single csv file

Each csv file should contain all the columns of the requested data.

The following requirements for these files are:

- All column IDs must have a description in the Meta_Data file (see below)
- For high frequency variables (data collected by DEMS/LEM, there must be 1 file per day from midnight to midnight)
- For all other data, it can be concatenated in a separate file with a larger base (60 days or 1 year depending on the type of data and the provider)
- The time step interval must be the smallest available (ideally 15 min or below) and has to be defined by the data provider.
- Date index must have the format yyyy-mm-dd HH:MM
- The names have to be defined by the data providers, but for DEMS/LEM it should contain the date of the day (yyyy_mm_dd)

Template:

“XXX_2017_10_01.csv” :

	1332152017	1332153500	...
2017-10-01 00:00	0.52	2.5	...
2017-10-01 00:15	0.46	3.6	...
2017-10-01 00:30	0.67	2.7	...
2017-10-01 00:45	0.55	3.4	...
...
2017-10-01 23:45	0.41	1.9	...
2017-10-02 00:00	0.39	2.4	...

Temperature_Time_series and **Energy_Time_Series** folders should also contain a **metatada description file** with JSON format, which should be uploaded once. These files give the structure

of the data that is provided (not the data itself e.g. meter values). These files must indicate the following information on each column header of the CSVs:

- Column ID in all uploaded csv files (uploaded in Time_series folder, ex: “sensor 1332152017”)
- Building
- Zone (for temperature data)
- Virtual asset
- Explicit meter name (ex: “Tower gas”)
- Category (ex: “Electricity import”, “Gas consumption”, “Temperature”, “Tariff”, etc.)
- Unit
- Channel type (“Physical Meter”, “Estimation”, “Forecast”, and “Simulation”). As a reminder, here are the following definitions:
 - Physical Meter: a measurement device on site is collecting the data physically (ex: electromechanical meter, thermohygrometer, etc.)
 - Estimation: the data is not metered physically, but is calculated with the aim of representing the reality (even during DR events)
 - Forecast: the data is calculated with the aim of predicting a virtual value based on a learning data set (ex: metered data without DR events)
 - Simulation: the data is calculated with the aim of predicting a virtual value based on a simulation tool which does not include any data learning process
- Controlled asset installed power in kW (for energy meters only)
- Uncontrolled asset installed power in kW (for energy meters only)

Example 1: energy time series description

```
{ "Time series": [
  { "Channel_ID": '1332152017',
    "Meter name": "Tower boilers gas meter",
    "Location": "Middlebrough Tower"
    "Virtual asset": "Boiler"
    "Category": "Gas consumption"
    "Unit": "m3"
    "Channel type": "Physical meter"},
  { "Channel_ID": '1332153500',
    "Meter name": "Stephenson Building Elec",
    "Location": "Stephenson building",
    "Virtual asset": "All",
    "Category": "Electricity import",
    "Unit": "kWh",
    "Channel type": "Physical meter"
  "Controlled assets power": 100
  "Uncontrolled assets power": 150},
  {...},
  {...}
]
```

Example 2: temperature time series description

```
{ "Time series": [
  { "Channel_ID": '4854x9f821',
    "Meter name": "Clarendon_SE_average",
    "Location": "Clarendon" ,
    "Zone": "SE_quadrant"
    "Category": "Temperature"
    "Unit": "C"
    "Channel type": "Estimation"},
  {...},
  {...}
]
```

9.3.6 EVENT DATA FILES

The **Event_data** folder will contain the event files with JSON format (1 per event), that must indicate the following events information:

- Scenario number
- Start date
- Duration
- Participating assets
 - Structured list of opt-in assets
 - Structured list of opt-out assets
- Financial reward or other kind of reward

Example:

```
{ "Event": [
  { "Scenario": '1',
    "Start date": '01/10/2017 10:00',
    "Duration": "30 min",
    "Opt-in assets": ["Clarendon General areas Chiller 1", "Clarendon
General areas Chiller 2"],
    "Opt-out assets": ["Constantine HVAC", "Clarendon Heating and
Ventilation Panel"],
    "Financial rewards": { "Currency": "GPB", "Utilization payment": 60 ,
Availability payment: 30} ]
}
```

The names of the files have to be defined by the data providers. The only requirements are:

- to have the scenario number in the event files names
- to avoid spaces and special characters

The frequency of upload of all files can be in an ad-hoc base (whenever the data changes).

9.3.7 PREVIEW OF FTP DATA STRUCTURE

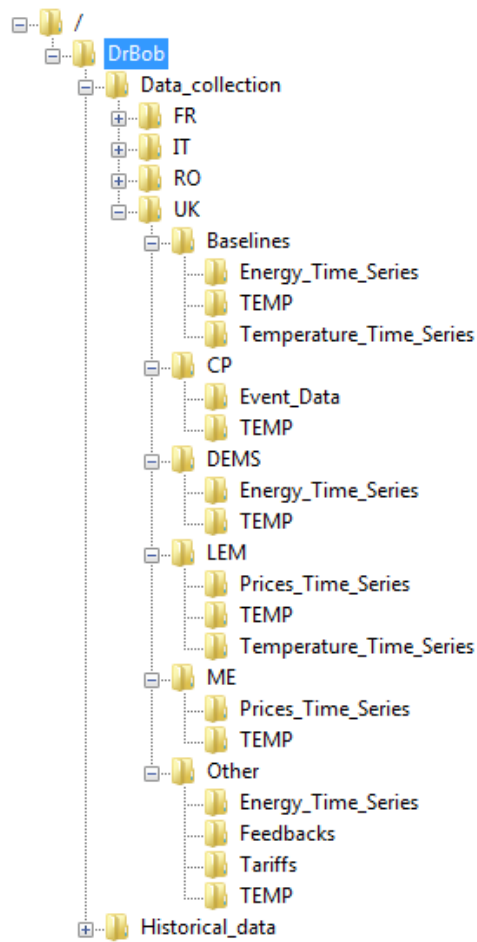


Figure 31: Preview of FTP data structure