Open Dynamic System for Saving Energy in Urban Spaces

D 5.2 Demonstration plans

Deliverable data

Deliverable no & name	**D5.2 .Demonstration plans**
Main Contributors	*TEL,MCC,ROM, ESO,**ADV**,PRI,TNO,CSTB*
Other Contributors	
Deliverable Nature	*Report*
Dissemination level	**PU** – Public – **X** **PP** – Restricted to other programme participants (including the Commission Services) **RE** – Restricted to a group specified by the consortium (including the Commission Services) **CO** – Confidential, only for members of the consortium (including the Commission Services)
Date	*18/12/2013*
Status	*Final version(Approved)*

Document history

Version	Date	Author /Reviewer	Description
0.1	13.11.12	ADV	Initial draft / Table of Contents
0.2	11.03.13	ADV	ToC evolution (v1)
0.3	20.03.13	ADV, TEL	ToC evolution (v2)
0.4	03.07.13	ADV, TEL	ToC evolution (v3)
0.5	31.07.13	ADV TEL	ToC and document structure
0.6	29.08.13	ROM	ROM UCs initial draft
0.7	13.09.13	MCC	MCC UCs initial draft
0.8	16.09.13	ADV, TEL	Comments to initial draft
0.9	23.09.13	ROM	UCs update
1.0	22.10.13	ADV, TEL	Review + UC DP summary table
1.1	25.10.13	ROM	Update + edition
1.2	25.10.13	MCC	Update + edition
1.3	29.10.13	ADV	Document structure modification
1.4	31.11.13	ADV	Update + edition
1.5	10.12.13	ADV	Consolidated Draft version
1.6	16.12.13	ESO, ROM	Final amendments and review version
1.7	17.12.13	MCC	Final amendments and review version
1.8	18.12.13	ADV	Final version

Table of Contents

1 Executive Summary

The objective of WP5 is to prepare, implement, monitor and assess the different pilots where the Odysseus solution will be deployed. In this report, demonstration plans goals and objectives, will be mapped against the ones proposed in the ICT PSP methodology for energy saving measurement in the scenarios defined in Rome and Manchester, according to Odysseus validation methodology described in D5.1 (Validation Methodology).

Due to the nature of the project and the type of ECMs (Energy Conservation Measures) expected to be applied; ICT PSP is considered the most suitable reference methodology. Odysseus validation methodology intends to upgrade ICT PSP principles with the inclusion of the neighbourhood point of view.

This document describes how the Odysseus solution will be implemented in the scenarios described in D1.1 (Pilot Business cases) and refined in D1.2 (Pilot integration scenarios), following the phases defined in D5.1 step by step. This report will present the different use cases identified for both pilot sites and the technical challenges to be addressed to fulfill the steps for the validation process; monitoring, baseline/analysis, ECMs definition and reporting, that will be implemented within T5.2 and T5.3 activities.

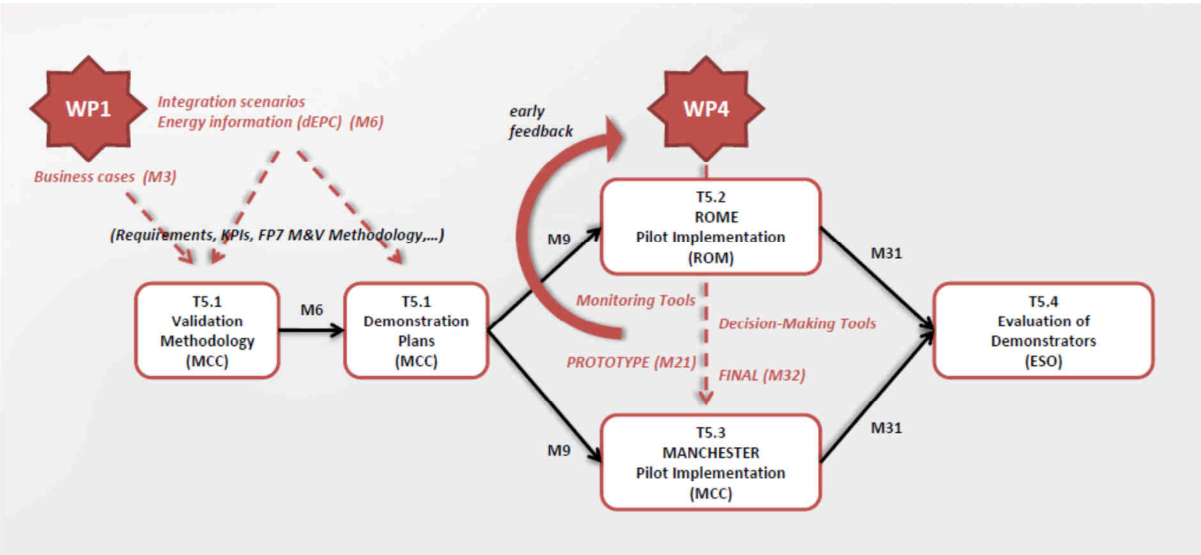


Figure 1 – Demonstration plans as guidelines for pilot implementation

2 Introduction

2.1 Purpose, Intended Audience and Scope

The purpose of this deliverable is to define the guidelines for the implementation of the pilots and the later validation process. It defines the approach taken for each pilot scenario and use case identified in Rome and Manchester. This document is the next step to D5.1, moving from the general description of the validation methodology defined to its particularization into real scenarios and associated plans.

The intended audience of this document is the whole consortium, though the partners involved in the technical issues of the pilots implementation and the stakeholders in Manchester and Rome are specifics targets. This document will be a reference for general audience when picturing the scope and boundaries of the scenarios defined for Odysseus validation purposes.

From a scope point of view this deliverable provides the approach taken from an energetic point of view and the details of the particular implementation of the methodology in both scenarios, Manchester and Rome.

2.2 Applicable Documents

- Odysseus Description of Work (DOW ODYSSEUS (600059) 2012-09-26.pdf)
- Odysseus D7.1 Project Plan, Approved version 1.0, 3. January 2013
- Odysseus D1.1 Pilot Business Cases
- Odysseus D1.2 Pilot Integration Scenarios and dEPC Requirements,
- Odysseus D5.1 Validation Methodology

3 Demonstration Plan I - Manchester

The demonstration in Manchester includes two use-cases: The Town Hall Extension (THX) which has recently undergone a major refurbishment and the proposed Manchester Civic Quarter Heat Network (MCQHN)

3.1 Energy flow

The THX energy system is combined with that for the adjoining Central Library into what is known as the Manchester Town Hall Complex (THC), which has recently been equipped with a "bespoke" heating and cooling system. This consists of a gas boiler installation to supply the main heating load as well as a CHP installation for electrical supply. Waste heat from the CHP is utilised efficiently, controlled through a Building Energy Management System (BEMs) as explained below. Two CHP engines supply all the electricity needs of THC. During heating periods (daytime) waste heat from CHP engines feed into + preheat three gas boilers for main LTHW system. Three LTHW buffer vessels in the HW system supply to floor zones of the Town Hall Extension (THX) via ultrasonic heat meters. Radiators with Thermostatic Radiator Valves (TRVs) are mounted under each of the windows in each floor zone. Main office floors in the THX are naturally ventilated and this provides for summer cooling (narrow plan floor plate).Overnight unused/waste heat from CHP is used to feed one absorption chiller which charges a chiller store which supports the base cooling load for most of the year (ICT area + some conference facilities). One electric chiller supports additional peak summer cooling load. A heat exchanger controls waste heat flow from CHP units to boilers and absorption chiller. In low occupancy periods, e.g. overnight, one of the two CHP units shuts down.

The buildings to be included in the MCQHN are: the Town Hall, the Town Hall Extension, Central Library, the Midland Hotel, Manchester Central (the conference and exhibition centre) and Number One St Peter's Square. Additional buildings that may be included are the Manchester Art Gallery, Heron House and the Bridgewater Hall. Each of the buildings to be included in the network is equipped with its own heating and cooling system. It is proposed to construct a new energy centre to include a new CHP installation together with thermal storage that will be located in the under-croft of Manchester Central.

3.2 Boundaries of the energy flow

City managers seek to address the overall City objective of 41% CO_2 abatement by 2030 The THX use case will explore city employees energy use i.e. that resulting from their employment by the City. So the overall energy boundary relates to the physical boundary of the THX building as well as to the adjoining neighbourhoods for the extent of the commuting distance of the employees. The experiment in the THX will initially focus on the energy consumed in comfortable occupational use of a zone or floor in the TTX and in a later phase the energy used collectively by the employees resulting from their choice of various modes of travel to work (TtW) will also be addressed to extend the experiment into the urban domain.

The boundaries for energy flow in the MCQHN encompass the buildings in the network.

3.3 Relevant KPIs

The following is a summary of the relevant KPIs for the Manchester use cases:

THX:

- Energy consumed /square meter of floor space
- Energy consumed /occupant or employee
- Energy consumed/ occupant or employee/ square meter of floor space.
- Energy consumed/occupant or employee/daily travel to work.

MCQHN:

- Heat energy consumed per square meter of floor space/annum (kWh/m^2/year).
- Electrical energy consumed per square meter of floor space/annum (kWh/m^2/year)
- Energy demand for commercial buildings (kWh/m^2/year)
- Heat transfers (MJ per year)
- Cost of heat supply (£/MJ)
- CO_2 emissions from the whole network (Kg per year)
- CO_2 emissions from the electrical consumption/supply in the network (Kg/m^2/year)
- CO_2 emissions from the overall heat supply in the network (Kg/m^2/year)
- CO_2 savings per square meter (Kg/m^2/year)
- Local economic effects of the heat network (£s/capita)
- Socioeconomic effects of the heat network (jobs/year)

3.4 Monitoring devices and equipment

THX heat energy to each floor zone can be monitored through an ultrasonic heat meter and electric meters all connected to the BEMs. Electricity meters are located in the lift/stair core adjacent to the floor zone. Electrical energy can be monitored through 3 meters, power circuit, lighting circuit and ancillary circuit (toilets, kitchen and print rooms). The meters/BMS can measure energy flows and present it/them over various timescales/periods for all the 64 zones. The energy use in each zone is displayed via a spread sheet in a variety of formats and time periods.

Rather than monitoring energy consumption and flow in the MCQH network after it has been created the intention is simulate its operation in advance in order to help in its design, for example, to select between technical options such as the proportion of CHP, biomass or solar, control systems options and delivery options such as PPP, ESCO or Private Company.

3.5 Building level UC-M1: Manchester Town Hall Extension(THX)

3.5.1 *Functional description*

The Manchester Town Hall Extension (THX) is an important facility for the city's administrationlocated between the town hall and the central library. It is a narrow plan steel and concrete framed building enclosing a courtyard mainly on 8 floors completed in 1938.It has undergone a major refurbishment during the period 2011-13 to bring it up to a modern office standard and is now being gradually re-occupied. The building is grade II*listed[1]clad in sandstone with steep pitched lead roof. As an important heritage building the options for the improvement to the thermal performance of the fabric were limited. The appearance of the exterior and much of the interior had to be maintained which, with the narrow frame section of the windows precluded application of internal or external insulation. Instead, to address the CO_2 abatement target, the design strategy has been to focus on increasing the efficiency of the new heating and cooling systems and in their control. In addition to a complete internal refit new metal framed doors were installed together with the refurbishment of the existing metal windows to restore functionality and improve air tightness, but in a manner that maintains the external and internal

[1]Grade II* buildings are particularly important buildings of more than special interest, see;https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137695/Principles_Selection_Listing_1_.pdf

appearance.

The plant room is located in the basement area and supplies both the THX and the central library which have been refurbished in parallel. The buildings are connected via an undercroft and together are known as the Town Hall Complex (THC). The ground floor and undercroft provide a range of public areas including the reception, drop in center and cafeteria. As can be seen in Figure 2.1a the ground floor area of the THX occupies the whole of the footplate of the building and the roof over these public areas has been renewed with well insulated and double glazed construction. However the public areas do not form part of the Odysseus experiment which concentrates on the office floors.

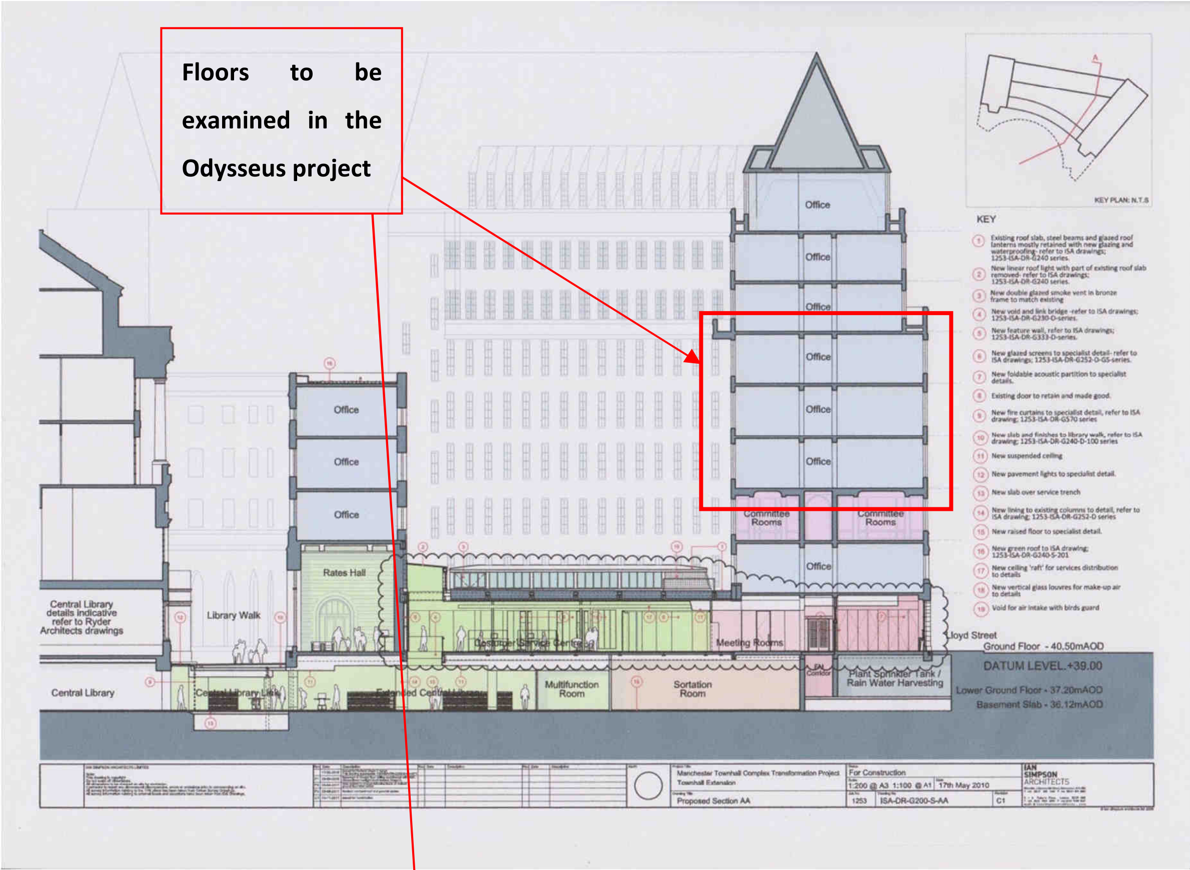
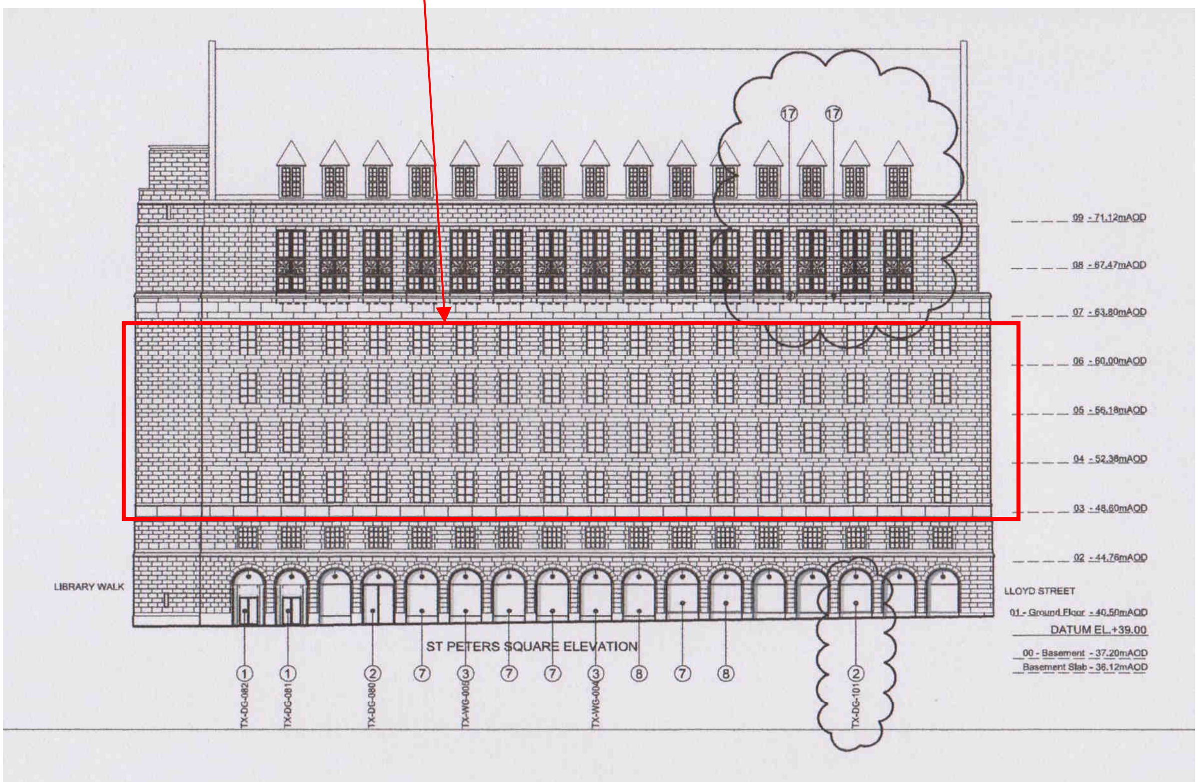


Figure 2.1a and b Section + Elevation through the Town Hall Extension



The THX use case is to compare the effectiveness of a scenario based on the city's guidance to and performance of individual energy managers on their floor zone/section in terms of energy/carbon reduction in relation with the City's 41% CO_2 reduction target by 2030. Figures 2.1a shows a section and 2.1b an elevation of the building showing the floor areas to be examined in the project.

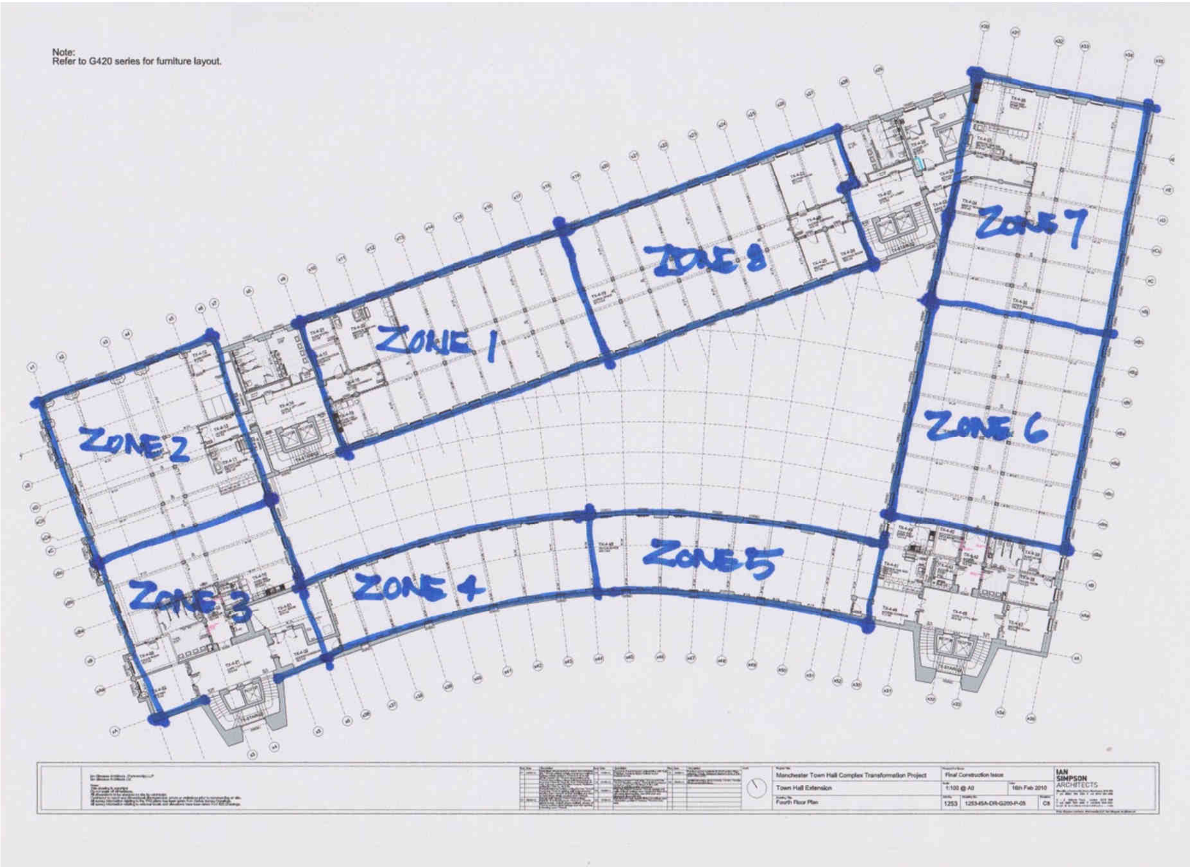


Figure 2.2- Floor Zones in Town Hall Extension – heating

The scenario is that energy managers have control of one floor, or part thereof, of the THX. The heating and electrical consumption for each one of 8 zones in each floor can be metered and fed remotely into the BEMS and managers will be able to monitor consumption on a regular basis –see figure 2.2.

The use case is essentially a comparative study of the application of Energy Conservation Measures (ECMs) between floors in terms of:

a) the application of a range of "soft" behavioral ECMs. The ECMs will explore the energy consumption in the building as well as that used for travel to work (TtW). The latter represents an urban dimension to the analysis as it provides the City managers with the global picture of energy consumption of the staff/employees engagement at their work.

b) A “hard” technical ECM exploring lower lighting levels appropriate for the increasing use of computers over traditional paper based working. The system is designed to supply 500 lux necessary for reading paper documents but this is to be reduced in the study zones to 300 lux which is adequate for reading from the computer screen.

The use case will focus on four zones in two of the floors already occupied - concentrating on Zones 1+ 8 and 6+7 on Floors 2 and 3 or on Floors 3 and 4 (exact floors zones still to be decided). The floor zones in the comparison have similar orientation, similar office use and occupancy and broadly similar occupant comfort expectations.Two of the four newly appointed floor zone energy managers will undertake the City’s Carbon Literacy Educational programme and be supported by the MCC Odysseus team to introduce a range of behavioral Energy Conservation Measures (ECMs).

Two floor zones will be used as control where soft ECMs will **NOT** be applied and to form a comparative study on the performance/effectiveness of the ECMs applied by the energy managers. Floors will be of similar area and although use factors vary slightly they will be directly comparable.

The Carbon Literacy training course includes a range of factors and this will be augmented by the trainers to address a range of building factors related to occupancy and use, including:

- Temperature control and management
- Ventilation control and management (particularly window opening behavior)
- Lighting controls and management
- Standing loads and management, e.g. computing equipment.
- TtW options, choices and incentives

Subsequently managers are to be introduced to the Odysseus software (based on the assumption that this can be interfaced with the THX BEMS on an agreed basis) and they could use the additional functionality to go through a further iteration of ECMs.

3.5.2 *Energy systems*

As outlined in section 3.1the THX is part of the Manchester Town Hall Complex (THC) which, in the refurbishment, has been equipped with a “bespoke” heating and cooling system. This consists of a gas boiler installation to supply the main heating load as well as a CHP installation for electrical supply. Waste heat from the CHP is utilised efficiently controlled by the Building Energy Management System (BEMs) as explained below.

Two 358 kWh CHP engines supply all the electricity needs of THC – 1MVa load. During heating periods (daytime) waste heat from CHP engines (330kW) feed into + preheat three 1062kW gas boilers for main LTHW system. Three 500l LTHW buffer vessels on HW supply to floor zones via ultrasonic heat meters. Radiators with TRV are mounted under windows in each floor zone. Connected heating load = 3MW. Main office floors are naturally ventilated and this supports summer cooling (narrow plan floor plate).

Overnight unused/waste heat from CHP is used to feed one 200kw absorption chiller which charges a chiller store of seven 7000l chilled water storage vessels which supports base cooling load for most of the year (ICT area + some conference facilities). One 486Kw electric chiller supports additional peak summer cooling load - max 600kW.

A heat exchanger controls waste heat flow from CHP units to boilers (330kw max) and absorption chiller (230Kw max). In low occupancy periods e.g. overnight one of the two CHP units shuts down (50% turndown ratio). A simplified view of the system is shown in Figure 2.3

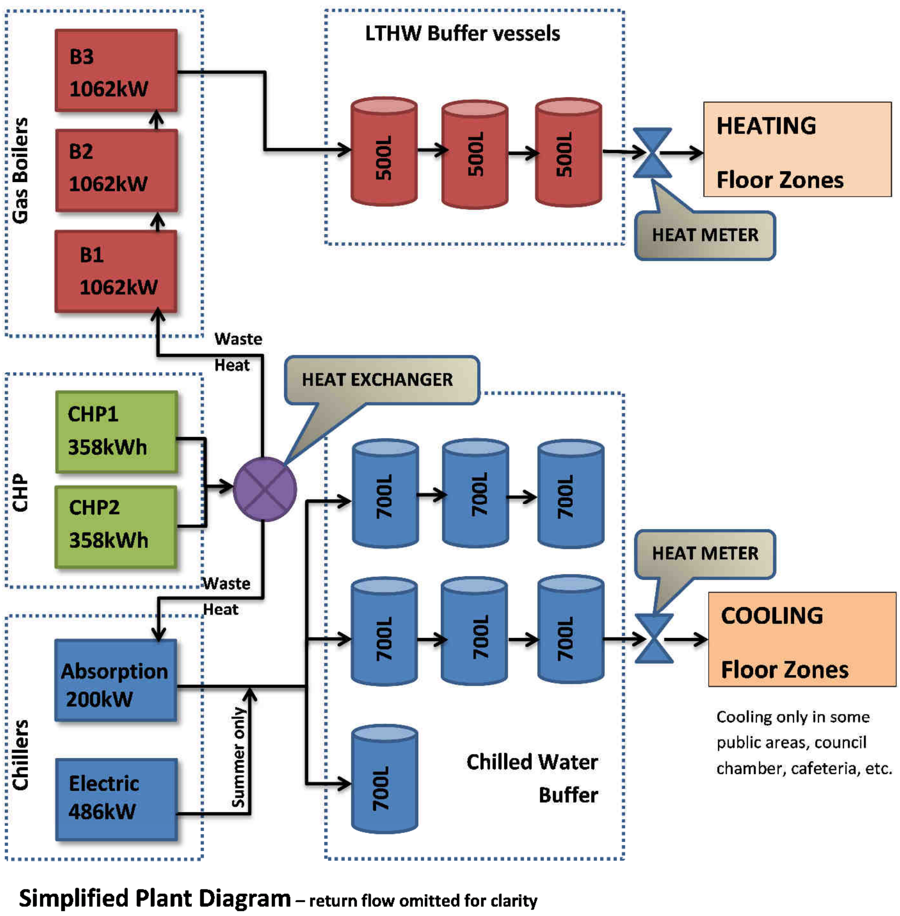


Figure2.3 Simplified Diagram of the THC System THC Heating and Cooling System

The use case will concentrate on the staff occupants/users of office floor zones. The main energy consumption per staff member will relate to preferred temperature, ventilation rate, lighting levels and computer/printer usage together with their travel to work.

The office floor zones are heated using a low temperature hot water (LTHW) circuit which supplies radiators located under each of the windows– see figure 2.4. Occupants can control the temperature of their workspace via a thermostatic radiator valve (TRV) on each radiator. Ventilation and summer cooling is facilitated by opening windows and due to the narrow plan format occupants can open the windows adjacent to their workspace.

Air conditioning (for active cooling) is supplied in the ground floor public areas, IT rooms, catering areas and conference chambers on the 1st floor, but these areas are not part of the Odysseus use case experiment.

On the office floors lighting supplying 500lux over the work area is located in the ceiling and is controlled by motion sensors. Separate sensors control a “circulation” strip down the centre of each floor zone and the workplaces in each of the work bays on each side of the building. Power sockets for IT equipment are located in the floor for each of the workstations which are not supplied with task lighting, however occupants are free to bring in additional desk lights if they wish. The lights at the perimeter (near the windows) have dimming control which responds to the external day lighting level. 30% of the lighting in each zone has this additional control.

Each floor zone has a service hub equipped with 2 printer/photocopiers and a shredder adjacent to a small kitchenette area equipped with food and drink preparation facilities (microwave oven, dishwasher, sink, etc.). The toilets have electrical hand driers.

3.5.3 *KPIs*

The relevant KPIs to this case:

- Energy consumed /square meter of floor space
- Energy consumed /occupant or employee
- Energy consumed/ occupant or employee/ square meter of floor space.
- Energy consumed/occupant or employee/daily travel to work.

For the project these are suitable measures for the assessment and evaluation of the relative success of the behavioural ECMs to be applied during the experimental period. The use of the three KPIs together will enable direct comparison even though occupancy factors will vary between floors. Energy consumed/occupant/sq M of floor space will enable the energy use in the building to be linked with that used for travel to work. Subsequently energy consumed will be converted to CO_2 released for use in reporting outcomes within the City's overall CO_2 abatement strategy plan.

3.5.4 *Monitoring plan*

Heat energy to each floor zone can be monitored through an ultrasonic heat meter and electric meters all connected to the BEMs– see figures 2.4. The heat meter is located on the main LTHW flow pipe to the perimeter radiators located under each window in the office area. Electricity meters are located in the lift/stair core adjacent to the floor zone. Electrical energy can be monitored through 3 meters, power circuit, lighting circuit and ancillary circuit (toilets, kitchenette and service area/print rooms).

The Heat meters are SONOMETER1100 ultrasonic compact energy meters as manufactured by Danfos with European type approval, see Figure2.4a. The meters have a dynamic range of qi/qp1: 250 inclass 2 with a measuring accuracy that meets the requirements of EN 1434 (MID) class 2 and 3. Calibration is to be based on the "worst case" option, i.e., the maximum heat energy in KWh that the system can deliver to each zone at the lowest external design temperature of -4 degrees Celsius. Actual usage can be compared against this over time.

The meters/BMS can measure energy flows and present it/them over various timescales/periods, viz: current; ½ hourly; today; yesterday; week; last week; month; last month; annual - for all the 64 zones.

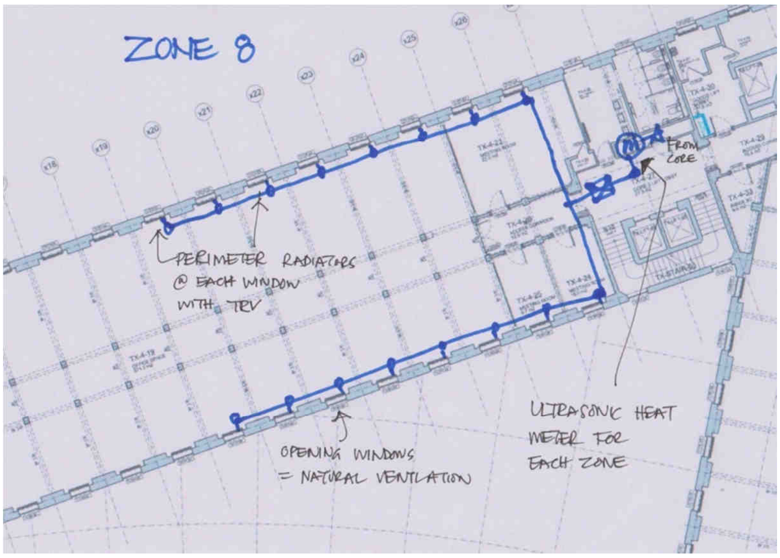


Figure 2.4. Typical Floor Zone (Zone 8, Level 4)

Figure 2.4a. Heat Meters in the THX

As the energy use in each zone can be displayed via a spread sheet in a variety of formats and time periods (as above)this is currently in use to help with the optimisation of the systems during the final commissioning and handover phases of the THX refurbishment. However this is too much information for floor/zone energy managers to use for the subsequent efforts in the Odysseus pilot study, i.e., to apply the management ECMs and a simplified format with one spread sheet for electrical energy and one for heat energy will conform to the CIBSE's TM22 format[2].

Through the BEMs, the ultrasonic heat meters and electricity meters will be able to define the energy used in each floor zone and floor.

External weather data (temperature, wind speed, humidity, rainfall) is available via the UK

[2]https://www.cibseknowledgeportal.co.uk/component/dynamicdatabase/%3Flayout%3Dpublication%26revision_id%3D103%26st%3DTM22

MetOffice weather station at Manchester airport (10KMsouth of the THX)[3]. Solar energy falling on the building will be monitored by additional UV + solar radiation sensors mounted on the roof or external wall

TtW details (mode, distance travelled)will be recorded manually via an addition to the weekly staff timesheets. This element of the case study will run in Phase 3 (see below) as the data will need to be manually uploaded into the Odysseus platform.

3.5.5 *Baseline: Period, Energy and Conditions*

The programme is to be run in 3 month iterative phases[4], as follows:

Phase #	Time Period	Comment
Phase 1	January-March 2014	Baseline energy monitoring. During this period selected energy floor managers will receive the behavioural ECM training
Phase 2	April -June 2014	Application of ECMs on selected floor zones of the THX and energy monitoring of experimental and control floor zones of the building
Phase 3	July – September 2014	1st comparative review of energy savings and success of the ECMs between floor zones, experimental (with) and control (without) application of ECM. Adjustment to the ECM and energy management regimen in response to the experience gained from phases 1 and 2. Training of floor energy managers on the use of Odysseus prior to

[3] Other weather providers might be considered for obtained detailed weather data for the Manchester case.

[4]It is important to note that the phasing is primarily to facilitate the energy management skills development by the floor zone energy managers

		phase 4
Phase 4	October – December 2014	Use of Odysseus software to support the application of ECMs. In this phase the TtW ECM will be added
Phase 5	January March 2015	whole year evaluation using energy data, to explore the potential roll out to the whole building and to other MCC facilities

Note: During phases 1-4 energy consumption will be reviewed on a weekly basis. The floor zone energy manager can view the weekly energy consumption for his zone via a TM22 spread sheet and use this in "toolbox" discussions over the ECMs with his/her office team. Monitoring will be undertaken in each phase and in phase 5 the building energy data from each phase will be consolidated to compare with the historical data (as explained and with the reservations explored below).

3.5.6 *Baseline analysis and ECM definition*

Baseline data exists for the whole THC (THX and Central Library) for year before refurbishment, January to December 2012: heat -3000MWh, electricity – 4500MWh. However this is very coarse in that it is energy consumption data for the whole complex (2 buildings and connecting under croft). Nevertheless it can be related to the floor area and previous occupancy, i.e., for the KPIs: energy consumed /sq M of floor space; energy consumed /occupant; energy consumed/ occupant/ sq M of floor space. However a key factor in the re-design of the building is to significantly increase occupancy factors through more open plan arrangement of space and, unadjusted, this would of itself tend to indicate improvement with the 2 of the KPIs.

Therefore although this "historic" data is available this case's primary aim is not a "before and after" comparative study but to help support effective commissioning of the systems and delivery of the design expectations in the building by exploring the effectiveness ECM soft measures with the occupants. Therefore the baseline data will be that collected in the 1st phase of the study and ECMs compared relative to this 1st phase and subsequently in the later phases to that in the control floor zones where the ECMs will **not** be applied.

As mentioned in Section 3.1 the main ECM measures to be applied relate to:

1. Temperature control and management
2. Ventilation control and management (particularly window opening behaviour)
3. Lighting controls and management
4. Standing loads and management, e.g. computing equipment.

5. TtW options, choices and incentives
6. Lighting levels

For ECMs 1 and 2, in each zone the two environmental controls available to the occupants in their local work area are the TRV on the radiator under each window and the opening window itself. Clearly with this freedom of choice (increasingly available in modern office buildings) a major factor in energy flow through the external fabric will be the window opening behaviour of the occupants. The potential for higher energy flow through the fabric and higher energy consumption due to opening windows for fresh air and cooling rather than, for example, turning down the TRVs and/or wearing more appropriate clothing for the season will form an important part of the management soft ECM training and demonstrate how all users can be “taught” how to maximise comfort whilst at the same time operating their part of the building more efficiently. Therefore the ECM soft measures will explore how occupants can optimise comfort conditions in relation to the weather conditions and the season, through clothing choices, use of the TRV settings and by minimising excessive ventilation cooling, e.g. closing windows when leaving the office at the end of day in the “heating” seasons (autumn, winter, spring).

ECMs 3 and 4 will reinforce the traditional energy messages about switching off when not in use. In each floor zone the main ceiling mounted lighting is controlled by occupancy sensors so this aspect will address the additional desk task lighting and control of computers and other items of equipment. Whilst the technical ECM, reducing the light levels from 500 down to 300lux,is aimed at assessing the reduction in energy consumption accruing from reduced illumination it will also seek staff views of any comfort/discomfort issues that may accrue from the change.

In phase 4 the TtW part of study will be introduced. Clearly it is not possible to alter the THX location in relation to that of the staff/employees home in order to reduce TtW distance and associated energy, however overall energy use/flow per occupant will be influenced by daily TtW choices (public transport, private car, cycling, etc.).Therefore in the later phase changing travel to work behaviour and transport mode choice is also to be part of the overall ECM "soft" measures, even though factors are complex[5].

3.5.7 *Reporting period*

The main phases of the study are outlined in 3.1.5. Within this overall plan the floor zone energy manager can view the weekly heat and electrical energy consumption for his zone via the TM22 spread sheet from the BMS and later (in Phase 5) via the Odysseus platform's dashboard) and use this information in weekly "toolbox" discussions about consumption and energy saving behaviour (e.g. less opening of windows) with his/her office team. The information can be interrogated and could illustrate particular weeks when energy consumption was higher/lower to explore the reasons for the increase/decrease so that preventative measures and/or reinforcement of "good" behaviour can be instigated by the floor zone manager.

3.5.8 *Basis for adjustments*

As the use case makes direct comparison between floor zones in the same building with very similar use characteristics and orientation over concurrent time periods there should

[5] E.G An analysis in Surrey (UK) shows that resident locations within 3km of the uncongested M3 and A31 are associated with commutes consuming 44% more energy than resident locations >3km from the strategic road network. (Hickman, R & Banister, D (2007), Working paper N° 1026, Transport Studies Unit, Oxford University Centre for the Environment; http://www.tsu.ox.ac.uk/)

be no need for major adjustment factors, e.g., climate, season, etc.

Although the proportion of the external wall that is glazed is low (26%) minor adjustments may be needed to reflect orientation of floor zones and slight differences in availability of solar energy. This aspect will be addressed in phase 4 through the use of externally mounted solar energy sensors and when the Odysseus platform becomes available to support more sophisticated analysis.

3.5.9 *Analysis procedure (Validation process)*

A key element of the validation will be to relate the energy consumption to the external temperature fluctuations to explore the degree to which consumption has been influenced by external conditions.

The main 12 step validation procedure to be adopted in Odysseus is identified in D5.1. The table below (Table 1) explains how this is to be applied to the MTX use case. In this use case where a phased monitoring programme comparing experimental floors zones with control floor zones steps 7-10 are not sequential as explored further in the table.

Steps	Validation Description
1	The use case physical boundaries are the external walls of the office floor zones of the THX, the gas/CHP heating system and electrical light and power system. The main e-Node will be represented by each floor zone in the building with a sub-set of e-Nodes representing the range of devices in use by the occupants (lights, IT equipment, etc.) in each floor zone.
2	The main predictor variable to be applied in the THX case is weather data.
3	As this main experiment in the THX use case is a comparison between floors the formal baseline period can be condensed into three months with a 3month cycle of phased application of ECMs and analysis thereafter. After 12 months the consolidated yearly data can be compared with (a) historical data from before the building was refurbished and (b) used as the basis for longer term energy management of the facility.
4	Heat meters have already been deployed into each floor zones (e-Nodes) which are integrated with the BEMS. Electrical metering is arranged in a similar zoning pattern. Weather data will be available from a local weather station. Solar energy monitoring will require additional sensors.

5	Raw data will be collected and stored for the floor zones (e-Nodes) in a three month phased monitoring cycle as explained in section 3.1.5during an overall monitoring and evaluation period - January to December 2014.
6	The raw data on heat and electrical energy usage stored by the BEMs will be transformed into the dEPC information structure of the Odysseus Platform in Phase 4(M21/ September 2014).
7	Initial baseline analysis at energy-system/e-Node level (facilities level) will be undertaken via the BEMS (TM22 format) in Phase 2. Subsequently this will be used to refine the ECMs deployed in phase 3. In phase 4(M21-24: the Odysseus decision-making tool will be used to define ECMs for later phases of monitoring and to define the TtW ECM
8	Connect e-Nodes (heat meters, etc) to the aggregation layer of the Odysseus Cloud Platform. The addition of the TtW (the form of this e-Node still to be defined) to establish an e-Network (building /neighbourhood/district) (Phase 4/5,M24-25).
9	Send e-Node dEPC information (real information) to the Odysseus Cloud Platform to begin to compose the e-Network level will take place in phases. Phase 4 for the building information later in phase 5 for neighbourhood (TtW) Analyse and conclude the neighbourhood baseline period for the pilot site with this information).
10	The ECMs are to be applied at e-Node level (Floor zones in the THX building) in phase two as explained in section 3.1.5.
11	The ECMs, with the addition of the TtW ECM to be applied at e-Network level (Odysseus Cloud Platform simulation) in phase four (section 3.1.5).
12	Results at e-Node level, i.e., comparison between floor zone levels is to be undertaken in a 3month cyclical reporting period as explained in 3.1.5. Results can be compared at the e-Network level (overall energy use - neighbourhood level) in phases four and five.

Table 1 - Odysseus validation methodology steps for the THX use case

3.6 Neighbourhood level UC-M2: Manchester Civic Quarter Heat Network

3.6.1 *Functional description*

This use case explores the feasibility of developing a heat network in the centre of

Manchester to support MCC's target or 41% CO_2 reduction by 2030. The core buildings to be included in the MCQHN are: the Town Hall, the Town Hall Extension, Central Library, the Midland Hotel, Manchester Central (the conference and exhibition centre) and Number One St Peter's Square. The use and construction characteristics of the buildings to be included in the network are shown in table 2 and their location is shown in Figure 3.

	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 2 Buildings to be included in the Manchester Civic Quarter Heat Network.

The relationship between the buildings is shown in Figure 3.5 and this also shows the additional buildings that may be included in the network; the Manchester Art Gallery, Heron House and the Bridgewater Hall. In broad terms the use case is to simulate the potential energy savings and associated financial returns on investment to help (a) the technical design of the system, e.g., to select between a centralised or decentralised plant systems together with the balance of CHP, energy storage, solar, etc. and (b) select between 5 delivery options for the network: private ownership, public ownership, and 3 variations of public/private partnership (PPP).

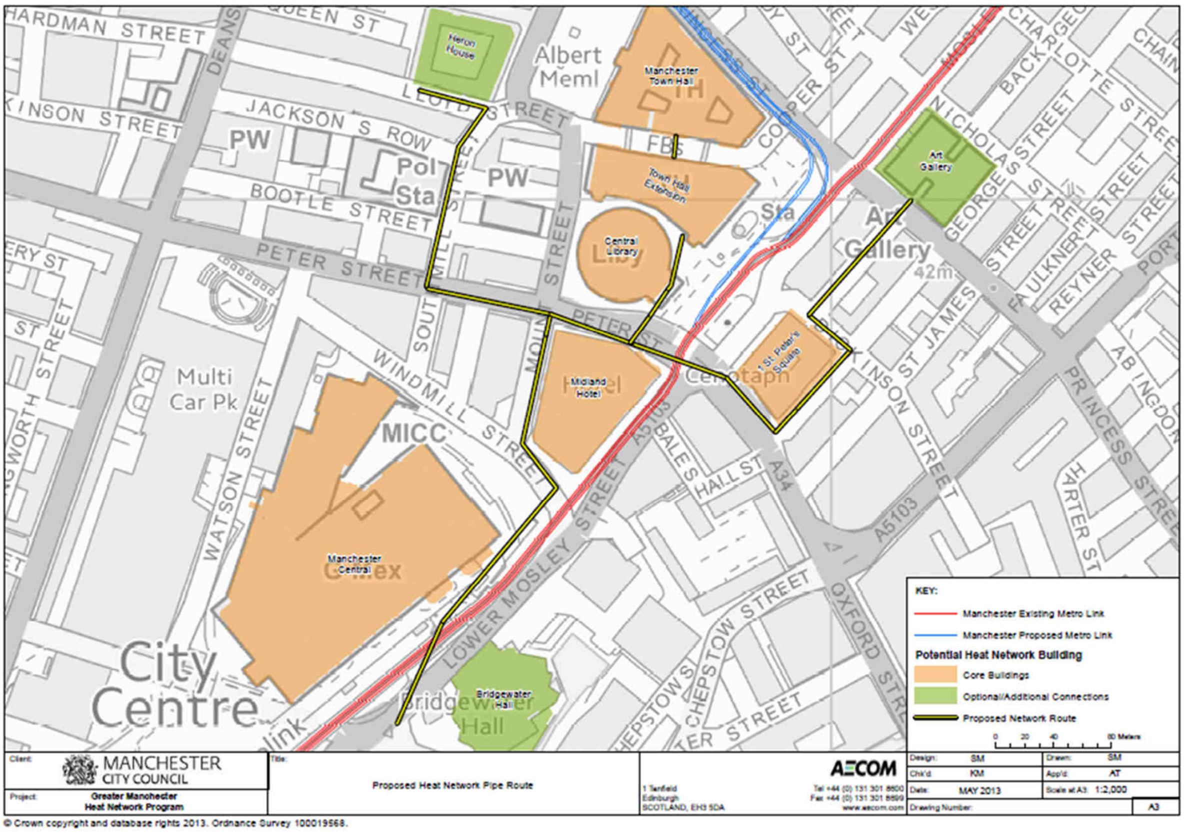


Figure 3. Location of the Buildings to be included in the MCQHN

3.6.2 *Energy systems*

There are several existing heating installations within the buildings which are new and could potentially be retained and used as part of a heat network scheme, including gas boilers at One St Peter's Square and the Town Hall, and gas boilers and CHP in the Town Hall Complex (described in section 3.1.2). The Midland Hotel may also install new gas boilers in the near future to replace the existing units approaching end of life. Options are being considered for retaining this plant in situ and using these boilers as decentralised peak / back-up plant, or for it being replaced by centralised boiler plant at the energy centre.

A number of technology options have been considered, but the location and size of the scheme promotes gas fired CHP engines as the most suitable option in two basic plant configurations:

- **Centralised**: In this option, the majority of CHP systems and peak / back-up boilers are located in a centralised energy centre. The DH network is used to provide all heating to the customers and sized for peak load. The benefits of this option are economies of scale through purchase and operation of centralised plant, and the reduction in need for dispersed plant in individual customers' buildings (with possible increase in useable space). Disadvantages include the requirement for a large central energy centre (and hence land take), the need to size the network for peak loads (which increases pipe costs), likely redundancy of existing boilers owned by customers, and a potential lack of resilience with no back-up at individual customers.
- **Decentralised**: In a decentralised option, some or all boiler plant is retained at some or all of the customers' sites, and the CHP plant is located at a separate energy centre, or at one of the customers' buildings. The CHP plant provides the base load heat with peak / back up being supplied by the decentralised boilers. Advantages of this option include reduced land take for central plant, potential for sizing the DH network for a lower 'base load' heat provision, greater resilience for customers, and maximising the use of existing assets. Disadvantages include the need to operate, maintain, and replace dispersed plant (with a possible loss of economy of scale), possible complex ownership and operation structures for the boilers, and less future flexibility although potentially boilers could gradually be centralised as they are replaced, as long as heat network pipes are sized for peak load.

Under both options it is assumed that the gas CHP system recently installed at the Town Hall Extension is retained in situ. Based on the energy demands of the potential building connections, new2 x 1.2MW gas CHP engines are proposed for the CQHN at a new energy centre, and these are assumed to run as the lead engines on the scheme. The monthly output from the CHP engines and gas boiler plant is shown in Figure 4 (GenSets 1 and 2 are the new CHP engines sized for the scheme; GenSets3 and 4 are the existing CHP engines at the Town Hall Complex).

Manchester Central (the conference and exhibition centre) has been identified as the potential location for the energy centre for the scheme. The existing plant room can be extended by annexing adjoining car parking space to host CHP plant for base load heat provision and some additional boiler plant for peak load/back-up provision. Thermal storage might potentially be located along the side of Manchester Central although this will require careful consideration of aesthetics and volume requirements given the constrained nature of the space, and listed status of the building.

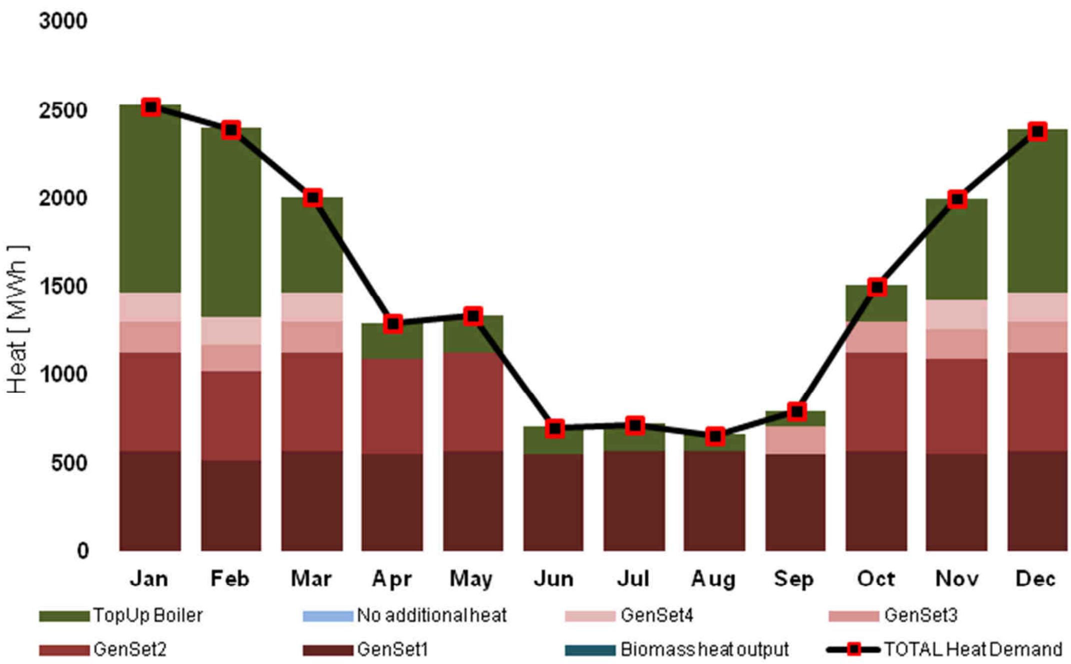


Figure 4. Monthly Output from the Plant Installations

The annual heat and electrical energy demands for the buildings to be included in the network are summarized in the Table 3 and monthly/seasonal demand is indicated in Figure 5.

The potential route for the network installation, shown in Figure 3, is 1.45km (total pipe length, flow and return, is 2.9km), assuming that all the potential buildings identified are connected. The network is assumed to operate with a delta T of 30°C, representing a flow temperature of 90°C and a return temperature of 60°C. The limiting maximum flow velocity is assumed to be 2.5m/s, and the limiting pressure is assumed to be 250Pa/m of pipe length.

Building (and data source)	Annual Heat Demand (Jan-Dec 2012, MWh)	Heat Demand Rank by Size	Estimated Peak Heat Demand (MW)	Assumed Average Existing Boiler Efficiency (%)	Annual Electricity Demand (Jan-Dec 2012, MWh)	Electricity Demand Rank by Size
TOWN HALL	3,900	1	1.8	80	1,700	7
TOWN HALL EXTENSION AND CENTRAL LIBRARY ('TOWN HALL COMPLEX')	3,300	2	3.7	80 (CHP 81.5 overall efficiency)	4,500	1
MIDLAND HOTEL	3,000	3	1.1	75	2,600	3
MANCHESTER CENTRAL CONVENTION COMPLEX	2,700	4	7.9	75	4,100	2
ART GALLERY	1,800	5	1.0	80	2,100	4
BRIDGEWATER HALL	1,400	6	1.5	83	1,900	6
HERON HOUSE	750	7	1.0	75	1,300	8
ONE ST PETER'S SQUARE	750	8	3.0	83	2,100	5

Table 3. Energy Demand for the Buildings in the Network

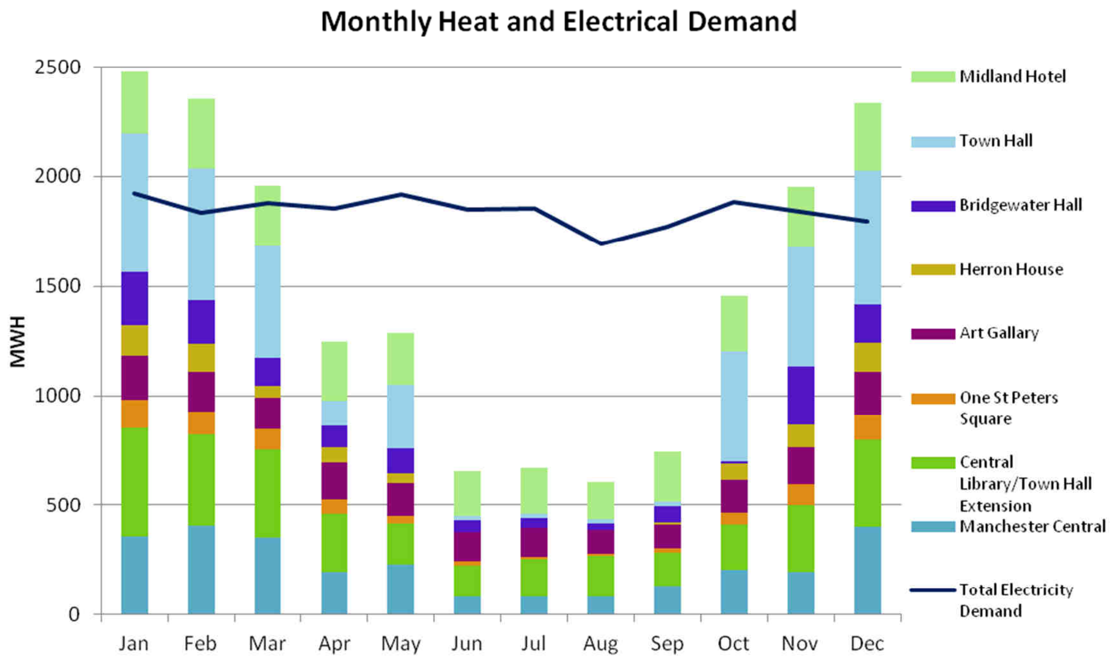


Figure 5. Monthly Heat and Electrical Demand from the buildings in the Network

3.6.3 *KPIs*

The indicators for this use case can be divided into two, those for the buildings in the network and those for assessing the overall performance of the network.

The Buildings:

- Heat energy consumed per square meter of floor space/annum (kWh/m2/year.
- Electrical energy consumed per square meter of floor space/annum (kWh/m2/year)
- Energy demand for commercial buildings (kWh/m2/year)

The Network:

- Heat transfers (MJ per year)
- Cost of heat supply (£/MJ)
- CO_2 emissions from the whole network (Kg per year)
- CO_2 emissions from the electrical consumption/supply in the network (Kg/m^2/year)
- CO_2 emissions from the overall heat supply in the network (Kg/m^2/year)
- CO_2 savings per square meter (Kg/m^2/year)
- Local economic effects of the heat network (£s/capita)
- Socioeconomic effects of the heat network (jobs/year)

This range of KPIs will allow development of understanding of where energy is consumed in the network, the performance of the network itself in terms of heat sharing and its contribution to the CO_2 reduction target as well as the economic and social benefits of the networks development and operation.

3.6.4 *Monitoring plan*

The Odysseus platform is to be used to simulate the potential for energy sharing and associated efficiency gains in optimising the operation of the various items of plant included in the network to minimise overall CO_2 emissions. Rather than monitoring energy consumption and flow in the MCQH network after it has been created the intention is simulate its operation in advance in order to help in its design, for example, to select between technical options such as the proportion of CHP, biomass or solar, control systems options and delivery options such as PPP, ESCO or Private Company.

For the simulation each building in the network will be represented as an e-Node made up of a collection of subservient e-Nodes, i.e., a combination of one or more energy consuming, energy storage and energy producing sections of building and/or items of equipment all connected together through e-Gateways. This can interconnect with real monitoring equipment, such as local weather monitoring/data and some of the existing BEMs data available from buildings in the network, such as the Manchester THX (as explored in the previous use case). These concepts are explained in more detail in section 7.2 of D4.1 the Odysseus Framework Definition. For instance, the eveCity software developed by CSTB is to be adapted for the Odysseus platform and outputs from the simulations will be presented graphically to assist non specialist in understanding the outcomes. Figure 6 shows a typical graphical output – an analysis of solar potential in a district (from Section 7.3.1 in D4.1).

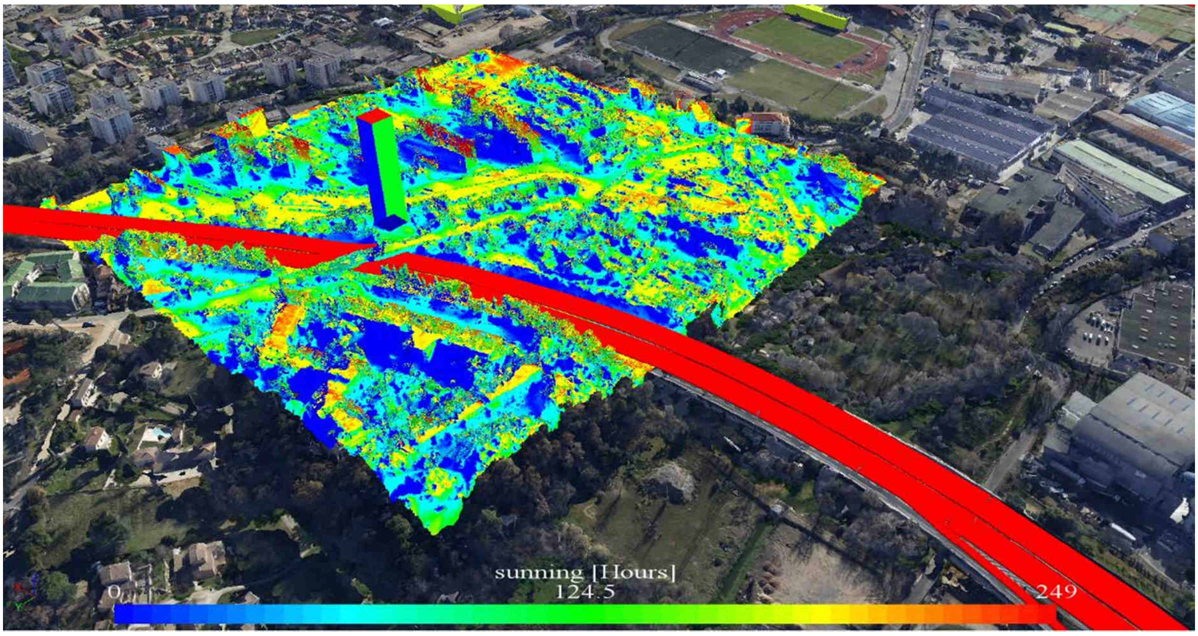


Figure 6. Example of the use of a 3D photogrammetry mock-up to compute solar potential on a district, and on a specific roof

3.6.5 *Baseline: Period, Energy and Conditions*

It is anticipated that the network would be constructed in 2015, and would commence operation in 2016. Delaying delivery too far beyond this date will undermine potential CO_2 savings from gas CHP which are projected to reduce as the planned changes to UK power generation decarbonizes the electricity grid over time. The 2016 date is considered the earliest possible start date given that time is needed to procure and build out a network.

The simulations will explore the energy consumption in an unimproved situation, i.e., without the network and this can be related to the baseline energy consumption as shown in Table 3 and Figure 5

3.6.6 *Baseline analysis and ECM definition*

Baseline data exists for the year January – December 2012 as shown in table 3.

The main ECMs are the network installation itself and the potential use of the Odysseus platform as a tool to simulate its operation so that ultimately when the network is constructed it will deliver more efficient energy utilisation and CO_2 reductions.

3.6.7 *Reporting period*

The platform will simulate monitoring of the network during the period September 2014 - September 2015. During this period various scenarios will be simulated to help the design team explore options in the design of the network, e.g. proportion of central CHP versus distributed gas boilers in the buildings in the network, proportion of energy storage required to optimize the system, etc.. The reporting timetable will be developed to fit the design schedule for the network.

3.6.8 *Basis for adjustments*

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 /…).

The 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.

3.6.9 *Analysis procedure (Validation process)*

A key element of the validation for the MCQHN will be to relate the energy consumption in the existing buildings as e-Nodes in the Odysseus cloud platform together with the related energy exchange characteristics.

The main 12 step validation procedure to be adopted in Odysseus is identified in D5.1. The table below (Table 4) explains how this is to be applied to the MCQHN use case. Because this use case is a simulation steps 4-8 are combined.

Steps	Description
1	The main boundaries for this use case are the buildings to be included in the network and their individual energy-system(s). Each building will be an e-Node in the system along with the new Energy Centre. At December 2013 it is known that 6 buildings are to be included. It is anticipated that the decision about 3 others that might be included will be taken in the first quarter of 2014.
2	The predictor variables to be applied in this use case are the weather and level of occupancy.
3	As this use case is a simulation the baseline period does not need to embrace a complete annual cycle, as the simulation will be able to use historical weather, occupancy and energy consumption data. Therefore the baseline can be addressed as soon as the Odysseus platform becomes available (from M21 – September 2014)
4 5 6 7 8	The platform will simulate monitoring and storage of raw data (e.g. gateways, sensors and actuators) for the network energy-system and e-Nodes, (the buildings) in order to simulate predictor variables (e.g. energy data). September – November 2014
9	Analyse and conclude the neighbourhood baseline simulation for the network. November 2014
10	Apply the identified ECMs (the Odysseus platform) at e-Node level (facilities level scale) (e.g. the various buildings in the network)January - March 2015
11	Apply the identified ECMs (the Odysseus platform) at e-Network level (Odysseus Cloud Platform simulation) to provide an holistic energy management vision of the network. March – June 2015
12	Evaluate the obtained results at e-Network level (neighbourhood level) by comparing the baseline simulation with a number of hypothetical strategies for operation of the network (e.g.) using various fuel options, CHP configurations, energy storage options and extent of investment in alternative energy technologies. June –September 2015

Table 4. Odysseus validation methodology steps for the MCQHN

4 Demonstration Plan II - Rome

The project aims to improve energy efficiency and reducing environmental impact (reduction of CO_2) through the rationalization of energy consumption (management and forecasting of energy consumption) in a district in view of a future electricity network which can intelligently integrate the actions of all users which are connected (producers and consumers) to a more efficient and safe distribution e-Network. The goal of the project is therefore to develop an integrated management system that allows, through the optimization and monitoring of energy consumption, the transfer of energy surplus from one building to another and vice versa.

Specifically, the project aims, through the acquisition and analysis of historical monthly consumption of the reference buildings and of the amount of energy produced by the photovoltaics (data to be provided by the City of Rome Department SIMU), to achieve the rationalization of electricity consumption by optimizing the energy produced by the photovoltaic system installed in building A (Cesare Battisti school), monitoring and analysing the different energy sources in buildings. Therefore, through starting with the modelling of the school 'Cesare Battisti', as a first step, the project aims to achieve the possible usage of energy in excess in building A to building B and/or to vary the size of the PV system in relation to energy consumption needs.

To achieve the above mentioned objectives, monitoring will be initially performed of the electricity consumption and production of Cesare Battisti school and subsequently a monitoring of the overall electricity consumption of the other buildings. The data collected (from such monitoring) will be transferred to the Odysseus platform which will analyse it and give recommendations for making decisions and actions for the containment of electrical consumption, for the use of the energy produced in the most efficient possible way and about the opportunity to transfer the surplus energy produced (during periods of school closure) to recharge the batteries of bicycles and to supply energy to other buildings used as a reference for the pilot case of Rome.

The target of this document is to represent in detail the use cases, describing procedures and deadlines.

4.1 Energy flow

The Rome pilot use cases manage energy efficiency in the buildings involved; the aim is the optimization of energy production and consumption. Modelling and validation methodology needs a description of buildings within “the Boundary” which defines the boundaries of the system which is object of the demonstration; the current status, AS IT IS right now is that currently a network of energy “exchange” (a network of connections between buildings) does not exist; the electricity distribution network is carried out by ACEA, operating mainly with radial structure or ring and designed for “unidirectional” power flow.

Following is the description of current situation as it is right now: energy flows:

- the energy sources (energy production nodes) involved in the use case are identified as the electricity produced by the photovoltaic panels located in the following buildings (they are 4 of the 7 buildings, provided of photovoltaic panels (ACEA utility network), that are included in the boundary and can be considered energy production node and consumption node the following buildings:
    - Building A part of the complex building “Primary School Cesare Battisti
    - Primary School: “LivioTempesta”
    - Nursery School: “I Monelli”
    - Building B of The Institutional Seat of the Town Hall Roma XI
- on the other hand, the remaining buildings or parts of them within the boundary, are not provided of photovoltaic panels; actually their energy demand is supplied by ACEA’s electric network; for that reason they cannot be considered energy sources but only energy use nodes as buildings to which transfer energy in excess:
    - Building A – of the complex building: Institutional Seat of the Town Hall Roma XI
        - Technical and Operating Unit: The electrical system is powered

directly at low voltage from a power supply by ACEA.

- Heating system: it is provided of an air conditioning system to a volume of variable refrigerant heat pump. Energy use node.

o Building B of the complex building: Cesare Battisti, it is considered an e-Node. The electrical system is powered directly at low voltage from a power supply ACEA.

o Kindergarten L'Aquilone Colorato. The electrical system is powered directly at low voltage from a power supply by ACEA. On the roof of the building there are installed solar panels for the production of hot sanitary water (thermal energy data are not available for, no tools to measure thermal energy production are available). Energy use node.

o Kindergarten Ciliegio Rosa The electrical system is powered directly at low voltage from a power supply ACEA. On the roof of the building are installed solar panels for the production of hot sanitary water thermal energy data are not available for, no tools to measure thermal energy production are available). Energy use node.

- Electrical bicycles should be considered as a system part or energy use or storage nodes

The expected scenario to be addressed at neighbourhood level is the simulation of the transfer of electricity surplus (in the summer where most of the school is closed) from the energy production nodes to supply the energy demand of the other remaining buildings described above - located in the Boundary- without giving back the energy in excess to ACEA, simulating a bidirectional power flows grid, where each energy production node can potentially become a producer of electricity energy, which buys and sells energy.

This step is entirely theoretical since the extension of the pilot project to more buildings presupposes a modernization of the electricity distribution network carried out by ACEA with a unification of the voltage to 400 V and the capacity in the future, by the same, to manage power in bidirectional flows.

The buildings within the Boundary and energy flows are summarised in the following table.

Buildings	Electricity Production (Photovoltaic System)			Electricity Consumption	
	Power Photovoltaic [kWp]	Yearly production[kWh]	Usage	Power Photovoltaic [kWp]	Yearly consumption[kWh]
Primary School "Cesare Battisti" Building A	4,84	6.100	Production Energy node and Use node	60	120.000
Primary School: "Livio Tempesta"	11,88	15.000	Production Energy node and Use node	25	61.000
Nursery School: "I Monelli"	4,025	4.700	Production Energy node and Use node	15	15.000
The Institutional Seat of the Town Hall Roma XI – Building B	5,28	7.450	Production Energy node and Use node	60	42.000
The Institutional Seat of the Town Hall Roma XI – Building A	/	/	Use energy node	90	93.000
Technical and Operating Unit (UOT)	/	/	Use energy node	50	86.000
"Cesar eBattisti" Building B	/	/	Use energy node	45	31.000
Kindergarten L'Aquilone Colorato	/	/	Use energy node	25	Not available
Kindergarten Ciliegio Rosa	/	/	Use energy node		40.000

Table 5. Energy flow boundaries: buildings, energy sources energy demand

The target of the project is to optimize energy production of the e-production nodes and energy consumption of overall buildings within the boundary by avoiding unnecessary expenditures and waste of energy (i.e. through campaigns that affect the behaviour of the users and young adults making them understand that, especially in times of economic crisis, the contribution of each involves a marginal utility at boundary level, at city level and higher and more extended levels, therefore the concept of scalability is also included in the energy savings through education of pupils and adults, for example, making them understand the utility of turning off the refrigerator during the summer, switching off the lights,...

Through simulation scenarios, Odysseus would recommend to the decision maker of the building to which transfer the energy in excess or, if there is not energy surplus, to increase the photovoltaic production adding new photovoltaic panels.

4.2 Boundaries of the energy flow

The aim of Roma pilot is to simulate the transferring of energy, in order to satisfy the demand of the System (Boundary) that includes the following buildings that are the object of the pilot.

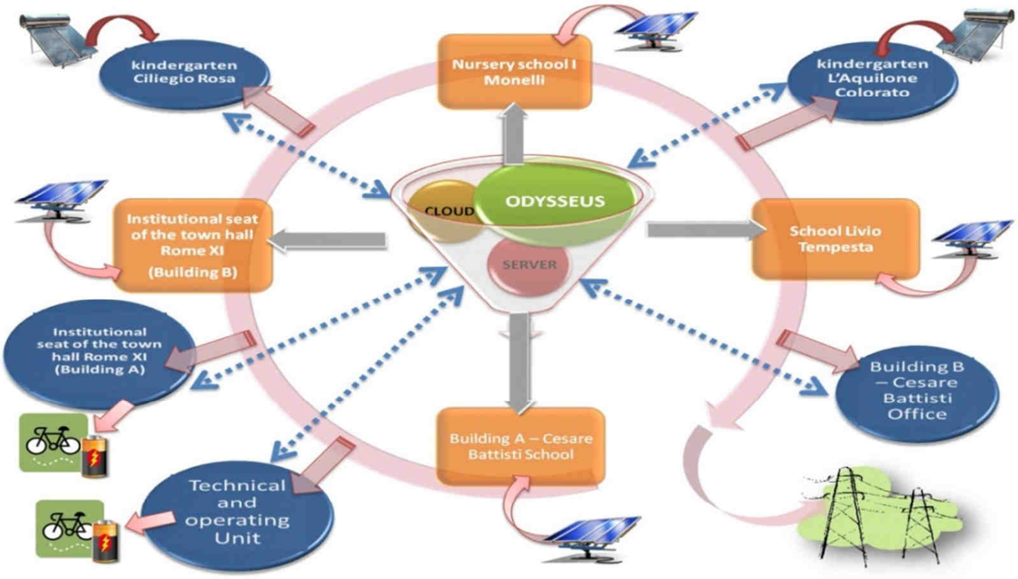


Figure7. Energy flows

	Buildings	Data and characteristics	production/ transferring of energy
1	CesareBattisti		
A	Building A – School	Photovoltaic system	Energy production node
B	Building B – Office	Use node	Energy use node
2	Technical and Operating Unit (TOU)	Bicycles pedal assisted with lithium batteries	Energy use node
3	The institutional seat of the Town Hall		Energy production node
A	Building A	Bicycles pedal assisted with lithium batteries	Energy use node
B	Building B	Photovoltaic system	Energy production node
4	Nursery school: “I Monelli”	Photovoltaic system	Energy production node
5	Primary school: “LivioTempesta”	Photovoltaic system	Energy production node
6	Kindergarten L’AquiloneColorato	Solar panels for the production of hot sanitary water	Use node
7	Kindergarten Ciliegio Rosa	Solar panels for the production of hot sanitary water	Use node

Table 6. Measurement Boundary- buildings involved in the Pilot

The Baseline Period (BP) will be defined in detail in further chapters.

Savings of energy must be expressed for each building or building section. Additional tables, like as follows, will be detailed for each building section and building within the Boundary system in order to obtain a correct evaluation of energy savings referred to consumption/production, monitored and measured “during” the reporting period, “before” and “after” the implementation of ECMs. The purpose of the testing is to measure and compare the production and consumption of energy before and after the implementation of the ECM in order to verify if the measures taken are the right ones which optimize energy production and consumption (Assessment) or if the measures taken are tending to get closer to a value "desired" of energy production, consumption and CO_2 reduction.

The assessment of the goodness, efficacy, efficiency and cheapness of the measures taken is measured by every KPI that is defined precisely to determine by field measurement if we are saving or not energy.

1	Building 1 CesareBattisti	Characteristics	Power Photovoltaic [kWh]	Period 1: Monitored E-Production Data [kWh] (average of peak, flat, valley)	Period 1: Monitored Consumption [kWh] (average of peak, flat, valley)	ECM	Period 2. Monitored production after ECM. [kWh]	Period 2: Monitored Consumption after ECM	Diff of Monitored E-Consumption (C P.1-C P2)	Diff of Monitored E-Production (C P.1-C P2)
		Photovoltaic system		Average OF PEAK FLAT VALLEY			Average OF PEAK FLAT VALLEY			
				Measured			Measured/estimated			
D										
J										
F										
M										
A										
M										
J										
J										
A										
S										
O										
N										
D										

Table 7. Table of comparison between energy flows before and after the implementation of ECMs

Savings of energy must be expressed for each building or building section. Additional tables like the previous one will be made for each building or building section for a correct evaluation of savings referred to consumption/production of the system measured in reporting period and measured/estimated after ECMs. Reporting minus baseline period is considered adjustments.

4.3 Relevant KPIs

The pilot case Municipality of Rome XI is based on the use of energy produced by the photovoltaic plant of Cesare Battisti school (placed on the roof of Building A). Currently the energy produced by the photovoltaic plant of building A (Cesare Battisti school) is used for the electric consumption of the loads of the school as the energy produced in excess is given back to the ACEA network. The target is using all the photovoltaic energy produced for own use without giving back to the grid the P.V. energy produced in excess and therefore to simulate the transfer of electricity in surplus (especially during the summer when the schools are closed for holidays) from the building A of the Cesare Battisti school to the building B, where there are offices , and also for charging the lithium batteries of electric bicycles and to supply the demand of energy of the other buildings used as a reference.

In D1.1 document, the main characteristics of the seven buildings used as reference for the pilot Roma case, have been described. In detail, for each building, have been listed the main plants (facilities), and have been represented historical data of electricity consumption and production of photovoltaic systems, through charts and diagrams.

In D1.2, for the pilot case of Rome, it has properly been described the following scenarios and use cases:

Building level: Monitoring the energy consumption by identifying of waste of energy-minimization

- UC-R1 Continuous monitoring of energy consumption at floor level;

- UC-R2 Analysis of monitored data
- UC-R3 Making decision advise support and taking action
- UC-R4 Increase the photovoltaic energy production
- UC-R5 Simulation tools

Neighbourhood level: Transferring all remaining energy from building A to charge batteries of electric bicycles at neighbourhood level

- UC-R1 Inform on energy production for making decision;
- UC-R2 Inform of energy surplus availability for making decision
- UC-R3 Consider weather and energy costs for making decision

The intent of the next table is to identify, for each scenario, the reference use case. At use case pilot level, KPIs are built in order to provide a precise and quantitative measure of what we are saving in terms of energy (and costs). For the way in which it was built, each KPI provides us with key information: goodness of actions taken based on project tools; and in case of negative feedback information, possible corrections of the taken measures.

KPIs for the uses cases of the neighborhood level scenario in Rome pilot case			
Use Case	KPI	Acronym	Description
UC-R1	KPIP1	$KPIP1 = \frac{\text{ELECTRICITY ENERGY IN SURPLUS [kWh]}}{\text{ELECTRICITY ENERGY PRODUCED [kWh]}}$	Indicates the electric energy produced by the photovoltaic systems which is not used.
	KPIP2	$KPIP2 = \frac{\text{ELECTRICITY ENERGY PRODUCED [kWh]}}{\text{BUILDING SURFACE [m2]}}$	Indicates therefore the specific electric energy [kW/mq] produced
UC-R2	KPIP1	$KPIP1 = \frac{\text{ELECTRICITY ENERGY IN SURPLUS [kWh]}}{\text{ELECTRICITY ENERGY PRODUCED [kWh]}}$	Indicates the electric energy produced by the photovoltaic systems which is not used.
UC-R3	KPIP3	$KPIP1 = \frac{\text{ELECTRICITY ENERGY PRODUCED [kWh]}}{\text{N° OF SUNNY DAYS}}$	This KPI relates the energy production with the number of sunny days.

Table 8. KPIs for the SC-NL-1 Scenario-NL-1

Next table provides KPIs definition for the SC-BL-1 Scenario-BL-1.

KPIs for the uses cases of the building level scenario in Rome pilot case			
Use Case	**KPI**	**Acronym**	**Description**
UC-R1	KPIEH	KPIEH = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{OPENING HOURS OF BUILDING [h]}}$	Indicates therefore the absorbed electric power during [kW] the opening hours of the buildings.
	KPIES	KPIES = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{BUILDING SURFACE [mq]}}$	Indicates therefore the specific electric energy absorbed [kWh/m^2].
	KPIEP	KPIEP = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{User}}$	Indicates therefore the electricity consumed on average by every person in the building.
UC-R2 and UC-R3	KPIE	KPIE% = $\frac{\text{EC1}-\text{EC2 [kWh]}}{\text{EC1 [kWh]}}\ x\ 100$ Legend: EC1 is for the monthly energy absorbed by the electrical loads during the baseline period. EC2 is for the monthly energy absorbed by electrical loads after the ECMs.	This KPI indicates the reduction of electrical consumption obtained after the actions (ECMs).
UC-R4	KPIP	KPIP% = $\frac{\text{EP2}-\text{EP1 [kWh]}}{\text{EP1 [kWh]}}\ x\ 100$ Legend: EP1 is the monthly energy produced by the photovoltaic plant during the Baseline period. EP2 monthly energy produced by the photovoltaic plant after the ECMs.	It indicates the increase of photovoltaic energy production after ECMs measures.
UC-R5	KPIS	KPIS = $\frac{\text{ELECTRIC ENERGY PRODUCED BY P.V.PLANT [kWh]}}{\text{DEMAND}}$ OF ELECTRIC ENERGY OF THE LOADS OF THE BUILDINGS [kWh]	t in relation the overall energy produced by the photovoltaic systems with the total energy needs of the buildings.
	KPIH	KPIH%= $\frac{\text{HOURS OF ELECTRIC ENERGY SELF SUFFICIENCY [h]}}{\text{8760 [h]}}$ x 100	Indicates therefore the percentage of hours in a year in which electricity self-sufficiency is reached.

Table 9. KPIs for the SC-BL-1 Scenario-BL-1

4.4 Monitoring devices and equipment

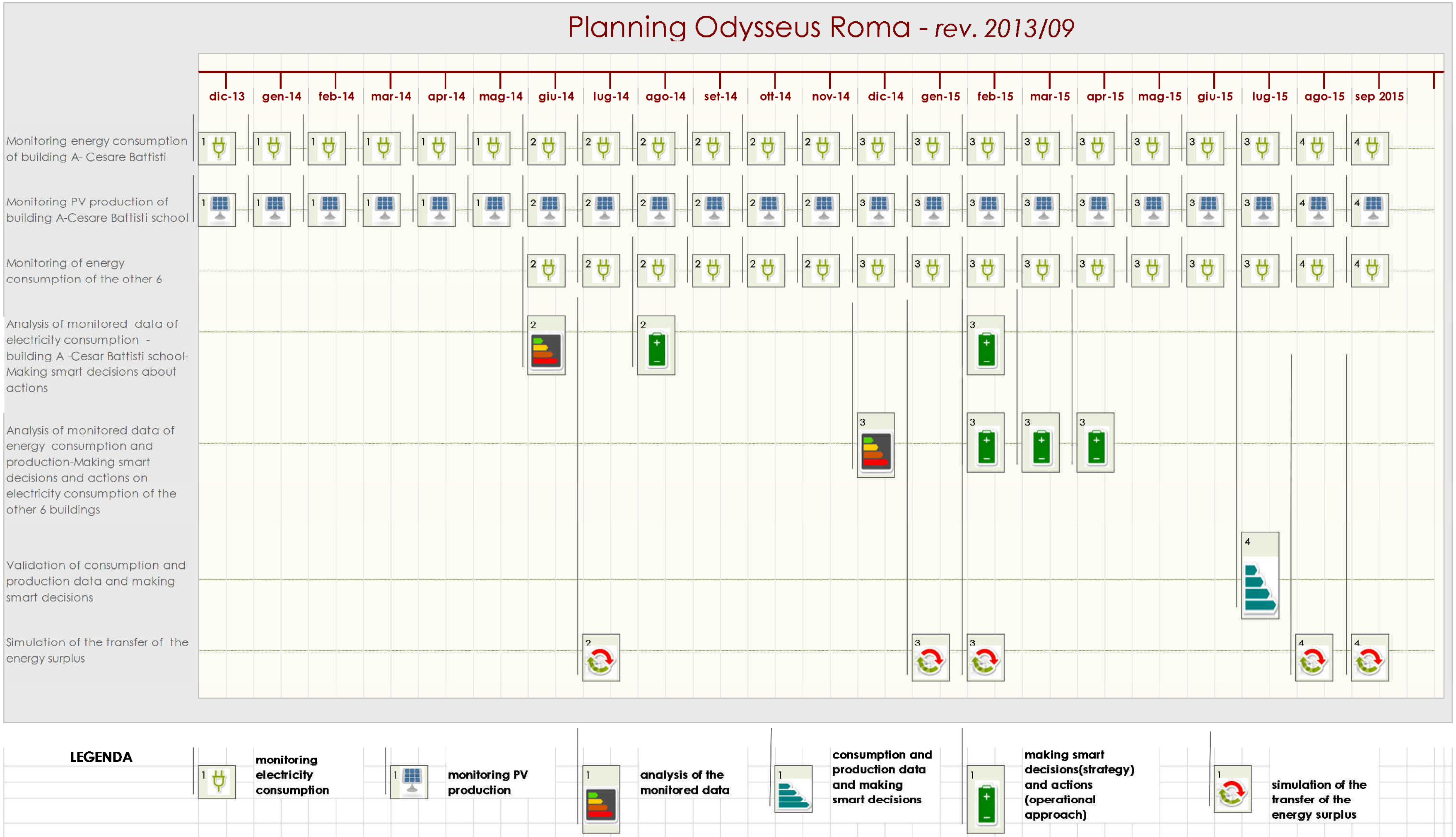
The measuring tools that will be used to monitor electric consumption of the referring buildings are as follows:

Buildings	Counters	Description
CesareBattisti		
Building A – School	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
	MSD	Continuous monitoring (h. 24) of electric energy consumption of the left and right side of the building
	MSL	Continuous monitoring (h. 24) of electric energy consumption of the left and right side of the building
	MDD	Continuous monitoring (h. 24) of electricity consumption (kWh), driving force on the right side
	MDL	Continuous monitoring (h. 24) of electricity consumption (kWh), lighting of the right side
	MA1	Continuous monitoring (h. 24) of electricity consumption (kWh), driving force and lighting of the association (ENFAL)(left side of the building)
	MK	Continuous monitoring (h. 24) of electricity consumption(kWh), driving force- lighting of the kitchen
	MO	Continuous monitoring (h. 24) of electric energy consumption of the ground floor on the left side of the building
Building B – Office	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
Technical and Operating Unit	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
The institutional seat of the town hall		
Building A	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
Building B	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
Nursery school: "I Monelli"	MG	Continuous monitoring (h. 24) ofdi electricity consumption(absorbed)(kWh) from the totality of

		the building's electrical loads
Primary school: "LivioTempesta"	MG	Continuous monitoring (h. 24) of electricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
Kindergarten L'AquiloneColorato	MG	Continuous monitoring (h. 24) ofelectricity consumption(absorbed)(kWh) from the totality of the building's electrical loads
Kindergarten Ciliegio Rosa	MG	Continuous monitoring (h. 24) ofelectricity consumption(absorbed)(kWh) from the totality of the building's electrical loads

Table 10.Description of measuring tools for monitoring energy consumption

The following timing chart describes the various stages in the development of the pilot of Rome:



Planning Odysseus Roma - rev. 2013/09
dic-13
gen-14
feb-14
mar-14
apr-14
mag-14
giu-14
lug-14
ago-14
set-14
ott-14
nov-14
dic-14
gen-15
feb-15
mar-15
apr-15
mag-15
giu-15
lug-15
ago-15
sep 2015
Monitoring energy consumption of building A- Cesare Battisti
Monitoring PV production of building A-Cesare Battisti school
Monitoring of energy consumption of the other 6
Analysis of monitored data of electricity consumption - building A -Cesar Battisti school-Making smart decisions about actions
Analysis of monitored data of energy consumption and production-Making smart decisions and actions on electricity consumption of the other 6 buildings
Validation of consumption and production data and making smart decisions
Simulation of the transfer of the energy surplus
LEGENDA
monitoring electricity consumption
monitoring PV production
analysis of the monitored data
consumption and production data and making smart decisions
making smart decisions(strategy) and actions (operational approach)
simulation of the transfer of the energy surplus

4.5 Building level UC-R1: Continuous monitoring of energy consumption at floor level

4.5.1 *Functional description*

This use case is designed to understand energy consumption pattern of building A Cesare Battisti school. The objective is to measure the consumption per floor or part of the building or per type of electrical load. The monitoring of energy consumption will be performed by meters properly installed in the building. The measurements will be accessible and processed by the Odysseus cloud platform solution.

The measure of the electricity absorbed throughout the day by the users of the school (lightning, driving force, refrigerators, ovens, elevators) is essential for the assessment of the wastage and leakage of energy. Then overall electricity consumption of the building B (Cesare Battisti school) will be measured as well as for the other 6 buildings used as reference in the pilot of Rome. In this Use Case, decisions relating to measures to be implemented to reduce the wastage of electricity will be taken by the Municipality of Rome XI.

4.5.2 *Energy systems*

The project will develop a schedule for and calibration of the various interventions to be carried out on electrical loads with the aim, in the near future, to make the whole complex of 'Cesare Battisti' buildings independent from an electric point of view. As an initial stage it is necessary to monitor and test, through appropriate electronic measuring instruments, a multifunction of different energy carriers of the buildings, providing consumption information in real time in a logical topology and detailed information through advanced Business Intelligence. Consequently, this will help to identify and determine any waste and inefficiency and possible responses to enable automatic control for their reduction and suggest possible guidelines to improve social behaviour of the users.

The electrical system is powered directly at low voltage from a power supply ACEA via a system of phase distribution of TT type (neutral connected to earth and grounded masses), rated (phase-to-phase) Vn=230V, nominal frequency fn = 50 Hz.

The main electrical loads in Cesare Battisti school are internal and external lighting, electrical sockets, (classrooms, hallways, teachers' lounge, fitness center, secretarial and school management room, etc..), elevators, refrigerators, freezers, ovens electric, electric water heaters, garden irrigation pumps and burners of the thermal plant.

4.5.3 *KPIs*

A necessary first step is required in order to achieve greater energy efficiency. This step consists to become aware of the way we consume our system. We must gather the consumption data by energy vector by the meters installed on the facility. The analysis of consumption, both on single energy vector and on multiple vectors, can be performed by querying the database in which the measurements are uploaded. The trend of consumption on the different levels of the plant will help to clarify the dynamics of consumption of the system and allow to get real time information on whichit is possible to perform analysis and make decisions. So it is necessary to have KPIs to check the consumption patterns over time. The following KPIs can be used to compare the values of consumption of the building with the historical ones and with other entities.

KPI	Acronym	Description
KPIEH	KPIEH = $\frac{\mathbf{POWERCONSUMPTION}\ [\mathbf{kWh}]}{\mathbf{OPENINGHOURSOFBUILDING}[\mathbf{h}]}$	indicates therefore the absorbed electric power during [kW] the opening hours of the buildings
KPIES	KPIES = $\frac{\mathbf{POWERCONSUMPTION}\ [\mathbf{kWh}]}{\mathbf{BUILDINGSURFACE}\ [\mathbf{mq}]}$	indicates therefore the specific electric energy absorbed [kWh/mq]
KPIEP	KPIEP = $\frac{\mathbf{POWERCONSUMPTION}\ [\mathbf{kWh}]}{\mathbf{User}}$	indicates therefore the electricity consumed on average by every person in the building

KPI	Stakeholder	Description of Decision Making Based On
KPIEH	MUNICIPIO ROMA XI	High-efficiency lighting, Electrical re-phasing, Balancing of electrical loads, Installation of presence sensors, timers and twilight and improvement in the behaviour of users

KPIES	MUNICIPIO ROMA XI	High-efficiency lighting, Electrical re-phasing, Balancing of electrical loads, Installation of presence sensors, timers and twilight and improvement in the behaviour of users
KPIEP	MUNICIPIO ROMA XI	improvement in the behaviour of users

To set the project target and to verify the results of energy efficiency project, we have to start by considering how the information system will support key goals above mentioned.

So the above mentioned KPIs are defined to track the performance and to measure the success of the energy management and each indicator is made to be measurable, possible, attainable and available.

4.5.4 *Monitoring plan*

Monitoring involves the installation and collection of energy measures on the general electric panel at building A of Cesare Battisti school, of eight measuring instruments according to the wiring diagrams shown in figure 8 and 9.

In December 2013 monitoring will begin in Cesare Battisti school, while regarding the remaining buildings, monitoring will start in December 2014 as scheduled. Each instrument will be equipped with an integrated Ethernet card for data connection via LAN and a set of three amperometric probes ”Rogowski”.

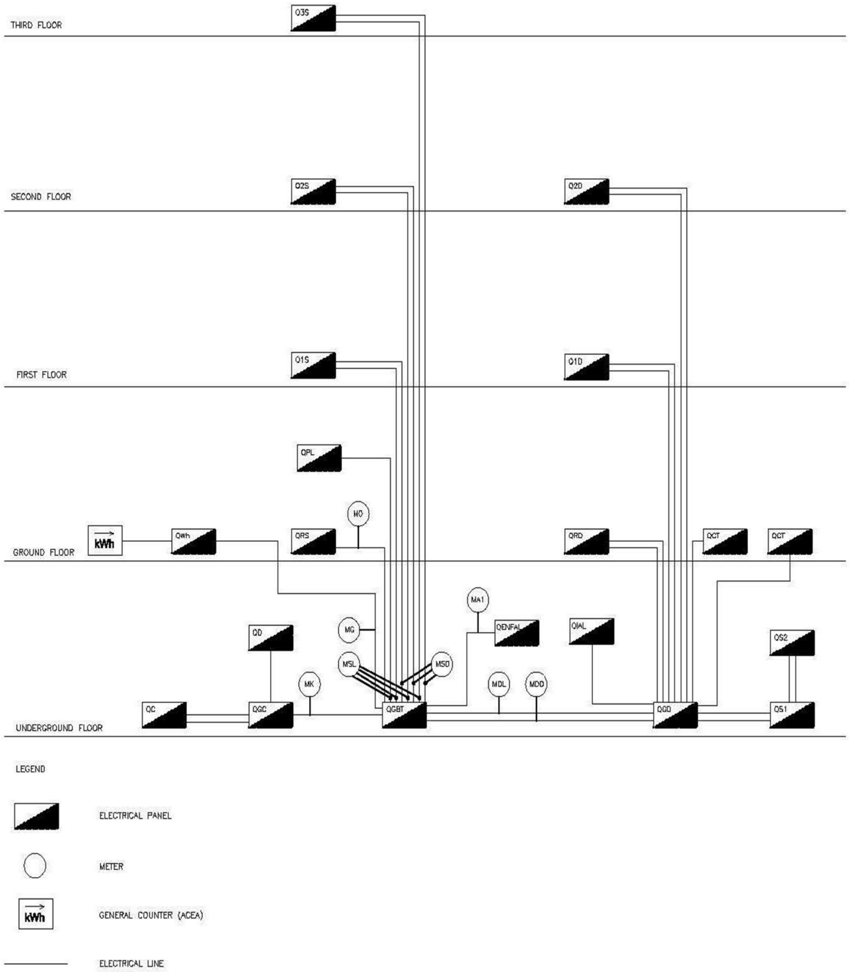


Figure 8. Meter installation diagram

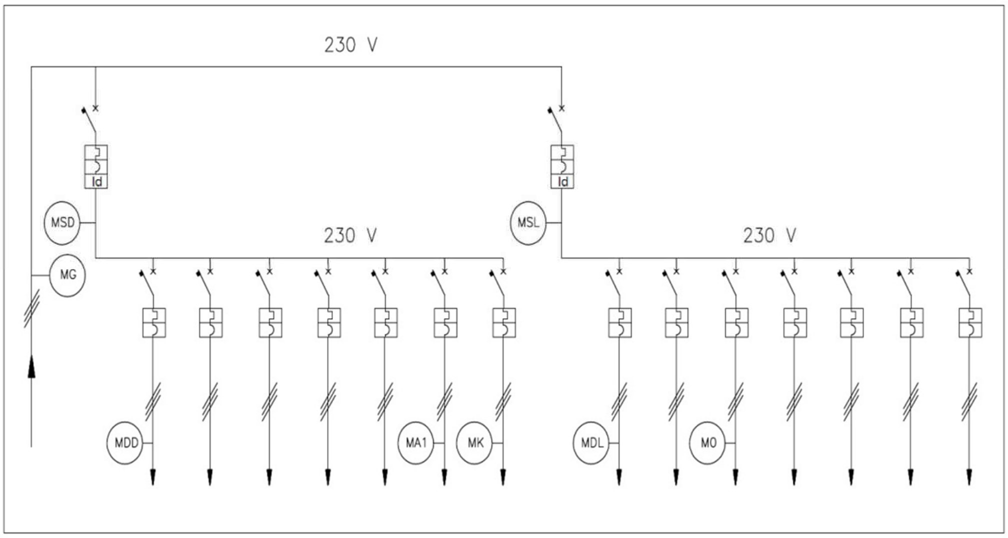


Figure 9. Single line wiring diagrams- General electric panel

The technical specification: the measuring instruments that will be installed (METER- DIN) are multifunctional tools that analyse and measure many electrical quantities, with the following general characteristics:

- Measures in RMS value
- Measures on 4 quadrants
- Graphic display with character size
- Full and clear information of any measurement
- 6 keyboard keys with auditable indication
- Pulse output active energy
- Pulse output reactive energy
- Minimum Alarm output setting the required size
- Maximum Alarm output setting the required size
- Graphic display of active and reactive power factor of the last three days
- 2 totalizer of energy drawn one of which is resettable

These instruments are connected to the network through a door at 100 Megabit twisted pair (10 base T); protocol used: TCP/IP in Internet Web.

The electric quantities that will be measured and analyzed are as follows:

hours	MG	MSD	MSL	MDD	MDL	MA1	MK	M0
	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
12:00:00 AM								
01:00:00 AM								
02:00:00 AM								
03:00:00 AM								
04:00:00 AM								
05:00:00 AM								
06:00:00 AM								
07:00:00 AM								
08:00:00 AM								
09:00:00 AM								
10:00:00 AM								
11:00:00 AM								
12:00:00 PM								
01:00:00 PM								
02:00:00 PM								
03:00:00 PM								
04:00:00 PM								
05:00:00 PM								
06:00:00 PM								
07:00:00 PM								
08:00:00 PM								
09:00:00 PM								
10:00:00 PM								
11:00:00 PM								

Table 11. Measurement scheduling

- MG (Overall electric energy Meter): electricity consumption (absorbed)(kWh) from the totality of the building's electrical loads (lighting, sockets, split system air conditioners, electric pumps, electric ovens, refrigerators, etc.).

- MSD (meter n. 1: measures electric energy consumption of the left and right side of the building) electricity consumption(kWh) from the following electrical loads:

  - Driving force behind the right side of the building
  - Driving force and gym lighting (ground floor)
  - Driving force - first floor -left side of the building
  - Driving force second floor left side of the building
  - Driving force third floor left side of the building
  - Driving force and Association 1' lighting (ENFAL) left side of the building
  - Driving force and kitchen lighting

- MSL (Meter n. 2: measures the electric consumption of the left and right side of the building): electricity consumption (kWh) from the following electrical loads:

  - Lighting- right side of the building
  - Lighting of the refectory and a refrigerator
  - Driving force and first floor' lighting-left side of the building
  - Lighting on the first floor - left side of the building
  - Lighting on the second floor- left side of the building
  - Lighting on the third floor - left side of the building

- MDD(meter n. 1 measures electricity consumption of the right side of the building): electricity consumption (kWh), driving force on the right side

- MDL(meter n. 2 measures electric energy consumption of the right side of the building): electricity consumption (kWh), lighting of the right side

- MA1 (meter measures the electric energy consumption of the association) electricity consumption (kWh), driving force and lighting of the association (ENFAL)(left side of the building)

- MK (meter that measures the electric energy consumption of the kitchen): electricity consumption(kWh), driving force- lighting of the kitchen

- MO (meter that measures the electric energy consumption of the ground floor on the left side of the building): electricity consumption(kWh), driving force- lighting of the first floor- left side of the building

Then it will be measured overall electricity consumptions of the building B (Cesare Battisti school) and of the other 6 buildings used as reference in the pilot of Rome through the installation of only one meter (MG) for each building.

4.5.5 *Baseline: Period, Energy and Conditions*

Over each six months period, Rome will collect, monitor and distribute kWh data to Odysseus cloud platform. These data will assist Odysseus with providing decision makers with effective real time information for making smart energy decisions.

Any further specification must be provided in order to identify the baseline period:

- after checking the reliability of the historical data on the average consumption of reference buildings that are actually provided by the ACEA (utility), comparing with the data that we are expected to acquire (after the installation of meters) for the next six months (December 2013 May 2014), we will verify the reliability of historical data;
- Once assessed the reliability of the historical data, the baseline will be expressed , for the months from June to November 2014, as an average of:
- consumption data over the past four years + consumption actually measured with meters installed during months from December 2013 to May 2014(see Fig.7)

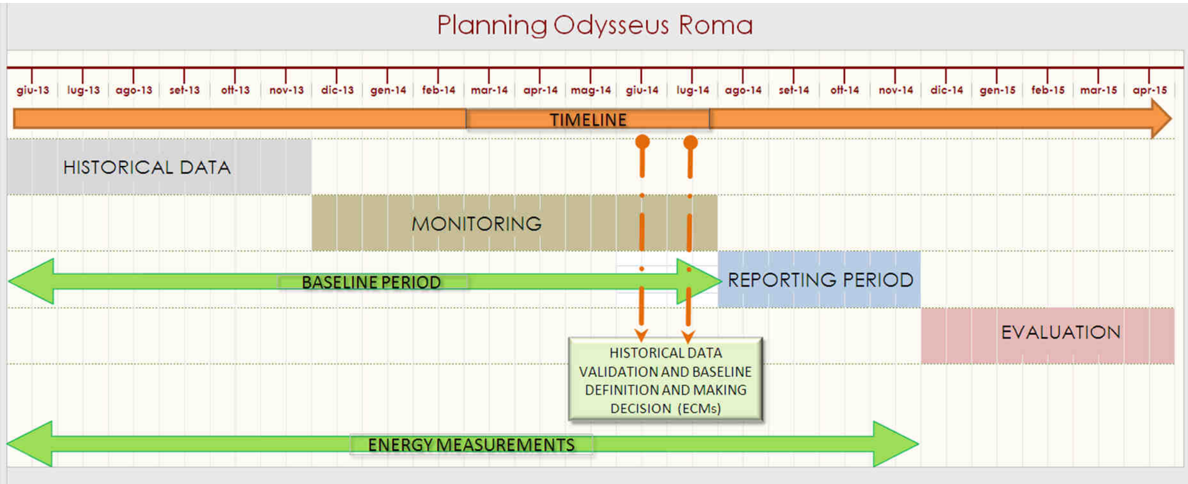


Figure 9. Planning

Then, established the reliable baseline period, (historical data and the gathered data of the established baseline period December 1th 2013 May31th 2014),the project will start by monitoring and measuring energy consumption for the following six months – reporting period (June 2014-November 2014), if the **KPIEH,KPIES, KPIEP**, will be reduced by 10% to set the (June 1th 2014-November 30th 2014)target and 15% to set the (December1th 2014-July 31th 2015) target.

Future vs Actual	**Expected Targets**	
	June 1th 2014- November 30th 2014	**December 1th 2014-July 31th 2015**
$\frac{\textbf{KPIEH [future]}}{\textbf{KPIEH [actual]}}$	0.90	0.85
$\frac{\textbf{KPIES [future]}}{\textbf{KPIES [actual]}}$	0.90	0.85
$\frac{\textbf{KPIEP [future]}}{\textbf{KPIEP [actual]}}$	0.90	0.85

4.5.6 *Baseline analysis and ECM definition*

Odysseus'hEMS is the main tool for processing and analyzing the data collected by the counters. This information is then distributed to the decision makers (Municipio Roma XI) in order to make the most effective and efficient decisions for the use of "smart energy".

The main actions that can be implemented for improving energy efficiency are as follows:

- High-efficiency lighting
- Electrical re-phasing
- Balancing of electrical loads
- Installation of presence sensors, timers and twilight
- Improvement in the behaviour of users

4.5.7 *Reporting period*

The information system must select data to collect in order to support key objectives: reduction of energy consumption through efficient energy management supported by info gathered, processed and analyzed by Odysseus solution and given back to the decision maker whom implements the strategies, through ECMs, can attain the optimization of energy consumption and the reduction of CO_2 emissions.

So the information must be distributed to the main decision making actor (typically the facility manager) to make smart energy decisions. After that, if there is an obtain of surplus of energy production to transfer, he will decide if it is more convenient to transfer the energy in excess to another building through the (bi-directional)e-network or to give it back to ACEA grid.

So the first step to attain the goals of the project is to convert these objectives in KPIs that can be measured and tracked. In a first step, as baseline period of historical energy consumption data should be selected as a reference.

The baseline period of energy consumption (if average energy consumption of years 2009, 2010, 2011, 2012 or the six months period) is measured in kWh.

The baseline measurement for the reference years will be:

- **KPIEH** = $\frac{\textbf{POWER CONSUMPTION [kWh]}}{\textbf{OPENING HOURS OF BUILDING [h]}}$
- **KPIES** = $\frac{\textbf{POWERCONSUMPTION [kWh]}}{\textbf{BUILDINGSURFACE [mq]}}$
- **KPIEP** = $\frac{\textbf{POWER CONSUMPTION [kWh]}}{\textbf{User}}$
- Education campaigns to raise awareness and improve users behaviour and particularly children and teachers about energy waste (we will provide and distribute in the schools, before and after the abovementioned campaigns, many forms about energy education to fill in in order to compare the consumption of the two periods).

- Calculation of the CO_2 indirectly produced

Meters will be installed as explained before to measure total facility of the buildings. The metering data collected will be converted into the three indicators for reporting against the target levels.

The following step should be to create a baseline model of the two indicators and then creating target models to track the performance after ECMs.

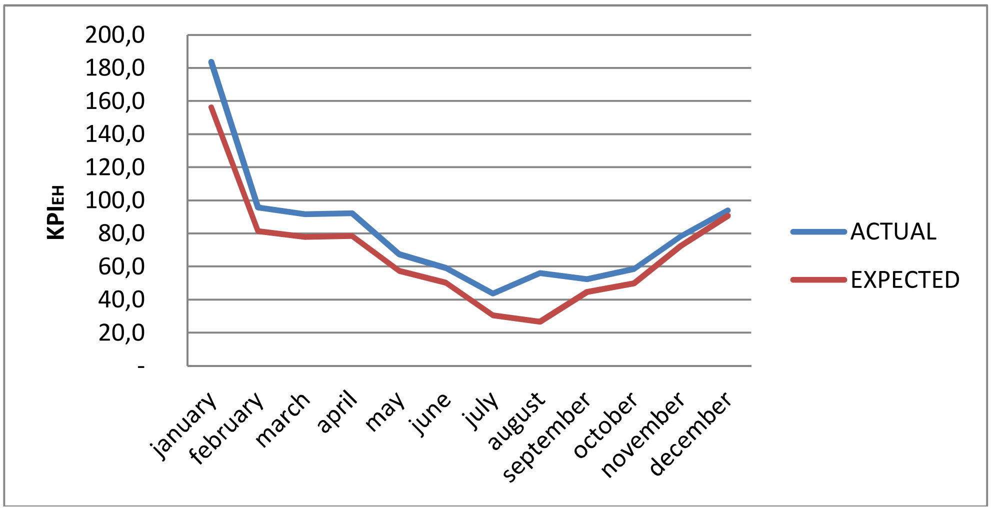


Figure10.KPIEH actual versus expected

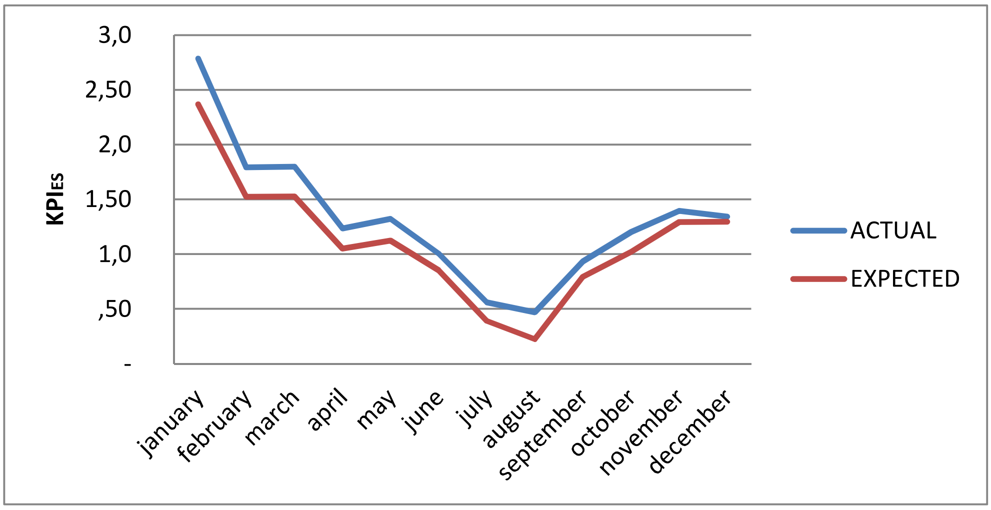


Figure 11. KPIES actual versus expected

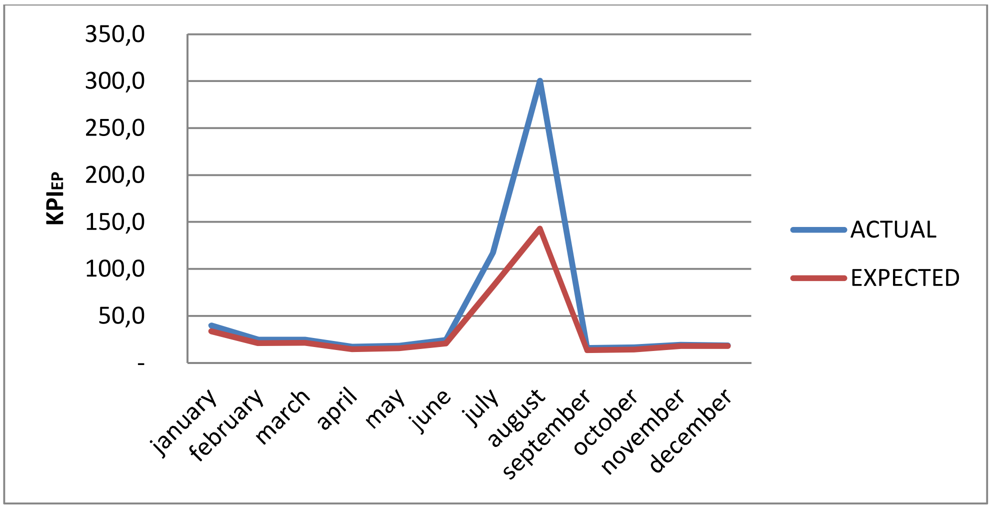


Figure 12. KPIEP actual versus expected

4.5.8 *Basis for adjustments*

In order to determine savings obtained after ECMs have been implemented(reporting period) and of the baseline period (before the measures have been implemented) we must compare savings of energy of the baseline and reporting period and rectifying with adjustments that take in account the differences in conditions between the baseline and reporting periods.

4.5.9 *Analysis procedure (Validation process)*

For the next months we plan to monitor an excess of energy consumption and we plan to have an initial report by the first six months at the latest. The information and the data will be processed by Odysseus platform and tools and analyzed and reported back to the main decision actor to recommend smart energy decisions:

- if there is a positive surplus of energy, the decision has been effective and the main decision maker is going to do the same, more and better; the main decision maker can decide that the energy in excess can be given back to the ACEA grid or can be transferred into the e-network to address to other buildings.
- if there is a negative surplus of energy, the recommendation have not been effective (feedback loop) so start checking for gaps in the performance is required.

It is required to check for validate the consistency with our proposed outcome (the output is consistent to the original proposal) and validate that the project is aligned with the original proposal (KPIs).

We check to validate the work and the recommendations with the original proposal if there are gaps in the performance.

The principle, in order to evaluate the efficiency of the energy management system applied to this use case, is to determine savings (measurable, attainable, possible) after abovementioned ECM have been implemented. The procedure establishes a baseline period before ECMs have been implemented and a reporting period after ECMs have been implemented. Savings are obtained by checking and comparing the reported period and the expected by modeling methods of consumption under conditions of this reporting period but assuming that ECMs have not been implemented.

The adjustments process restates the baseline demand of energy of the reported period under a common set of conditions and compares the actual trend to that desired to achieve the goal (KPIs fixed).

4.6 Building level UC-R2: Analysis of monitored data

4.6.1 *Functional description*

This use case deal with the analysis of data collected in the previous case to understand how the energy is produced and consumed. In this use case decisions relating to measures to be implemented will be taken by the Municipality of Rome XI

4.6.2 *KPIs*

In this Use Case will be used the following KPI:

KPI	Acronym	Description
KPIE%	KPIE% = $\frac{\mathbf{EC1-EC2\ [kWh]}}{\mathbf{EC1\ [kWh]}} \boldsymbol{x100}$ Legend: EC1 is for the monthly energy absorbed by the electrical loads during the baseline period. EC2 is for the monthly energy absorbed by electrical loads after the ECMs.	This KPI indicates the reduction of electrical consumption obtained after the actions (ECMs).

4.7 Building level: UC-R3: Making decision advise support and taking action

4.7.1 *Functional description*

This use case deal with the energy measured in the previous case and then taking decision on its employment and avoiding energy wastes or employ energy produced in the most efficient way possible. Consequential actions on how to avoid energy wastes will be taken by the Odysseus system based on the data collected.

In this use case decisions relating to measures to be implemented will be taken by the Municipality of Rome XI.

4.7.2 *KPIs*

In this use case will be used the following KPI:

KPI	Acronym	Description
KPIE%	**KPIE%** = $\frac{\mathbf{EC1-EC2\ [kWh]}}{\mathbf{EC1\ [kWh]}} \boldsymbol{x100}$ Legend: EC1 is for the monthly energy absorbed by the	This KPI indicates the reduction of electrical consumption obtained after the actions (ECMs).

	electrical loads during the baseline period. EC2 is for the monthly energy absorbed by electrical loads after the ECMs**.**	

4.8 Building level: UC-R4: Increase the photovoltaic energy production

4.8.1 *Functional description*

The availability of data and the information no provided by Odysseus support the manager to make decision on the opportunity of expanding energy production in order to archive power self-sufficiency of buildings. In this use case Odysseus recommendations the decision maker.

4.8.2 *KPIs*

In this use case will be used the following KPI:

KPI	Acronym	Description
KPIP%	**KPIP% =** $\frac{\mathbf{EP2-EP1\ [kWh]}}{\mathbf{EP1\ [kWh]}}\boldsymbol{x100}$ Legend: EP1 is the monthly energy produced by the photovoltaic plant during the Baseline period. EP2 monthly energy produced by the photovoltaic plant after the ECMs.	It indicates the increase of photovoltaic energy production after ECMs measures.

4.9 Building level UC-R5: Simulation tools

4.9.1 *Functional description*

The results of the analysis done by Odysseus simulation service will provide a solution that simulates the optimization of the electricity production. This will help the manager to make decision about opportunities to transfer and use the energy surplus produced, to supply respectively building B or electrical bicycles or to give it back to the ACEA grid (utility).

Odysseus provides a solution that simulates the transferring of energy surplus in order to make strategic decisions on expanding electricity production and to connect the seven schools to an independent grid that connects the seven schools of the district in order to achieve energy self-sufficiency rather than giving the energy surplus back to the network of ACEA.

This use case is about the simulation of the transfer of the surplus of energy from building A, -in the first step- to supply the energy demand of building B and to charge lithium batteries of electrical bicycles(building A), -in the second step- this simulation will be extended to the set of reference buildings in the district.

4.9.2 *Energy systems*

This use case consists in the simulation of the transfer of electric energy from one building to another through an e-network very similar to an 'internet of energy' where every electrical device and each system of micro-generation must be connected to the network and be able to communicate data and receive and react in real time to information that arrive from other energy network elements or from the power supply itself.

The Odysseus project will simulate the potential energy saving for sub systems integration in close cooperation with the final users (typically the facility managers).

The intent of the use case is therefore to develop an integrated management system that allows, through the monitoring of energy consumption, the optimization of energy use by transferring the energy surplus from one building to the other and vice versa through a smart e- network.

The baseline period establishes a reporting period before the ECM are implemented. Comparing the energy consumption of the two periods: a one year –reporting period- before implementing ECM (historical consumption data) and the energy consumption and CO_2 emissions of the year after the ECM implementing, shall give information about energy savings and costs, behaviour conditions, etc.

Optimization will target the interactions between the various subsystems of the e-network, in view to reducing the energy consumption and waste and CO_2 emissions at the level of neighborhood extending the results to the district level.

4.9.3 *KPIs*

The goal is to simulate the transfer of surplus of electric energy generated by the photovoltaic systems and to make reference buildings of the pilot project of Roma self-sufficient from an electrical point of view, at least for the few hours (between 11.00 AM and 3.00 PM) of the days when all the reference buildings are closed (Saturdays, Sundays and public holidays). The KPIs that can be used for the assessment, in this use cases are the following ones:

$$\mathbf{KPIS} = \frac{\mathbf{ELECTRICENERGY\ PRODUCED\ BY\ P.V.PLANT\ [kWh]}}{\mathbf{DEMAND\ OF\ ELECTRIC\ ENERGY\ OF\ THE\ LOADS\ OF\ THE\ BUILDINGS\ [kWh]}}$$

The overmentioned KPIS put in relation the overall energy produced by the photovoltaic systems with the total energy needs of the buildings.

$$\mathbf{KPIH\%} = \frac{\mathbf{HOURSOFELECTRICENERGYSELFSUFFICIENCY\ [h]}}{\mathbf{8760\ [h]}} \mathbf{x\ 100}$$

The over mentioned KPIH indicates therefore the percentage of hours in a year in which electricity self-sufficiency is reached.

4.9.4 *Monitoring plan*

Through the consumption and production monitored data that Odysseus cloud platform receives as described in the two previous use cases (Continous monitoring of energy consumption at floor level and Inform on energy production for making decision), it is possible to proceed to the simulation of the transfer of the energy surplus from buildings equipped with photovoltaic system to the other buildings taken to reference. In figure 11 and 12 are shown the diagrams which will be simulated by Odysseus.

In figure 12 is shown the use of any surplus of electrical energy produced by the photovoltaic plant of building A (Cesare Battisti school) to power the batteries of the bicycles, for the supply of electrical loads of building B and to supply the electrical loads of the technical Offices (UOT) of the City Hall.

In picture 13 is shown the use of any surplus of electrical energy produced by the four photovoltaic systems that supplies the electrical loads of the reference buildings overall.

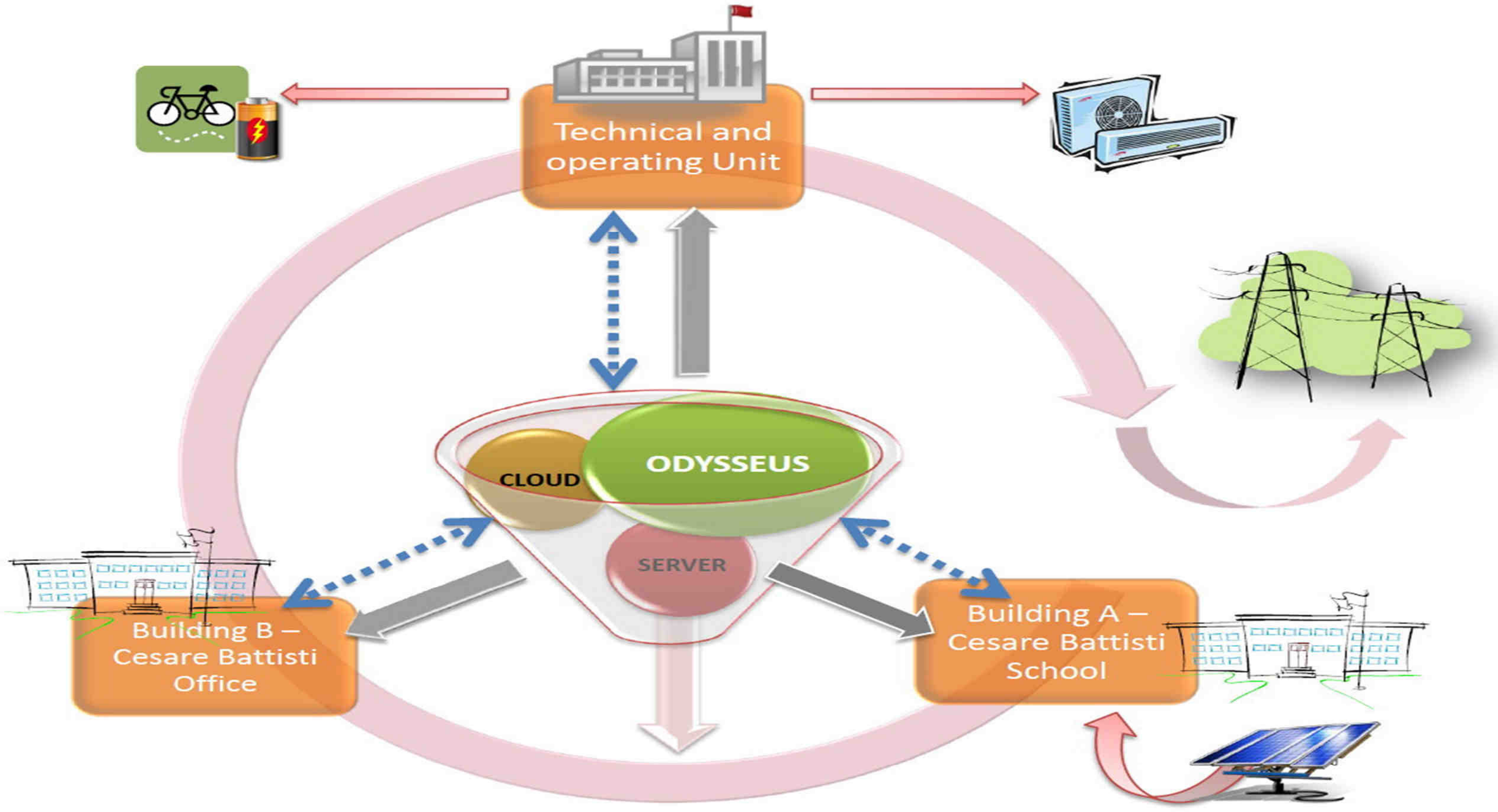


Figure 12. Surplus of electrical energy produced in Building A

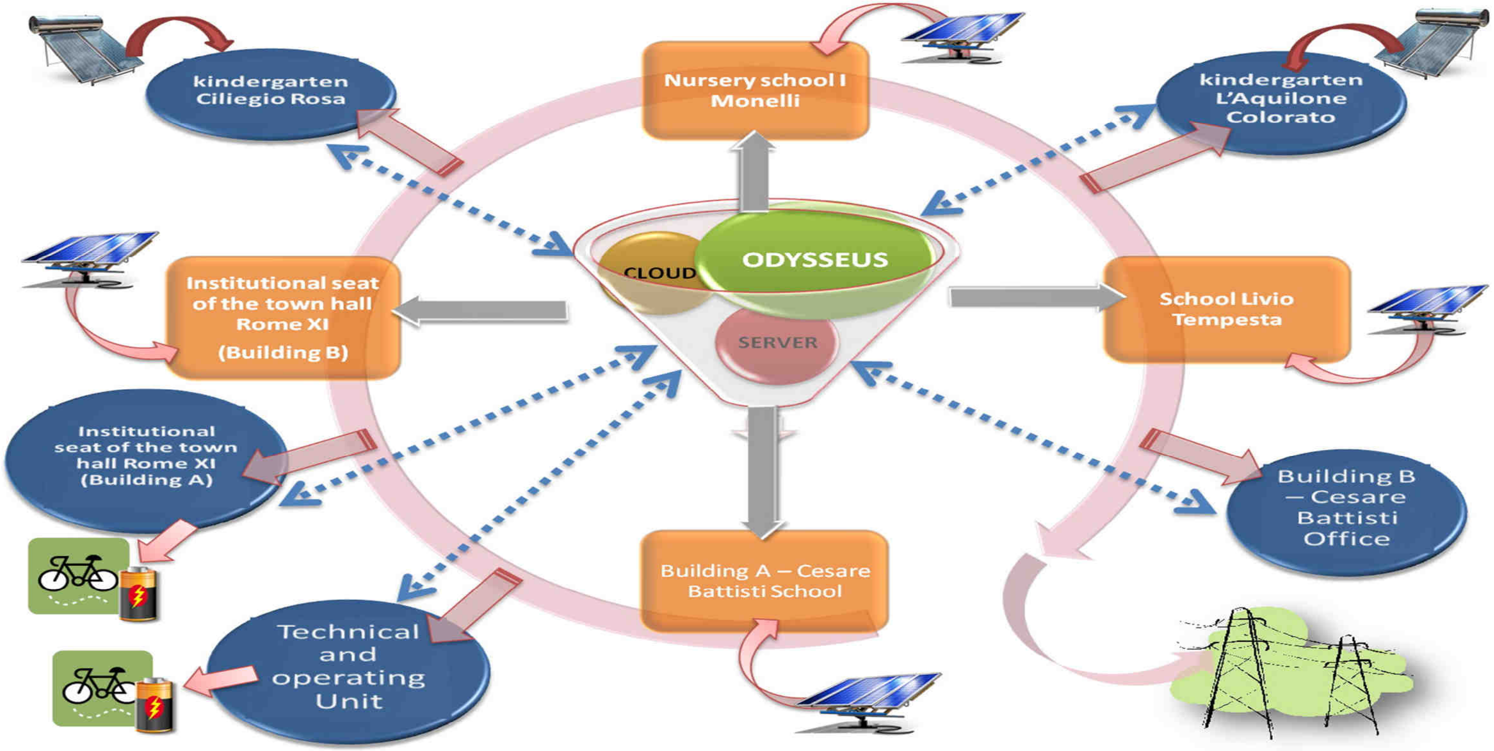


Figure13. Surplus of energy produced in buildings at neighbourhood level

4.9.5 *Baseline: Period, Energy and Conditions*

During the periods of monitoring of electricity consumption and electricity production should be performed by Odysseus, through the first simulations, analysis and assessments and decisions must be made taken in order to maximize the positive surplus of electricity, especially during periods when buildings are closed.

The final simulations planned in this use case will be performed between July 1st and September 30th - year 2015.

4.9.6 *Baseline analysis and ECM definition*

Odysseus hEMS is the main tool for processing and analyzing the data collected by the meters. This information is then distributed to the decision makers in order to make the most effective and efficient decisions for the use of “smart energy”.

The main actions that can be made to empower, by an electrical point of view, for a few hours of the year, the demand of energy of the reference buildings(ELEMENTARY SCHOOL: “CESARE BATTISTI”, THE TECHNICAL AND OPERATING UNIT (U.O.T.) OF THE TOWN HALL ROMA XI, PRIMARY SCHOOL “LIVIO TEMPESTA” , NURSERY SCHOOL”THE MONELLI“, INSTITUTIONAL SEAT OF THE TOWN HALL ROME XI, KINDERGARTEN “AQUILONE COLORATO”, KINDERGARTEN “CILIEGIO ROSA”) and therefore to increase and exploit the surplus of electricity during the days of closure of the buildings are the following:

- Reduction of electricity consumption of buildings;
- Increase in periodic maintenance on photovoltaic (cleaning panels and controls, proper working of the system components);
- Increase in power photovoltaic energy (kWp) through the installation of additional panels;
- Assessment, through Odysseus platform and tools, of the exact distribution of amount of energy surplus produced by the photovoltaic systems among the seven buildings as a reference.

4.9.7 *Reporting period*

During the simulations, the following KPI must be assessed:

$$\textbf{KPIS} = \frac{\textbf{ELECTRICENERGY PRODUCED BY P.V.PLANT [kWh]}}{\textbf{DEMAND OF ELECTRIC ENERGY OF THE LOADS OF THE BUILDINGS [kWh]}}$$

$$\textbf{KPIH\%} = \frac{\textbf{HOURSOFELECTRICENERGYSELFSUFFICIENCY [h]}}{\textbf{8760 [h]}} \textbf{x 100}$$

4.9.8 *Basis for adjustments*

During the periods of electricity consumption and production, through the first simulations, analysis and assessment should be performed by Odysseus cloud platform, and decisions should be made in order to maximize the surplus of electricity, especially during the periods when the buildings are closed. After the ECMs, additional simulations should be done and compared with the previous simulations, in order to assess the success of the interventions proposed.

4.9.9 *Analysis procedure (Validation process)*

For the incoming months we plan to monitor energy consumption and P.V. production, and through gathered data we anticipate that, later than six months, Odysseus cloud platform can begin to perform the first simulations of the transfer of energy. The information and the data will be processed and analyzed and reported back to the main decision actor to recommend smart energy decisions:

- if there is a positive surplus of energy, the decision has been effective and the main decision maker is going to do the same, more and better;
- the main decision maker can decide that the energy in excess can be given back to the ACEA grid or can be transferred into the e-network to address to other buildings
- if there is a negative surplus of energy, the recommendation have not been effective (feedback loop) so start checking for gaps in the performance is required).

It is required to check for validate the consistency with our proposed outcome (the output is consistent to the original proposal) and validate that the project is aligned with the original proposal (KPIs).

We check to validate the work and the recommendations with the original proposal. There are gaps in the performance.

The principle in order to evaluate the efficiency of the energy management system applied to this use case, is to determine savings (measurable, attainable, possible) after abovementioned ECMs have been implemented. The procedure establishes a baseline period before ECMs have been implemented and a reporting period after ECMs have been implemented. Savings are obtained by checking and comparing the reported period and the expected by modeling methods of consumption under conditions of this reporting period but assuming that ECM have not been implemented.

The adjustments process restates the baseline demand of energy of the reported period under a common set of conditions and compares the actual trend to that desired to achieve the goal (KPIs fixed).

4.10 Neighborhood level UC-R1: Inform on energy production for making decision

4.10.1 *Functional description*

This use case regards the assessment of energy produced by the PV plant that supplies building A demand of energy (Cesare Battisti school). The target is to measure the energy produced by the photovoltaic system and to define/measure the amount of electric energy given back to the ACEA grid, mostly when the school is closed (Saturdays, Sundays or summer holidays period).

In this use case the SIMU department will make decisions.

4.10.2 *Energy systems*

The project aims to improve energy efficiency and reducing environmental impact (reduction of CO_2) through the rationalization of energy consumption (management and forecasting of energy consumption) in a district in view of a future electricity network which can intelligently integrate the actions of all users which are connected (producers and consumers) to a more efficient and safe distribution e-network. The goal of the project is therefore to develop an integrated management system that allows, through the optimization and monitoring of energy consumption, the transfer of energy surplus from one building to another and vice versa. Specifically, the project aims, through the acquisition and analysis of historical monthly consumption of the reference buildings of the amount of energy produced by the photovoltaic month (data to be provided by the City of Rome Department SIMU), to achieve the rationalization of electricity consumption by optimizing the energy produced by the photovoltaic system installed in building A (Cesare Battisti school), monitoring and analysing the different energy sources in buildings. Therefore, through starting with the modelling of the school ‘Cesare Battisti’, as a first step,the project aims to achieve the verification of the possible usage of energy in excess in building A and building B and/or to vary the size of the PV system in relation to energy consumption needs.

This use case deals with the measurement of energy production and transferring of energy produced by photovoltaic panels into the e-network by the Building A. The energy production of the PV will be measured and monitored by SIMU department through the remote, on the Department portal, of available data provided by the inverter of the plant.

On the roof of the buildings is installed a photovoltaic system connected to the network (the network operator is ACEA Spa) with the sale of the energy produced in excess to the electricity grid to which the plant is connected.

The PV plant consists of 22 polycrystalline silicon modules of 220 Wp power unit for a total power plant equal to 4.84 kWp and a floor space equal to 37.4 square meters. The annual production of the plant is approximately 7,000 kWh, a reduction in CO_2 emissions of approximately 3,700 kg / year. The photovoltaic system, at the service of building A, is exposed with an orientation of 0.00 ° (azimuth) than in the south at an angle of 32 ° to the horizontal (angle of tilt).

4.10.3 *KPIs*

With regards to electricity energy production of the PV system, it can be used the following KPIs:

KPI	Acronym	Description
KP1P1	**KPIP1** = $\frac{\textbf{ELECTRICITYENERGYINSURPLUS [kWh]}}{\textbf{ELECTRICITYENERGYPRODUCED [kWh]}}$	Indicates the electric energy produced by the photovoltaic systems which is not used.
KP1P2	**KPIP2** = $\frac{\textbf{ELECTRICITYENERGYPRODUCED [kWh]}}{\textbf{BUILDINGSURFACE [m2]}}$	Indicates therefore the specific electric energy [kW/mq] produced

KPI	Stakeholder	Description of Decision Making Based On
KP1P1	SIMUDEPARTMENT	Increasing periodical maintenance interventions on the P.V. Plant (panel cleaning and controlling the right working of the plant components) and Increasing of photovoltaic electric energy (kWp) through the installation of more PV panels.
KP1P2	SIMU.DEPARTMENT	Increasing periodical maintenance interventions on the P.V. Plant (panel cleaning and controlling the right working of the plant components) and Increasing of photovoltaic electric energy (kWp) through the installation of more PV panels.

To set the project target and to verify the results of energy efficiency project, we have to start by considering how the information system will support key goals above mentioned.

So the above mentioned KPIs are defined to track the performance and measure the success of the energy management and each is made to be measurable, possible, attainable, available.

4.10.4 *Monitoring plan*

The monitoring of the electricity production of the photovoltaic system will be implemented by the SIMU Department under the contract of maintenance of photovoltaic systems of Roma Capitale. Through the installation of a data logger, overall data: the inverter data, the production meter data, the meter exchange and strings data, will be sent to a dedicated portal (see figure14).

The main data that will be displayed relate to the energy produced by the plant, the energy used and sold in the network, the CO_2 savings, etc…

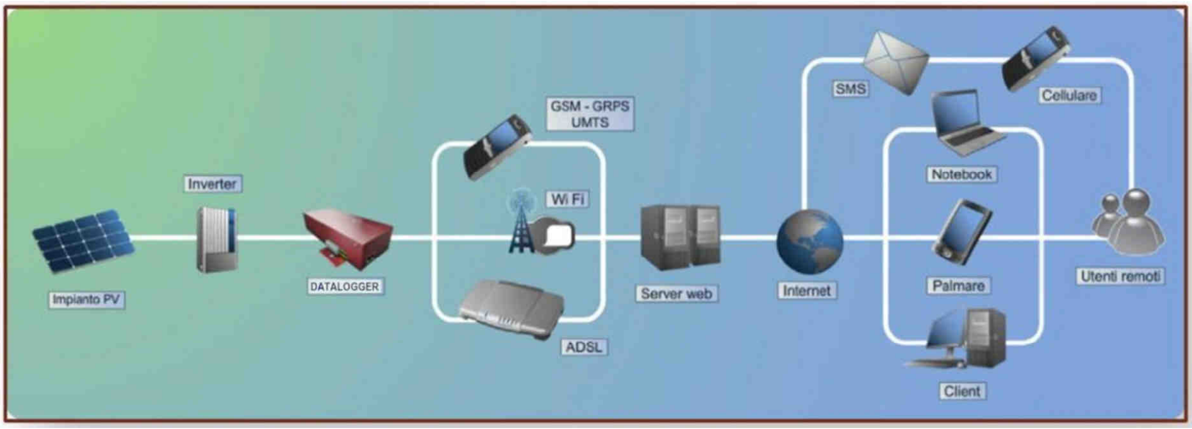


Figure 14

4.10.5 *Baseline: Period, Energy and Conditions*

The data relating to the production of electricity and the amount of energy that is given back to the network, can be analyzed by Odysseus considering the different efficiencies of the same P.V. plant during different periods of the year, after a full year of monitoring (period October 1th to 2013 September 30th, 2014).

4.10.6 *Baseline analysis and ECM definition*

Odysseus hEMS is the main tool for processing and analyzing the data collected by the counters. This information is then distributed to the decision makers (SIMU Department) in order to make the most effective and efficient decisions for the use of "smart energy".

The main actions that can be made to increase P.V. energy production and consequently increasing electric energy surplus when the school is closed, are as follows:

- Reducing energy consumption (see previous use case)
- Increasing periodical maintenance interventions on the P.V. Plant(panel cleaning and controlling the right working of the plant components)
- Increasing of photovoltaic electric energy (kWp) through the installation of more PV panels.

4.10.7 *Reporting period*

The following KPIs will be assessed through monitoring the P.V. energy production during the reference period:

$$\mathbf{KPIP1} = \frac{\mathbf{ELECTRICITY\ ENERGY\ IN\ SURPLUS\ [kWh]}}{\mathbf{ELECTRICITY\ ENERGY\ PRODUCED\ [kWh]}}$$

$$\mathbf{KPIP2} = \frac{\mathbf{ELECTRICITY\ ENERGY\ PRODUCED\ [kWh]}}{\mathbf{BUILDING\ SURFACE\ [m2]}}$$

The measured values of KPIs will be compared with the KPI measured after the making actions in order to reduce electricity consumption and to increase P.V. electric production.

4.10.8 *Basis for adjustments*

After ECMs have been implemented, the data of the energy produced and given back to the grid will be compared with the data gathered after the first monitoring year and (the decision maker) will assess if the actions made have given the result of increasing the energy produced.

4.10.9 *Analysis procedure (Validation process)*

For the next months we plan to monitor the energy production of the P.V. plant and we plan to have an initial report after 12 months.The information and the data will be processed and analyzed and reported back to the main decision actor to recommend smart energy decisions:

- if there is a positive surplus of energy, the decision has been effective and the main decision maker is going to do the same, more and better; the main decision maker can decide that the energy in excess can be given back to the ACEA grid or can be transferred into the e-network to address to other buildings;
- if there is a negative surplus of energy, the recommendation have not been effective (feedback loop) so start checking for gaps in the performance is required.

It is required to check for validate the consistency with our proposed outcome (the output is consistent to the original proposal) and validate that the project is aligned with the original proposal (KPIs).

We check to validate the work and the recommendations with the original proposal. There are gaps in the performance.

The principle in order to evaluate the efficiency of the energy management system applied to this use case, is to determine savings (measurable, attainable, possible) after abovementioned ECMs have been implemented. The procedure establishes a baseline period before ECMs have been implemented and a reporting period after ECMs have been implemented. Savings are obtained by checking and comparing the reported period and the expected by modeling methods of consumption under conditions of this reporting period but assuming that ECMs have not been implemented.

The adjustments process restates the baseline demand of energy of the reported period under a common set of conditions and compares the actual trend to that desired to achieve the goal (KPIs fixed).

4.11 Neighbourhood level UC-R2: Inform of energy surplus availability for making decision

4.11.1 *Functional description*

This case deals with the analysis of the surplus available by the photovoltaic panels of the Building A, this data made available by the monitoring of the previous case.

4.11.2 *KPIs*

In this use case the SIMU will be the decision maker. In this Use Case the following KPI will be used:

KPI	Acronym	Description
KPIP1	$\mathbf{KPIP1} = \frac{\text{ELECTRICITY ENERGY IN SURPLUS [kWh]}}{\text{ELECTRICITY ENERGY PRODUCED [kWh]}}$	Indicates the electric energy produced by the photovoltaic systems which is not used.

4.12 Neighbourhood level UC-R3: Consider weather and energy costs for making decision

4.12.1 *Functional description*

This case deals with weather and energy costs analysis for taking decision on how to employ and redirect energy surplus by the Building A photovoltaic panels. The Odysseus system will be able to constantly access these data and suggest best decision for energy employment.

4.12.2 *KPIs*

In this use case the following KPI will be used:

KPI	Acronym	Description
KP1P3	$\mathbf{KPIP3} = \frac{\textbf{ELECTRICITY ENERGY PRODUCED [kWh]}}{\textbf{N° OF SUNNY DAYS}}$	This KPI relates the energy production with the number of sunny days.

5 Conclusions

This deliverable covers the initial approach of the demonstration plan for the pilot scenarios, identifying for both sites Manchester and Rome, the energy flow, the boundaries, the relevant KPIs and the existing technical infrastructure that is relevant for project monitoring purposes.

Based in the work achieved in WP1, where the scenarios are initially described in D1.1 (Pilot Business cases) and refined in D1.2 (Pilot integration scenarios),this document present the different use cases identified for both pilot sites and the technical challenges to be addressed in order to achieve the validation process. The demonstration plans here described intend to provide an accurate vision of the different phases to be implemented in the two scenarios, from monitoring to ECMs definition and implementation.

The plan implementation, at facilities and neighbourhood level will be further linked with the progress on WP4 (Odysseus platform – tools) and the details of the implementation and integration activities carried out, this results along with any modification in the plans within that phase will be reported in D5.3.

6 Annex I: Scenarios & Use cases Summary Tables

Validation Methodology reference (D5.1)	Building level	UC-M1: Manchester Town Hall Extension (THX)		
Step 1-2	Scope	To test the effectiveness of the city's guidance to and performance of individual energy managers on their floor zone/section in the THX in terms of energy/carbon reduction		
	(Desired) outcomes	To demonstrate how floor/zone section managers and individual employees can contribute to meeting the City's 41% CO_2 reduction target through the application of a range of "soft" behavioral ECMs. To explore potential energy savings accruing from lower artificial illumination levels in office spaces (300lux for reading from computer rather than 500lux reading from paper documents).		
	Energy systems	Heating (LTHW)	Electrical	Transport (travel to work)
	KPIs	• Energy consumed /sq M of floor space • Energy consumed /occupant • Energy consumed/ occupant/ sq M of floor space.	• Electricity consumed /sq M of floor space • Electricity consumed /occupant • Electricity consumed/ occupant/ sq M of floor space.	• Energy consumed /occupant
	Monitoring plan			
Step 4	Equipment description/metering devices	Ultrasonic Heat Meters	Electrical sub-meters	Manual
	Other tools	BEMs	BEMs	Spreadsheet
	(Expected) date of installation	Already installed	Already Installed	
	(Expected) date to start data acquisition	November 2013	November 2013	February 2014
	Baseline definition			
Step 3	Duration (start/end date)	01/11/13 – 31/10/14	01/11/13 – 31/10/14	01/2/14 – 31/10/14
	Reference data	Collected during 1st 3months of the study and updated iteratively as ECMs are applied	Collected during 1st 3months of the study and updated iteratively as ECMs are applied	Collected during 2nd 3months of the study and updated iteratively as ECMs are applied
	Energy conditions	Comparison of consumption between control zones in the building (no ECMs applied) and study zones (ECMs applied).	Comparison of consumption between control zones in the building (no ECMs applied) and study zones (ECMs applied).	Comparison of consumption between control zones in the building (no ECMs applied) and study zones (ECMs applied). Zones have similar energy,

		Zones have similar energy, climate and occupancy conditions	Zones have similar energy, climate and occupancy conditions	climate and occupancy conditions
	Baseline analysis			
Step 7	Expected date for baseline analysis	After 3, 6, 9 and 12 months	After 3, 6, 9 and 12 months	After 3, 6, 9 and 12 months
	ECM definition			
Step 6-11	Expected date for ECM identification	At outset	At outset	01/02/14
	ECMs identified	• Temperature control and management • Ventilation control and management (particularly window opening behavior) • Lighting controls and management • Standing loads and management, e.g. computing equipment.	• Lower artificial light levels supplied to office floors	• TtW options, choices and incentives
	Expected date for ECM set up	01/02/14	01/02/14	01/05/14
	Expected goals	Energy reductions per floor of the building. Staff engagementand ownership of energy saving and CO_2 targets	Evaluation of whether higher light levels are need in spaces where staffprimarily work with computers	Energy and C02 reductions from staff TtW.
	Reporting Period			
Step 12	Duration (start/end date)	February 2014 – March 2015	February 2014 –March 2015	March 2014- March 2015
	Reference data	Monitored energy consumption in control floors where ECMs	Monitored energy consumption in control floors where ECMs are	Monitored TtW data collected during period March 2014- July 2015

		are NOT applied	NOT applied	
	Energy conditions	Weather data	Weather data	-
	Adjustments	Non anticipated	Non anticipated	Non anticipated

Validation Methodology reference (D5.1)	Neighbourhood level	UC-M2: Manchester Civic Quarter Heat Network (MCQHN)	
Step 1-2	Scope	To reduce CO_2 emissions in Central Manchester through a Heat Network that will seek to optimise energy supply and demand for 6 large buildings including the Town Hall, the Town Hall Extension, Central Library, the Midland Hotel, Manchester Central (the conference and exhibition centre) and Number One St Peter's Square. This will involve the owners of the buildings, their energy managers and technicians and those of a new energy centre that is to be established	
	(Desired) outcomes	To simulate the potential energy savings and associated financial returns on investment to help to (a) select between centralised or decentralised plant systems and associated equipment and (b) select between 5 delivery options for the network: private ownership, public ownership, and 3 variations of public/private partnership (PPP).	
	Energy systems	The 6 buildings in the network - their existing heating, cooling and electrical systems.	The Heat Network including the new Energy Centre composed of heating, energy storage and electrical generation capacity.
	KPIs	• Heat energy consumed per square meter of floor space/annum (kWh/m^2/year. • Electrical energy consumed per square meter of floor space/annum (kWh/m^2/year) • Energy demand for commercial buildings (kWh/m^2/year) • CO_2 savings per square meter (Kg/m^2/year)	• Heat transfers (MJ per year) • Cost of heat supply (£/MJ) • CO_2 emissions from the whole network (Kg per year) • CO_2 emissions from the electrical consumption/supply in the network (Kg/m^2/year) • CO_2 emissions from the overall heat supply in the network (Kg/m^2/year) • Local economic effects of the heat network (£s/capita) • Socioeconomic effects of the heat network (jobs/year)
	Monitoring plan		
Step 4	Equipment description/metering devices	Odysseus Platform	Odysseus Platform
	Other tools	BEMs in each building	Weather monitoring
	(Expected) date of installation	Odysseus Platform – September 2014	Odysseus Platform – September 2014

		Building BEMs - already installed	Weather monitor - already installed
	(Expected) date to start data acquisition	October 2014	October 2014
	Baseline definition		
Step 3	Duration (start/end date)	01/09/14 – 31/09/15	01/09/14 – 31/09/15
	Reference data	Historical data on energy consumption of each of the buildings in the network	To be defined
	Energy conditions		
	Baseline analysis		
Step 7		This will involve validating baseline simulations run via the platform to comply with historical weather and energy consumption data	To be defined
	ECM definition		
Step 6-11	Expected date for ECM identification	April 2014	April 2014
	ECMs identified	Simulation of the installation of the heat network Simulation of performance each building's plant and equipment	Simulation of the installation of the heat network Simulation of the performance of the Energy Centre CHP and energy storage system
	Expected date for ECM set up	01/02/14	01/02/14
	Expected goals	Understanding of the potential increased efficiency of the use (boilers, coolers, etc) in each of the networked buildings	Understanding of the efficiency gains from the network
	Reporting Period		
Step 12	Duration (start/end date)	September 2014 = September 2015	
	Reference data	Historical data on the energy use in each of the buildings	

	Energy conditions		
	Adjustments	Non anticipated	Non anticipated

Validation Methodology reference (D5.1)	Building level	UC-R1, UC-R2, UC-R3, UC-R4, UC-R5	
Step 1-2	Scope	**UC-R1 Continuous monitoring of energy consumption at floor level** **UC-R2 Analysis of monitored data** **UC-R3 Making decision advise support and taking action** **UC-R4 Increase photovoltaic energy production** **UC-R5 Evaluate simulation tools** • measure energy consumption per floor or part of the building or by type of electrical load. • data analysis as an analytical foundation for strategy planning of decision makers • decision-making, avoid energy wastes or employ energy produced in the most efficient way possible • simulate the transferring of energy surplus in order to make strategic decisions on expanding electricity production • simulation of the transfer of the surplus of energy from building A to building	
	(Desired) outcomes	• Identify energy waste • Quantify energy demand • Minimize energy waste • Recommend strategies • Identify proper ECMs • Recommending strategies to optimize consumption and identification of waste energy minimization(Odysseus is in this role an ECM itself) • Identifying proper ECMs • Obtain an excess of energy, • Give back the energy surplus to the grid (ACEA Utility) • Optimizing production expanding electricity production • Transferring and redressing energy at neighborhood level or to charge batteries • Achieve energy self-sufficiency, scalability • Reduce energy demand of the loads of overall buildings • decision support to archive power self-sufficiency of buildings	
	Energy systems	Photovoltaic	PV after implementation of ECMs
	KPIs	KPIEH = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{OPENING HOURS OF BUILDING [h]}}$	KPIS = $\frac{\text{ELECTRICENERGY PRODUCED BY P.V.PLANT [kWh]}}{\text{DEMAND OF ELECTRIC ENERGY OF THE LOADS OF THE BUILDINGS [kWh]}}$ KPIH%= $\frac{\text{HOURSOFELECTRICENERGYSELFSUFFICIENCY [h]}}{\text{8760 [h]}}$ x 100

		KPIES = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{BUILDING SURFACE [mq]}}$ KPIEP = $\frac{\text{POWER CONSUMPTION [kWh]}}{\text{User}}$ KPIE% = $\frac{\text{EC1}-\text{EC2 [kWh]}}{\text{EC1 [kWh]}} x\ 100$	
	Monitoring plan		
Step 4	Equipment description/metering devices	Monitoring involves the installation and collection of energy measures on the general electric panel at building A of Cesare Battisti school, of 8 measuring instruments to determine by field measurement if we are saving or not energy. Submission data to the Odysseus Cloud Platform. thegateway can forward communications from the field to Odysseus system Meters by field provide energy consumption measurement	
	Other tools		
	(Expected) date of installation	December 2013	
	(Expected) date to start data acquisition	December 2013/ January 2014	
	Baseline definition		
Step 3	Duration (start/end date)	consumption data over the past four years + consumption actually measured with meters installed - December 2013	
	Reference data	after checking the reliability of the historical data on the average consumption of reference buildings that are actually provided by the ACEA (utility), comparing with the data that we are expected to acquire (after the installation of meters) for the next six months (December 2013 May 2014, we will verify the reliability of historical data; Once assessed the reliability of the historical data, the baseline will be expressed, for the months from June to 30 November 2014,as an average of : consumption data over the past four years + consumption actually measured with meters installed during months from 1 December 2013 to 31 May 2014	
	Energy conditions		
	Baseline analysis		

Step 7	Expected date for baseline analysis	December 2013/January 2014 to June- July 2014
	ECM definition	
Step 6-11	Expected date for ECM identification	June 2014 - 31 July 2014
	ECMs identified	• Education campaigns to raise awareness and improve users behavior and particularly children and teachers about energy waste and relative costs • High-efficiency lighting electrical rephasing • Balancing of electrical loads • Identify any energy losses- review of the facilities • Awareness level: building facility manager and users • Optimize consumption and the use of surplus energy, active lighting of additional facilities in times of surplus of solar energy. • Maximizes the yield of the PV system by selecting the mode of operation more convenient between the grid and the direct use of energy self-generated (self-consumption) • Increasing periodical maintenance interventions on the P.V. Plant (panel cleaning and controlling the right working of the plant components) and Increasing of photovoltaic electric energy (kWp) through the installation of more PV panels.
	Expected date for ECM set up	June- July 2014
	Expected goals	Energy consumption reduction: • 10% second half of 2014 • 15% first half of 2015
	Reporting Period	
Step 12	Duration (start/end date)	June/July 2014
	Reference data	Data gathered over every 6 months (June 2014/ July 2014 ---- November 2014/ December 2014) and the first half of 2015 (starting from the end of 2014/2015)
	Energy conditions	
	Adjustments	adjustments that take in account the differences between the consumption data during the Baseline (BP) and Reporting Periods(RP) (after ECMs).

		if there is a positive surplus of energy, the decision has been effective and the main decision maker is going to do the same, more and better. Possible adjustments: • if there is a negative surplus of energy, ECMs and Odysseus recommendation have not been effective so start checking for gaps in the performance is required. • strengthen and extend the campaigns designed to reduce energy consumption,identify any energy losses- review of the facilities • strengthen and extend the campaigns designed to reduce energy consumption,identify any energy losses- review of the facilities • identify any energy losses- review of the facilities.

Validation Methodology reference (D5.1)	Neighbourhood level	UC-R1, UC-R2 , UC-R3
Step 1-2	Scope	**UC-R1 Inform on energy production for making decision;** **UC-R2Inform of energy surplus availability for making decision** **UC-R3Consider weather and energy costs for taking decision** • Energy production monitoring and data collection from Building A • Quantify surplus of energy • Optimization of energy surplus in the more efficient, effective and economic way
	(Desired) outcomes	• Provide real-time and reliable data needed to reach a smart decision for energy optimizing • Transfer all the remaining energy to charge batteries or giving energy to another building of the system or to give it back to ACEA grid • Minimization of costs.
	Energy systems	Photovoltaic
	KPIs	KPIP1 = $\frac{\textbf{ELECTRICITYENERGYINSURPLUS}\ [\textbf{kWh}]}{\textbf{ELECTRICITYENERGYPRODUCED}\ [\textbf{kWh}]}$ KPIP2 = $\frac{\textbf{ELECTRICITYENERGYPRODUCED}\ [\textbf{kWh}]}{\textbf{BUILDINGSURFACE}\ [\textbf{m2}]}$ KPIP1 = $\frac{\textbf{ELECTRICENERGYINSURPLUS}\ [\textbf{kWh}]}{\textbf{ELECTRICENERGYPRODUCED}\ [\textbf{kWh}]}$ KPIP3 = $\frac{\textbf{ELECTRICENERGYPRODUCED}\ [\textbf{kWh}]}{\textbf{N°OFSUNNYDAYS}}$
	Monitoring plan	
Step 4	Equipment description/metering devices	Regarding the energy production of the photovoltaic system, the facility manager has access to the energy production meter data from the energy Department of the Rome city hall.
	Other tools	Desired tool TO MONITOR PRODUCTION

	(Expected) date of installation	Adquired as described above
	(Expected) date to start data acquisition	Production Data available and adquired as described above (source: Simu Department)
	Baseline definition	
Step 3	Duration (start/end date)	Actually energy production data are provided by SIMU Department and must be compared with the consumption data. The duration of the baseline period for production data is aligned and constructed uniformly to consumption baseline period as specified in the use cases. After checking the reliability of the historical data on the average production of reference buildings that are actually provided by (SIMU department), comparing with the data that we are expected to acquire for the next six months (December 2013 May 2014), we will verify the reliability of historical data. Once assessed the reliability of the historical data, the baseline will be expressed, for the months from June/July to November 2014, as an average of production data over the past four years + production actually measured with tools (if yes) installed during next months (from December 2013 to May 2014)
	Reference data	Production data provided by SIMU Department
	Energy conditions	
	Baseline analysis	
Step 7	Expected date for baseline analysis	June/July 2014
	ECM definition	
Step 6-11	Expected date for ECM identification	June/July 2014
	ECMs identified	• Elimination of inefficiencies or any technical malfunctions • Increasing periodical maintenance interventions on the P.V. Plant (panel cleaning and controlling the right working of the plant components) • High-efficiency lighting • Electrical re-phasing • Balancing of electrical loads

		• Installation of presence sensors, timers and twilight To obtain energy savings in re-distribution of energy in excess and weather forecasting
	Expected date for ECM set up	June /July 2014 at the latest
	Expected goals	• Consequential availability of energy efficiency production and energy savings (also in terms of cost) • Use of maximized production in the more effective and efficient way (minimizing costs)
	Reporting Period	
Step 12	Duration (start/end date)	Over each six months period, collecting, monitoring and distributinge- data by Odysseus platform
	Reference data	Data gathered over six months starting in January 2014 to July 2014 /December 2014
	Energy conditions	
	Adjustments	July 2014