SEVENTH FRAMEWORK PROGRAMME

Open Dynamic System for Saving Energy in Urban Spaces

D5.1.ODYSSEUS Validation Methodology

Deliverable data

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Table of Contents

1 Glossary

Term	Description
Baseline	Pertaining to the *baseline period*.
Baseline Energy	The *energy* use occurring during the *baseline period* without adjustments.
Baseline Period	The period of time chosen to represent operation of the facility or system before implementation of an ECM. This period may be as short as the time required for an instantaneous measurement of a constant quantity, or long enough to reflect one full operating cycle of a system or facility with variable operations.
Commissioning	A process for achieving, verifying and documenting the performance of equipment to meet the operational needs of the *facility* within the capabilities of the design, and to meet the design documentation and the owner's functional criteria, including preparation of operating personnel.
Constant	A term used to describe a physical parameter which does not change during a period of interest. Minor variations may be observed in the parameter while still describing it as constant. The magnitude of variations that are deemed to be ‘minor’ must be reported in the *M&V Plan*.
Demand	The rate of energy use. Many utilities base a portion of their bills on the highest (or peak) demand they measure during each billing period. Peak demand value is sometimes referred to as simply “demand.” Electrical demand is normally expressed in kilowatts (kW). The sum of monthly billed kW quantities can be expressed in unit of kW-months.

District	A district is a type of administrative division, in some countries managed by a local government[1]. From the Odysseus point of view is an administrative division of the city composed by one or several neighbourhoods of different urban scale.
Energy	Energy or water use, or demand.
Energy Conservation Measure (ECM)	An activity or set of activities designed to increase the *energy* efficiency of a *facility*, system or piece of equipment. ECMs may also conserve *energy* without changing efficiency. Several ECM's may be carried out in a *facility* at one time, each with a different thrust. An ECM may involve one or more of: physical changes to *facility* equipment, revisions to operating and maintenance procedures, software changes, or new means of training or managing users of the space or operations and maintenance staff. An ECM may be applied as a retrofit to an existing system or *facility*, or as a modification to a design before construction of a new system or *facility*.
Energy Performance Contract	A contract between two or more parties where payment is based on achieving specified results, such as reductions in *energy* costs or payback of investment within a stated period.
Energy Services Company (ESCO)	A firm which provides services of design and construction of *ECMs* under an *energy performance contract*.
Estimate	A process of determining a parameter used in a *savings* calculation through methods other than measuring it in the *baseline* and *reporting periods*. These methods may range from arbitrary assumptions to engineering estimates derived from manufacturer's rating of equipment performance. Equipment performance tests that are not made in the place where they are used during the *reporting period* are estimates, for purposes of adherence with IPMVP.
Facility	A building or industrial site containing several *energy* using

[1] Wikipedia: http://en.wikipedia.org/wiki/District

	systems. A wing or section of a larger *facility* can be treated as a *facility* of its own if it has meters which separately measure all of its *energy*.
Independent Variable	A parameter that is expected to change regularly and have a measurable impact on the *energy* use of a system or *facility*.
Measurement and Verification (M&V)	The process of using measurements to reliably determine actual *savings* created within an individual facility by an *energy* management program. *Savings* cannot be directly measured, since they represent the absence of *energy* use. Instead *savings* are determined by comparing measured use before and after implementation of a project, making appropriate adjustments for changes in conditions.
Measurement Boundary	A notional boundary drawn around equipment and/or systems to segregate those which are relevant to *savings* determination from those which are not. All *energy* uses of equipment or systems within the measurement boundary must be measured or estimated, whether the *energy* uses are within the boundary or not.
Metering	Collection of *energy* data over time at a *facility* through the use of measurement devices.
Neighbourhood	A group of facilities in an urban area which are included within a measurement boundary for addressing ECMs at the urban scale. This can include a mix of uses (housing, industry, retail, commerce, etc.), or a collection of facilities for a single use (e.g. an office complex).
Normalized *Savings*	The reduction in *energy* use or cost that occurred in the *reporting period*, relative to what would have occurred if the *facility* had been equipped and operated as it was in the *baseline period* but under a normal set of conditions. These normal conditions may be a long term average, or those of any other chosen period of time, other than the *reporting period*. Normal conditions may also be set as those prevailing during the *baseline period*, especially if they were used as the basis for predicting *savings*. If conditions are those of the *reporting*

	period, the term *avoided energy use*, or just *savings*, is used instead of normalized savings.
Operational Verification	Verification that the ECMs are installed and operating properly and have the potential to generate savings. *Operational verification* may involve inspections, functional performance testing, and/or data trending with analysis.
Reporting Period	The period of time following implementation of an *ECM* when *savings* reports adhere to IPMVP. This period may be as short as the time for an instantaneous measurement of a constant quantity; long enough to reflect all normal operating modes of a system or *facility* with variable operations; the length of the financial payback period for an investment; the duration of a performance measurement period under an *energy performance contract*; or indefinite.
Savings	The reduction in *energy* use or cost. Physical savings may be expressed as *avoided energy use* or *normalized savings*. Monetary savings may be expressed analogously as "cost avoidance" or "normalized cost savings". Savings, as used in IPMVP, are not the simple difference between baseline and reporting period utility bills or metered quantities.
Static Factors	Those characteristics of a *facility* which affect *energy* use, within the chosen *measurement boundary*, but which are not used as the basis for any *routine adjustments*. These characteristics include fixed, environmental, operational and maintenance characteristics. They may be constant or varying.

2 Executive Summary

The Odysseus project is about reducing energy consumption in urban areas by means of decision making support (strategic, tactical and operational) with the provision of a holistic energy management vision of neighbourhoods. This management requires a complete and right information picture of the area in terms of energy nodes (e-Nodes) and their energy interactions.

The WP5 of the Odysseus project has the objective to prepare, implement, monitor and asses use cases to be conducted in the two pilot cases in Manchester and Rome. These use cases to be implemented will have both a building oriented and neighbourhood oriented scale.

Inside this WP5, task 5.1 we propose the Odysseus validation methodology. Because of the nature of the project and the ECMs (Energy Conservation Measures) that will be implemented, ICT PSP is considered the most suitable methodology in which Odysseus one. The Odysseus validation methodology will be developed by upgrading ICT PSP principles with the inclusion of the neighbourhood point of view. We take also into consideration requirements from WP1 results.

Proposed Odysseus validation methodology is summarised in the following 12 steps and phases. Also, next figure provides a timeline based vision of the methodology.

Steps	Description	Phase
1	Define the set of project boundaries for the pilot site: energy-system(s)/e-Node(s) definition.	• Monitoring plan
2	Select the predictor variables to be applied on the pilot site.	• Monitoring plan
3	Set the baseline period for the pilot site without improvements and optimization at neighbourhood level.	• Monitoring plan
4	Deploy monitoring hardware (e.g. gateways, sensors and actuators) for energy-systems /energy nodes (e-Nodes) at facilities level in the pilot site (e.g. floors, buildings) in order to monitor predictor variables (e.g. energy data).	• Monitoring plan
5	Collect and store raw data of predictor variables at energy-systems / e-Node (facilities level scale) (M13-M24)	• Monitoring plan • Baseline analysis
6	Transform raw data into dEPC information structure (M21: Monitoring tool).	• Monitoring plan • Baseline analysis
7	Perform initial baseline analysis at energy-system/e-Node level	• Baseline analysis

	(facilities level) (M21: decision-making tools). Define ECMs.	• ECMs definition
8	Connect e-Nodes to the aggregation layer of the Odysseus Cloud Platform. From e-Node to e-Network (building /neighbourhood/district) (M24).	• Extended boundaries to e-Network
9	Send e-Node dEPC information (real information) to the Odysseus Cloud Platform to compose the e-Network level (simulated). Analyse and conclude the neighbourhood baseline period for the pilot site with this information). **Note:** At this step we will have a neighbourhood level scale vision.	• Extended boundaries to e-Network • Baseline analysis
10	Apply the identified ECMs at e-Node level (facilities level scale) (e.g. building). **Note:** This step implies the start of the reporting period for the pilot site.	• ECMs • Reporting period
11	Apply the identified ECMs at e-Network level (Odysseus Cloud Platform simulation). **Note:** At this step we expect to have the Odysseus Cloud Platform and the integrated versions of energy efficiency tools. We will provide a holistic energy management vision of the neighbourhood.	• Extended boundaries to e-Network • ECMs • Reporting period
12	Evaluate the obtained results at e-Node level (facilities level) and e-Network level (neighbourhood level) by comparing baseline and reporting periods.	• Evaluation period

Table 1 - Odysseus validation methodology steps

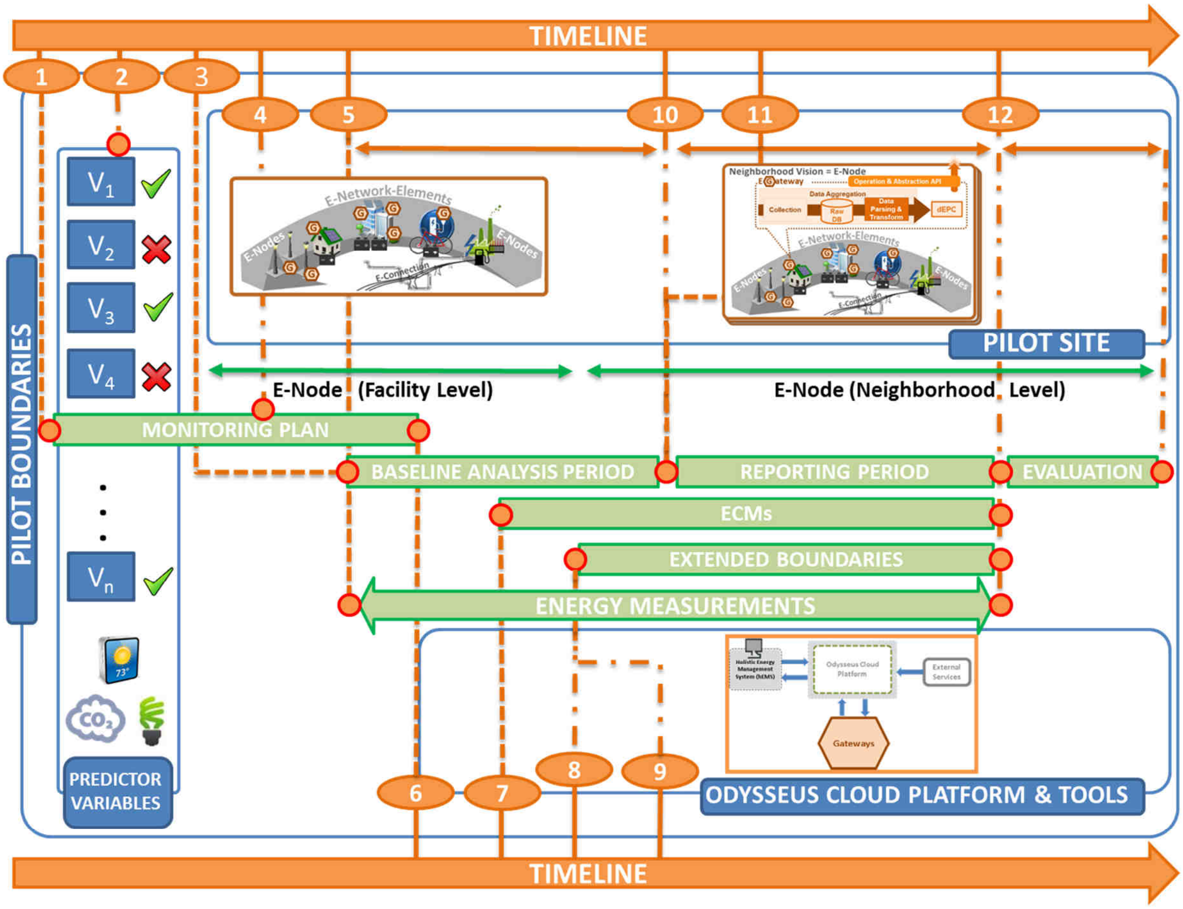

Figure 1 - Odysseus validation timeline

The Odysseus validation methodology tries to address the question on how to go from facilities level towards an upper level scale like the neighbourhood of a city. In this sense, Odysseus tools and solutions will be deployed for monitoring e-Nodes and energy systems levels in pilot sites for the application of the ECMs at facilities level. Simulation approaches will be mainly conducted when the Odysseus Cloud Platform and the decision making tools enters into scene for the application of ECMs at neighbourhood level.

This deliverable includes a description and tries to set-up the basis of:

- The definition of the Odysseus boundaries based on pilot cases specificities
- The set of relevant predictor variables, by considering energy data, simulated variables, independent variables, (like weather conditions and energy tariff prices) and static factors for both pilot cases
- A baseline definition that summarises the energy flows, the identification of the boundaries of these energy flows, a proposal for the relevant KPIs and the monitoring equipment and devices for implementation of use cases at Manchester

and Rome pilots cases

- Baseline analysis to be applied by the identification of ECMs, their commissioning and finally the set of conditions to which ECMs will be adjusted
- How will be carried out the reporting period in terms of monitoring /measurement, reporting and analysis activities.

Finally, it is important to note that the “D5.2 Odysseus Demonstration Plan” will be based on the Odysseus validation methodology proposed in this deliverable, including the baseline definition for identified scenarios and use cases. The implementation of the Odysseus validation methodology will be addressed in the specific tasks (T5.2 and T5.3) for each pilot case.

3 Introduction

3.1 Purpose, Intended Audience and Scope

The purpose of this document is to propose the Odysseus validation methodology based on the analysis of existing methodologies (IPVMP and ICT PSP) available across the community and select the methodology (ICT PSP) that best matches with the characteristics of the Odysseus project scenarios and use cases to be implemented in both pilots sites Manchester and Rome to provide the evidence base to develop the demonstration plan for validation in further deliverables (D5.2 Demonstration Plan, D5.3 Rome and Manchester Pilots Final Report and D5.4 Evaluation Report).

The intended audience of this document is both the Odysseus project team, specifically those working on the next stages of developing the integration requirements and the validation of the dynamic (energy management) system, and the partners and stakeholders in each of the pilot cases, in Manchester and Rome, in order to ensure that they are fully engaged with the validation process of the project. Moreover this document will be a reference for ICT PSP audience when dealing with scenarios at neighbourhood, district or even city scale levels, as the proposed Odysseus validation methodology will address a scale beyond the facilities (i.e.mainly building) scale.

From a scope point of view this deliverable provides the explanation of the validation process that will be applied in both scenarios Manchester and Rome. B both scenarios will be described in detail in the further deliverable D5.2.

Chapter 4 Background on Energy Efficiency M&V Methodologies provides the current existing key initiatives being used by the community in similar ICT and energy efficiency projects, in order to have the capability of selecting the one which best covers the Odysseus needs and constraints.

Chapter 5 ODYSSEUS: Validation Methodology introduces the proposed Odysseus validation methodology to be implemented within the framework of the project in order to develop the Odysseus demonstration plan. This plan will serve to verify whether the actions taken by stakeholders within the project in relation to energy efficiency serve their purpose.

As part of the validation methodology, predictor variables related to energy data, simulated variables, independent variables like weather and energy tariff and static factors of both pilot sites have been identified. In this sense, a baseline period and a reporting period have been defined taking in account particularities of both scenarios, Manchester and Rome. By following this approach, the proposed ECMs to be implemented were identified, and we obtained the predictor variables. This includes those to be measured, because they are involved in a certain ECM as well as and other independent variables that could have an influence in the final consumption.

3.2 Applicable Documents

AD(1). DOW ODYSSEUS (600059) 2012-09-26.

AD(2). D1.1 Pilot Business Cases.

AD(3). D1.2 Pilot Integration Scenarios & dEPC Requirements.

4 Background on Energy Efficiency M&V Methodologies

4.1 Standards and Initiatives

Energy savings cannot be measured directly because the targeted scenarios might be different over time, so in this circumstance, it is always necessary to compare between different situations. A more practical approach is to setup the calculation of the energy savings using a standardized calculation methodology that supports comparisons of energy savings in a homogeneous way.

By reviewing results regarding validation methodologies applied by other FP7 projects (SEEDS, E3SoHo, eeMeasure, eSESH, 3e-HOUSES, BECA) through their official web sites, it has been found that most of them base their validation methodologies in either the International Performance Measurement Validation Protocol (IPMVP[2]) best practice or in the ICT-PSP[3] methodology for energy saving measurement, which in itself is derived from IPMVP.

4.1.1 *EVO International Performance Measurement and Verification Protocol*

The International Performance Measurement Validation Protocol (IPMVP) is one of the most recognized worldwide protocols for measurement and verification of energy savings.

The main principles of this protocol are (a) to define the parameters involved in the assessment, (b) gather the base data against these parameters over a certain period of time before (c) implementing the retrofitting actions, and finally (d) measuring the parameters again. At the end, these latter measurements are compared with the base data to calculate the energy saved, taking into account the external variables that can influence the energy consumption to remove them from the equation (known as adjustments).

The general equation proposed by the IPMVP protocol is:

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

The baseline (shown in red at Figure 2) in an existing facility energy evaluation project is

[2] http://www.evo-world.org/index.php?option=com_content&view=article&id=272&Itemid=397&lang=en

[3] ICT Policy Support Programme

usually the performance of the facility or system prior to modification. This baseline physically exists and can be measured before changes are implemented. In new construction, the baseline is usually hypothetical and defined based on code, regulation, common practice or documented performance of similar facilities. In either case, the baseline model must be capable of accommodating changes in operating parameters and conditions so “adjustments” can be made.

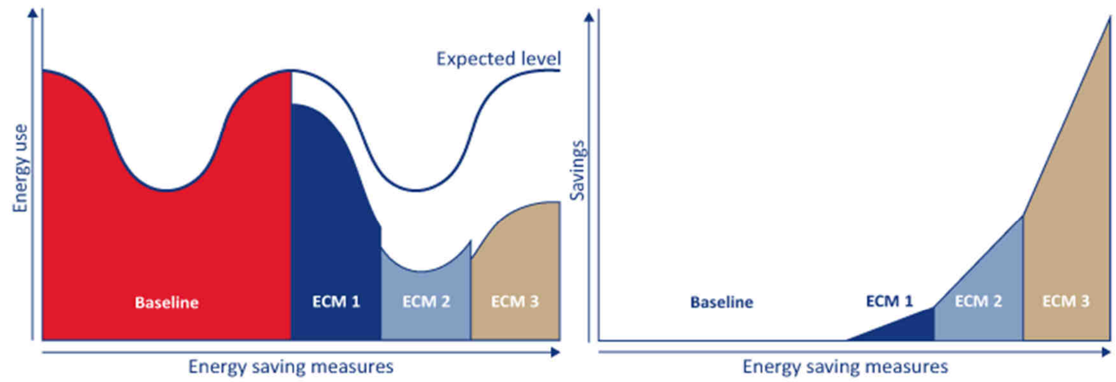

Figure 2- Energy saving measures versus energy use and versus savings

The IPMVP measurement and verification plan (M&V Plan) includes the following 13 topics (IPMVP,vol. 1, page 36 ff.):

1. Intent of energy conservation measures (ECM).
2. Selection of option and measurement boundary.
3. Definition of baseline: Period, Energy data and conditions.
4. Definition of reporting Period.
5. Definition of basis for adjustment.
6. Specification of analysis procedure.
7. Specification of energy prices.
8. Meter specifications.
9. Assignment of monitoring responsibilities.
10. Evaluation of expected accuracy.
11. Definition of budget.
12. Specification of report format.

13. Specification of quality assurance.

Regarding item 1, an Energy Conservation Measure (ECM) is any type of activity or set of activities designed to increase the energy efficiency of a facility, system or piece of equipment. ECMs may also conserve energy without changing efficiency. Several ECM's may be carried out in a facility at one time, each with a different thrust. An ECM may involve one or more of: physical changes to facility equipment, revisions to operating and maintenance procedures, software changes, or new means of training or managing users of the space or operations and maintenance staff. An ECM may be applied as a retrofit to an existing system or facility, or as a modification to a design before construction of a new system or facility.

According the second topic, this protocol provides 4 options for determining savings; option A - Retrofit Isolation: Key Parameter Measurement; option B - Retrofit Isolation: All Parameter Measurement; option C - Whole Facility; option D – Calibrated simulation.

Type	Name	Description
Option A	Retrofit Isolation: Key Parameter Measurement	Savings are determined by field measurement of the KPI which define the energy use of the system. Secondary parameters are estimated.
Option B	Retrofit Isolation: All Parameter Measurement	Savings are determined by field measurement of the energy use of the system.
Option C	Whole Facility	Savings are determined by field measurement of the energy use of the whole facility or sub-facility level.
Option D	Calibrated simulation	Savings are determined through simulation of the energy use of the whole facility or sub-facility level.

Table 2- IPMVP protocol options

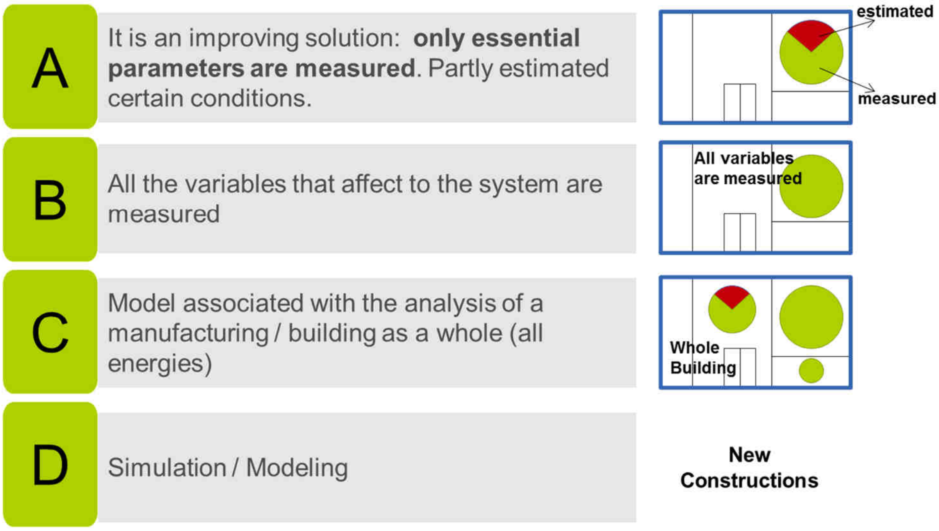

Figure 3- IPMVP protocol options

To select the right option from the IPMVP protocol and to identify the best practices to be followed up in our validation methodology that best fits the constraints of the Odysseus pilot scenarios, the decision graph flow shown in the Figure 3 has been considered.

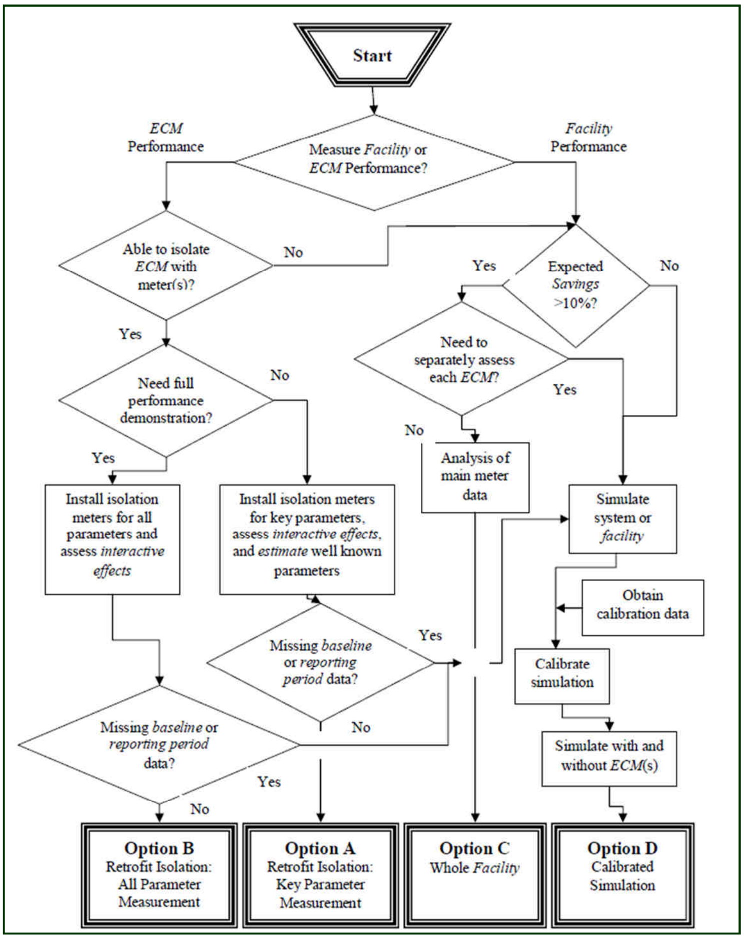

Figure 4- IPVMP option selection

Using this graph every project can select the right option based on their constraints and follow-up the recommendations. In the next section 5.2, a route will be defined through this graph answering the questions of every box in order to propose the validation methodology for Odysseus project.

4.1.2 *The ICT PSP Methodology for Energy Saving Measurement*

ICT-PSP is an evolution of IPMVP developed by the 3e-Houses[4], e3SoHo[5] and eSESH[6] project consortia. First version was published in September 2010 by 3e-Houses project, second version was published on September 2011 by eSESH project and third version[7] was published as part of the BECA[8] project. This methodology has been developed for residential sectors.

ICT PSP for the residential sector is based on IPMVP and adapts its provisions to the very much smaller scale of energy consumption in the residential sector than in the industrial sector. One of the adaptations is to reduce the costs of measurement by the use of larger time intervals for measurement and less sub-metering.

ICT-PSP changes the four options proposed by IPMVP to three, merging options A and B to one called “Constant demand”, renaming option C to “Variable demand as a result of the ICT application” and also renaming option D to “Modelling variable demand”.

Type	Name	Description	IPMVP
1	Constant demand	If a facility constant demand of energy is assumed, energy savings can be measured by the change in energy consumption before and after the intervention.	Options A, B
2	Variable demand as a result	This approach is similar to the	Option C

[4] http://www.3ehouses.eu/

[5] http://www.e3soho.eu/

[6] http://www.esesh.eu/home/

[7] http://eemeasure.smartspaces.eu/eemeasure/static/files/eemeasure_residential_methodology.pdf

[8] http://beca-project.eu/home/

	of the ICT application	option C offered by IPMVP introducing a control group approach to verify the energy savings results.	
3	Modelling variable demand	The demand structure can be fully modelled	Option D

Table 3 - ICT PSP residential methodology options

They discard options 1 and 3 because in the residential sector an assumption of constant demand (Option A) or cyclically predictable demand (Option B), or another demand structure which can be fully modelled (Option D), cannot be made.

One of the main characteristics of this methodology is to implement an evaluation using control buildings which involves the following steps:

1. Select a group of buildings representative of the future exploitation potential of the energy saving intervention (ICT application).
2. Divide the pilot buildings into 2 groups: treatment /experimental and control.
3. (Optionally) establish pairs of analogues cases from both groups.
4. (Optionally) measure dependent and independent variables during the baseline period in each group.
5. Implement the Energy Saving Intervention (ESI) in the treatment group.
6. Measure dependent and independent variables during the reporting period.
7. Use appropriate statistical techniques to estimate non-intervention consumption in the treatment group during the reporting period based on baseline model and control group model. Or use matched-pair statistical techniques to estimate the energy saving.
8. Calculate energy saving as difference between the estimated non-intervention consumption and the measured energy consumption in the treatment group in the reporting period. Or use matched-pair statistical techniques to estimate the energy saving.

This approach removes the need for the baseline period permitting realisation of the retrofit action at the early stages reducing the overall time need to undertake the assessment.

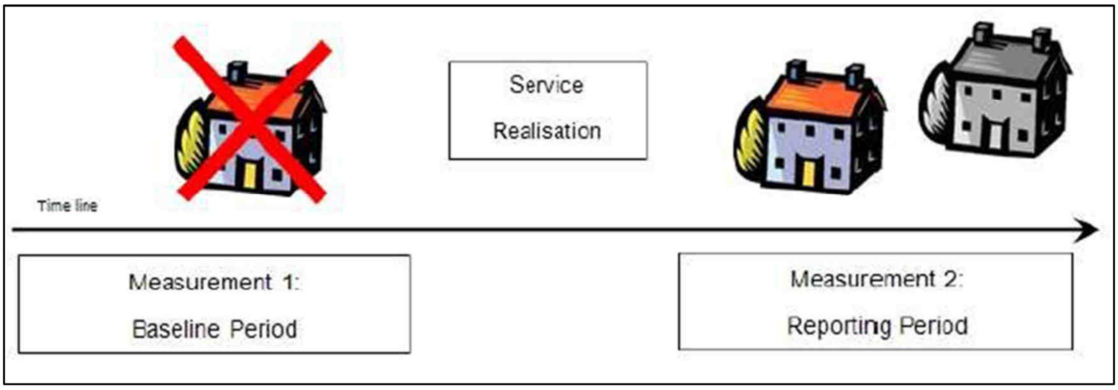

Figure 5 Control building design

4.1.3 *The ICT PSP Non-residential Methodology*

This methodology[9] has been produced as part of the eeMeasure project (August 2011) under SMART 2011/0072. It covers the non-residential sectors and is based on the previous methodologies.

The following shows the high level process described by this methodology.

[9] http://eemeasure.smartspaces.eu/eemeasure/static/files/eemeasure_non_residential_methodology.pdf

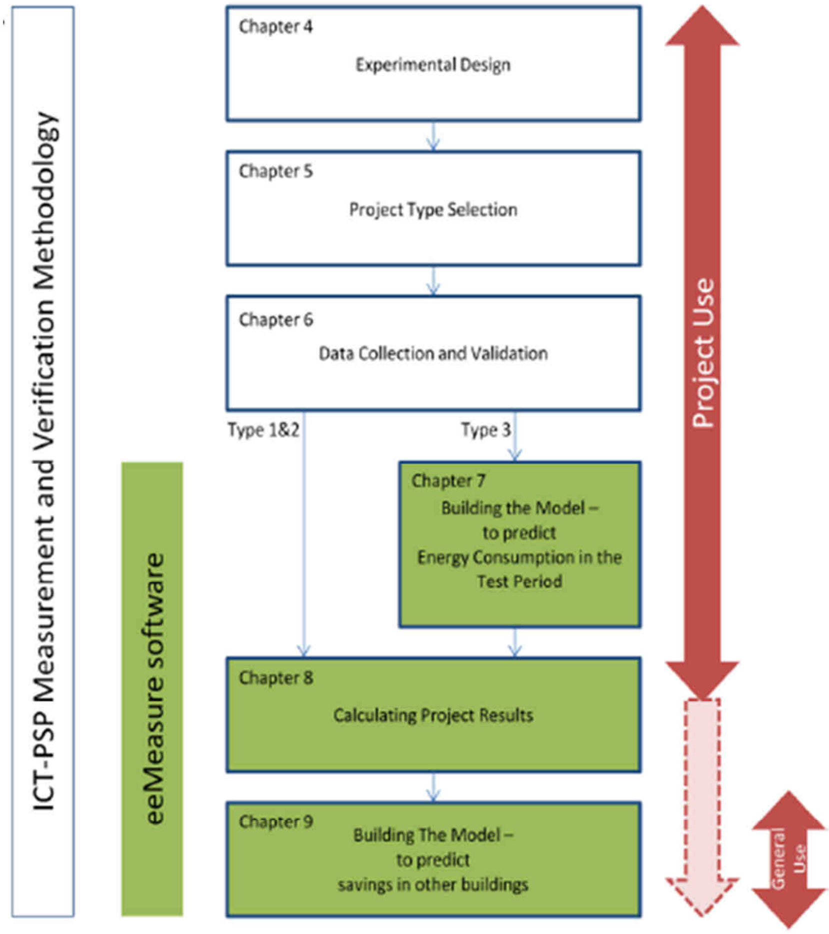

Figure 6- ICT PSP non-residential methodology

In this methodology three project types are proposed, Type 1, Type 2 and Type 3.

Type	Description	IPMVP
1	Energy Saving can be calculated by subtracting the Post-Intervention Energy Consumption from the Pre-Intervention Energy Consumption. In this case the Energy Consumption may be either measured or calculated from trusted device specifications.	Option A
2	Variation of Energy Consumption during the Baseline Period is closely replicated by the variation of Energy Consumption during the Test Period and is closely replicated by the variation of Energy Consumption in the Control Group.	Option B or C
3	Energy Consumption is significantly impacted by Predictor	Option B or C

	Variables (e.g. external temperature, daylight hours, occupancy variations, equipment failure) that cannot be fully compensated for by a Control Group.	

Table 4 - ICT PSP non-residential methodology options

The option D of IPMVP is beyond the scope of this methodology.

Figure 7 will help to decide the appropriate type for each project (below):

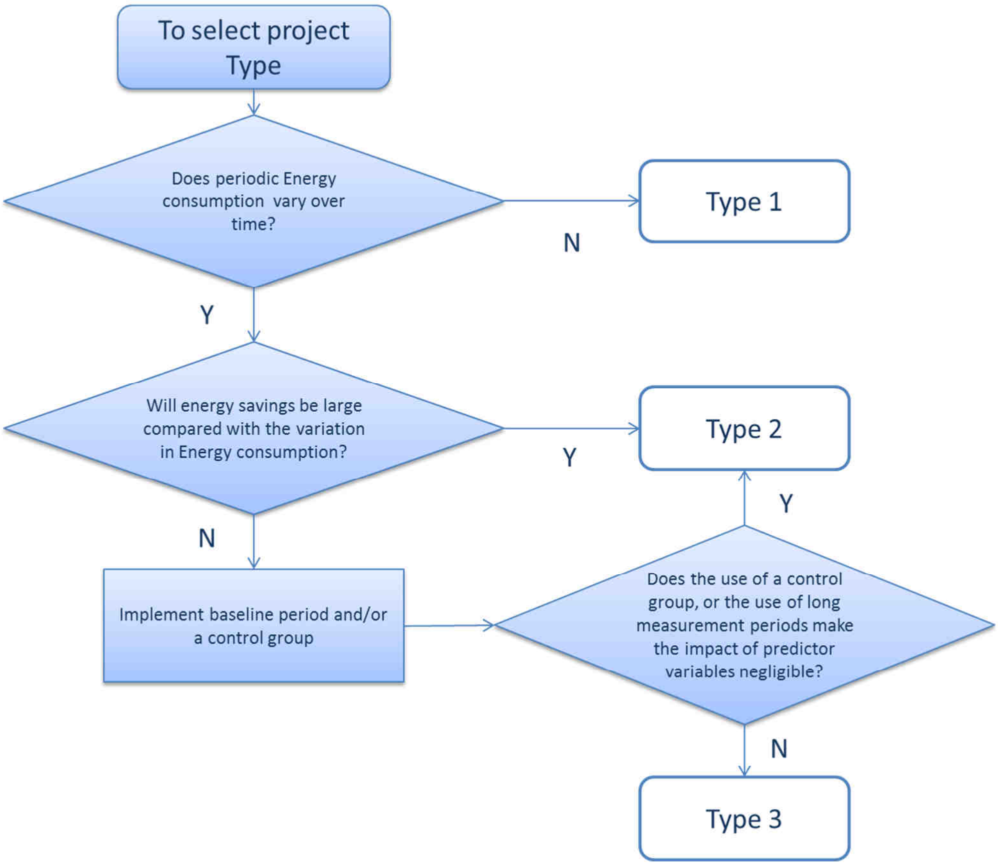

Figure 7 - Project Type Selection Flow Diagram

This methodology was designed to be used with the eeMeasure software building the prediction model with their released tool.

4.2 EC Energy Efficiency Related Projects

The table below shows the key projects reviewed and the validation methodology that they applied for their pilot scenarios.

Project	Methodology	Comments
SEEDS	IPMVP	Uses the IPMVP methodology
E3SoHo	IPMVP	Uses the IPMVP methodology
3e-HOUSES	ICT PSP	Publishers of First version of the ICT PSP methodology.
BECA	ICT PSP	Publishers of Third version of the ICT PSP methodology.
eeMeasure	ICT PSP	Differentiates two methodologies, one for residential environments and other for industrial.

Table 5 - EC Energy Efficiency related projects

4.2.1 *SEEDS*

Self-learning Energy Efficient builDings and open Spaces (SEEDS[10]) project goal is to define, model and implement a Building Energy Management System (BEMS) and architecture based on self-learning techniques which will allow the system to anticipate energy uses for optimal performance.

The project aims to develop an open architecture and system shown at Figure 8 for adaptive real-time energy management for buildings, surrounding areas and open spaces that integrate self-learning methods, advances in wireless sensor technology and building technologies to optimize building's performance in terms of comfort, energy efficiency, resource efficiency, economic return, functionality and lifecycle value.

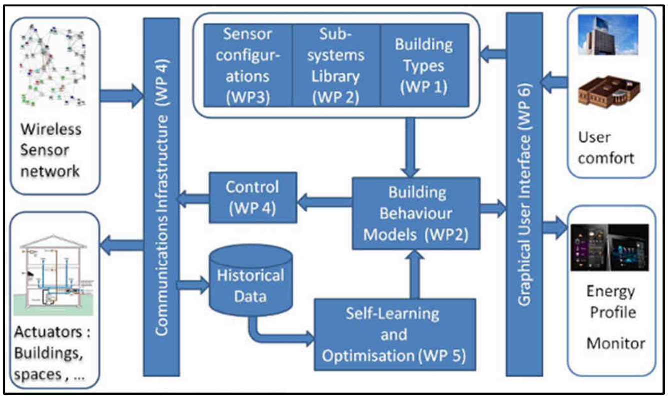

Figure 8 - SEEDS architecture overview

[10] http://seeds-fp7.eu/index2.php

The solution will be validated in two locations, a building with 6 floors for offices and 3 underground floors for car parking in Madrid (Spain) and part of a University Campus at University of Stavanger (Norway), which includes several interconnected buildings, atria, deck, bicycle parking lots, parking lot belonging both to the commercial sector at opposite sides of Europe, with different climate and way of life.

Given that the project manages energy efficiency in buildings for public use, this project selected option C of the IPMVP methodology. The D option was discarded at the expense of the option C on the basis that the cost of the option C is much lower when it comes to whole buildings and grounds. Option C is also far more precise since it is based on actual measurements.

, One of the SEEDS deliverables is D8.1 Validation Methodology[11] that shows the option being chosen and describes the steps followed in making the selection.

SEEDS project proposed validation methodology covers the following steps:

1. Description of building, energy consumers and energy sources
2. Description of ECM to be applied
3. Definition of energy system where savings are calculated and measurement boundaries plus the location of energy meters
4. Baseline and reporting period data: identification of time period, characterization variables and static factors
5. Basis equations for adjustment
6. Procedure for data analysis and saving computation

This deliverable shows the option chosen and describes the path followed.

4.2.2 *E3SoHo*

The overall objective of E3SoHo[12] project was to implement and demonstrate in 3 Social housing pilots an integrated and replicable ICT-based solution which aimed to bring about a significant reduction of 25% of energy consumption in European social housing.

The energy reduction target was be addressed by providing tenants with feedback on

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[11] http://seeds-fp7.eu/documents/Deliverables//SEEDS_D8.1_Validation_Methodology_r0.pdf

[12] http://www.e3soho.eu/

consumption and by offering personalised advice for improving their energy efficiency, reducing the energy consumption and increasing the share of RES (Renewable Energy Sources).

Also, the project informed and supported the users to explore and decide the most appropriate behaviour in terms of energy efficiency, cost, comfort and environmental impact, monitoring and transmitting consumption data to Energy Services.

The E3SoHo service was built up of the following sub-services that can be provided separately:

- Perform an audit in the building to identify the energy saving potential.
- Provide the owner with an ICT based blue-print to reduce the energy consumption.
- Implement the system according to the blue-print
- Tuning of energy consumption by monitoring
- Maintenance of the installed system.

The E3SoHo is being demonstrated within three clusters of Social Housing developments in three European countries (more than 400 estimated users).

This project is part of the consortia which developed the first version of the ICT PSP methodology based on IPMVP.

In this project IPMVP is used as part of the D6.1 Methodology[13] where details are provided for the preliminary part of the global methodology that are being developed during the project and which will be composed of four deliverable submissions: methodology for design, methodology for implementation, methodology for monitoring, and global methodology. The other relevant deliverables regarding the implemented validation methodology are not yet publicly available at their official project website.

4.2.3 *3e-HOUSES*

3e-HOUSES[14] project deals with the integration of the most established ICT technologies in social housing in order to provide an innovative service for energy efficiency:

[13] http://www.e3soho.eu/spip.php?article65

[14] http://www.3ehouses.eu/

- Real time monitoring and management of the energy consumption.
- Integration of renewable energies.
- Creating the resources to lower energy consumption.

The project allows tenants to develop or enhance their relationship with the utility, the environment, and as an underlying concept, saving energy is equivalent to saving CO_2 emissions. This is to be achieved by piloting in several social housing case study buildings where the interaction between smart devices and the users is to create, in a first approach, awareness around their energy consumption and therefore a change in their energy-use patterns.

As part of this project the IPMVP protocol is used to develop the first version of the ICT PSP residential methodology.

4.2.4 *BECA*

The BECA[15] (Balanced European Conservation Approach – ICT services for resource saving in social housing) project started on January 2011 aimed at reducing the energy consumption in European social housing developing advanced ICT-based Resource Use Awareness Services (RUAS) and Resource Management Services (RMS).

In this context, the BECA's project evolved the ICT-PSP methodology based in the IPMVP protocol for the residential sector using their experiences through the project's life and published the third version of the methodology. This is the version used in the project eeMeasure described below.

4.2.5 *eeMeasure*

The eeMeasure[16] portal provides access to the results achieved on the various project pilots that have been implemented within the ICT PSP projects initiative. The energy saving for each project is reported as calculated in accordance with the ICT PSP Residential and Non-Residential Methodology. Currently the site has reports for more than 15 projects.

They have a contact mail for projects that wish to use their online energy efficiency assessment tool.

[15] http://beca-project.eu/home/

[16] http://eemeasure.smartspaces.eu/eemeasure/

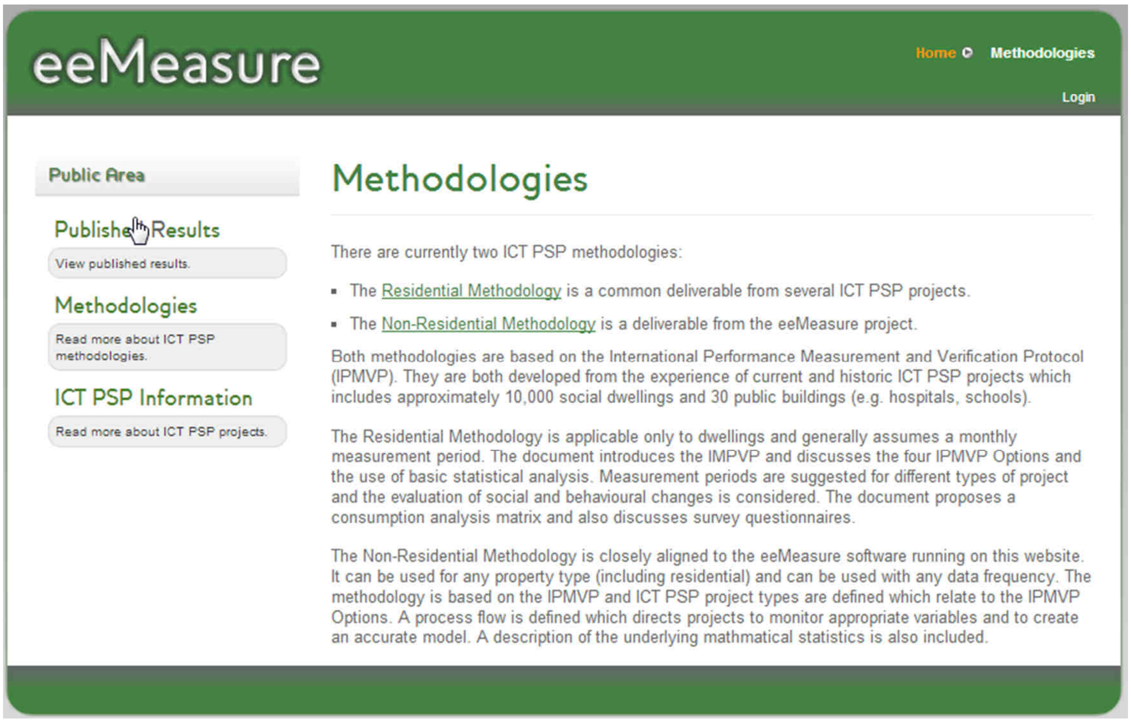

Figure 9 - eeMeasure methodologies page

On the methodologies web page[17] shown at Figure 9 a link to the 3rd version of the ICT PSP residential methodology[18] can be found as well as one to the second version of the non-residential methodology[19].

4.2.6 *Additional Projects to Take Into Consideration*

A range of different EU-funded projects strive to optimize energy management at neighbourhood and/or district level and can therefore contribute to developing the ODYSSEUS tools. Some relevant related projects have been identified and are described below.

Project Name	logo	Timeline	Website
SMARTKYE	Smart Grid Key Neighborhood Indicator Cockpit SmartKye	Nov. 2012- Apr. 2015	http://smartkye.eu/

[17] http://eemeasure.smartspaces.eu/eemeasure/generalUser/methodology

[18] http://eemeasure.smartspaces.eu/eemeasure/static/files/eemeasure_residential_methodology.pdf

[19] http://eemeasure.smartspaces.eu/eemeasure/static/files/eemeasure_non_residential_methodology.pdf

Project Overview
SmartKYE proposes to develop a system for the future neighbourhood smart grid that will enable better business decisions to be made based on real-time fine-grained data coming from heterogeneous energy systems. Key end-users targeted are the public authorities who can monitor and manage key indicators in neighbourhoods with the goal of better energy efficiency and CO_2 reduction.

Project Name	**logo**	**Timeline**	**Website**
e-hub		Dec. 2010 – Nov. 2014	http://www.e-hub.org/
Project Overview			
A novel type of district energy infrastructure is being developed to include advanced systems for matching supply and demand of energy (heat, cold and electricity) and incorporating advanced heat storage technologies such as Thermo Chemical Materials. The technology will be demonstrated at full scale in the district of Tweewaters, Belgium.			

Project Name	**logo**	**Timeline**	**Website**
FCdistrict		Sep. 2010 – Aug. 2014	http://fc-district.eu/
Project Overview			
The overall objective of the FC-DISTRICT project is to optimize and implement an innovative energy production and distribution concept for sustainable and energy efficient refurbished or new "energy autonomous" districts, exploiting decentralized co-generation coupled with optimized building and district heat storage and distribution network.			

Project Name	**logo**	**Timeline**	**Website**
URB-GRADE		Nov. 2012 – Jan. 2016	http://urb-grade.eu/
Project Overview			

The URB-Grade project designs, develops and validates a Platform for Decision Support that will allow the city authorities and utilities to promote and choose the correct actions to upgrade a district to become more energy efficient, cost effective and to increase comfort for its citizens in a District as a Service Platform approach.

Project Name	logo	Timeline	Website
EPIC-HUB		Oct. 2012 – Mar. 2016	http://www.epichub.eu
Project Overview			
The goal of EPIC-HUB is to develop a new methodology, an extended architecture and services able to provide improved Energy Performances to Neighbourhoods. By combining powerful Energy-Hub-based Energy Optimization capabilities with seamless integration of pre-existing and new ICT systems., EPIC-HUB will contribute to achieve the global objective of the Energy-positive Neighbourhood.			

Project Name	logo	Timeline	Website
KnoholEM		Sep. 2011 – Aug. 2014	http://www.knoholem.eu
Project Overview			
KnoholEM is knowledge-based energy management for public buildings through holistic information modelling and 3D visualization. The main objective of the project is to elaborate an intelligent energy management solution for energy efficient buildings and spaces of public use.			

Project Name	logo	Timeline	Website
CAMPUS 21		Sep. 2011 – Aug. 2014	http://www.campus21-project.eu
Project Overview			
Campus 21 addresses the need for integration strategies of ICT in building and			

neighbourhood energy management systems to achieve optimised and holistic operation of Energy-, Security-, Safety and other Facilities Services aiming to optimise the energy usage and operational cost and to reduce the overall CO_2 emission of buildings and public spaces.

Project Name	**logo**	**Timeline**	**Website**
ORIGIN		Nov. 2012 – Oct. 2015	http://www.origin-energy.eu/
Project Overview			
ORIGIN project's mission is to develop a sophisticated intelligent ICT system for the management of energy in a community, and associated business models. The purpose of the proposed solutions is to orchestrate efficient and balanced use of locally generated energy from renewable sources, such as wind or solar energy.			

	logo	**Timeline**	**Website**
address		Jun. 2008 – May. 2013	http://www.addressfp7.org/
Project Overview			
ADDRESS stands for Active Distribution network with full integration of Demand and distributed energy RESourceS and its target is to enable the Active Demand in the context of the smart grids of the future, or in other words, the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants.			

	logo	**Timeline**	**Website**
E+		Nov. 2012 – Apr. 2016	http://eplusproject.eu/
Project Overview			
E+ aims to develop, implement and demonstrate a new energy management operation and			

business model based on ICTs, able to increase the energy efficiency at neighbourhood level, while achieving near zero emissions neighbourhoods. The new control system (E+) will be prepared to manage and control energy sources, stationary storage devices, street lighting, electric vehicles charging infrastructure, etc.

	logo	**Timeline**	**Website**
RESILIENT	RESILIENT	Sep. 2012 – Aug. 2016	http://www.resilient-project.eu/
Project Overview			
The RESILIENT project aims to design, develop, install and assess the energy and environmental benefits of a new integrated concept of interconnectivity between buildings, DER, grids and other networks at a district level. The RESILIENT approach will combine different innovative technologies including smart ICT components, optimized energy generation and storage technologies, also for RES, integrated to provide real time accounts of energy demand and supply at a district level and assist in decision-making process.			

	logo	**Timeline**	**Website**
NRG4Cast	NRG4Cast Energy Forecasting	Dec. 2012 – Nov. 2015	http://nrg4cast.org/
Project Overview			
NRG4Cast is developing real-time management, analytics and forecasting services for energy distribution networks in urban/rural communities. NRG4Cast is analysing information regarding network topology and devices, energy demand and consumption, environmental data and energy prices data.			

Other strategy projects with relevance to ODYSSEUS' objectives:

	logo	Timeline	Website
NiCE	NiCE Networking intelligent Cities for Energy efficiency	Sep. 2011 – Feb. 2014	http://www.greendigitalcharter.eu/niceproject/objectives
Project Overview			
The NiCE project aims to support the fulfilment of the Green Digital Charter commitments. It aims: 1. To create a foundation for action under the Green Digital Charter and a structure for monitoring these actions that is easily replicable; 2. To transfer the monitoring and implementation framework to cities and deliver practical support for the achievement of Charter commitments; 3. To double the number of Green Digital Charter signatory cities, facilitate exchange with similar initiatives in China, and engage with key stakeholders to be involved as implementation partners			

	logo	Timeline	Website
IREEN	IREEN ICT Roadmap for Energy Efficient Neighbourhoods	Sep. 2011 – Aug. 2013	http://www.ireenproject.eu
Project Overview			
IREEN is a strategy project which examines the ways that ICT for energy efficient and performance can be extended beyond individual homes and buildings to the wider context of neighbourhoods and communities			

Special mention should be made to the collaborative cluster initiated at the ICT4SP event as an outcome from the workshop organized by Odysseus to share experiences to address the Energy Positive Neighbourhood concept. These projects are: INTrEPID, EEPOS, AMBASSADOR and IDEAS.

Project Name	**logo**	**Timeline**	**Website**
INTrEPID		Nov. 2013 - Oct. 2015	http://www.fp7-intrepid.eu
Project Overview			
The INTrEPID project aims to develop technologies that will enable energy optimization of residential buildings, both performing an optimal control of internal sub-systems within the Home Area Network and also providing advanced mechanisms for effective interaction with the external world, including other buildings, local producers, electricity distributors, and enabling energy exchange capabilities at district level.			

Project Name	**logo**	**Timeline**	**Website**
EEPOS		Oct. 2012 - Sep.2015	http://eepos-project.eu/
Project Overview			
EEPOS is a research and development project aiming to put into effect the idea of energy positive neighbourhoods. The EEPOS consortium develops tools for energy optimization and end user involvement to improve the management of energy generation and consumption on the neighbourhood level.			

Project Name	**logo**	**Timeline**	**Website**
AMBASSADOR		Nov. 2012 – Oct.2016	http://ambassador-fp7.eu/
Project Overview			
Ambassador is a research and development project aiming to develop and Autonomous			

Management System Developed for Building and District Levels by developing real time adaptive and predictive behavioural models of buildings and districts, exposed to weather conditions, human presence, energy-efficient materials and technologies. Such models will allow finding optimal supply/demand balancing. Within the aims of the project is the development of a solution that tackles the district energy management and information system (DEMIS) concept that will establish in real-time energy schemes for a district.

Project Name	logo	Timeline	Website
IDEAS		Nov. 2012 – Oct. 2015	http://www.ideasproject.eu
Project Overview			
IDEAS, "Intelligent Neighbourhood Energy Allocation & Supervision", project is focused on the development and operation of energy positive neighbourhoods. IDEAS aims to illustrate how communities, public authorities and utility companies across the EU can be engaged in this context. In addition, IDEAS will focus on the economic and environmental benefits of doing so			

4.3 Energy Efficiency Assessment Tools

Considering the scope of Odysseus several tools have been identified that can be helpful in the quality evaluation of the methodology proposed in this project. Some are outputs from EC funded projects, others are from particular initiatives. They are classified here into two categories according to the potential extension of their boundaries, i.e. the building and district level.

4.3.1 *Building Level*

4.3.1.1 eeMeasure Assessment Tool

eeMeasure[20] enables ICT PSP projects to calculate and record energy saving results using a consistent methodology. In turn this enables the European Commission and other interested parties to produce a better quantitative analysis of the energy savings potential of ICT based solutions in residential and non-residential buildings.

The eeMeasure software contains a Public Area and a Restricted Area[21].

The Public Area contains:

- Published Results[22]: energy savings data and project information.
- Methodologies[23]: An overview of the measurement and verification methodologies with links to the latest documents.
- ICT PSP Information[24]: introduction to ICT PSP and projects.

The Restricted Area is used by ICT PSP project teams to upload and model project data, then calculate and publish results that can ultimately be accessed in the Public Area.

[20] http://eemeasure.smartspaces.eu/eemeasure/generalUser/search

[21] http://eemeasure.smartspaces.eu/eemeasure/projectManager/index

[22] http://eemeasure.smartspaces.eu/eemeasure/generalUser/search

[23] http://eemeasure.smartspaces.eu/eemeasure/generalUser/methodology

[24] http://eemeasure.smartspaces.eu/eemeasure/generalUser/public_area

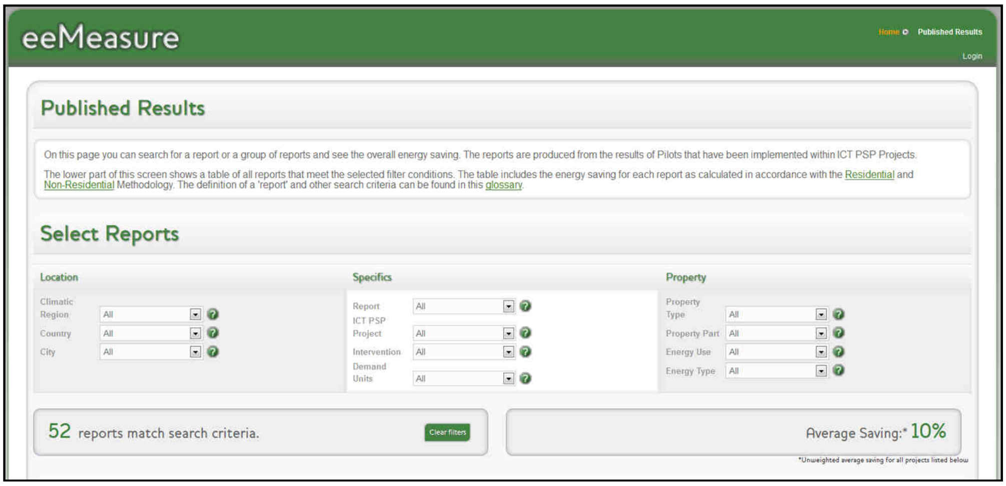

Figure 10 – eeMeasure assessment tool

4.3.1.2 ENERGYWARDEN

The EW-Policy tool has been developed as a part of the FP7 EC co-funded project "energywarden"[25] (Design and Real Time Energy Sourcing Decisions in Buildings) to provide a high level functionality software for the assessment of a building's energy performance as well as the in-situ performance monitoring of the installed renewable energy (RET) devices, with reference to existing policies or standards. In this way, the EW-Policy tool supports both user and policy conformance and CO_2 emission trading.

The EW-Policy tool communicates either with the EW-Controller or with a stand-alone set of sensors installed in the monitored building/location, in order to acquire field data that are subsequently used to evaluate the actual on-site real-time performance of all installed RET devices and perform carbon emission calculations.

[25] http://www.energywarden.net/index.php?option=com_content&view=article&id=107&Itemid=24

Figure 11 – energywarden assessment tool

4.3.2 *District Level*

4.3.2.1 District Energy Concept Adviser

Within the framework of the German research initiative EnEff:Stadt (launched by the German Federal Ministry for Economy and Technology), the Fraunhofer Institute for Building Physics IBP has developed a computer software to support actors in the field of urban planning during the first stages of conceptual planning of energy-efficient districts [26]. This software was developed in collaboration with international partners from IEA ECBCS Annex 51 "Energy Efficient Communities“ and comprises a set of individual supporting tools. At the heart of the software is a tool for the energy assessment of districts, which uses archetypes and other pre-set configurations to allow for a simple and quick data input mapping of all the buildings in the district. Thus it takes the user just a few steps to identify the energy saving potential of various strategies in the areas of building construction, building services systems, and centralized supply systems. Another tools included are a case study viewer with 19 exemplary energy efficient city quarters, information on energy efficient technologies and strategies and a benchmarking tool for measured energy use.

[26] http://www.district-eca.com/index.php?lang=en

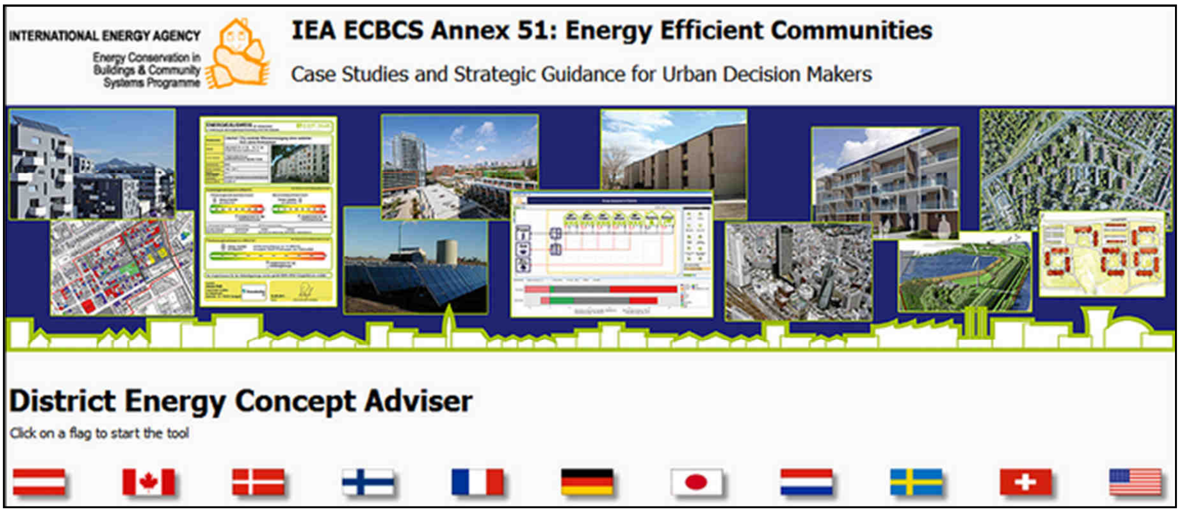

Figure 12 - District Energy Concept Adviser assessment tool

4.3.2.2 TRACE

The TRACE tool has been developed for the Energy Sector Management Assistance Program (ESMAP), which is a global, multi-donor technical assistance trust fund administered by the World Bank.

The Tool for Rapid Assessment of City Energy (TRACE)[27] is a decision-support tool designed to help cities quickly identify under-performing sectors, evaluate improvement and cost-saving potential and prioritize sectors and actions for energy efficiency (EE) intervention. It covers six municipal sectors: passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat.

TRACE consists of three modules: an **energy benchmarking** module which compares key performance indicators (KPIs) among peer cities, a **sector prioritization** module which identifies sectors that offer the greatest potential with respect to energy-cost savings, and an **intervention selection** module which functions like a “playbook” of tried-and-tested EE measures and helps select locally appropriate EE interventions.

TRACE is designed with the intention to involve city decision makers in the deployment process. It starts with benchmark data collection, goes through an on-location assessment involving experts and decision makers, and ends with a final report to city authorities with recommendations of EE interventions tailored to the city’s individual context.

[27] http://www.esmap.org/TRACE

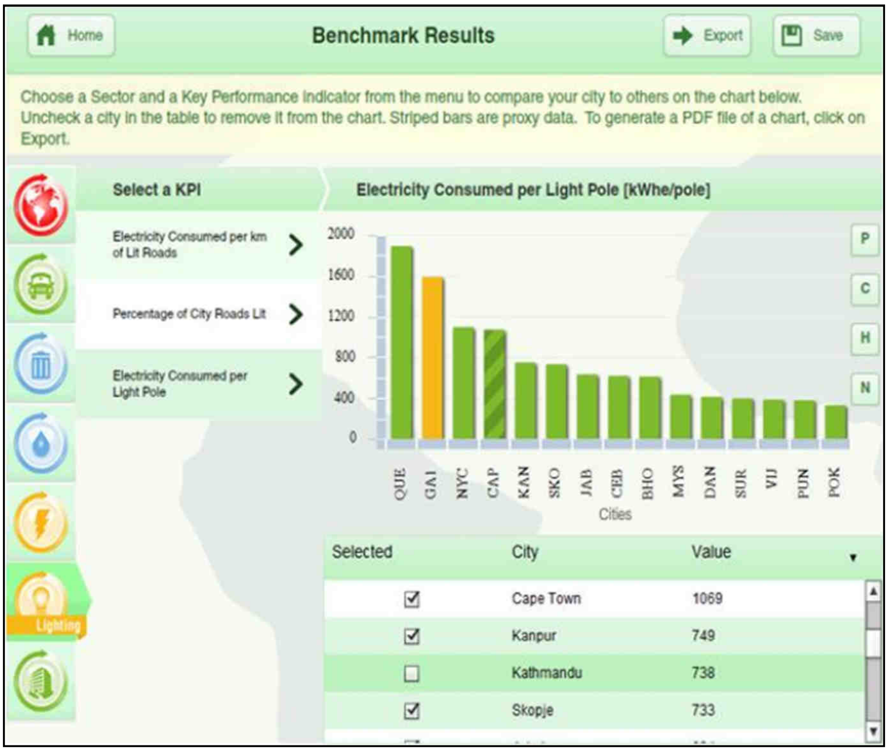

Figure 13 – Trace assessment tool

4.3.2.3 EPA-NR software

The EPA-NR software[28], developed in the IEE programme consists of a calculation engine and a generic input and output interface together with libraries. In principle the software is applicable in all European member states by incorporating context dependent data in the libraries (climate data, fuel costs, national constants and typical building components). However national legislation may set a standardized calculation approach, excluding the use of the EPA-NR software. Adapting the software to these national requirements may solve this problem.

The EPA-NR version 1.7.6.19 software can be used to support the production of an Energy Performance Certificate in accordance with the EPBD. The software calculates the energy consumption of a non-residential building. After selecting 'energy-saving measures' the software calculates the new energy consumption, including the investments, savings, CO_2 emission reduction and annual savings on energy costs.

[28] http://www.epa-nr.org

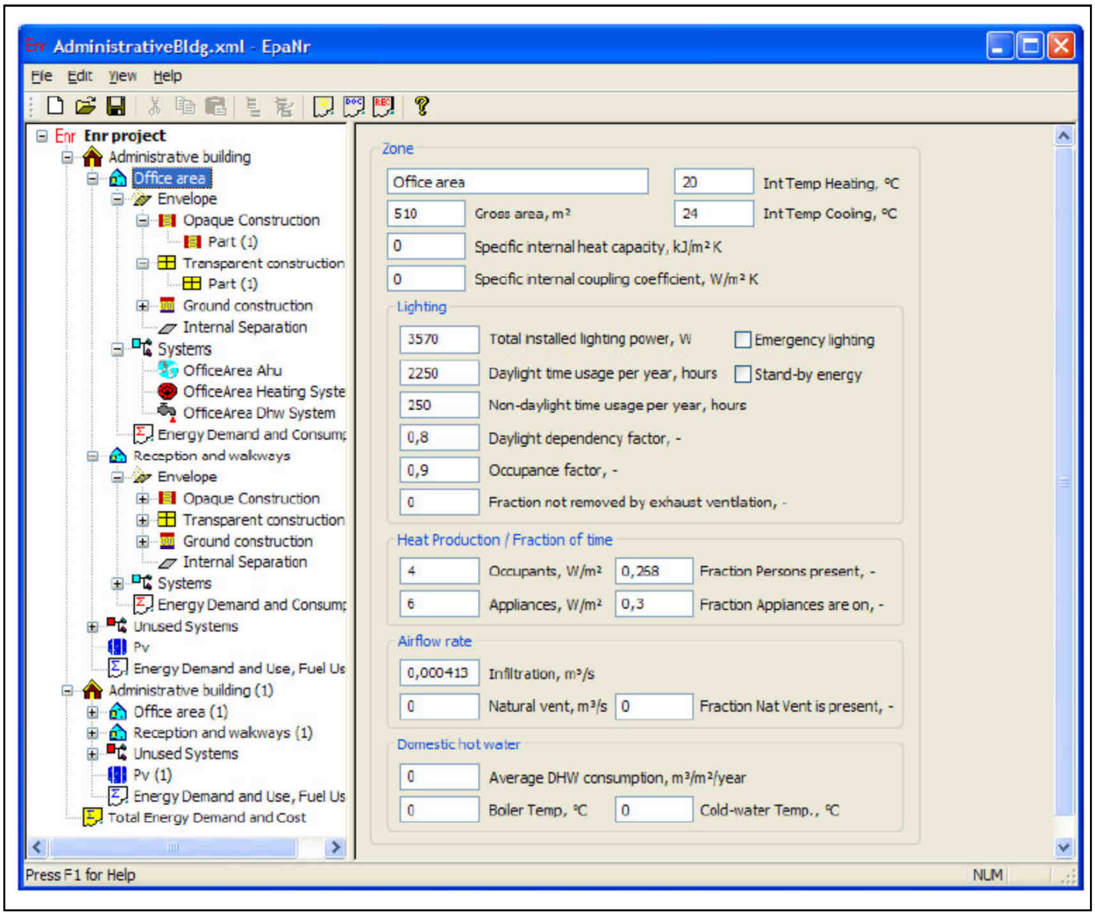

Figure 14 – EPA-NR Software tool

4.3.2.4 Nice Toolkit

The Action Tool Catalogue[29] is part of the Green Digital Charter which commits participating cities across Europe to running and cooperating over large scale pilot projects, aimed at reducing their ICT carbon footprint by 30%. It is available in the green digital activities and tools area of the toolkit. The activities and tools listed are provided by the cities themselves. The catalogue is supported by additional features to aid city comparison and communication, found in the "City exchange" area i.e. city snapshots, forum, tool rating. An additional tool has been developed with match funding from Manchester and made available through the Tools catalogue. This tool allows city administrators to map and view low carbon projects using Open Data City open source software.

[29] http://www.greendigitalcharter.eu/toolkit/gdctoolkit_Home.php

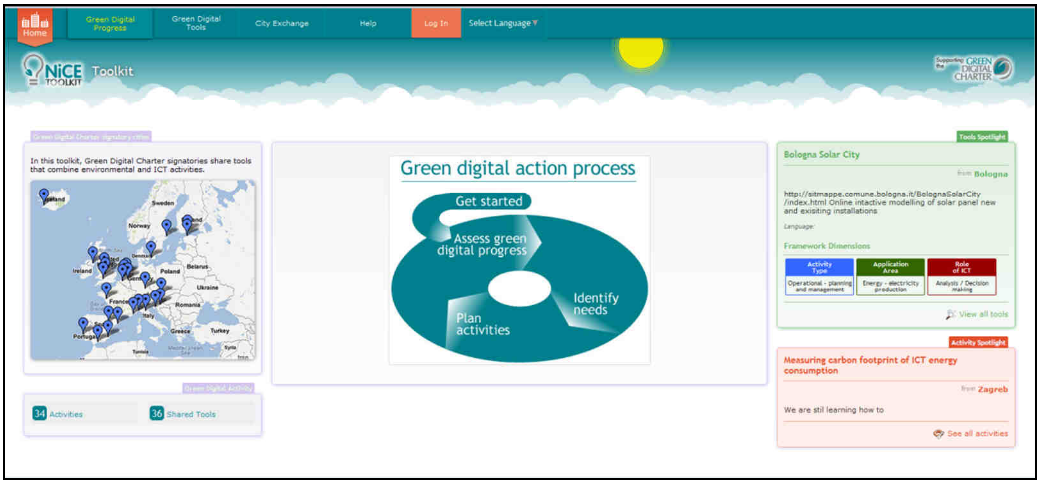

Figure 15 – Nice Toolkit

4.3.2.5 MURE

MURE[30] (Mesures d'Utilisation Rationnelle de l'Energie) provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union and enables the simulation and comparison at a national level of the potential impact of such measures. The MURE database is therefore an important tool to show "demonstrable progress" as requested by the Kyoto Protocol. It has been designed and developed by a team of European experts, led and coordinated by ISIS (Institute of Studies for the Integration of Systems, Rome) and the Fraunhofer Institute for Systems and Innovation Research ISI (Germany).

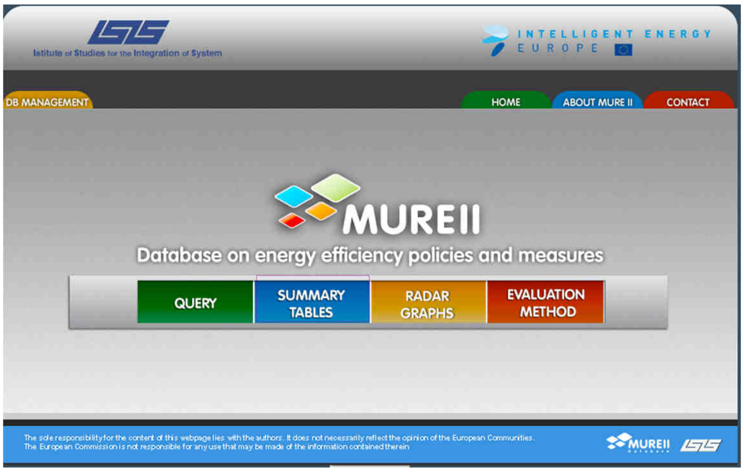

Figure 16 – Mure tool

[30] http://www.muredatabase.org/aboutmure.html

4.3.2.6 LEAP Tools for Sustainable Energy Analysis

LEAP[31], the Long range Energy Alternatives Planning System, is a widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute. LEAP has been adopted by thousands of organizations in more than 190 countries worldwide. Its users include government agencies, academics, non-governmental organizations, consulting companies, and energy utilities. It has been used at many different scales ranging from cities and states to national, regional and global applications.

LEAP is fast becoming the de facto standard for countries undertaking integrated resource planning, greenhouse gas (GHG) mitigation assessments, and Low Emission Development Strategies (LEDS) especially in the developing world. Many countries have also chosen to use LEAP as part of their commitment to report to the U.N. Framework Convention on Climate Change (UNFCCC).

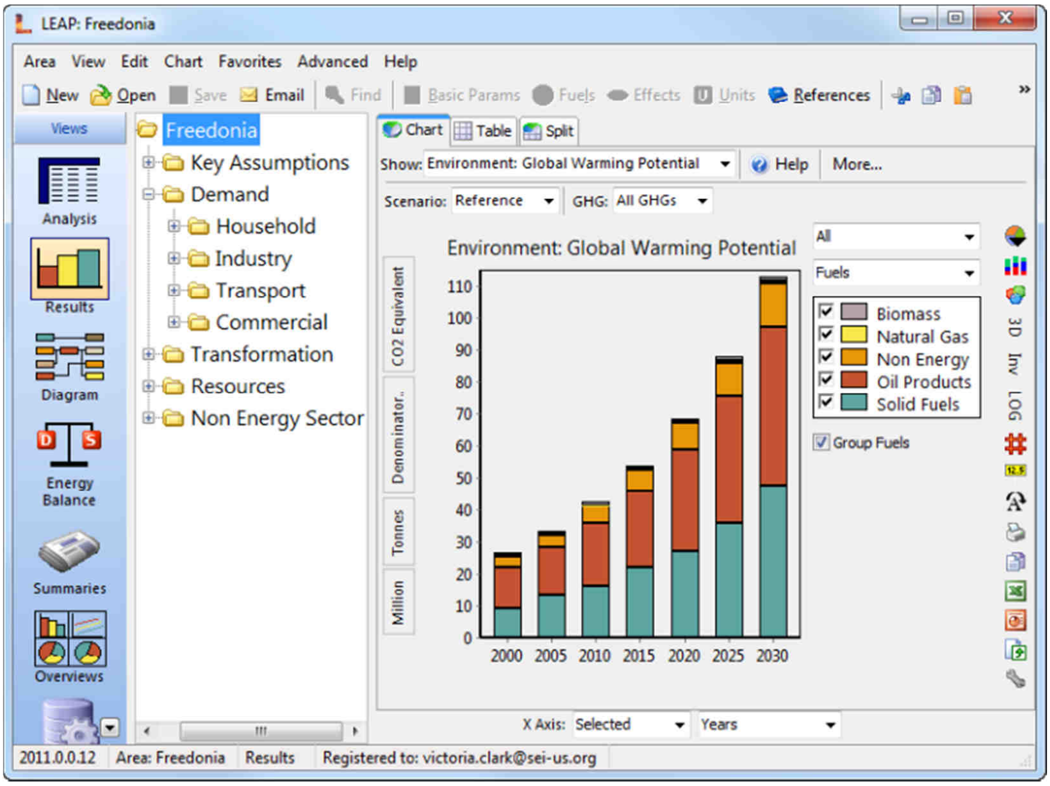

Figure 17 - LEAP tool example report

[31] http://www.energycommunity.org/default.asp?action=47&gclid=CKv5hayP1LcCFYXMtAodvGEAYA

4.3.3 *Other Tools of Interest*

Table 5 below presents a number of other on-going projects and initiatives. Some of the expected outcomes are software tools for energy efficiency assessment at different levels so they could be of interest to evaluate the Odysseus methodology. At this stage of the project, these tools would be considered as illustrative examples for the tools we have to develop within the scope of the WP4 for addressing the strategic objective for the project of the provision of a holistic Energy Management Solutions (hEMS).

Project	Description	Reference
Reference Framework for Sustainable Cities (RFSC)	A set of tools that local authorities and diverse stakeholders need to make aligned decisions on their city strategy, policies and plans. These tools can also help organise the assessment of sustainability and the monitoring of their urban strategy and to find examples of policies	http://www.rfsustainablecities.eu/
IDEAS	IDEAS will develop and validate different tools and business models needed for demonstrating the cost-effective and incremental implementation of an energy positive neighbourhood. The neighbourhood energy management tool will enable intelligent energy trading and operation of equipment and buildings along with local energy generation and storage.	http://www.ideasproject.eu/wordpress/objectives/
CASSANDRA	CASSANDRA aims to build a platform for the realistic modelling of the energy market stakeholders, also involving small-scale consumers. CASSANDRA will not provide another tool for visualization. Rather, it will provide users with the ability to test and benchmark working scenarios that can affect system operation and company/environmental policies at different levels of abstraction, starting from a basic level (single consumer) and shifting up to large consumer areas (i.e. a city). The project main outcomes will be the aggregation methodology and the framework of key performance indicators for scenario assessment, as well as an expandable software platform that providing different energy stakeholders with the ability to model	http://www.cassandra-fp7.eu/

	the energy market, in order to assess scenarios for their own purposes	
BaaS	The BaaS system aims to optimize energy performance in the application domain of "non-residential buildings, in operational stage. In the building operational life-cycle three significant tasks have to be continuously performed: • collect information and assess the buildings current state; • predict the effect that various decisions will have to Key Performance Indicators (KPIs); • optimise performance	https://www.baas-project.eu/
SEMANCO	Integrated tools that access and update the semantically modelled data which support: • Automatic classification of building types within a given area • Energy data analysis • Energy simulation, visualization and optimisation • Interactive urban design	http://www.semanco-project.eu/index.htm
CITINES	The CitInES tool can help cities and large industrial complex owners identify sources of energy and cost savings, in which proportions and how such savings can be achieved. The tool is also able to generate and evaluate new operational management strategy, both simple and energy-efficient.	http://www.citines.com/energy-efficiency/
URBGRADE	The URB-Grade project designs, develops and validates a Platform for Decision Support that will allow city authorities and utilities to promote and choose the correct actions to upgrade a district to become more energy efficient and cost effective and at the same time to increase comfort for its citizens in a District. It has a Service Platform approach.	http://urb-grade.eu/

Table 6 – Related projects

5 ODYSSEUS: Validation Methodology

5.1 Odysseus Validation Methodology Approach: ICT PSP based

The Odysseus project goals are principally to reduce the CO_2 emissions by 29% and increase the energy efficiency using retrofitting actions within various scenarios located in two cities, Manchester and Rome. Part of the project objectives is to find a way (a methodology for validation) to certificate the energy efficiency achievements made in these scenarios. In this context the project team has studied the different protocols and methodologies developed and used in sister-projects covered in the previous sections of this deliverable report.

As the scenarios to be examined by the cities are non-residential the validation methodology selected as the most appropriate to be used in Odysseus is The ICT PSP Non-residential Methodology. The reasons for this decision are explored in more detail below. Next steps to follow up are to implement the methodology within the framework of the project.

The descriptions of the ECM's to be applied in each pilot site scenario will be described in detail at deliverable D5.2 *Demonstration plans*. In the next sections of this deliverable the following topics and questions are explored:

- What is the applicable methodology for validation keeping in mind the Odysseus project specificities, by arguing the selected option from the ICT PSP methodology?
- Identification of the boundaries for scenarios at both pilot sites – the Manchester Town Hall Complex and Rome XI neighbourhood.
- The identification of the variables involved in the validation (independent, static factors, …).
- Baseline period definition and analysis for Manchester and Rome XI scenarios by identifying energy flows and their boundaries, target KPI's and the monitoring aspects to be taken into account by solving questions like what are the required metering devices, what are the monitoring points to be considered, …
- Establishing the reporting period in relation to the target ECMs, their commissioning and required adjustments. This includes the proposed monitoring procedure, and the ECM quantification and the analysis procedure to be adopted

With these topics clarified and with the information gathered at deliverable *D5.2 Demonstration plans,* there will be adequate information and argument to materialize the validation plan enabling the project team to verify the quality and effectiveness of the retrofitting actions applied to achieve the objectives.

5.2 Odysseus Option Selection

To select the correct type of project, based on The ICT PSP Non-residential Methodology for the Odysseus project purposes, the decision graph previously introduced in section 4.1.3 will be used. The path followed is represented in the **¡Error! No se encuentra el origen de la referencia.** and the supporting argument for the decisions are shown in Table 6

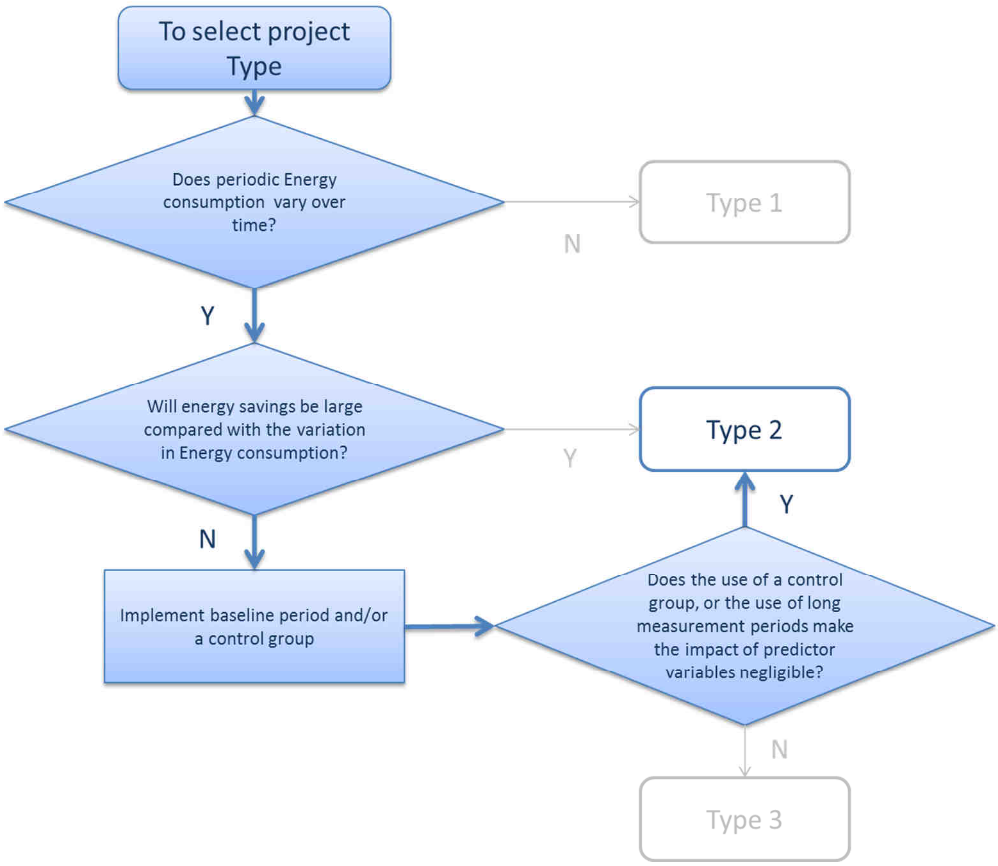

Figure 18- ICT PSP option selection

#	Question	Odysseus Answer
Question 1	“Does periodic Energy Consumption vary over time?	**Yes** because as we can see at page 76 in deliverable D1.1 consumption over the same months varies affected by additional factors like occupation, etc.

Question 2	Will energy saving be large compared with the variation in energy consumption?	The answer to this question is **No** because the envisaged potential savings will be directly related to the energy consumption.
Question 3	Does the use of a control group, or the use of long measurement periods make the impact of predictor variables negligible?	**Yes**, because collecting sufficient data from the installed metering devices at the scenarios will cover all the potential influences on energy consumption.

Table 7 - ICT PSP option selection

Therefore based on these arguments the ICT PSP type 2 validation methodology approach is the one that best suits the Odysseus project needs.

Both pilot projects include scenarios in both Rome and Manchester that manage single buildings, or networked buildings thus, we cannot define a control group of buildings in which ECM measures are not applied to compare within our scenarios, so the mode of action will be by assessing a base period and then to compare the results. However one of the experiments to be addressed in Manchester will employ a control group of floors in the refurnished Town Hall Extension building.

Thus the concrete option selected for the Odysseus project is the 2.2 which have the following characteristics, (p.21 of ICT PSP non-residential methodology see 4.1.3): *Variation of Energy Consumption during the Baseline Period is closely replicated by the variation of Energy Consumption during the Test Period and each period includes a representative range of conditions that significantly impact Energy Consumption.*

It is also important to take into account that in the Rome use case scenario steps 2 and 3 are entirely theoretical and in the Manchester heat network scenario it will be necessary to simulate part of the system, it is anticipated that this project will need to extend the current methodology to include the simulation option. This will provide the neighbourhood scale to the methodology for validation once the Odysseus cloud platform and implemented tools are deployed.

To conclude this exploration the Odysseus validation methodology based on ICT PSP is to consist of the following steps:

Steps	Description	Phase
1	Define the set of project boundaries for the pilot site: energy-	• Monitoring plan

	system(s)/e-Node(s) definition.	
2	Select the predictor variables to be applied on the pilot site.	• Monitoring plan
3	Set the baseline period for the pilot site without improvements and optimization at neighbourhood level.	• Monitoring plan
4	Deploy monitoring hardware (e.g. gateways, sensors and actuators) for energy-systems /energy nodes (e-Nodes) at facilities level in the pilot site (e.g. floors, buildings) in order to monitor predictor variables (e.g. energy data).	• Monitoring plan
5	Collect and store raw data of predictor variables at energy-systems / e-Node (facilities level scale) (M13-M24)	• Monitoring plan • Baseline analysis
6	Transform raw data into dEPC information structure (M21: Monitoring tool).	• Monitoring plan • Baseline analysis
7	Perform initial baseline analysis at energy-system/e-Node level (facilities level) (M21: decision-making tools). Define ECMs.	• Baseline analysis • ECMs definition
8	Connect e-Nodes to the aggregation layer of the Odysseus Cloud Platform. From e-Node to e-Network (building /neighbourhood/district) (M24).	• Extended boundaries to e-Network
9	Send e-Node dEPC information (real information) to the Odysseus Cloud Platform to compose the e-Network level (simulated). Analyse and conclude the neighbourhood baseline period for the pilot site with this information). **Note:** At this step we will have a neighbourhood level scale vision.	• Extended boundaries to e-Network • Baseline analysis
10	Apply the identified ECMs at e-Node level (facilities level scale) (e.g. building). **Note:** This step implies the start of the reporting period for the pilot site.	• ECMs • Reporting period
11	Apply the identified ECMs at e-Network level (Odysseus Cloud Platform simulation). **Note:** At this step we expect to have the Odysseus Cloud Platform and the integrated versions of energy efficiency tools. We will provide a holistic energy management vision of the neighbourhood.	• Extended boundaries to e-Network • ECMs • Reporting period
12	Evaluate the obtained results at e-Node level (facilities level) and e-Network level (neighbourhood level) by comparing baseline and reporting periods.	• Evaluation period

Table 8 - Odysseus validation methodology steps

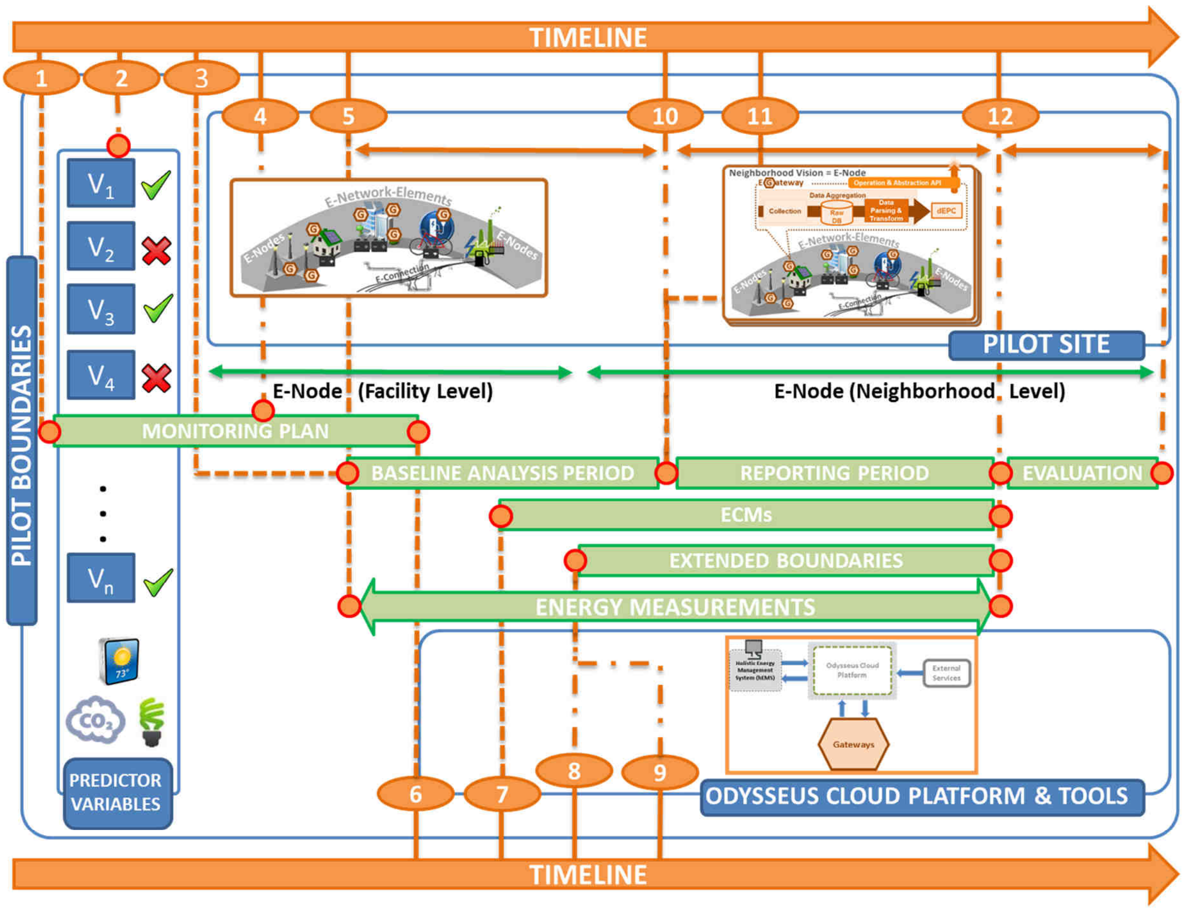

Figure 19 - Odysseus validation methodology timeline

5.3 Odysseus Boundaries

The measurement boundary for Odysseus is beyond the “facility” level covering a specific geospatial area including (typically) multiple “facilities”. The ECMs foreseen in the project typically also involve multiple facilities (under same or different authorities) at one time in the study area (planned or simulated).

Because the weather is an important external factor in the case study situations for all but one of the scenarios the project will need a baseline period of at least a year to cover all seasons.

For the Rome scenarios, the baseline period of a year is important because in these scenarios it is hard to work with a control group during the reporting period. So, the baseline monitoring data has to be collected by measuring the daily energy production and consumption for an entire year continuously on the various buildings, in total as well as left/right side of the building A of the Cesare Battisti school. If possible, the baseline will be provided by historical data available for the facilities or e-Nodes in the area which data is aggregated for the total area.

For the Manchester scenarios, a control group of zones will be used during the reporting period and thus a baseline period is not necessary for Manchester.

The reporting period after taking the ECMs also covers an entire year in order to take into account the relevant deviations (like the weather). During that period continuous measurements will be done at a fine-grained scale, 5-30 minutes scale for Manchester and 1 day scale for Rome. These measurements can be aggregated to larger time-scale levels such as week, month, 3-months (season) and the entire year.

Odysseus boundaries	
Scope	“Facility” level covering a specific geospatial area including (typically) multiple “facilities”
Baseline period	One year to cover all seasons for Rome. No baseline period required for Manchester.
Reporting period	One year with measurements at fine-grained time scales that can be aggregated to higher-level time scales. For Manchester, control groups of zones will be used to measure the effects of the ECMs.

5.4 Predictor Variables (within measurement boundary)

Predictor variables are each measurable factor that has a significant impact on energy consumption at the pilot site. These predictor variables are monitored data that must follow the dEPC information structure when pushed to the Odysseus Cloud Platform from pilot sites. These variables must have a specific time stamp with an appropriate accuracy.

All these predictor variables will be categorized and classified in the following subsections:

- Energy data that provides measures of sub-meter information from deployed monitoring systems both indoor (energy sources, comfort parameter or other parameter), or outdoor (mainly weather).
- Simulated variables that provide simulated measures of energy data based on simulation approaches.
- Independent variables, parameters that are expected to change regularly (like

weather conditions and energy tariff prices) and has a measurable impact on the energy use of a system or facility, meanwhile are independent of the system or facility

- Static factors, those that do not change during the implementation phase of the evaluation to be applied following the validation methodology (like space heated, building characteristics, facility usage, …).

5.4.1 *Energy Data*

At a minimum, a dedicated monitoring system would measure the power consumed at the service entrance. Typically, such systems are implemented to provide sub-meter information for selected parts of the overall facility. Monitoring systems are generally designed for accurate measurements. The measurements of many other parameters may be correlated to help analyse the demand and usage profiles. Dedicated monitoring systems are generally at the core of larger, fully integrated monitoring and control systems.

INDOOR Parameters

Electrical power and energy measurements provide an operational fingerprint of the many systems and pieces of equipment in a facility. They show clearly where and how electrical power and energy are used and provide insight into how equipment and systems consume other forms of energy.

Energy sources		
	SI Units	**Impact**
Electricity consumption	J/ KWh	KPI dependant
Gas consumption	J/ m3	KPI dependant
Energy production	J/ KWh	KPI dependant
Energy storage	J/ KWh	KPI dependant

Temperature measurement provides opportunities to quantify thermal energy consumption and losses in a variety of ways. Air fluid and surface temperature are commonly measured. Humidity measurements are often used to assess the cooling load present in a system or to determine the amount of latent energy present in exhaust airflow. Light or luminance meters provide a simple and effective method for determining actual delivered light levels. It is useful to compare actual levels with suggested or recommended levels for specific activities or areas. Airflow measurements are useful when analysing facility HVAC and exhaust systems. Accurate airflow measurements are generally difficult to make, particularly in naturally ventilated buildings, however some simple airflow measurements can be made to provide data for initial estimates of energy use and savings.

Comfort parameters		
	SI Unit	**Impact**
Temperature	ºC	KPI dependant
Humidity	%	KPI dependant
Lighting level	Lux	KPI dependant
CO_2 level	PPM	KPI dependant
Airflow	m3/h	KPI dependant

Other key variables that influence energy consumption are occupancy of a room/space within a building in terms of persons and hours and the status of windows and doors.

Other relevant parameters		
	SI units	**Impact**
Occupancy	% (hours/day)	KPI dependant
Contact closure (door/window)	open/ closed	KPI dependant

<u>OUTDOOR Parameters</u>

The effect of weather conditions can also be correlated by means of measurement of specific parameters from day to night and from season to season.

Weather parameters

	SI units	Impact
Temperature	ºC	KPI dependant
Humidity	%	KPI dependant
Solar radiation	W/m2	KPI dependant
UV radiation	UV index	KPI dependant
Wind speed	m/s	KPI dependant
Wind direction	Degrees	KPI dependant
Rainfall	mm	KPI dependant

5.4.2 *Simulated Variables*

There will be several situations where data or measures will be missing in dEPC. Most of the time, it is possible to replace these missing records by estimated data applying some simple simulation models and algorithms.

We have identified below some cases where it is justified in case of missing data to replace them by simulated variables:

1. the measurements are done on a period of time that is limited whereas the parameters used in the calculation of the KPIs need data over a longer period of time (temporal aspect + incompleteness of data)
2. the set of available measurements do not cover the totality of the needed values to calculate the KPIs and assess the benefit of the ECMs (spatial aspect + incompleteness of data)
3. there exists some parameters used in the calculation of the KPIs that are not directly available through measurements but can be calculated from them
4. Need to adjust the measures in order to have corrected values comparable to the baseline by taking into account the independent variables (weather)

Factor	Example	Simulation approach
1	The consumption measurements are taken during a given period of time and there is a need to have data for a longer period (i.e. measures are taken during Spring but there is a need to have	The simulation of data will be performed based on the baseline and taking into account the deviations from the baseline of the data acquired during the measurement period.

	values also for Summer period) An acquisition device is broken during a part of the measurement period	
2	There is only a global measure of electric consumption for a zone but it is necessary to have distinct consumption for parts/devices within this zone The calculation of the KPIs needs local data that is not available. Only general data is available (i.e. wind speed at the district level but the considered building is protected by other structures. Similarly the mask effect with solar radiation). The occupancy of an office room is needed where the only available value is about the occupancy of the whole building.	(Global measure) There are existing models of consumption profiles of devices according to various environments (i.e. a microwave oven for a family composed of 2 adults and 2 children). This kind of simulation could be applied to estimate sub parts (or sub contributions) of smaller e-nodes. There are also methods available for electricity loads disaggregation (NIALM: a NIALM system disaggregates the overall energy consumption into individual ones using advanced algorithms (Local Data i.e. Occupancy) (Occupancy) This case is perhaps more about calculation rather than simulation. With a lack of direct measures, only a statistical occupancy could be provided. This will be based on direct ratio (normal occupancy of the considered area by total occupancy of the building for the considered period of time).
3	A KPI requests value for consumed primary energy while measurements are only related to final energy consumption (Same issue applies for CO_2 emission).	
4	The measurements are done in weather conditions that are significantly far from the weather baseline.	A corrective coefficient should be applied to the data in order to lower the consequence of such circumstance. This coefficient will take into account the baseline and the measures after and before the weather event (case 1 has some similarities with this one)

Depending on the different cases, the simulated variables will be generated by applying some interpolation rules or some extrapolations.

5.4.3 *Independent Variables*

Another important type of variable for the validation methodology are those variables that are independent of the system to be validated and can therefore not be influenced by the system. An independent variable is a parameter that is expected to change regularly and has a measurable impact on the energy use of a system or facility. For example, a common independent variable governing building energy use is outdoor temperature. In this context we distinguish between two sets of variables: weather parameters and energy prices.

5.4.3.1 Weather

Climatic changes or weather conditions are one of the key reason of variability in energy use of an e-Node (e.g. it has a direct impact in the energy consumption profile of a building, energy production profile of a PV panel or windmill, etc.). For this reason, the weather conditions are considered within the independent variable category.

Firstly, data on hourly average daily temperatures are available from external weather services providers, from the internet or networks of dedicated meteorological stations located close to the e-Node (e.g. a meteorological station on a campus). Secondly there are dedicated measurements that could be used from the e-Nodes (e.g. buildings) in the pilot cases.

Weather conditions parameters that might have a measurable impact on the energy use of e-Nodes are:

Parameter	Frequency on the Measure (Range)	Metric Units
Atmospheric pressure	15 minutes to 1 hour	Bar
Cooling degree days (CDD)	Daily calculated from temperature	-[32]
Heating degree days (HDD)	Daily calculated from temperature	-[33]
Relative humidity	15 minutes to 1 hour	%
Rain precipitation volume	15 minutes to 1 hour	Liters/square meter
Solar irradiation	15 minutes to 1 hour	Watts/square meter
Sunrise	1 per day	-[34]

[32] No metric unit, but reference in ºC

[33] No metric unit, but reference in ºC

Sunset	1 per day	-[35]
Temperature	15 minutes to 1 hour	ºC
Wind direction	15 minutes to 1 hour	Degrees
Wind velocity	15 minutes to 1 hour	Meter/second

Table 9 – Weather variables frequency measurement and units

Using the captured data it is possible to compute the average temperature or heating degree days (HDD) and cooling degree days (CDD) that can be used as reference for the e-Node.

Heating degree days are defined relative to a base temperature, the outside temperature above which a building (e-Node) needs no heating. This base temperature differs on location.

5.4.3.2 Energy Tariff

Energy tariff data will definitely have an influence on the way the neighbourhood energy management is optimised but in the time frame of the project this data would not be acquired through measurement.

Therefor the only way to take it into account for the Odysseus evaluation will be to simulate its impact will be by estimating the hourly flexible rates retrieved from the energy spot market sites. Such estimation will only provide an idea of the dynamic of the energy

[34] No metric unit, but reference in hh:mm:ss

[35] No metric unit, but reference in hh:mm:ss

price curves.

Parameter	Frequency on the Measure (Range)	Units
Electricity tariff rate	1 hour to 1 day	Euros (Pound) per kilowatt hour
Gas tariff rate	1 hour to 1 day	Euros (Pound) per litre
Unbalance price	15 min	Euros (Pound) per kilowatt hour
Heat tariff rate - indexed to the gas tariff rate[36]	1 hour to 1 day	Euros (Pound) per litre

Table 10 – Energy tariffs frequency measurement and units

5.4.4 *Static Factors*

5.4.4.1 Static factors for the Manchester Town Hall Extension (THX) use case

The static factors in Table 10 are the characteristics of the THX facility which influence overall energy use within the boundaries of the use case. They include the area or space being heated or cooled, the performance of the external envelope, the internal environmental standards and the occupancy factors (number of occupants and the equipment they use).

Static Factor	Description
Amount of space being	The total floor space in a typical floor in the THX is 2,968

[36] The Manchester Heat network is at an early stage of development but it can be anticipated that the heat tariff will be indexed to the gas tariff as this is common practice in other heat networks in the UK see Developing District Heating in the UK – What Works: http://www.heatandthecity.org.uk/__data/assets/pdf_file/0010/71884/Heat_and_the_City_-_developing_DH_in_the_UK.pdf

heated or air conditioned	m^2 (level 4). The use case will concentrate on Zones 7 and 8 and Floors 2, 3, and 4. Zone 7 = 444.3 m^2; zone 8=356.3 m^2. The zones are shown on the floor plan at **¡Error! No se encuentra el origen de la referencia.** in section 5.5.2.
Building envelope characteristics (new insulation, windows, doors, air tightness)	The listed building is of steel and concrete frame and floors clad in brick and stone with metal framed single glazed windows and at the recent refurbishment its “heritage” status has meant that the fabric has largely remained unaltered only with repairs where required, e.g. to the metal framed windows to improve operability and airtightness. The reasons for lack of thermal upgrading to the fabric are explained in deliverable D5.2. In the office floors 50% of the external wall thickness = 400mm, the remainder = 700mm (brick inner leaf, cavity, sandstone outer leaf). This has high thermal transmittance (400mm thickness RVal = 0.910M2k/W). In the office floor zones (1, 6, 7 and 8) that are the subject of the Odysseus experiment the windows form approximately 26% of the total wall area. The opening section of the windows in turn is approximately 9% of the wall area.
Amount, type or use of the facility’s and the users’ equipment	Overall the THX has a number of uses including office space, conference, library, meeting chambers, etc. However the use case will concentrate on a comparison between the similar zones (zones 7 and 8) on 3 office floors, therefor the use is typical for public sector local authority offices, with open plan office furniture layout with the main equipment of computers, both desk-top and lap-top with monitors. There are small meeting rooms, typically two per zone (total 30-40 m^2), a small food preparation area (20 m^2) and space for printing and recycling (20-30 m^2).
Indoor environmental standard (e.g. light levels, temperature, ventilation rate)	Light levels are set for reading paper documents: 500 lux. Temperature: 20 degree Celsius. Occupants have some

	control over the temperature by limited adjustment of the setting of the Thermostatic Radiator Valve (TRV) and by opening windows adjacent to their workplace.
Occupancy type or schedule	The floors are for office use with 42-46 persons occupying each of floor zones 1,6,7 and 8 (see Figure 23)

Table 11: Static Factors for the Manchester Town Hall Extension Case.

5.4.4.2 *Static factors for the Manchester Civic Quarter Heat Network (MCQHN) Use Case*

The static factors in Table 12 presents the main characteristics of the buildings that are to form part of the Manchester Civic Quarter Heat network which influence overall energy use within the boundaries of the use case.

	Building	Main Function	Occupancy types/rooms	Building Characteristics	Overall floor area [m^2]
1	Manchester Town Hall	Ceremonial and political center for the City	Council Chambers, meeting halls, ceremonial spaces, public reception areas	Grade I listed opened in 1877. Considered the finest example of Victorian neo-gothic in the UK. Mainly 6 floors with a clock tower 87meters in height. Sandstone externally, terracotta internally.	tbc
2	Manchester Town Hall Extension	Public Administrat ive offices	Offices, conference and meeting rooms, public reception areas and public service hub, cafe	Grade II* listed steel and concrete framed – narrow plan with courtyard on 8 floors, completed in 1938. Clad in sandstone with steep pitched lead roof. Currently being refurbished.	25,000 (approx.)
3	Manchester Central Library	Library and Education, knowledge hub	Book stacks, reading/study rooms, meeting rooms, display areas, small theatre	Neoclassical rotunda built in 1930, Grade II*listed with Tuscan colonnade in Portland stone, low pitched leaded roof and a two-storey five-bay Corinthian portico entrance. Currently being refurbished.	tbc
4	Midland Hotel	4* Hotel	312 bedrooms, 16 meeting rooms, 2 bars, 2 restaurants, kitchens, etc., spa complex	Edwardian Baroque listed, constructed 1898-1903. Steel frame, concrete floors (8), clad in red brick, terracotta and polished granite.	tbc
5	Manchester Central	Conference and Exhibition Centre	Large exhibition hall, undercroft car park, convention center, 12conference and meeting rooms, 117 bedroom hotel, restaurant	Converted from former Midland railway station in 1982. Large span 64m segmental wrought iron arched structure and glass roof with red brick cladding. Convention Centre added in 2001 of steel and concrete construction clad in brick and glass.	Main Hall = 10,730 Conference centre tbc
6	Number One St Peter's Square	"Grade A" rentable office space	Offices, Meeting Rooms, café and some retail spaces on ground floor	Modern 14 floor office building currently under construction - due for completion in 2014. Concrete framed clad in limestone and glass, designed to meet BREEAM "Excellent" standard	24,898

Table 12. Static Factors for the Manchester Civic Quarter Heat Network Case.

5.4.4.3 Static Factors for Rome Use Case

The static factors in next table summarise the characteristics of the Rome network facilities which have influence in the overall energy use within the boundary of the use case. The table summarises the overall and average surface per building, the number of rooms the number of occupants and the average occupancy per room.

	Building	Overall Surface [m^2]	Average surface per room	Number of rooms	Occupancy	Occupancy type	Average occupancy per room
1	Primary School “Cesare Battisti”	10.290	actually not available	currently not available	230	pupils	25 (to be confirmed)
2	Technical and operating unit	1.460	actually not available	currently not available	60	employees	25
3	The Institutional Seat of the Town Hall Roma XI	3.970	actually not available	currently not available	200	employees	25
4	Nursery School: “I Monelli”	372	actually not available	currently not available	80	kids	25
5	Primary School: “LivioTempesta”	2.400	actually not available	currently not available	200	pupils	25
6	Kindergarten L’AquiloneColorato	760	actually not available	currently not available	100	kids	25
7	Kindergarten Ciliegio Rosa	760	actually not available	currently not available	100	kids	25

Table 13. Static Factors for Roma Case

For the purposes of the educational function and practicability of classrooms "for every person (teacher, student) present in a classroom, in compliance with current law it must be guaranteed a net area of 1.80 square meters in the school in addition to a minimum height of 3 m” (this data will be confirmed during project execution).

5.5 Baseline Definition for Odysseus Pilot Cases

The baseline definition will deal with the identification of relevant information concerning to:

- What is the current situation of **the energy flows** for the facilities; by considering all the energy sources, their current usage and their key features regarding to the energy lifecycle (production, consumption, storage) and their energy figures in terms of yearly production, consumption. Moreover, will be identified what are their energy exchange capabilities; including the existing technical infrastructure, like PV panels, CHP installation, heating systems, …, and their relevant energy characteristics (e.g. energy production by PV panels).
- What are the **boundaries of the energy flows** in relation to the proposed energy objectives to be addressed taking into account the ECMs to be applied.
- What are the relevant **Key Performance Indicators** (KPIs) for supporting the decision making by the stakeholders (e.g. city energy managers, building energy managers). Identified KPIs must be defined both at building and neighbourhood level, accordingly with the proposed scenarios and use cases in D1.2. At use case level, KPIs are built in order to provide a precise and quantitative measure of what we are saving in terms of energy (and costs). Each KPI will provide us with key information: goodness of actions taken based on Odysseus developed tools (monitoring tool and decision making tool); and in case of negative feedback information, possible corrections of the taken measures.
- What are the **monitoring metering devices and equipment** to be employed in the proposed use cases at facilities (building) and neighbourhood levels.
    - At facilities level, a specification of the metering points and monitoring timing (continuous or scheduled) and how the calibration of the metering devices will be based must be provided.
    - At neighbourhood level we will use expected simulation capabilities provided by Odysseus Cloud Platform and developed tools for addressing the proposed use cases

In “D5.2 Demonstration plan” a detailed definition for each pilot case (Manchester and Rome) will be covered in relation to these specific questions of the energy baseline.

5.6 Baseline Analysis

The baseline analysis to be implemented in each pilot case must be described in the following terms by:

- The identification of the Energy Conservative Measures (ECMs)
- The proposal of the ECMs commissioning
- The identification of the ECMS adjustments to be considered

5.6.1 *Identify ECM*

At the district / neighbourhood level, an Energy Conservative Measure (ECM) aims at saving, reducing the amount of energy used by its different sub components in order to:

- minimise the energy requested from the external grid
- maximise the excess of energy that could be transferred to the external grid.

ECMs may have various forms. It can be simple recommendations like “improve building insulation” or “Replace white goods by their equivalent from higher rank in energy saving”.

There are already available lists of ECMs in the literature and over the Internet that are recapping / listing typical ECMs.

Destination	ECM
Building Envelope	B1. Install Storm Windows B2. Install Replacement Windows B3. Install Window Sun Shades B4. Install Storm Doors B5. Install/Increase Attic Insulation B6. Install Roof Insulation B7. Install Wall Insulation B8. Control Air Leakage

Space Heating and Cooling	H1. Install Vent Dampers H2. Convert to Electronic Ignition H3. Install Boiler Controls H4. Replace Inefficient Heating Plant H5. Install Programmable Thermostats H6. Install Radiator Controls H7. Insulate Hot Water or Steam Pipes H8. Convert Steam Heating to Hot Water Distribution H9. Seal and Insulate Ducts H10. Install Geothermal Heat Pumps H11. Install Swamp Coolers
Domestic Water-Heating Systems	W1. Install Water-Efficient Showerheads and Faucet Aerators W2. Insulate Hot Water Tanks W3. Install Hot Water Off-Peak Controls W4. Convert Laundry to Cold Rinse W5. Replace Inefficient Water Heaters W6. Install Summertime Water Heaters W7. Convert Water Heater System to Solar
Lighting	L1. Replace Incandescent Lighting with Compact Fluorescent Lamps in Dwelling Units L2. Replace Incandescent Lighting with Fluorescent Lighting in Common Areas L3. Replace Standard Fluorescent Lamps with Energy-Saving Lamps and Install Electronic Ballasts in Common Areas L4. Install Lighting Controls in Common Areas L5. Convert Exterior Lighting Fixtures L6. Install Photo-Controls for Exterior Lighting
Miscellaneous ECMs	M1. Replace Older Refrigerators with High-Efficiency Units M2. Install Energy- and Water-Efficient Washers and Dryers M3. Convert Water Supply Pumps M4. Install Check metering or Individual Metering M5. Install Water-Saving Toilets

Table 14. Example of ECMs (ECMs for Public Housing – U.S Department of Housing & Urban Development)

But in the frame of our project, it is not intended to proceed to heavy equipment or refurbishment. Then the ECMs that can be envisaged will rely mainly on the functionalities our Odysseus Cloud Platform (OCP) will be able to offer and will turn around Facilities Management Enhancement.

The following kind of ECMs are possible in the frame of the project:

- **Adapt the lighting conditions to building occupancy activities**: The implementation of lighting controls in public areas may generate tangible energy savings. The sensors will detect inactivity in a space and turn lights off when unoccupied. It is also possible to modulate the lighting intensity in order to provide a constant value (i.e. 500 lux) inside the building independently from the external conditions (Thus, it will be possible to decrease the lighting and save energy during good daily conditions). Depending on certain conditions, MCC pilot envisages to decrease this intensity down to 300 lux for screen based activities.
- **Adapt the indoor temperature to building occupancy**: In both pilots, it is possible to have a good prediction of the building occupancy and adapt the way the building are pre-heated or pre-cooled to reach the optimal conditions when they will open. Same measure could be applied that will anticipate the closure time of buildings and anticipate cooling/heating conditions accordingly.

But this kind of ECMs needs that the OCP platform can act directly on these different devices (via "actuation" capabilities) which is not the case. Therefore, the ECMs mentioned above can be implemented only partially and grouped under a generic ECMs which consist in informing the users (e.g. building facility manager) about actions they can perform (reduce the light, open/close the windows, increase / decrease set points for various comfort parameters, etc.).

An identification of the ECMs for both pilot cases will be covered in D5.2.

5.6.2 *ECM commissioning*

The different scenarios mentioned by the two pilots are based on the deployment of sensors and sub-metering devices to measure different parameters in the pilot areas. Looking at the envisaged ECMs, the application of them will mainly rely on human interactions. The OCP platform and tools will inform the different users according to their profile and suggest them actions (open/close the windows; change heating/cooling set points; turn light on/off) to optimise the overall energy consumption at E-Node level (facilities level).

Ideally the system should be able to directly act on the various E-Nodes / E-Gateways to manage directly with the actions it suggested but at this stage no actuation services are clearly defined.

Specificities regarding to the ECMs commissioning will be provided in D5.2.

5.6.3 *Adjustment*

For a generic and global point of view, all changes in the equipment (white goods, HVAC, lighting systems, lift motors, etc, …) of the two pilots should be taken into account as it will have an impact on energy profile.

The duration of the baseline period will be defined in the "D5.2 Demonstration Plan". We can already predict that there will be a need for different kinds of adjustments. The following parameters will have an important impact:

- The weather and the seasons (T°, duration of the day, etc, ...);
- Occupancy levels of zones of the facilities (buildings) and activities (meeting/screen based activities /others /…).

Adjustments will be made taking into account the influence of these parameters on the overall energy consumption when comparing the baseline period and the ECMs period.

Specificities regarding to the ECMs adjustment will be provided in D5.2.

5.7 Reporting Period

In this section we describe how the activities during the reporting period are carried out. These can be divided between monitoring /measurement, reporting and analysis activities, each of them described in more detail below.

5.7.1 *Monitoring and measurement activities*

In this subsection we define the operational verification procedures that will be used to verify successful implementation of each ECM. As stated in section 5.2, following the ICT-PSP non-residential methodology the option selection process resulted in Type 2. This means that the periodic energy consumption can vary over time (e.g. due to additional factors like occupation), the energy savings are directly related to the energy consumption and sufficient data will be collected from the installed metering devices to cover all energy consumption. For the reporting period this means that either a control group is used or the variation of energy consumption during the reporting period has to be closely replicated by the variation in the energy consumption during the baseline period and each period includes a representative range of conditions that significantly impacts energy consumption.

The assessment measurements during the reporting period will be done on the performance of the facility as a whole (or parts of or devices in the facility) and not on specific ECM performance. How assessment measurements applied to each pilot case must be specified in D5.2.

The reporting period after taking/implementing/installing/activating the ECMs will be identified. Measurements will be done on a small time-scale basis, e.g. every 5 minutes or 30 minutes and collected extensively. In addition, aggregation of the measured values over longer periods can be done afterwards or on the fly. At a monthly basis the results can be aggregated to take into account the relevant deviations (like the weather in different seasons). In general, the operational verification procedures should be such that the variables of section 5.4 can be measured for the time intervals in the reporting period.

For a good assessment the indoor energy data parameters of section 5.4.1 should be measured to verify the energy efficiency of facilities or the combined/total energy efficiency of a set of facilities in a geospatial area. All the indoor energy data parameters can be measured by existing metering equipment.

Specificities of the reporting period for each pilot case will be identified in D5.2.

In addition to the specific indoor energy data parameters, the outdoor energy data parameters, weather parameters and energy tariff parameters as defined in sections 5.4.1 and 5.4.3 should be measured at a less fine-grained level, e.g. at a cumulated daily level. This is necessary to make adjustments on the energy efficiency by accounting for external variables that might have a relatively strong influence on the energy consumption/production. These parameters can be followed via public information sources, such as websites of local weather stations and websites of national energy markets. If necessary, the outdoor energy data parameters very close to the building(s) can be measured by specific meters.

Before executing the various measurements during the reporting period, it should be verified that the ECMs are installed and operating properly and that they have the potential to generate savings. Operational verification may involve inspections, functional performance testing, and/or data trending with analysis.

5.7.2 *ECM quantification and reporting*

In this subsection, we specify how results will be reported and organized. The reports to be generated as a result of the measurement, validation and verification activities should include the baseline-period energy efficiency versus the reported-period energy efficiency or in the case of a control group the energy efficiency of the control group versus that of the group in which the ECMs have been taken. The detailed measured values for both periods should be part of an appendix of the report. The main part of the report should concentrate on various curves that can be derived from the measured data, such as an electricity demand and energy consumption curve per day/month/year or a temperature curve. In addition, various comparison curves between the baseline-period and the reporting-period should be included. Furthermore, analysis results on the measured data should be presented in which the energy efficiency of the facility is defined and calculated. Last but not least, concluding statements on the comparison of the energy efficiency should be made at the end of the report.

5.7.3 *Analysis procedures and models*

In this section, we specify data analysis procedures, algorithms and assumptions to be used in each savings report. We are looking for (re)usable models for the definition of energy efficiency for buildings/facilities/urban areas that can be used before and after the ECMs that we put into place. The various KPI definitions to be described for the Manchester and Rome cases can be used as basis for a model of how to define the energy efficiency. On top of that, we will look at specific patterns in the measured data. What will be analysed regarding to the energy lifecycle (consumption, production and storage) in relation to the ECMs is closely related to the decisions to be made in each pilot case. Examples of required activities during the reporting period will be proposed in D5.2.

6 Conclusions

This deliverable covers the proposed Odysseus validation methodology supported by existing state of the art methodologies and best practices from other energy efficiency research projects that have been analysed. Existing well known validation methodologies used in ICT projects such as the IPMVP and ICT PSP have been checked to identify how the neighbourhood/district perspective has been considered or incorporated in their methodologies. Both methodologies are focused in facilities (mostly building) scale.

Thus, taking ICT PSP as basis and existing state of the art, we have proposed in this deliverable the Odysseus validation methodology for covering the neighbourhood/district point of view without losing the facilities (building's) scope. Both scales are covered in the project scenarios for both sites Manchester with the THX scenario (building level) and the MCQHN scenario (neighbourhood scale); and Rome XI with the scenario in the Cesare Battisti school (building scale) and the scenario with several public building in the Garbatella district (neighbourhood scale). The methodology tries to address the question on how to go from facilities level towards an upper level scale like the neighbourhood of a city.

The Odysseus proposed validation methodology has been summarised in 12 steps that covers the demonstration plan for both pilot cases in several phases. Phases proposed include: monitoring plan, baseline analysis, ECMs definition, extended boundaries to e-Network, reporting period and evaluation period. Each of these phases will be covered in future tasks T5.2 and T5.3 for each site.

Several phases have been considered in the methodology: monitoring plan, baseline analysis, ECMs definition, extended boundaries to energy network, reporting period and evaluation period. The content of these phases are described in detail and represent the basis for further description of specificities in D5.2 Demonstration Plan. For both pilot cases in Manchester and Rome D5.2 must consider the specificities to be monitored (predictor variables), the baseline definition for the energy nodes involved in pilots cases for both cities, the ECMs to be applied at building and neighbourhood scales within the baseline analysis phase and the required activities during the reporting period.

These validation methodology phases and steps will be further linked with the Odysseus D5.2 Demonstration Plan deliverable, where more detail will be provided at use case level for the proposed use cases in both cities.

7 References

ICT PSP v3 http://eemeasure.smartspaces.eu/eemeasure/static/files/eemeasure_residential_methodology.pdf

eeMeasure http://eemeasure.smartspaces.eu/eemeasure/

SEEDS http://seeds-fp7.eu/index2.php

E3SoHo http://www.e3soho.eu/

3e-HOUSES http://www.3ehouses.eu/

BECA http://beca-project.eu/home/