BaaS

Building as a Service

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Plan of Implementation of Measure and Verification Methodology in Pilot Buildings

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Deliverable Summary Sheet

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Deliverable 6.3.1: Short Description

This document contains the Plan of implementation of the methodology of measure and verification in BaaS building demonstrators.

Keywords: M&V Plan, IPMVP Process

Deliverable 6.3.1: Revision History

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1.0	30/06/2014	Final	Final version
1.1	10/07/2014	Final	CARTIF: Review according DoW

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Abbreviations and Acronyms

BaaS	Building as a Service
ESCO	Energy Services Company
DWH	Data Warehouse
ECM	Energy Conservation Measure
DoW	Document of Work
M&V	Measurement & Verification
HVAC	Heating, Ventilation and Air Conditioning
KPI	Key Performance Indicators
IPMVP	International Performance Measurement and Verification Protocol
SES	Sierra Elvira School
HDD	Heating Degree Day
CDD	Cooling Degree Day
RAD	Solar Radiation
WP	Workpackage
ABE	Adjusted Baseline Energy
R^2	Coefficient of Determination
SE	*Standard Error*

Executive Summary

The purpose of this document is to apply the Measurement and Verification methodology selected in the framework of the project (see D1.2 - *Energy saving measurement and verification methodology to evaluate the BaaS solution*), in order to evaluate the energy savings related to the implementation of the Energy Conservation Measures (ECM) deployed in BaaS System in the demo sites.

These ECMs have been driven through the definition of specific use cases (see D5.1.b - *Advanced Use Cases*) considering the existing energy systems and building controls in the demosites, therefore this methodology will be applied to each use case, defining for each of them the necessary parameters defined in the methodology.

This document contains the definition of the M&V Plan, specified by Demosite Building, considering the necessary baseline period, reporting period and parameters which adjust the measured energy consumption.

As stated in the DoW, this document is completed with other two reports containing the information about the results measured during the baseline period and reporting period, including the results of the energy savings resulted from the comparison of the adjusted baseline with the reported measured consumptions.

With the content included in this deliverable, all the necessary information in order to start the baselining period of the validation of the BaaS solution is delivered.

1 Introduction

The objectives of Measurement and Verification Plan (M&V) are to provide an impartial, credible, transparent and replicable process that can be used to quantify and assess the impacts and sustainability of the BaaS project.

M&V Plan should assess the initial energy situation of buildings and energy systems, explore energy efficiency measures proposed for energy savings, define the different parameters that influence the generation of energy savings and finally establish a procedure for calculating energy savings generated against the initial energy situation. The whole plan is framed within the concept of energy saving, economic evaluation of the results, generating periodic reports, continuous measurement and impartiality of the results. Each M&V Plan follows a common structure, but must adapt independently to each building or energy system. So three different plans should be performed for each of the Pilots.

The conclusions obtained from the M&V Plan will serve to evaluate the energy savings and cost savings generated by the BaaS system, allowing to know the possibilities for replication and implementation as energy saving system. To make decisions about whether to invest in BaaS for obtaining savings in energy systems.

1.1 Purpose and target group

Measure and Verification Plan is usually employed by ESCO or energy efficiency project investors to verify energy savings generated by ECMs and established contract conditions. ESCO will design ECMs to generate energy savings, payed by an Energy Contract between Building Owner and ESCO. The way to verify energy saving in different periods or different conditions and apply this over Contract Rules is by a M&V Plan.

M&V Plan is an impartial tool inside Energy Contract to evaluate energy savings (kWh and €).

1.2 Contribution of partners

This task is headed by DALKIA, who is supported and monitored by CARTIF and Fraunhofer and the rest of research partners.

Table 1: Summary of Contributions of Partners

Partner	Deliverable Focus
DALKIA	Provide the M&V plan for Pilot Buildings to be implemented regarding the baseline, reporting period and basis for adjustment.
CARTIF	Support Dalkia on the Use Cases definition for CARTIF building and M&V plan related with this uses cases.
FHG	Support Dalkia on the Use Cases definition for ZUB building and M&V plan related with this uses cases.

1.3 Relation to other activities in the project

This deliverable continues with the work in the demonstration activities in the project (started in D6.1), and also the Research and Technological Development activities, which aims to the BaaS solution validation and standardization.

Table 2: D6.3 tasks relationship with other BaaS activities

Deliverable	Relationship
D1.2	D1.2 established the M&V methodology in order to validate the BaaS solution and the requirements of metering and monitoring for the demonstration buildings
D4.1	D4.1 provide information about the simulation models in the buildings.
D5.1.b	D5.1 indentify the Uses Cases and the KPI asociated
D6.1	D6.1 selected and provided the information of the demonstration buildings to be adapted in this taks
D6.2	D6.2 will be in charge of the analysis of the operation inefficiencies of the demonstration buildings, in order to deploy the M&V plan, baselining and reporting

2 International Performance Measurement and Verification Protocol.

International Performance Mesasurement and Verification Protocol (IPMVP) is a protocol develop by Efficiency Valuation Organization (EVO www.evo-world.org). EVO is a non-profit organization whose mission is to develop and promote the use of standardized protocols, methods and tools to quantify and manage the performance risks and benefits associated with end-use energy-efficiency, renewable-energy, and water-efficiency business transactions.

The International Performance Measurement and Verification Protocol (IPMVP) Volume I is a guidance document describing common practice in measuring, computing and reporting savings achieved by energy or water efficiency projects at end user facilities. The IPMVP presents a framework and four measurement and verification (M&V) Options for transparently, reliably and consistently reporting a project's saving. M&V activities include site surveys, metering of energy or water flow(s), monitoring of independent variable(s), calculation, and reporting. When adhering to IPMVP's recommendations, these M&V activities can produce verifiable savings reports.[1]

According to has been determined in the *Deliverable 1.2: "Energy Saving Measurement and Verification Methodology to evaluate the BaaS solution"* the methodology for verification and measurement will be the **IPMVP**.

To develop IPMVP methodology in each pilot is necessary to include at least 13 topics described in IPMVP Chapter 5:

1. ECM Intent
2. Selected IPMVP Option and Measurement Boundary
3. Baseline: Period, Energy and Conditions
4. Reporting Period: Identify the reporting period
5. Basis for Adjustment
6. Analysis Procedure
7. Energy Prices
8. Meter Specifications
9. Monitoring
10. Expected Accuracy
11. Budget
12. Report Format
13. Quality Assurance

Will be analized each of the topics in each BaaS Pilot, being some similar and some different.

[1] *International Performance Measurement and Verification Protocol (IPMVP) Volume I*

2.1 Energy Conservation Measure Intent.

TOPIC 1 ECM Intent.

Describe the ECM, its intended result, and the operational verification procedures that will be used to verify successful implementation of each ECM. Identify any planned changes to conditions of the baseline.

ECMs.

Once selected and analysed Pilot Buildings, different inefficiencies are detected and Use Cases are developing according with buildings possibilities. A shared ECM in all Pilots is ***BaaS System***; BaaS will be implemented in the three Pilots with the main objective, from energy point of view, to reduce energy consumption and generate energy savings. CARTIF Building and ZUB Building as are technically sophisticated buildings, which are also used for research and development activities, don’t need additional ECMs. SES Building was built in a common way without high level equipment, in this case other ECMs are necessary in order to achieve a first step of energy savings.

Table 3: ECM at Pilot buildings

Pilot	ECMs
CARTIF Building	BaaS System.
ZUB Building	BaaS System.
SES Building	BaaS System. Thermostatic Valves. Variable Flow Pumps.

Intended Results.

The expected amount of energy savings depends on the building, the results will be different depending on the potential for energy savings. In the case of CARTIF Building and ZUB Building, both buildings have a high energy equipment and variables associated with energy consumption are monitored continuously. Taking into account a previous data analysis from demosite leaders and Dalkia as ESCO company, energy savings expected with ***BaaS System*** are over 15%.

SES Building is a different case, where we have a standard building with a basic energy design, which has a potential for further savings. Besides installing ***BaaS System***, installation of thermostatic valves and pumps with variable flow will reduce energy demand. Taking into account Dalkia’s previous experiences as ESCO company, total expected energy savings, taking into account production and distribution energy systems, will be 20%.

Table 4: Intended Results at Pilot buildings

Pilot	Energy Savings Expected
CARTIF Building	15%
ZUB Building	15%
SES Building	20%

Verification Procedures.

To verify successful implementation of each ECM, we will define different verification procedures for each ECM.

BaaS System: The operability of the functions will be verified in the test-beds, before being implemented in pilot buildings. CARTIF Building and ZUB Building are simultaneously test-beds and pilots, so when the system is operating the ECM will be implemented. SES Building needs a first step of verification according with the implementation process in the test-beds, in the same way when the system is operating the ECM will be implemented.

Thermostatic Valves: Hydraulic installation verification of thermostatic valves will be used. The ECM will be implemented when the verifiación and commissioning tests are finished.

Variable Flow Pumps: Hydraulic installation verification of thermostatic valves will be used. The ECM will be implemented when the verifiación and commissioning tests are finished.

Table 5: ECM Verification Procedures

ECM	Pilot	Procedure
BaaS System	CARTIF Building ZUB Building SES Building	Test-beds verification. Commissioning test.
Thermostatics Valves	SES Building	Hydraulic verification. Commissioning test.
Variable Flow Pumps	SES Building	Hydraulic verification. Commissioning test.

Planned Changes.

The use of all buildings is stable for several years and is not planned any change from baseline.

2.2 Select IPMVP Option and Measurement Boundary.

TOPIC 2 Selected IPMVP Option and Measurement Boundary.

Specify which IPMVP Option will be used to determine savings. This identification should include the date of publication or the version number and Volume number of the IPMVP edition being followed. Identify the measurement boundary of the savings determination. Describe the nature of any interactive effects beyond the measurement boundary together with their possible effects.

In BaaS Project we will followed 'IPMVP Volume I EVO 10000-1:2012' that is the last version at this moment.

IPMVP Option.

IPMVP methodology has four different options depending how savings are calculated:

Option A: Partially Measured Retrofit Isolation.

Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous.

Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.

Option B: Retrofit Isolation.

Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.

Option C: Whole Facility.

Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.

Option D: Calibrated Simulation.

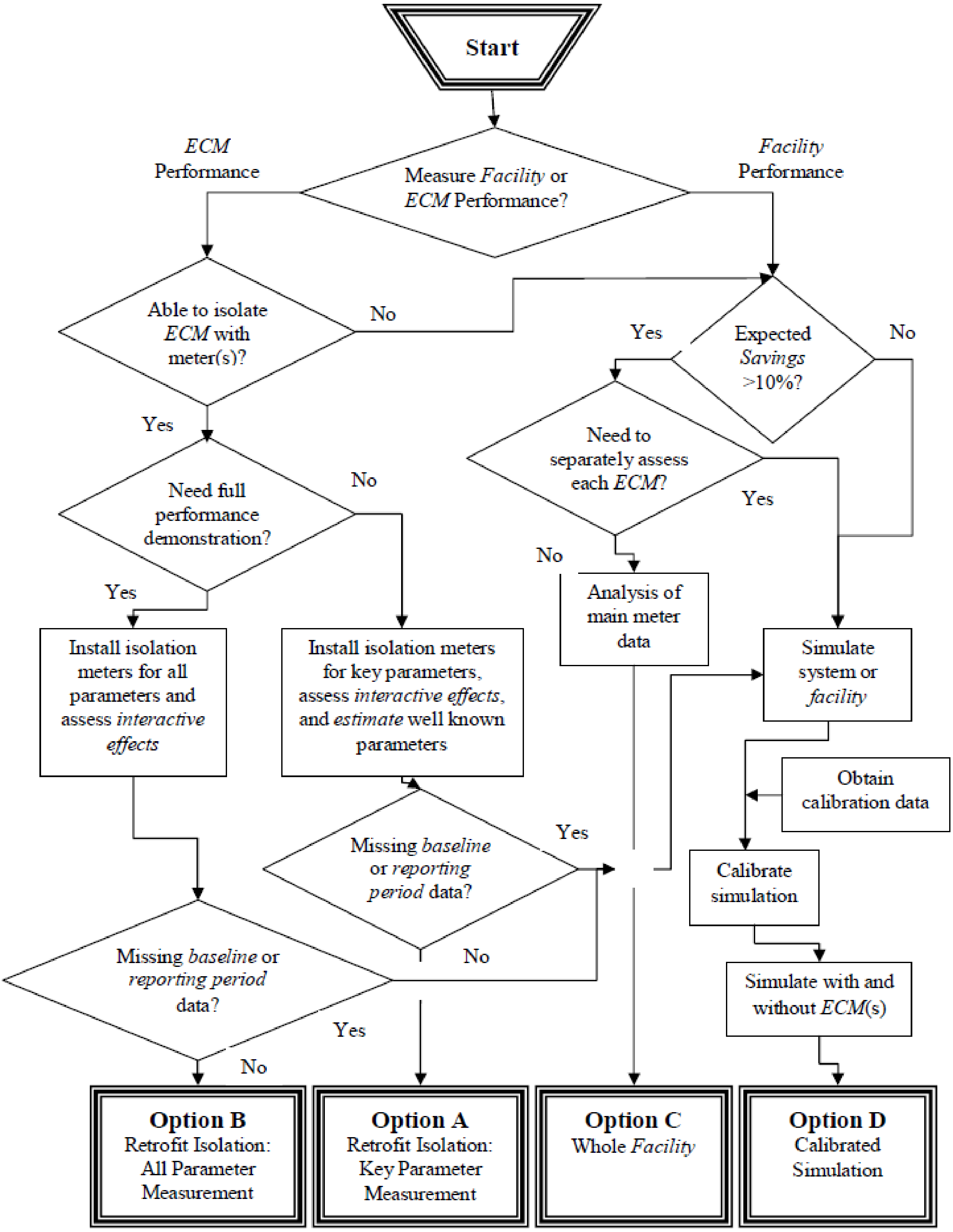
Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.

Table 6: M&V Options

Option	How Savings Are Calculated	Typical Applications
A	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one half hour per day longer than store open hours.
B	Engineering calculations using short term or continuous measurements	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the baseyear this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
C	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month baseyear period and throughout the post-retrofit period.
D	Energy use simulation, calibrated with hourly or monthly utility billing data and/or endues metering.	Multifaceted energy management program affecting many systems in a building but where no baseyear data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Baseyear energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

Each option could be different in each building and will be determinate following a selection process describe in IPMVP and showed in the next figure, based on the full set of project conditions, analysis, budget and professional judgment:

Figure 1: IPMVP Selection Process



Solving the different questions, we will select IPMVP Option for each building:

Table 7: CARTIF Building Option Selection

CARTIF Building	
Decision Question	**Answer**
Measure Facility or ECM Performance?	*ECM Performance*. It's possible to measure at ECM level with different energy meters installed.
Able to isolate ECM with meter(s)?	*NO*. BaaS ECM combine different energy systems with different functionalities and it's no possible to isolate with meters.
Expected Savings > 10%?	*YES*. Some inefficiencies are detected.
Need to separately assess each ECM?	*NO*. All ECM are related with BaaS Project.
Option C: Whole Facility	

Table 8: ZUB Building Option Selection

ZUB Building	
Decision Question	**Answer**
Measure Facility or ECM Performance?	*ECM Performance*. It's possible to measure at ECM level with different energy meters installed.
Able to isolate ECM with meter(s)?	*NO*. BaaS ECM combine different energy systems with different functionalities and it's no possible to isolate with meters.
Expected Savings > 10%?	*YES*. Some inefficiencies are detected.
Need to separately assess each ECM?	*NO*. All ECM are related with BaaS Project.
Option C: Whole Facility	

Table 9: SES Building Option Selection

SES Building	
Decision Question	**Answer**
Measure Facility or ECM Performance?	*ECM Performance*. It's possible to measure at ECM level with different energy meters installed.
Able to isolate ECM with meter(s)?	*NO*. BaaS ECM combine different energy systems with different functionalities and it's no possible to isolate with meters.
Expected Savings > 10%?	*YES*. Some inefficiencies are detected.
Need to separately assess each ECM?	*NO*. All ECM are related with BaaS Project.
Option C: Whole Facility	

Measurement Boundary.

The measurement boundary is determined by the choice of IPMVP Option. Is necessary to define what are the measures that must be performed in order to evaluate correctly the energy savings achieved.

All Demosite Buildings have been selected *Option C: Whole Facility*, in this option, measures from baseline are collected to calibrate the *Regression Model*, defined mathematically by equations with energy variables, and after that, all baseline energy consumptions are determinate by the *Regression Model*. Once ECMs are implemented, energy cosumption is measured by energy meters.

Table 10: Measurement Boundary

Building	Measurement Boundary
CARTIF Building	Gas Consumption from gas supplier. Electricity Consumption from electricity supplier
ZUB Building	Thermal Energy Consumption from District Heating. Electricity Consumption from electricity supplier
SES Building	Biomass Consumption from biomass supplier. Electricity Consumption from electricity supplier

2.3 Baseline: Period, Energy and Conditions.

TOPIC 3 Baseline: Period, Energy and Conditions.

Document the facility's baseline conditions and energy data, within the measurement boundary. This baseline documentation should include:

a) Identification of the baseline period.

b) All baseline energy consumption and demand data.

c) All independent variable data coinciding with the energy.

d) All static factors coinciding with the energy data:

Occupancy type, density and periods

Operating conditions for each baseline operating period and season, other than the independent variables.

Description of any baseline conditions that fall short of required conditions. Details of all adjustments that are necessary to the baseline energy data to reflect the energy-management program's expected improvement from baseline conditions.

Size, type, and insulation of any relevant building envelope elements such as walls, roofs, doors, windows.

Equipment inventory: nameplate data, location, condition.

Equipment operating practices (schedules and setpoints, actual temperatures and pressures)

Significant equipment problems or outages during the baseline period.

Baseline Period.

The baseline period should represent all operating models of the building. The length of the baseline period should be such that it contains all situations of building energy consumption. Each building has a different use and could have a different baseline period, where all energy profiles can be.

CARTIF Building is an offices building that has heating and cooling systems and is located in Valladolid (Spain). Energy consumption depends on occupancy and weather. All season (heating seasons, cooling season and intermediate seasons) should be included within baseline period.

ZUB Building is an offices building that has heating and cooling systems and is located in Kassel (Germany). Energy consumption depends on occupancy and weather. All season (heating seasons, cooling season and intermediate seasons) should be included within baseline period.

SES Building is an school building that has heating system and is located in Granada (Spain). Energy consumption depends on occupancy and weather. Heating season should be included within baseline period.

Table 11: Pilots Baseline Period

Building	Energy Systems	Energy Consumption Factors	Baseline Period
CARTIF Building	Heating and Cooling	Occupancy and weather	**One year.**
ZUB Building	Heating and Cooling	Occupancy and weather	**One year.**
SES Building	Heating	Occupancy and weather	**Eight months.** From October to May.

Baseline Energy Consumption.

Energy consumption in the baseline period has been obtained by the energy meters installed or through power purchase bills. The energy consumption in previous year, gives an overall idea of energy magnitude in each building, and will be replaced by energy consumption in baseline period.

Table 12: CARTIF Building Electricity consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	29,033	31,331	31,318	26,502	29,384	31,823
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	32,208	31,999	25,485	24,893	22,490	22,940

Table 13: CARTIF Building Gas consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	34,299	27,821	15,654	12,750	6,977	1,851
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	1,379	1,548	1,580	6,106	16,304	18,280

Table 14: ZUB Building Electricity consumption in 2,012

2.012	Jan	Feb	Mar	Apr	May	Jun
kWh	7,829	8,345	7,330	6,127	4,811	5,610
2.012	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	4,888	5,650	6,248	6,792	8,941	5,692

Table 15: ZUB Building District Heating consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	7,199	7,649	1,651	652	0	0
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	0	0	0	2,193	5,972	7,304

Table 16: SES Building Electricity consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	1,025	912	1,426	2,581	2,798	1,918
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	630	624	2,464	2,870	1,277	1,032

Table 17: SES Building Biomass consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	96,826	102,373	85,666	42,973	0	0
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	0	0	0	44,862	96,253	86,533

Independent Variables.

As we have seen above, the energy consumption in Pilot buildings depends mainly on weather and occupancy. Weather conditions are *independent variables* that are related to energy consumption. Weather data is available from weather stations located in each Pilot.

The weather data normally used as *independent variables* are computed from daily average or high/low temperature data. Even though temperature can be used as an *independent variable*, it has been established by experience that it is best to use two weather severity variables: Cooling Degree Days (CDD) and Heating Degree Days (HDD).

HDD is a measurement designed to reflect the demand for energy needed to heat a building. It is derived from measurements of outside air temperature. The heating requirements for a given structure at a specific location are considered to be directly proportional to the number of HDD at that location. A similar measurement, CDD reflects the amount of energy used to cool a building.

A high temperature for a very short period during a day would require less cooling energy to maintain internal building comfort levels than if the same temperature continued for a longer period. In some cases temperature can be high but may not be high enough to require any cooling energy at all to maintain internal building comfort levels. The converse applies to low temperatures, the duration of the low temperatures and the heating energy required to maintain internal building comfort levels.

HDD are defined relative to a base outside temperature above which a building needs no heating. The most appropriate base temperature for any particular building depends on the temperature that the building is heated to, and the nature of the building. The base temperature is usually an indoor temperature of 18°C or 19°C which is adequate for human comfort, because internal gains increase this temperature by about 1ºC to 2°C.

To use the standard base temperature is not appropriate for modeling every building energy consumption. Each building reacts differently to external weather influences depending on construction materials, insulation, internal heating from occupants and equipment, and building control strategies, and therefore each building has its own best base temperature. It’s possible to have separate Cooling base temperature and Heating base temperature.

Static Factors.

Static factors or parameters are those that describe the installation and operation of the building and remain 'static' coinciding with baseline period, from energy consumption point of view:

Occupancy type, density and periods.

Operating conditions: operating period and season, schedules and setpoints.

Size, type, and insulation of any relevant building envelope elements such as walls, roofs, doors, windows.

Equipment inventory: nameplate data, location, condition.

All static factors ar define in Deliverable 6.1 ‘*Identification and definition of BaaS demonstration buildings*’:

Table 18: Static Factors for Pilot Buildings

Building	Measurement Boundary
CARTIF Building	Deliverable 6.1 Appendix C
ZUB Building	Deliverable 6.1 Appendix A
SES Building	Deliverable 6.1 Appendix E

2.4 Reporting Period: Identify the reporting period.

TOPIC 4 Reporting Period.

Identify the reporting period. This period may be as short as an instantaneous measurement during commissioning of an ECM, or as long as the time required to recover the investment cost of the ECM program

The usual application of the IPMVP methodology is that user of the savings reports, should determine the length of the reporting period, to evaluate and analyze results depending on his interest. Anyway, the reporting period should be at least one normal operating cycle of the installation or of the building, in order to characterize the savings in all normal operating modes.

In BaaS Project case, we will select one operating cycle of the building as reporting period. As showed above in 2.3 "*Baseline: Period, Energy and Conditions*" CARTIF Building and ZUB Building have an operating cycle of twelve months and SES Building has an operating cycle of eight months. So the lengh of the reporting period will be at least the same of the baseline period.

Table 19: Reporting Period for Pilot Buildings

Building	Reporting Period
CARTIF Building	**One year.**
ZUB Building	**One year.**
SES Building	**Eight months.** From October to May.

2.5 Basis for Adjustment.

TOPIC 5 Basis for Adjustment.

Declare the set of conditions to which all energy measurements will be adjusted. The conditions may be those of the reporting period or some other set of fixed conditions.

As has been described in Deliverable 1.2 "*Energy saving Measurement and Verification Methodology to evaluate the BaaS solution*" savings are calculated with the next equation:

Equation 1: Energy Savings

Savings = (Baseline-Period Use or Demand - Reporting-Period Use or Demand) ± Adjustments

The adjustments are used to assess the impact on energy consumption of the installation, which have different variables. This variables as showed in section 2.3 "*Baseline: Period, Energy and Conditions*" could be ***Independent Variables*** or ***Static Factors***, depending on the kind of variables, adjustments are different.

Adjustments from independent variables are considered **routine adjustments**, and take into account the variations of the independent variables in the reporting period and its influence on energy consumption. A several multiple parameter non-linear equations each correlating energy with one or more independent variables clould be used to define the routine adjustment. Baseline definition showed that weather conditions and occupancy could be independent variables. Each Pilot building should define his independent variables and therefore his routine adjustments.

Adjustments from statics factors are considered **non-routine adjustments**, and take into account the variations of the statics factors in the reporting period and its influence on energy consumption. Non-routine adjustments are needed where a change occurs to equipment or operations within the measurement boundary after the baseline period. Such change occurs to a static factor not to independent variables. Sometimes it may be difficult to quantify the impact of changes. If the facility's energy consumption record is used to quantify the impact of such changes, the impact of the ECMs on the facilitiy's energy consumption must first be removed by Option B techniques. Option C cannot be used to determine savings when the facilitiy's energy meter is also used to quantify the impact of changes to static factors.

In the case of BaaS Project, only routine adjustments will be considered.

Savings reported, under the conditions of the reporting period, quantifies savings in the reporting period relative to what energy use would have been without the ECMs, so baseline period energy needs to be adjusted to reporting period conditions. Therefore savings will calculated by the next equation:

Equation 2: Energy Savings: Adjusted Baseline Energy

Savings = (Baseline Period Energy ± Routine Adjustments to Reporting Period conditions) ± Reporting Period Energy = Adjusted Baseline Energy – Reporting Period Energy

2.6 Analysis Procedure.

TOPIC 6 Analysis Procedure

Specify the exact data analysis procedures, algorithms and assumptions to be used in each savings report. For each mathematical model used, report all of its terms and the range of independent variables over which it is valid.

Once the IMPMVP option has been chosen and have determined the independent variables, must be defined the analysis procedure for obtaining the function that calculates the Adjusted Baseline Energy (ABE). ABE is calculated by developing a valid mathematical model that includes factors derived from regression analysis which correlate energy to one or more independent variables such as weather conditions or occupancy in BaaS Pilots. Models can also include a different set of regression parameters for each range of conditions, such as summer or winter in buildings with seasonal energy use variations.

The data used for the calculation of the mathematical model using regression analysis, should have the same structure in all periods, following the same time schedule. BaaS Pilots should use continuous data during baseline period and reporting period. Meter data can be hourly, daily or monthly whole-facility data. Hourly data should be combined into daily data to limit the number of independent variables required to produce a reasonable baseline model, without significantly increasing the uncertainty in computed savings. Variation in the daily data often results from the weekly cycle of most facilities.

In order to evaluate how well a particular regression model explains the relationship between energy use and independent variables, three statistical terms should be considered:

- R^2: *Coefficient of Determination*. Shows how well a regression model explains the variations observed in the dependent variable.
- *SE*: *Standard Error*. This term is used in estimating precision of a sample mean.
- *t-statistic*. To determine whether an estimate has statistical significance.

R^2: Coefficient of Determination

The first step in assessing the accuracy of a model is to examine R^2, a measure of the extent to which variations in the dependent variable Y from its mean value are explained by the regression model.

Equation 3: R^2 expression

$$R^2 = \frac{Explained\ Variation\ in\ Y}{Total\ Variation\ in\ Y} = \frac{\sum\left(\hat{Y}_i - \bar{Y}\right)^2}{\sum(Y_i - \bar{Y})^2}$$

where:

$\hat{Y}_i$: model predicted energy value for a particular data point using the measured value of the independent variable, i.e., obtained by plugging the X values into the regression model.

$\bar{Y}$: mean of the n measured energy values

Y_i: mean actual observed value of energy

The range of possible values for R^2 is from 0.0 to 1.0. An R^2 of 0.0 means none of the variation is explained by the model, therefore the model provides no guidance in understanding the variations in Y, i.e., the selected independent variables give no explanation of the causes of the observed variations in Y. An R^2 of 1.0 means the model explains 100% of the variations in Y, i.e., the model predicts Y with total certainty, for any given set of values of the independent variables. Neither of these limiting values of R^2 is likely with real data.

In general, the greater the coefficient of determination, the better the model describes the relationship of the independent variables and the dependent variable. Though there is no universal standard for a minimum acceptable R^2 value, 0.75 is IPMVP considered a reasonable indicator of a good causal relationship amongst the energy and independent variables.

SE*: *Standard Error

When a model is used to predict an energy value (Y) for given independent variables, the accuracy of the prediction is measured by the standard error of the estimate.

Equation 4: SE expression

$$SE = \sqrt{\frac{\sum\left(\hat{Y}_i - \bar{Y}\right)^2}{n - p - 1}}$$

where:

$\hat{Y}_i$: model predicted energy value for a particular data point using the measured value of the independent variable, i.e., obtained by plugging the X values into the regression model.

$\bar{Y}$: mean of the n measured energy values.

n: number of measured energy values.

p: number of independent variables in the regression equation.

t-statistic

Since regression-model coefficients are statistical estimates of the true relationship between an individual X variable and Y, they are subject to variation. The accuracy of the estimate is measured by the standard error of the coefficient and the associated value of the t-statistic. Following table shows t-values depending on confidence level:

Table 20: *t-statistic* values

Degrees of Freedom DF	Confidence Level				Degrees of Freedom DF	Confidence Level			
	95%	90%	80%	50%		95%	90%	80%	50%
1	12.71	6.31	3.08	1.00	16	2.12	1.75	1.34	0.69

2	4.30	2.92	1.89	0.82	17	2.11	1.74	1.33	0.69
3	3.18	2.35	1.64	0.76	18	2.10	1.73	1.33	0.69
4	2.78	2.13	1.53	0.74	19	2.09	1.73	1.33	0.69
5	2.57	2.02	1.48	0.73	21	2.08	1.72	1.32	0.69
6	2.45	1.94	1.44	0.72	23	2.07	1.71	1.32	0.69
7	2.36	1.89	1.41	0.71	25	2.06	1.71	1.32	0.68
8	2.31	1.86	1.40	0.71	27	2.05	1.70	1.31	0.68
9	2.26	1.83	1.38	0.70	31	2.04	1.70	1.31	0.68
10	2.23	1.81	1.37	0.70	35	2.03	1.69	1.31	0.68
11	2.20	1.80	1.36	0.70	41	2.02	1.68	1.30	0.68
12	2.18	1.78	1.36	0.70	49	2.01	1.68	1.30	0.68
13	2.16	1.77	1.35	0.69	60	2.00	1.67	1.30	0.68
14	2.14	1.76	1.35	0.69	120	1.98	1.66	1.29	0.68
15	2.13	1.75	1.34	0.69	∞	1.96	1.64	1.28	0.67

To calculate degrees of freedom, it's necessary to use the next expression:

Equation 5: Degrees of freedom expression for a regression model

$$Degrees\ of\ Freedom = n - p - 1$$

where:

n: number of measured energy values.

p: number of independent variables in the regression model.

Once the values of independent variables are plugged into the regression model to estimate an energy value $\hat{Y}$, an approximation of the range of possible values for $\hat{Y}$ could be calculated:

Equation 6: Range of possible values

$$\hat{Y} \pm t \times SE$$

2.7 Energy Prices.

TOPIC 7 Energy Prices

Specify the energy prices that will be used to value the savings, and whether and how savings will be adjusted if prices change in future.

Cost savings are determined by applying next expression:

Equation 7: Cost savings

$$Cost\ savings = C_b - C_r$$

where:

C_b: cost of the baseline period energy adjusted.

C_r: cost of the reporting period energy.

Costs should be determined by applying the same price schedule, that should be obtained from the energy supplier, in computing both C_b and C_r.

In BaaS Project, conditions of the reporting period are used as the basis for reporting energy savings, the price schedule of the reporting period is normally used to compute avoided cost, so C_b should evaluated multiplying ABE by price schedule of the reporting period.

Depending on the Pilot, different kind of suppliers have different price schedules:

Table 21: Price schedule by Pilot

Building	Energy Supplier
CARTIF Building	Gas Supplier. Electricity Supplier.
ZUB Building	District Heating. Electricity Supplier.
SES Building	Biomass Supplier. Electricity Supplier.

Each reporting period should define evolution of price schedules, if prices increase will shorten the payback period and if prices decrease will lengthen the payback period though total energy costs will drop when prices drop.

2.8 Meter Specifications.

TOPIC 8 Meter Specifications

Specify the metering points, and periods if metering is not continuous. For non-utility meters, specify: meter characteristics, meter reading and witnessing protocol, meter commissioning procedure, routine calibration process, and method of dealing with lost data.

BaaS Project used IPMVP Option C where utility meters are used. All meter characteristics are defined in Deliverable 6.1 "*Identification and definition of BaaS demonstration buildings*" and in Deliverable 6.2 "*Summary of metering and monitoring systems by demosite*":

Table 22: Utility meters by Pilot

Building	Energy Supplier
CARTIF Building	Gas meter. Electricity meter.
ZUB Building	District Heating Energy meter. Electricity meter.
SES Building	Biomass meter. Electricity meter.

Data measurements are performed continuously in partial meters and total meters involved or not involved in IPMVP.

2.9 Monitoring Responsibilities.

TOPIC 9 Monitoring Responsibilities

Assign responsibilities for reporting and recording the energy data, independent variables and static factors within the measurement boundary during the reporting period.

Baas project involves three different Pilot Buildings and each has a Pilot-Building Leader, which is responsible for decision making in the building:

Table 23: Pilot-Building Leader

Building	Leader
CARTIF Building	CARTIF
ZUB Building	FRAUNHOFER
SES Building	DALKIA

Taking to account this leadership, different responsibilities are assigned:

Table 24: Monitoring Responsibilities

Action	Responsible
Reporting Energy Data	Task 6.3 Leader
Recording Energy Data	Pilot Leader and WP2 Leader
Recording Independent Variables	Pilot Leader and WP2 Leader
Detecting Changes in Static Factors	Pilot Leader

Each responsible will be responsible that every action is properly conducted.

2.10 Expected Accurancy.

TOPIC 10 Expected Accurancy

Evaluate the expected accuracy associated with the measurement, data capture, sampling and data analysis. This assessment should include qualitative and any feasible quantitative measures of the level of uncertainty in the measurements and adjustments to be used in the planned savings report.

The measurement of any physical quantity includes errors because no measurement instrument is 100% accurate. Errors are the differences between observed and true energy use. In a savings-determination process, errors prevent the exact determination of savings. IPMVP usually involves at least two such measurement errors: baseline period errors and reporting period errors. To ensure that the resultant error, called uncertainty, is acceptable to the users of a savings report, be certain to manage the errors inherent in measurement and analysis when developing and implementing the IPMVP Plan.

Three types of errors could appear in this process:

1. Measurement: Measurement equipment errors are due to calibration, inexact measurement, or improper meter selection installation or operation. In IPMVP Option C the utility meter was used to obtain the reporting-period value, its reported values may be treated as 100% accurate (SE = 0%) because the utility meter defines the amounts paid, regardless of meter error.
2. Modeling: The inability to find mathematical forms that fully account for all variations in energy use. Modeling errors can be due to inappropriate functional form, inclusion of irrelevant variables, or exclusion of relevant variables. Parameters to evaluate this errors are: R^2, SE and t-statistic.
3. Sampling: Use of a sample of the full population of items or events to represent the entire population introduces error as a result of: the variation in values within the population, or biased sampling. In BaaS Project, measurement is continuous recording of all parameters.

Table 25: Uncertainty Assessment

Errors	Period	Uncertainty
Measurement	Baseline Reporting	Utility meters
Modeling	Baseline	R^2 SE t-statics
Sampling	Baseline Reporting	Continuous recording

Savings are deemed to be statistically valid if they are large relative to the statistical variations. Specifically, the savings need to be larger than twice the standard error of the baseline value. In each period, uncertainty should be calculated.

2.11 Budget.

TOPIC 11 Budget

Define the budget and the resources required for the savings determination, both initial setup costs and ongoing costs throughout the reporting period.

When using IPMVP Option C, there are no measuring equipment costs because the utilities meters are used. All costs associated with the determination of savings, are personnel costs. Usually are considered a maximum budget of 10% of energy costs, expected savings more than 10%. Monitoring costs against budget, must be performed in each period.

2.12 Report format.

TOPIC 12 Report Format

Specify how results will be reported and documented. A sample of each report should be included.

To define the Report's Table of Contents, of the reporting period, is necessary to have in mind the following considerations:

- Report's Timetable: Since energy consumption is seasonal, a report will be performed every three months.
- Reporting period starts once BaaS System is deployed in BaaS Pilot.

Table of Contents

1. *Executive Summary*. Summary of the savings achieved, measured period, evolution of the prices, IPMVP cost and conclusions. Data are presented in graphical and numerical way.
2. *Data*. The measurement period start and end points in time, the energy data, and the values of the independent variables Description and justification for any corrections made to observed data.
3. *ABE*. Calculation of ABE, including all details of any baseline non-routine adjustment performed. Details should include an explanation of the change in conditions since the baseline period, all observed facts and assumptions, and the engineering calculations leading to the adjustment.
4. *Energy Price*. Shows energy price schedule and its evolution from baseline period.
5. *Savings*. Calculate energy and cost savings, including uncertainty values.

6. *IPMVP Costs*. Determinate IPMVP costs and compare it with budget.
7. *Other issues*.

2.13 Quality Assurance.

TOPIC 12 Quality Assurance

Specify quality-assurance procedures that will be used for savings reports and any interim steps in preparing the reports.

Once done each report and before final delivery, will be reviewed by Pilot-Building Leader and another Pilot-Building Leader, as follows:

Table 26: Quality Report Review

Pilot	Report Responsible	Reviewers
CARTIF Building	DALKIA	CARTIF DALKIA
ZUB Building	DALKIA	FRAUNHOFER CARTIF
SES Building	DALKIA	DALKIA FRAUNHOFER

In the case of Dalkia, the reviewer is a person who has not participated in the process of preparing the report.

3 CARTIF Building Pilot.

3.1 Use Cases.

CARTIF Building Use Cases are defined in Deliverable 5.1 "*Building Services: Functional and interoperability requirements*", as follows:

- CAR_Uc1: Optimize energy performance of CARTIF working in winter mode (using BaaS System).
    - Here, "optimization of energy performance" means: Maximize the use of solar thermal generation to minimize the global energy consumption (energy cost of electrical and gas consumption) associated to the HVAC system working on heating mode (in winter and inter-season). Considering comfort constraints.
    - To achieve this goal the BaaS System is designed to incorporate the following functionality:
        - Assessment functionality: i.e.: DetectFaults and AdvanceMonitoring. A set of assessment tasks has been preselected in order to assure as much as possible the system works properly, thus the set of assessment task, using fault detection analytics and energy monitoring, are optimizing the behavior of the HVAC system.
        - Prediction (simulation) functionality: using an external tool as predictor.
        - Control Design and Optimal Control Design: OperateEnergySystems. This functionality is in charge of adjusting schedulers and operational setpoints.
- CAR_Uc2: Optimize energy performance of CARTIF working in summer mode (using BaaS System).
    - Here, "optimization of energy performance" means: Minimize the global energy consumption (energy cost of electrical consumption) associated to the HVAC system working on cooling mode (in summer in inter-season). Considering comfort constraints.
    - To achieve this goal the BaaS System is designed to incorporate the following functionality:
        - Assessment functionality: DetectFaults and AdvanceMonitoring. A set of assessment tasks has been preselected in order to assure as much as possible the system works properly, thus the set of assessment task, using fault detection analytics and energy monitoring, are optimizing the behavior of the HVAC system.
        - Prediction (simulation) functionality: using an external tool as predictor.
        - Control Design and Optimal Control Design: OperateEnergySystems. This functionality is created by means of adjusting schedulers and operational setpoints.

These use cases will be applied on the whole HVAC system working in CARTIF Building.

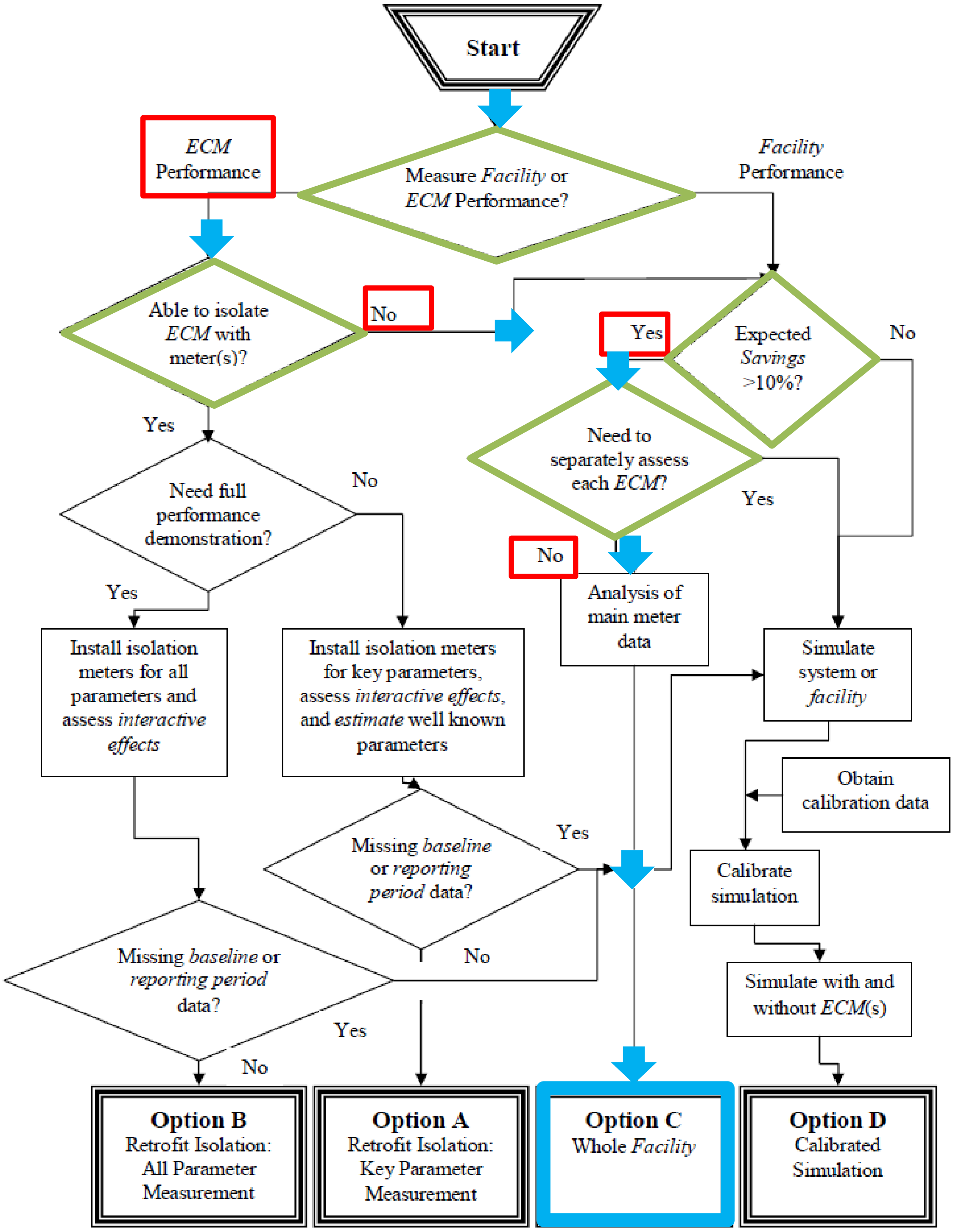
3.2 IPMVP Plan.

3.2.1 ECM Intent.

ECM in CARTIF Building is **BaaS System.** Taking into account Building description in D5.1 and D6.1, expected energy savings in CARTIF Building are over **15%**.

3.2.2 *Selected IPMVP Option and Measurement Boundary.*

Figure 2: CARTIF Building Selection Process



Measurement Boundary

Energy meters use to evaluate energy savings in CARTIF Building are:

G1: Gas meter that measure energy consumption from gas supplier.

E1: Electrical meter that measure energy consumption from electrical nertwork.

Figure 3: CARTIF Building Summer Energy Scheme

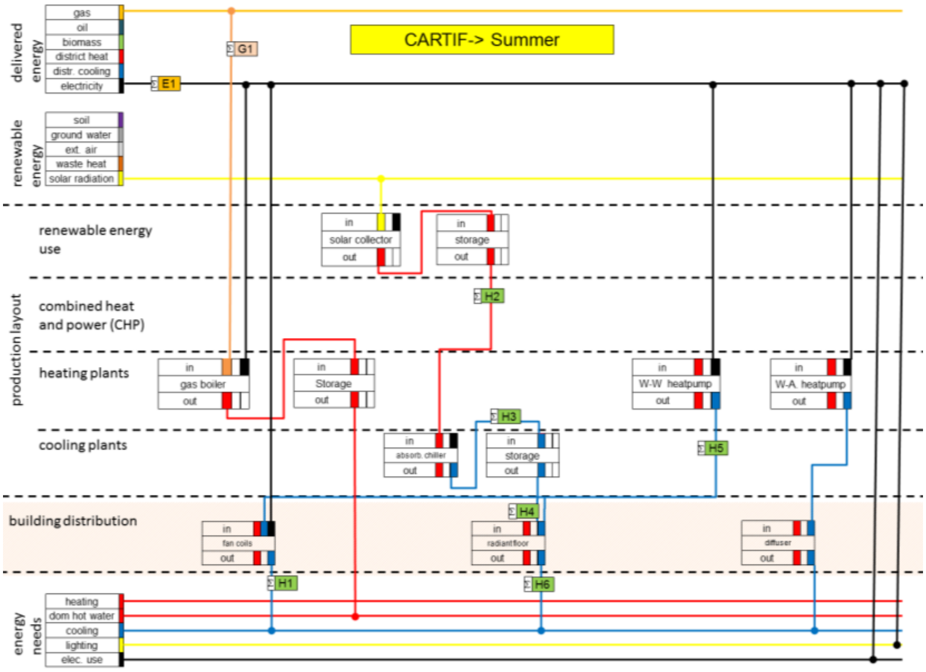
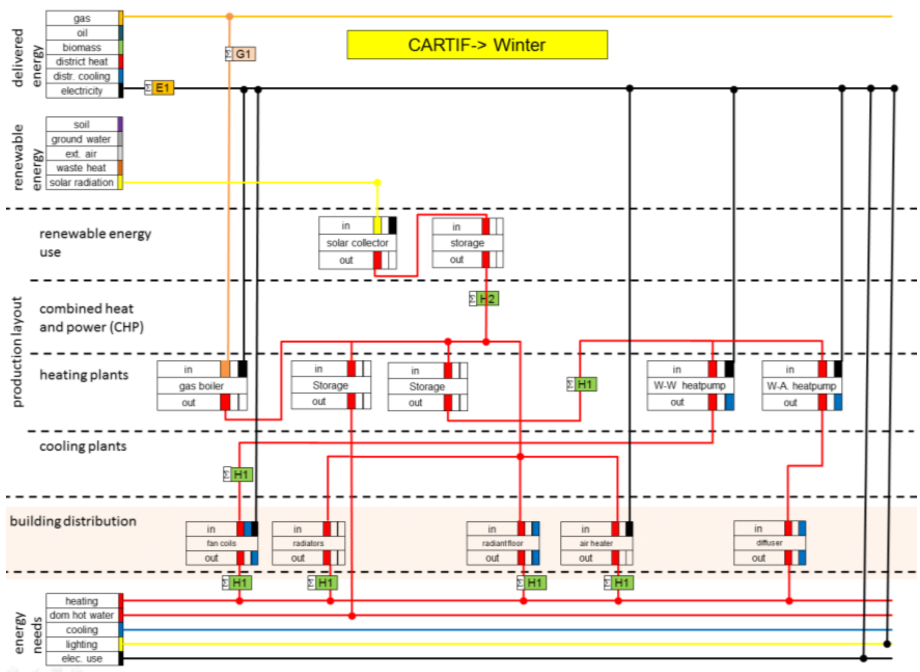


Figure 4: CARTIF Building Winter Energy Scheme



3.2.3 Baseline: Period, Energy and Conditions.

Baseline Period

To determine the reference period is necessary to consider the occupation profiles and weather conditions at building location.

Figure 5: CARTIF Building daily occupation profile

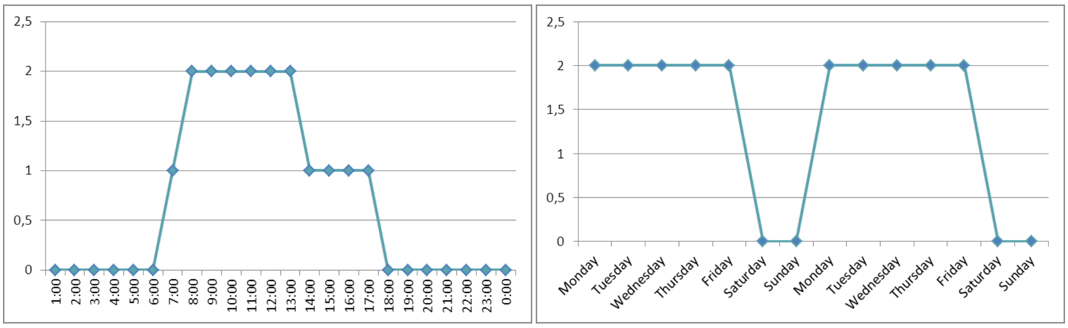


Figure 6: CARTIF Building yearly occupation profile

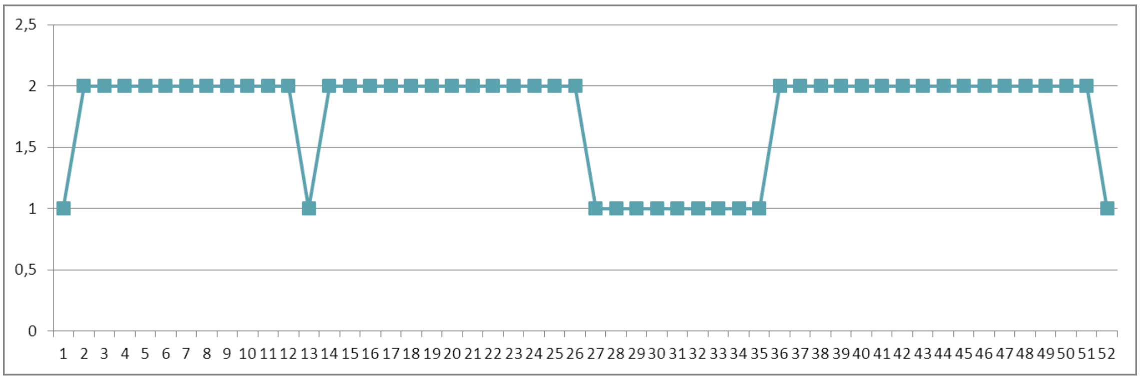


Table 27: Climate values for Valladolid

	T (ºC)	TM (ºC)	Tm (ºC)	R (mm)	RH (%)	DR (d)	DN (d)	DT (d)	DF (d)	DH (d)	DD (d)	I (h/mo)
Jan	4,0	8,3	0,0	40	83	7	3	0	11	17	4	100
Feb	6,1	11,4	0,9	32	72	6	2	0	4	12	4	141
Mar	8,4	15,0	2,3	23	62	5	1	0	2	8	6	209
Apr	10,1	16,3	4,0	44	62	8	1	1	1	4	4	222
May	13,8	20,5	7,2	47	61	9	0	4	1	1	4	260
Jun	18,1	25,9	10,7	33	54	5	0	3	1	0	7	310
Jul	21,7	30,4	13,3	16	47	3	0	3	0	0	15	352
Aug	21,6	29,8	13,6	18	49	3	0	3	0	0	13	330
Sep	18,1	25,7	10,9	31	56	4	0	2	2	0	8	244
Oct	12,8	18,8	6,9	42	69	7	0	1	3	1	5	176

Nov	7,7	12,6	2,9	51	78	6	0	0	8	8	5	114
Dec	5,0	8,8	1,3	56	84	8	1	0	10	13	3	81
Total	12,3	18,6	6,2	435	65	71	8	17	42	61	76	2534

T: monthly average temperature; TM: monthly average of highest daily temperatures; Tm: monthly average of lowest daily temperatures; R: monthly average of rainfall; RH: monthly average of relative humidity; DR: monthly average of rainy days (rainfall ≥ 1mm); DN: monthly average of snow days; DT: monthly average of storm days; DF: monthly average of foggy days; DH: monthly average of frost days; DD: monthly average of cloudless days; I: monthly average of sunny hours

Taking into account both parameters (occupancy and weather) and ECM implementation plan, selected baseline period of CARTIF Building is:

Table 28: CARTIF Building baseline period

Start of baseline period	End of baseline period
1st October, 2013	30th September, 2014 Extended period if necessary: 28th February, 2015

The length of baseline period is one year. It's also considered an extended period until February 2015 if necessary.

Baseline Energy Consumption.

Energy consumption in the baseline period has been obtained by the energy meters installed or through power purchase bills. The energy consumption in previous year, gives an overall idea of energy magnitude in each building, and will be replaced by energy consumption in baseline period.

Table 29: CARTIF Building Electricity consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	29,033	31,331	31,318	26,502	29,384	31,823
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	32,208	31,999	25,485	24,893	22,490	22,940

Table 30: CARTIF Building Gas consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	34,299	27,821	15,654	12,750	6,977	1,851
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
kWh	1,379	1,548	1,580	6,106	16,304	18,280

This initial energy consumption, gives an overall idea of energy magnitude in CARTIF Building, and will be replaced by energy consumption in baseline period.

Independent Variables.

Energy consumption in CARTIF Building depends mainly on weather and occupation. Weather conditions are *independent variables* that are related to energy consumption.

CARTIF Building has two different energy schemes depending on the season: Winter Energy Scheme and Summer Energy Scheme. In winter time HDD is the independent variable and in summer time CDD is the independent variable. Difference between winter time and summer time depends on the use of gas boilers and heatpumps. Taking into account climate values for Valladolid of the previous table, we consider summer mode is from June to Septembre, where monthly average of highest daily temperatures is over 25ºC and monthly average of lowest daily temperatures is over 10ºC.

Also the solar radiation (RAD) is used as secondary independent variable, due to the direct effect on the glass surfaces and mainly on the solar cooling system.

Table 31: CARTIF Building independent variables

1st Independent Variable	2nd Independent Variable
HDD – CDD	RAD

Static Factors.

All CARTIF Building static factors have been defined in Deliverable 6.1 Appendix C

Reporting Period.

The reporting period should be at least one normal operating cycle of the installation or of the building, in order to characterize the savings in all normal operating modes. CARTIF Building has an operating cycle of twelve months, from January to December.

In order to define the dates of the reporting period, it's necessary taking into account the baseline period and BaaS implementation period. Baseline period has been defined from 1st October of 2013 to 30th September of 2014 (Extended period until 28th February of 2015).

As the period of deployment and commissioning will take place in March 2015, April 2015 will be considered as the starting date of the reporting period. Accordingly, reporting period ends in 31th March of 2016, having a length of twelve months and covering all modes of operation in CARTIF Building.

Figure 7: CARTIF Building reporting period

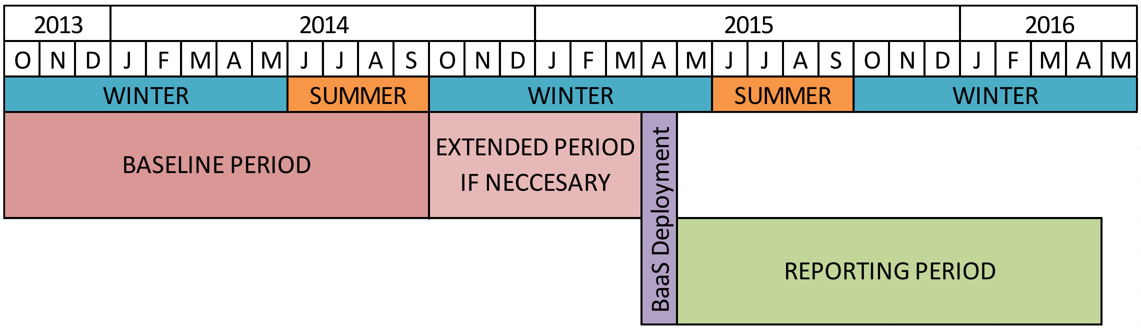


Table 32: CARTIF Building reporting period

Start Date	End Date
1st April, 2015	31th March, 2016

Deployment and commissioning phase should be completed in one month, but depends on the develop of other WPs. In the case that the starting date would be delayed, reporting period could be finished at the same time if summer and winter time are covered.

3.2.4 Basis for Adjustment.

To establish the basis for adjustment is considered that CARTIF Building has selected IPMVP Opction C to evaluate savings, so only routine adjustments will be considered and independent variables are HDD and RAD.

As we described in section 2.6 "*Basis for Adjustment*" savings will calculated by the next equation:

Equation 8: Energy Savings

Savings = (Baseline Period Energy ± Routine Adjustments to Reporting Period conditions) ± Reporting Period Energy = Adjusted Baseline Energy – Reporting Period Energy

The adjusted baseline energy is normally calculated by developing a mathematical model which correlates actual baseline energy data with independent variables in the baseline period. Each reporting period's independent variables are then inserted into this baseline mathematical model to produce the adjusted baseline energy.

Equation 9: CARTIF Building: Adjusted Baseline Energy

Adjusted Baseline Energy = f (HDD, CDD, RAD)

3.2.5 Analisys Procedure.

Once CARTIF Building has selected IPMVP Opction C to evaluate savings and routine adjustments will be considered to calculate ABE, it's necessary to define the analysis procedure for obtaining the function that calculates ABE.

ABE for CARTIF Building should calculated by a valid mathematical model that includes factors derived from regression analysis which correlate energy to independent variables: HDD, CDD and RAD.

Equation 10: CARTIF Building: Adjusted Baseline Energy

$$ABE_{WINTER} = a \cdot Rad + b \cdot HDD + c \cdot Rad \cdot HDD + d \cdot Rad^2 + e \cdot HDD^2 + f$$

$$ABE_{SUMMER} = a \cdot Rad + b \cdot CDD + c \cdot Rad \cdot CDD + d \cdot Rad^2 + e \cdot CDD^2 + f$$

CARTIF Building should use continuous data during baseline period and reporting period, so the data used for the calculation of the mathematical model using regression analysis could use different intervals:

Table 33: CARTIF Building: Data Time Intervals

Time Interval	Data
Daily	Accumulation of Data for a Day
Weekly	Accumulation of Daily Data
Monthly	Accumulation of Weekly Data
Yearly	Accumulation of Monthly Data

In order to evaluate how well a particular regression model explains the relationship between energy use and independent variables, three statistical terms should be considered:

- R^2: *Coefficient of Determination*. Shows how well a regression model explains the variations observed in the dependent variable.
- *SE*: *Standard Error*. This term is used in estimating precision of a sample mean.
- *t-statistic*. To determine whether an estimate has statistical significance.

3.2.6 Energy Prices.

Cost savings are determined by applying next expression:

Equation 11: Cost savings

$$Cost\ savings = C_b - C_r$$

where:

C_b: cost of the baseline period energy adjusted.

C_r: cost of the reporting period energy.

Costs should be determined by applying the same price schedule, that should be obtained from the energy supplier, in computing both C_b and C_r.

Table 34: CARTIF Building: Price schedule

Building	Energy Supplier
CARTIF Building	Gas Supplier. Electricity Supplier.

Each reporting period should define evolution of price schedules, if prices increase will shorten the payback period and if prices decrease will lengthen the payback period though total energy costs will drop when prices drop.

3.2.7 Meter Specifications.

CARTIF Building used IPMVP Option C where utility meters are used. All meter characteristics are defined in Deliverable 6.1 "*Identification and definition of BaaS demonstration buildings*" and in Deliverable 6.2 "*Summary of metering and monitoring systems by demosite*":

Table 35: CARTIF Building: Utility meters

Building	Energy Supplier
CARTIF Building	Gas meter. Electricity meter.

Data measurements are performed continuously in partial meters and total meters involved or not involved in IPMVP.

3.2.8 Monitoring Reponsibilities.

Different responsibilities are assigned:

Table 36: CARTIF Building Monitoring Responsibilities

Action	Responsible
Reporting Energy Data	DALKIA
Recording Energy Data	CARTIF and UCC
Recording Independent Variables	CARTIF and UCC

Detecting Changes in Static Factors	CARTIF

Each responsible will be responsible that every action is properly conducted.

3.2.9 *Expected Accurancy.*

Errors occur in three ways: modeling, sampling, and measurement:

Table 37: CARTIF Building: Uncertainty Assessment

Errors	Period	Uncertainty
Measurement	Baseline Reporting	Utility meters: SE=0
Modeling	Baseline	R^2 SE t-statics
Sampling	Baseline Reporting	Continuous recording: SE=0

Savings are deemed to be statistically valid if they are large relative to the statistical variations. Specifically, the savings need to be larger than twice the standard error of the baseline value. In each period, uncertainty should be calculated.

3.2.10 *Budget.*

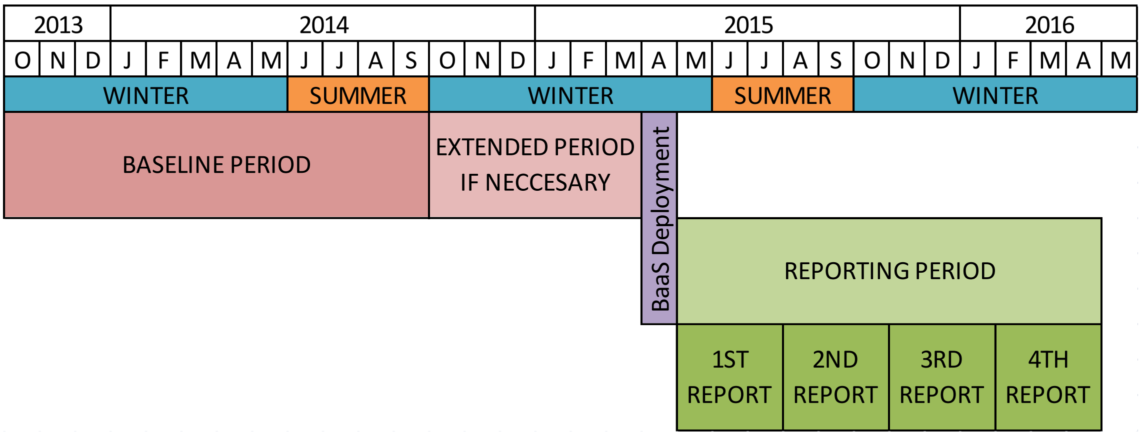
There are no measuring equipment costs because the utilities meters are used. All costs associated with the determination of savings, are personnel costs. Usually are considered a maximum budget of **10%** of energy costs, expected savings more than 10%. Monitoring costs against budget, must be performed in each period.

3.2.11 *Report Format.*

To define the Report's Table of Contents, of the reporting period, is necessary to have in mind the following considerations:

- Report's Timetable: Since energy consumption is seasonal, a report will be performed every three months.
- Reporting period starts once BaaS System is deployed.

Figure 8: CARTIF Building: Report's Timetable



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4. *Energy Price*. Shows energy price schedule and its evolution from baseline period.
5. *Savings*. Calculate energy and cost savings, including uncertainty values.
6. *IPMVP Costs*. Determinate IPMVP costs and compare it with budget.
7. *Other issues*.

3.2.12 Quality Assurance.

Once done each report and before final delivery, will be reviewed by Pilot-Building Leader and another Pilot-Building Leader, as follows:

Table 38: CARTIF Building: Quality Report Review

Pilot	Report Responsible	Reviewers
CARTIF Building	DALKIA	CARTIF DALKIA

In the case of Dalkia, the reviewer is a person who has not participated in the process of preparing the report.

4 ZUB Building Pilot.

4.1 Use Cases.

ZUB Building Use Cases are defined in Deliverable 5.1 "*Building Services: Functional and interoperability requirements*", as follows:

- ZUB_Uc1: Utilization of solar energy for energy savings, while ensuring visual and thermal comfort

  The first use case for the FIBP building includes the cooperation of the blinds, the heating/cooling system, air quality sensors, presence sensors, and the artificial lights, to produce a combined control strategy, able to consume less energy compared to normal operation, while maintaining or even improving visual and thermal comfort.

- ZUB_Uc2: Model-based comfort assessment

  Although identifying every problem is infeasible, detecting and informing on inefficiencies can be equally beneficial, since the building manager can physically check the target zone and the involved systems and prevent further performance deterioration.

- ZUB_Uc3: Occupancy faults

  The problem of low air quality and thermal comfort in the lecture hall during unexpected occupancy will be treated. What differentiates this use case compared to the previous ones for ZUB is that in case of unexpected occupancy by a high number of people, there is no time to optimize a model-based control strategy.

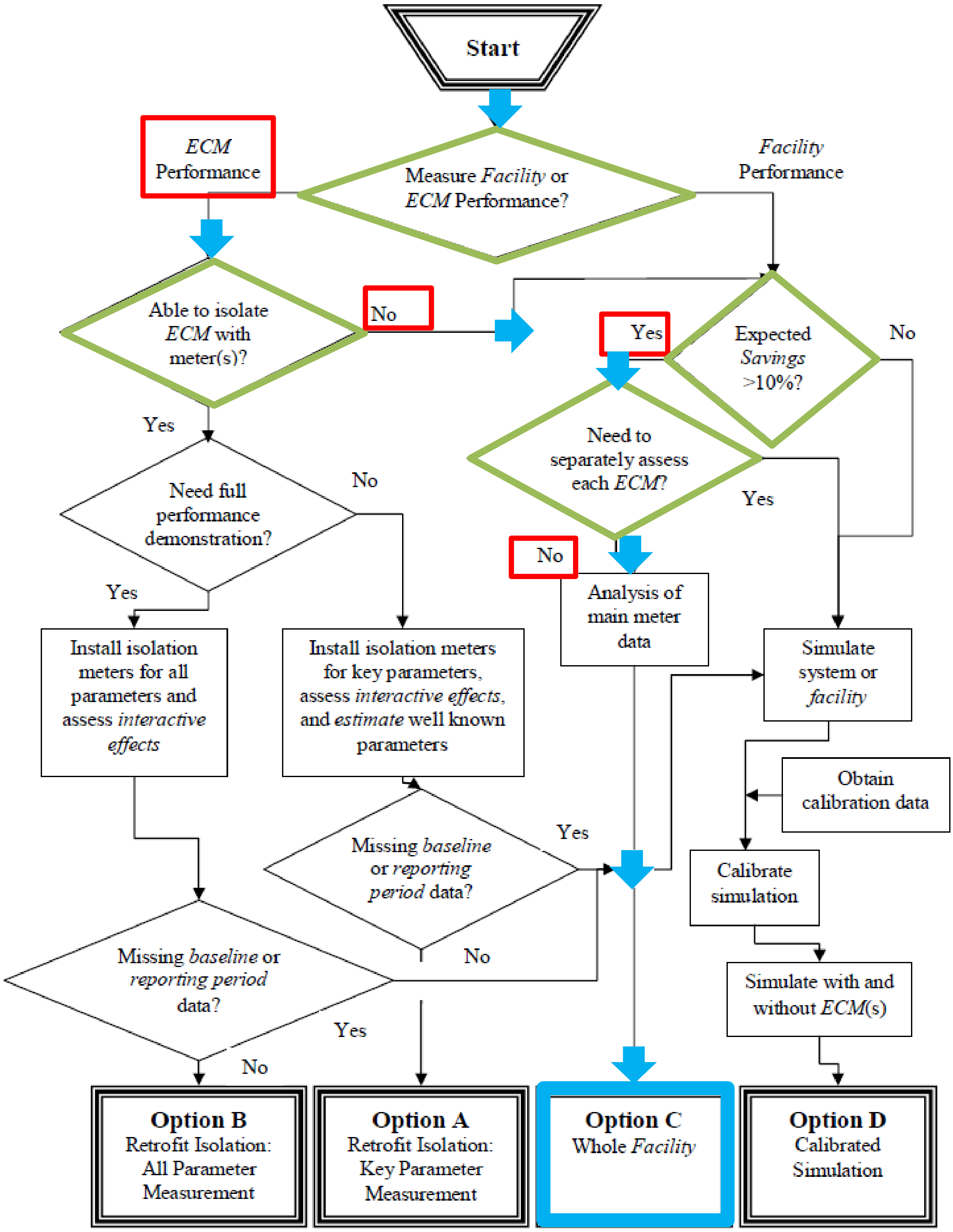
4.2 IPMVP Plan.

4.2.1 ECM Intent.

ECM in ZUB Building is **BaaS System.** Taking into account Building description in D5.1 and D6.1, expected energy savings in ZUB Building are over **15%**.

4.2.2 Selected IPMVP Option and Measurement Boundary.

Figure 9: ZUB Building Selection Process



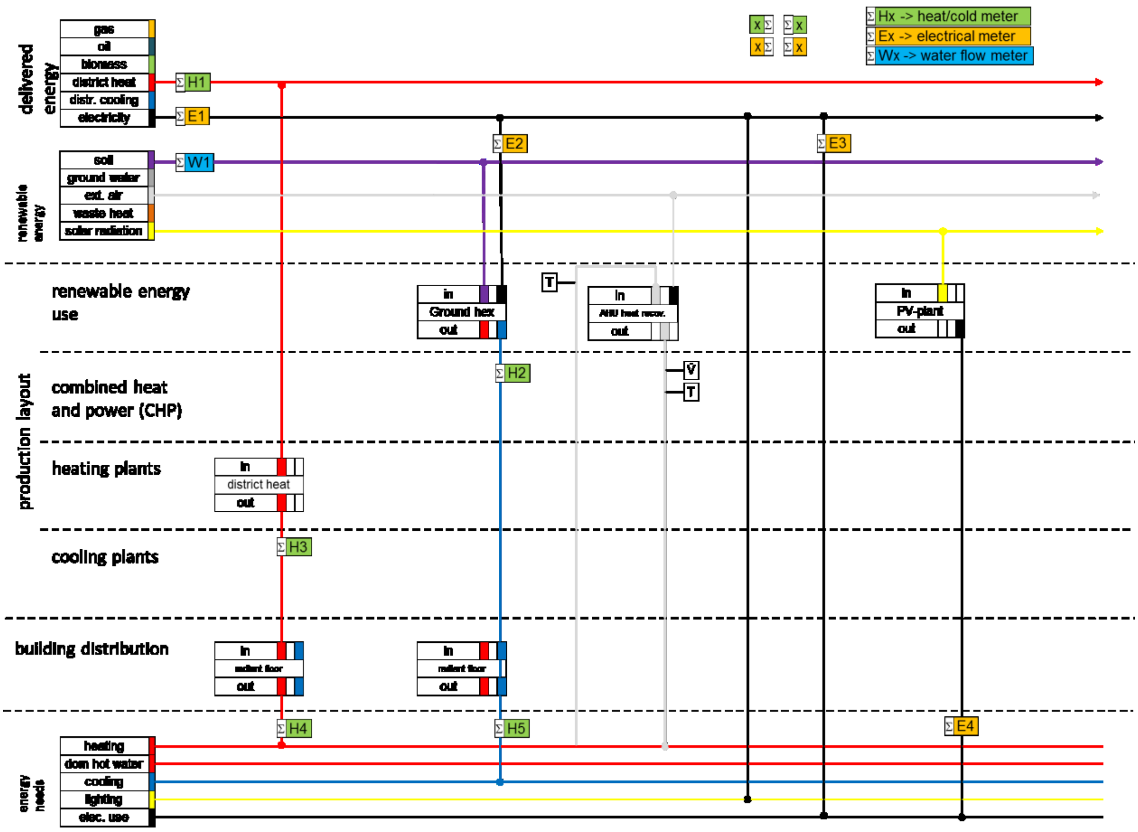
Measurement Boundary

Energy meters use to evaluate energy savings in ZUB Building are:

H1: Heat meter that measure energy consumption from District Heating.

E1: Electrical meter that measure energy consumption from electrical nertwork.

Figure 10: ZUB Building Energy Scheme



4.2.3 Baseline: Period, Energy and Conditions.

Baseline Period

To determine the reference period is necessary to consider the occupation profiles and weather conditions at building location.

Kassel Building is occupied from 08:00 to 17:00 from Monday to Friday and is closed at weekend.

Table 39: Climate values for Kassel

	T (ºC)	TM (ºC)	Tm (ºC)	R (mm)	RH (%)	DR (d)	DN (d)	DT (d)	DF (d)	DH (d)	DD (d)	I (h/mo)
Jan	1.5	4.2	-1.5	29	84	11	8	-	3	-	-	37.2
Feb	2	5.9	-1.5	25.4	80	9	9	-	4	-	-	64.4
Mar	5	10.1	0.8	26.4	75	11	8	-	4	-	-	108.5
Apr	8.5	14.4	3	30.3	70	9	3	-	3	-	-	144
May	13	19.4	7	36.1	69	10	0	-	5	-	-	195.3
Jun	16	22.1	10	33.7	70	11	0	-	5	-	-	189
Jul	17.5	24.4	11.9	41.4	70	9	0	-	6	-	-	195.3
Aug	17.5	24.4	11.8	47	72	9	0	-	7	-	-	189
Sep	13.5	19.5	8.6	34.6	78	9	0	-	10	-	-	136.4
Oct	9.5	14.1	5.1	33	82	9	0	-	12	-	-	99.2
Nov	4.5	8	1.6	33.4	84	11	4	-	7	-	-	45
Dec	1.5	4.3	-1	32	85	13	9	-	4	-	-	31
Total	9.15	14.25	4.65	33.54	76.58	10.1	3.4	-	5.83	-	-	119.53

T: monthly average temperature; TM: monthly average of highest daily temperatures; Tm: monthly average of lowest daily temperatures; R: monthly average of rainfall; RH: monthly average of relative humidity; DR: monthly average of rainy days (rainfall ≥ 1mm); DN: monthly average of snow days; DT: monthly average of storm days; DF: monthly average of foggy days; DH: monthly average of frost days; DD: monthly average of cloudless days; I: monthly average of sunny hours

Taking into account both parameters (occupancy and weather) and ECM implementation plan, selected baseline period of ZUB Building is:

Table 40: ZUB Building baseline period

Start of baseline period	End of baseline period
1st October, 2013	30th September, 2014 Extended period if necessary: 28th February, 2015

The length of baseline period is one year. It’s also considered an extended period until February 2015 if necessary.

Baseline Energy Consumption.

Energy consumption in the baseline period has been obtained by the energy meters installed or through power purchase bills. The energy consumption in previous year, gives an overall idea of energy magnitude in each building, and will be replaced by energy consumption in baseline period.

Table 41: ZUB Building Electricity consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	7,829	8,345	7,330	6,127	4,811	5,610
	Jul	Aug	Sep	Oct	Nov	Dec
kWh	4,888	5,650	6,248	6,792	8,941	5,692

Table 42: ZUB Building District Heating consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	7,199	7,649	1,651	652	0	0
	Jul	Aug	Sep	Oct	Nov	Dec
kWh	0	0	0	2,193	5,972	7,304

This initial energy consumption, gives an overall idea of energy magnitude in ZUB Building, and will be replaced by energy consumption in baseline period.

Independent Variables.

Energy consumption in ZUB Building depends mainly on weather and occupation. Weather conditions are *independent variables* that are related to energy consumption.

In winter time HDD is the independent variable and in summer time CDD is the independent variable. ZUB Building has passive systems to storage energy and has a big influence of solar radiation, due to his building design. Also the solar radiation (RAD) is used as secondary independent variable.

Table 43: ZUB Building independent variables

1st Independent Variable	2nd Independent Variable
HDD – CDD	RAD

Static Factors.

All ZUB Building static factors have been defined in Deliverable 6.1 Appendix A

4.2.4 Reporting Period.

Reporting Period.

The reporting period should be at least one normal operating cycle of the installation or of the building, in order to characterize the savings in all normal operating modes. ZUB Building has an operating cycle of twelve months, from January to December.

In order to define the dates of the reporting period, it's necessary taking into account the baseline period and BaaS implementation period. Baseline period has been defined from 1st June of 2013 to 30th September of 2014 (Extended period until 28th February of 2015).

As the period of deployment and commissioning will take place in March 2015, April 2015 will be considered as the starting date of the reporting period. Accordingly, reporting period ends in 31th March of 2016, having a length of twelve months and covering all modes of operation in ZUB Building.

Figure 11: ZUB Building reporting period

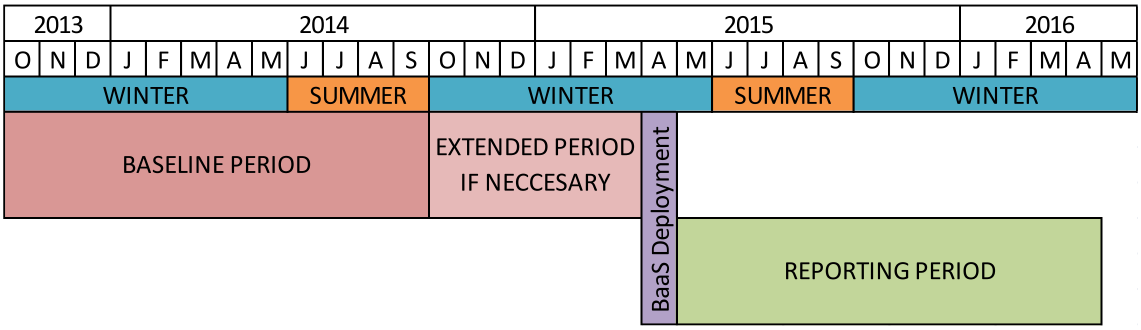


Table 44: ZUB Building reporting period

Start Date	End Date
1st April, 2015	31th March, 2016

Deployment and commissioning phase should be completed in one month, but depends on the develop of other WPs. In the case that the starting date would be delayed, reporting period could be finished at the same time if summer and winter time are covered.

4.2.5 Basis for Adjustment.

To establish the basis for adjustment is considered that ZUB Building has selected IPMVP Opction C to evaluate savings, so only routine adjustments will be considered and independent variables are HDD and RAD.

As we described in section 2.6 "*Basis for Adjustment*" savings will calculated by the next equation:

Equation 12: Energy Savings

Savings = (Baseline Period Energy ± Routine Adjustments to Reporting Period conditions) ± Reporting Period Energy = Adjusted Baseline Energy – Reporting Period Energy

The adjusted baseline energy is normally calculated by developing a mathematical model which correlates actual baseline energy data with independent variables in the baseline period. Each reporting period's independent variables are then inserted into this baseline mathematical model to produce the adjusted baseline energy.

Equation 13: ZUB Building: Adjusted Baseline Energy

Adjusted Baseline Energy = f (HDD, CDD, RAD)

4.2.6 *Analisys Procedure.*

Once ZUB Building has selected IPMVP Opction C to evaluate savings and routine adjustments will be considered to calculate ABE, it's necessary to define the analysis procedure for obtaining the function that calculates ABE.

ABE for ZUB Building should calculated by a valid mathematical model that includes factors derived from regression analysis which correlate energy to independent variables: HDD, CDD and RAD.

Equation 14: ZUB Building: Adjusted Baseline Energy

$$ABE_{WINTER} = a \cdot Rad + b \cdot HDD + c \cdot Rad \cdot HDD + d \cdot Rad^2 + e \cdot HDD^2 + f$$

$$ABE_{SUMMER} = a \cdot Rad + b \cdot CDD + c \cdot Rad \cdot CDD + d \cdot Rad^2 + e \cdot CDD^2 + f$$

ZUB Building should use continuous data during baseline period and reporting period, so the data used for the calculation of the mathematical model using regression analysis could use different intervals:

Table 45: ZUB Building: Data Time Intervals

Time Interval	Data
Daily	Accumulation of Data for a Day
Weekly	Accumulation of Daily Data
Monthly	Accumulation of Weekly Data
Yearly	Accumulation of Monthly Data

In order to evaluate how well a particular regression model explains the relationship between energy use and independent variables, three statistical terms should be considered:

- R^2: *Coefficient of Determination*. Shows how well a regression model explains the variations observed in the dependent variable.
- *SE*: *Standard Error*. This term is used in estimating precision of a sample mean.
- *t-statistic*. To determine whether an estimate has statistical significance.

4.2.7 *Energy Prices.*

Cost savings are determined by applying next expression:

Equation 15: Cost savings

$$Cost\ savings = C_b - C_r$$

where:

C_b: cost of the baseline period energy adjusted.

C_r: cost of the reporting period energy.

Costs should be determined by applying the same price schedule, that should be obtained from the energy supplier, in computing both C_b and C_r.

Table 46: ZUB Building: Price schedule

Building	Energy Supplier
ZUB Building	District Heating. Electricity Supplier.

Each reporting period should define evolution of price schedules, if prices increase will shorten the payback period and if prices decrease will lengthen the payback period though total energy costs will drop when prices drop.

4.2.8 *Meter Specifications.*

ZUB Building used IPMVP Option C where utility meters are used. All meter characteristics are defined in Deliverable 6.1 "*Identification and definition of BaaS demonstration buildings*" and in Deliverable 6.2 "*Summary of metering and monitoring systems by demosite*":

Table 47: ZUB Building: Utility meters

Building	Energy Supplier
ZUB Building	District Heating Energy meter. Electricity meter.

Data measurements are performed continuously in partial meters and total meters involved or not involved in IPMVP.

4.2.9 *Monitoring Reponsibilities.*

Different responsibilities are assigned:

Table 48: ZUB Building Monitoring Responsibilities

Action	Responsible
Reporting Energy Data	DALKIA
Recording Energy Data	FRAUNHOFER and UCC
Recording Independent Variables	FRAUNHOFER and UCC
Detecting Changes in Static Factors	FRAUNHOFER

Each responsible will be responsible that every action is properly conducted.

4.2.10 *Expected Accurancy.*

Errors occur in three ways: modeling, sampling, and measurement:

Table 49: ZUB Building: Uncertainty Assessment

Errors	Period	Uncertainty
Measurement	Baseline Reporting	Utility meters: SE=0
Modeling	Baseline	R^2 SE t-statics
Sampling	Baseline Reporting	Continuous recording: SE=0

Savings are deemed to be statistically valid if they are large relative to the statistical variations. Specifically, the savings need to be larger than twice the standard error of the baseline value. In each period, uncertainty should be calculated.

4.2.11 *Budget.*

There are no measuring equipment costs because the utilities meters are used. All costs associated with the determination of savings, are personnel costs. Usually are considered a maximum budget of 10% of energy costs, expected savings more than 10%. Monitoring costs against budget, must be performed in each period.

4.2.12 Report Format.

To define the Report's Table of Contents, of the reporting period, is necessary to have in mind the following considerations:

- Report's Timetable: Since energy consumption is seasonal, a report will be performed every three months.
- Reporting period starts once BaaS System is deployed.

Figure 12: ZUB Building: Report's Timetable

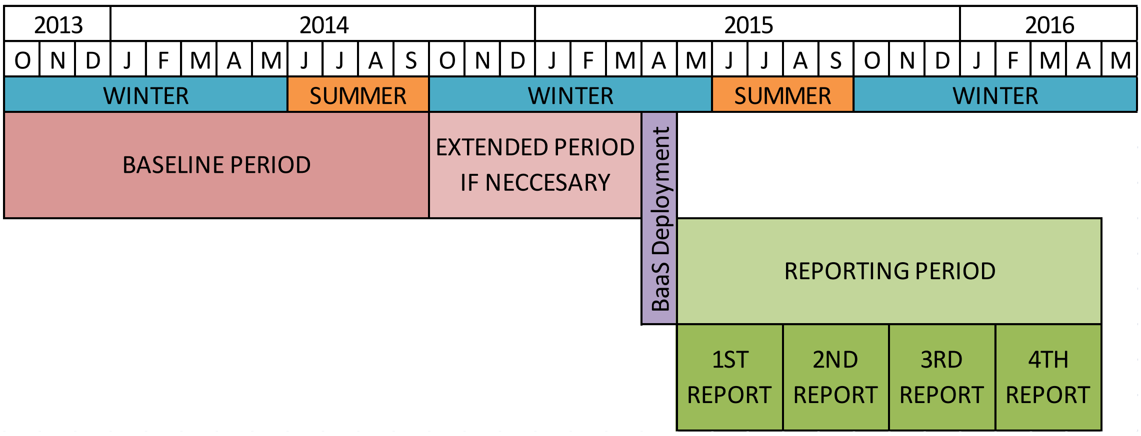


Table of Contents

1. *Executive Summary*. Summary of the savings achieved, measured period, evolution of the prices, IPMVP cost and conclusions. Data are presented in graphical and numerical way.
2. *Data*. The measurement period start and end points in time, the energy data, and the values of the independent variables Description and justification for any corrections made to observed data.
3. *ABE*. Calculation of ABE, including all details of any baseline non-routine adjustment performed. Details should include an explanation of the change in conditions since the baseline period, all observed facts and assumptions, and the engineering calculations leading to the adjustment.
4. *Energy Price*. Shows energy price schedule and its evolution from baseline period.
5. *Savings*. Calculate energy and cost savings, including uncertainty values.
6. *IPMVP Costs*. Determinate IPMVP costs and compare it with budget.
7. *Other issues*.

4.2.13 Quality Assurance.

Once done each report and before final delivery, will be reviewed by Pilot-Building Leader and another Pilot-Building Leader, as follows:

Table 50: ZUB Building: Quality Report Review

Pilot	Report Responsible	Reviewers
ZUB Building	DALKIA	FRAUNHOFER CARTIF

5 Sierra Elvira School Building Pilot.

5.1 Use Cases.

SES Building Use Case is defined in Deliverable 5.1 "*Building Services: Functional and interoperability requirements*", as follows:

- SES_Uc1: Reduce the energy and electrical consumption associated to the distribution system according to demand installation and comfort constraints balancing the thermal comfort levels and the energy consumption of the complete system.

  The propose Use Case for this typology of buildings is to manage in the best way the heating system according to the real demand of the building. This use case is applicable to a large number of facilities that have the same structure for the district heating system that distributes thermal energy to secondary circuits. In this cases, the more usual operation of the heat generators are associated with the demand in any secondary circuit. The secondary circuits usually operate according to a set schedule of operation that is determined depending on the needs of the user, the weather conditions and the experience of personal and maintenance.
  For this reason it is very common for heating times are scheduled so that all building spaces are desired comfort levels, which means that there are areas with overheating so other areas have the required levels of comfort.

5.2 IPMVP Plan.

5.2.1 ECM Intent.

A shared ECM in all Pilots is ***BaaS System***; BaaS will be implemented in the three Pilots with the main objective, from energy point of view, to reduce energy consumption and generate energy savings. SES Building was built in a common way without high level equipment, in this case other ECMs are necessary in order to achieve a first step of energy savings.

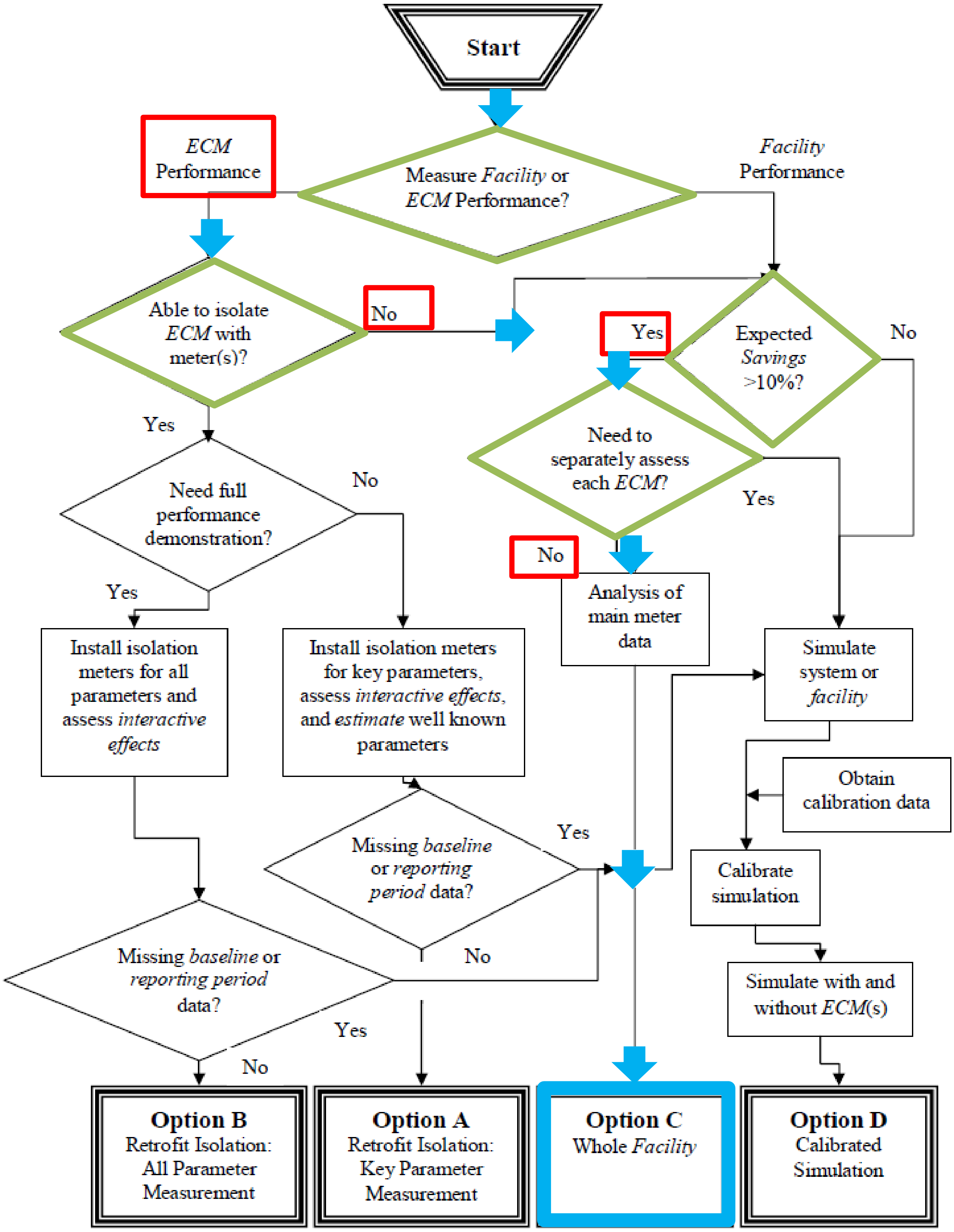
Table 51: ECM at SES buildings

Pilot	ECMs
SES Building	BaaS System. Thermostatic Valves. Variable Flow Pumps.

SES Building has a standard building with a basic energy design, The total expected energy savings, taking into account production and distribution energy systems, will be 20%.

5.2.2 *Selected IPMVP Option and Measurement Boundary.*

Figure 13: SES Building Selection Process



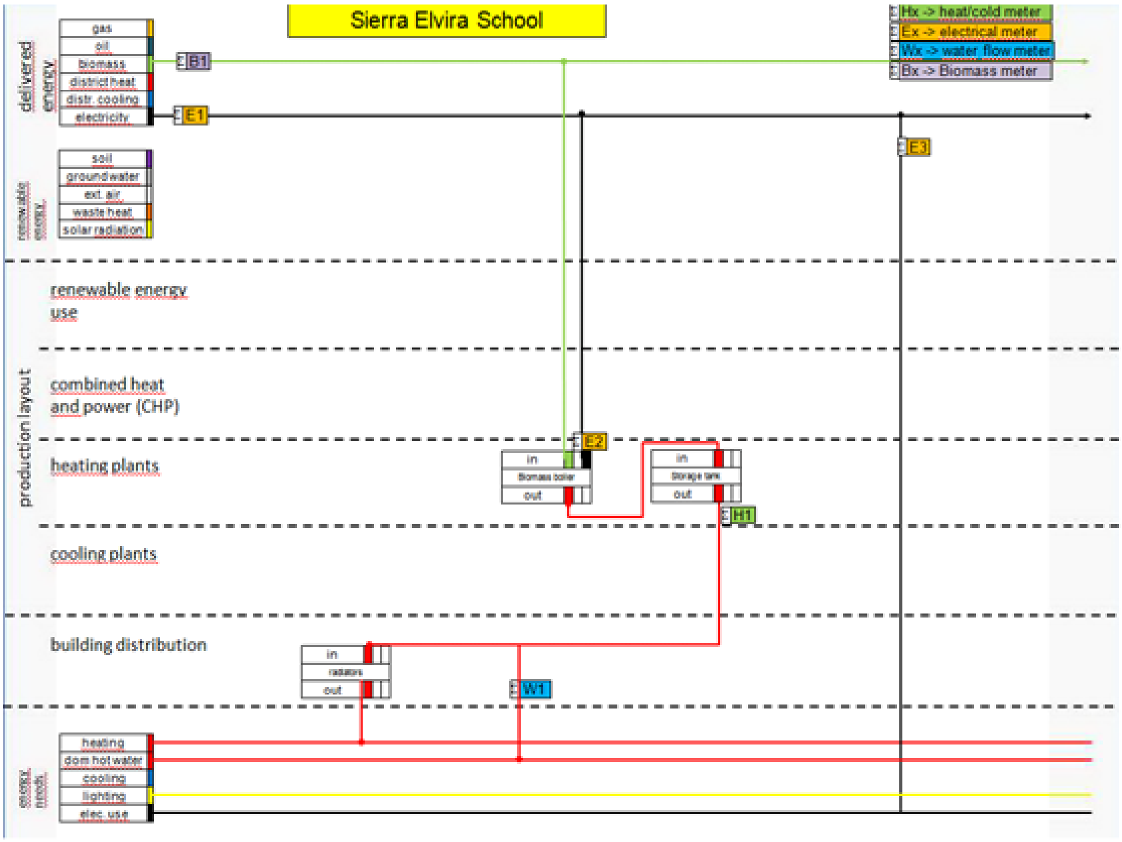
Measurement Boundary

Energy meters use to evaluate energy savings in SES Building are:

B1: Biomass meter that measure energy consumption from biomass supplier.

E1: Electrical meter that measure energy consumption from electrical nertwork.

Figure 14: SES Building Energy Scheme



5.2.3 *Baseline: Period, Energy and Conditions.*

Baseline Period

To determine the reference period is necessary to consider the occupation profiles and weather conditions at building location.

Figure 15: SES Building daily occupation profile

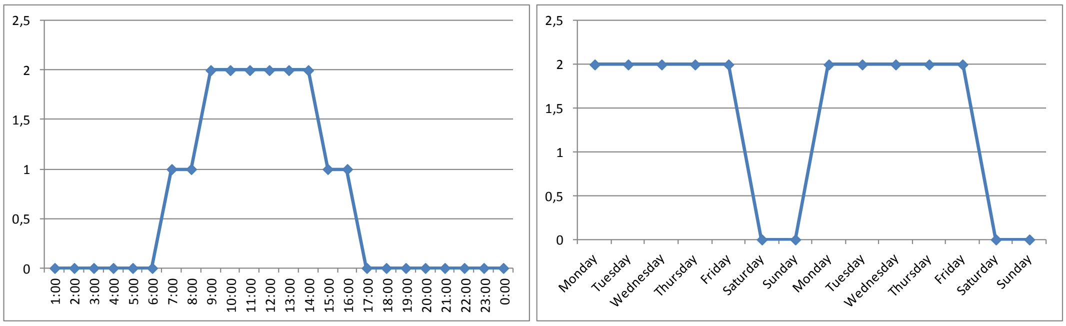


Figure 16: SES Building yearly occupation profile

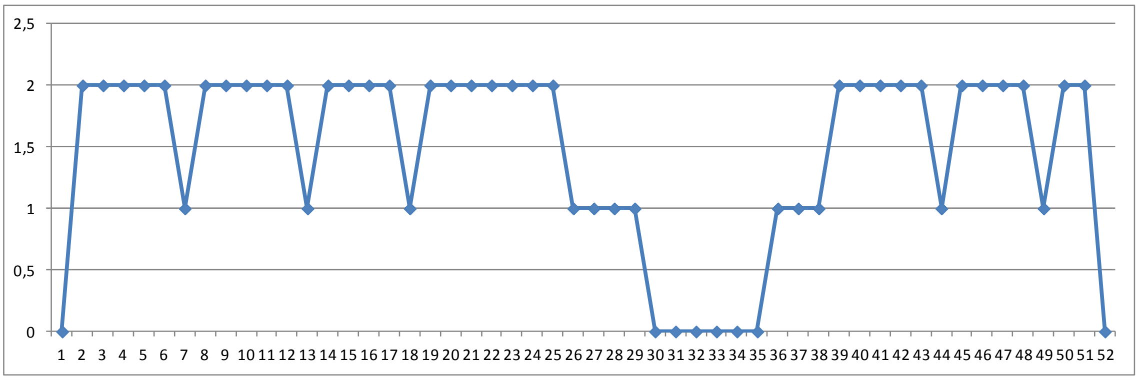


Table 52: Climate values for Granada

	T (ºC)	TM (ºC)	Tm (ºC)	R (mm)	RH (%)	DR (d)	DN (d)	DT (d)	DF (d)	DH (d)	DD (d)	I (h/mo)
Jan	6.8	12.2	1.3	44	74	6	0	0	3	13	9	161
Feb	8.4	14.1	2.6	36	69	6	0	0	2	6	7	161
Mar	10.7	17.0	4.3	37	62	6	0	1	1	2	7	207
Apr	12.6	18.8	6.4	40	59	7	0	1	1	0	5	215
May	16.5	23.1	9.8	30	55	5	0	2	1	0	5	268
Jun	21.3	28.8	13.9	16	48	2	0	2	0	0	11	314
Jul	25.3	33.5	17.1	3	41	0	0	1	0	0	22	348
Aug	25.1	33.2	17.1	3	42	1	0	1	0	0	18	320
Sep	21.2	28.5	14.0	17	52	2	0	2	0	0	10	243
Oct	15.7	21.9	9.5	40	64	5	0	1	1	0	7	203
Nov	10.6	16.2	5.1	46	73	6	0	1	2	3	8	164
Dec	7.9	13.1	2.8	49	76	7	0	0	3	8	7	147
Total	15.2	21.7	8.7	361	60	54	2	11	13	31	115	2751

T: monthly average temperature; TM: monthly average of highest daily temperatures; Tm: monthly average of lowest daily temperatures; R: monthly average of rainfall; RH: monthly average of relative humidity; DR: monthly average of rainy days (rainfall ≥ 1mm); DN: monthly average of snow days; DT: monthly average of storm days; DF:

monthly average of foggy days; DH: monthly average of frost days; DD: monthly average of cloudless days; I: monthly average of sunny hours

Taking into account both parameters (occupancy and weather) and ECM implementation plan, selected baseline period of SES Building is:

Table 53: SES Building baseline period

Start of baseline period	End of baseline period
1st October, 2013	28th February, 2015

Baseline Energy Consumption.

Energy consumption in the baseline period has been obtained by the energy meters installed or through power purchase bills. The energy consumption in previous year, gives an overall idea of energy magnitude in each building, and will be replaced by energy consumption in baseline period.

Table 54: SES Building Electricity consumption in 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	1,025	912	1,426	2,581	2,798	1,918
	Jul	Aug	Sep	Oct	Nov	Dec
kWh	630	624	2,464	2,870	1,277	1,032

Table 55: SES Building Biomass consumption 2,012

	Jan	Feb	Mar	Apr	May	Jun
kWh	96,826	102,373	85,666	42,973	0	0
	Jul	Aug	Sep	Oct	Nov	Dec
kWh	0	0	0	44,862	96,253	86,533

This initial energy consumption, gives an overall idea of energy magnitude in SES Building, and will be replaced by energy consumption in baseline period.

Independent Variables.

Energy consumption in SES Building depends mainly on weather and occupation. Weather conditions are *independent variables* that are related to energy consumption.

HDD is the independent variable. Also the solar radiation (RAD) is used as secondary independent variable, due to the direct effect on the glass surfaces.

Table 56: SES Building independent variables

1st Independent Variable	2nd Independent Variable
HDD	RAD

Static Factors.

All SES Building static factors have been defined in Deliverable 6.1 Appendix E

Reporting Period.

The reporting period should be at least one normal operating cycle of the installation or of the building, in order to characterize the savings in all normal operating modes. SES Building has an operating cycle of eight months, from October to May.

In order to define the dates of the reporting period, it's necessary taking into account the baseline period and BaaS implementation period. Baseline period has been defined from 1st October of 2013 to 28th February of 2014.

As the period of implementation and commissioning will take place in one month will be considered as the starting date of the reporting period the 1st May of 2015. Accordingly, reporting period ends in 30th April of 2016, having a length of eight months and covering all modes of operation in SES Building.

Figure 17: SES Building reporting period

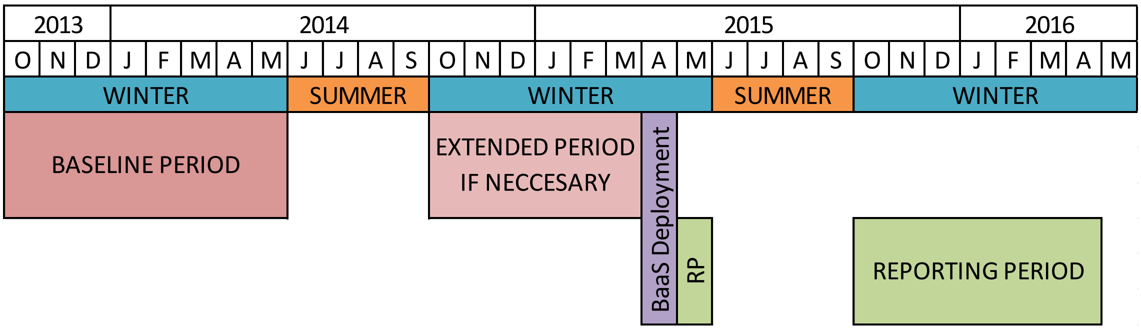


Table 57: SES Building reporting period

Start Date	End Date
1st May, 2015	30th April, 2016

Deployment and commissioning phase should be completed in one month, but depends on the develop of other WPs. In the case that the starting date would be delayed, reporting period could be finished at the same time if winter time is covered.

5.2.4 Basis for Adjustment.

To establish the basis for adjustment is considered that SES Building has selected IPMVP Opction C to evaluate savings, so only routine adjustments will be considered and independent variables are HDD and RAD.

As we described in section 2.6 "*Basis for Adjustment*" savings will calculated by the next equation:

Equation 16: Energy Savings

Savings = (Baseline Period Energy ± Routine Adjustments to Reporting Period conditions) ± Reporting Period Energy = Adjusted Baseline Energy – Reporting Period Energy

The adjusted baseline energy is normally calculated by developing a mathematical model which correlates actual baseline energy data with independent variables in the baseline period. Each reporting period's independent variables are then inserted into this baseline mathematical model to produce the adjusted baseline energy.

Equation 17: SES Building: Adjusted Baseline Energy

Adjusted Baseline Energy = f (HDD, RAD)

5.2.5 Analisys Procedure.

Once SES Building has selected IPMVP Opction C to evaluate savings and routine adjustments will be considered to calculate ABE, it's necessary to define the analysis procedure for obtaining the function that calculates ABE.

ABE for SES Building should calculated by a valid mathematical model that includes factors derived from regression analysis which correlate energy to independent variables: HDD and RAD.

Equation 18: SES Building: Adjusted Baseline Energy

$$ABE_{WINTER} = a \cdot Rad + b \cdot HDD + c \cdot Rad \cdot HDD + d \cdot Rad^2 + e \cdot HDD^2 + f$$

SES Building should use continuous data during baseline period and reporting period, so the data used for the calculation of the mathematical model using regression analysis could use different intervals:

Table 58: SES Building: Data Time Intervals

Time Interval	Data
Daily	Accumulation of Data for a Day
Weekly	Accumulation of Daily Data
Monthly	Accumulation of Weekly Data
Yearly	Accumulation of Monthly Data

In order to evaluate how well a particular regression model explains the relationship between energy use and independent variables, three statistical terms should be considered:

- R^2: *Coefficient of Determination*. Shows how well a regression model explains the variations observed in the dependent variable.
- *SE*: *Standard Error*. This term is used in estimating precision of a sample mean.

- *t-statistic*. To determine whether an estimate has statistical significance.

5.2.6 Energy Prices.

Cost savings are determined by applying next expression:

Equation 19: Cost savings

$$Cost\ savings = C_b - C_r$$

where:

C_b: cost of the baseline period energy adjusted.

C_r: cost of the reporting period energy.

Costs should be determined by applying the same price schedule, that should be obtained from the energy supplier, in computing both C_b and C_r.

Table 59: SES Building: Price schedule

Building	Energy Supplier
SES Building	Biomass Supplier. Electricity Supplier.

Each reporting period should define evolution of price schedules, if prices increase will shorten the payback period and if prices decrease will lengthen the payback period though total energy costs will drop when prices drop.

5.2.7 Meter Specifications.

SES Building used IPMVP Option C where utility meters are used. All meter characteristics are defined in Deliverable 6.1 "*Identification and definition of BaaS demonstration buildings*" and in Deliverable 6.2 "*Summary of metering and monitoring systems by demosite*":

Table 60: SES Building: Utility meters

Building	Energy Supplier
SES Building	Biomass meter. Electricity meter.

Data measurements are performed continuously in partial meters and total meters involved or not involved in IPMVP.

5.2.8 Monitoring Reponsibilities.

Different responsibilities are assigned:

Table 61: SES Building Monitoring Responsibilities

Action	Responsible
Reporting Energy Data	DALKIA
Recording Energy Data	DALKIA and UCC
Recording Independent Variables	DALKIA and UCC
Detecting Changes in Static Factors	DALKIA

Each responsible will be responsible that every action is properly conducted.

5.2.9 Expected Accurancy.

Errors occur in three ways: modeling, sampling, and measurement:

Table 62: SES Building: Uncertainty Assessment

Errors	Period	Uncertainty
Measurement	Baseline Reporting	Utility meters: SE=0
Modeling	Baseline	R^2 SE t-statics
Sampling	Baseline Reporting	Continuous recording: SE=0

Savings are deemed to be statistically valid if they are large relative to the statistical variations. Specifically, the savings need to be larger than twice the standard error of the baseline value. In each period, uncertainty should be calculated.

5.2.10 Budget.

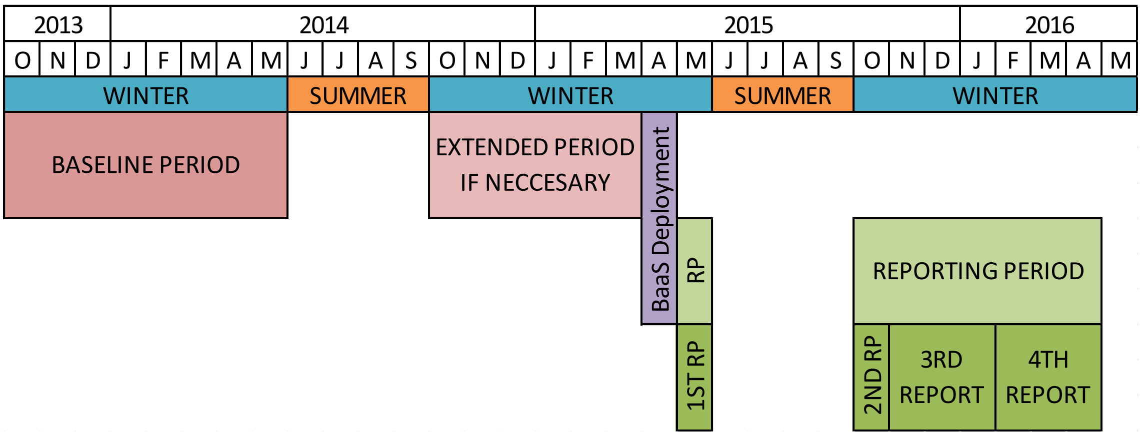
There are no measuring equipment costs because the utilities meters are used. All costs associated with the determination of savings, are personnel costs. Usually are considered a maximum budget of 10% of energy costs, expected savings more than 10%. Monitoring costs against budget, must be performed in each period.

5.2.11 Report Format.

To define the Report's Table of Contents, of the reporting period, is necessary to have in mind the following considerations:

- Report's Timetable: Since energy consumption is seasonal, a report will be performed every three months.
- Reporting period starts once BaaS System is deployed.

Figure 18: SES Building: Report's Timetable



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6. *IPMVP Costs*. Determinate IPMVP costs and compare it with budget.
7. *Other issues*.

5.2.12 Quality Assurance.

Once done each report and before final delivery, will be reviewed by Pilot-Building Leader and another Pilot-Building Leader, as follows:

Table 63: SES Building: Quality Report Review

Pilot	Report Responsible	Reviewers
SES Building	DALKIA	DALKIA FRAUNHOFER

In the case of Dalkia, the reviewer is a person who has not participated in the process of preparing the report.

References

[1] IPMVP 2012. International Performance Measurement and Verification Protocol 2012

[2] "BaaS Deliverable 1.1: Definition of Theoretical Case Studies including Key Performance Indicators". September 2012.

[3] "BaaS Deliverable 1.2: Definition of Theoretical Case Studies including Key Performance Indicators". September 2012.

[4] "BaaS Deliverable 5.1: Functional and interoperability requiremenets for building services." June 2014.

[5] "BaaS Deliverable 6.1: Identification and definition of BaaS demonstration buildings". May 2013.

[6] "BaaS Deliverable 6.2: Operative pilots after adapting". August 2013.