SEVENTH FRAMEWORK PROGRAMME

Open Dynamic System for Saving Energy in Urban Spaces

D4.1 Odysseus Framework Definition

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1 Executive Summary

The Odysseus project is about reducing energy consumption in urban areas ('neighbourhoods') by improved (tactical or operational) energy management. This energy management requires a complete and accurate information picture of the area in terms of energy nodes and their potential and actual interconnections/interactions.

The main goal of this document is to describe a first global vision of the platform, without enough details to implement the exposed functionalities, but sufficient to have a complete vision of the whole platform, based on the identified top-down set of requirements from D1.2. This exercise of envisage the architecture is important in order to be a key input to the following tasks T4.2 Monitoring tool and T4.3 Decision-making tools, where the technical part, in a very detailed way, of the described modules in this document, should be implemented.

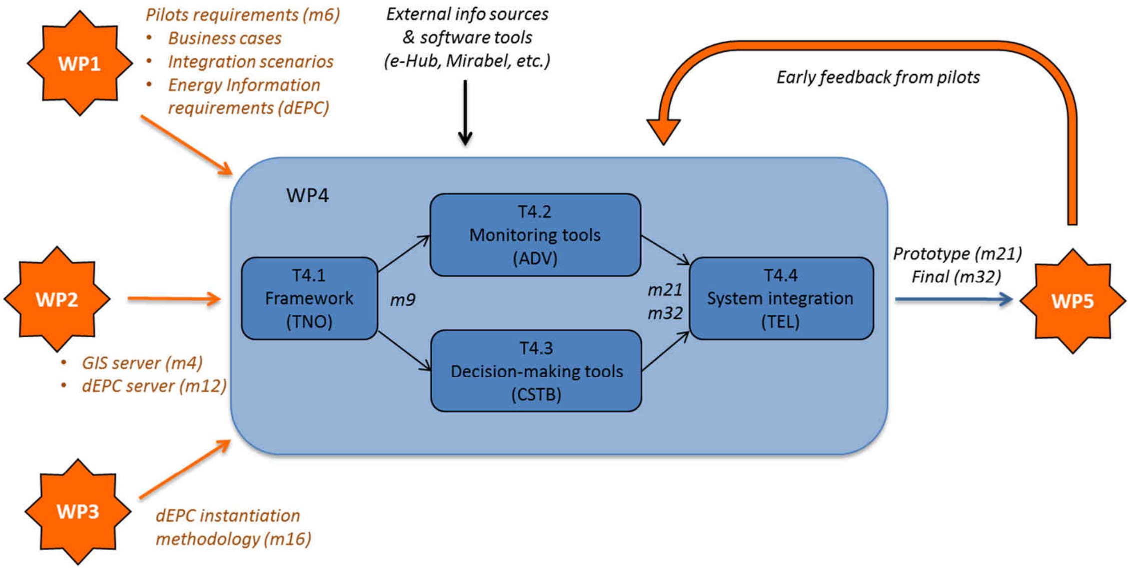


Figure 1 - The role of the Odysseus platform in the project

The deliverable provides a detailed description of the design principles for the Odysseus architectural framework which represent constraints on the technological approach for the problem to be addressed. Moreover potential Odysseus platform stakeholders are introduced and the ones to be addressed in pilots scenarios are highlighted.

In concrete, the document describes the most important concepts of the architecture, their modules (such as aggregation layer, communication layer, GIS service, analytic services …)

and exposed functionalities by these modules in a general manner. Also, security quality attributes are introduced. Concepts like the Odysseus Cloud Platform are clarified, and thus the main modules that compose it.

Also an initial version of the exposed services by each module is being described, due to the fact that all these modules will collaborate and be linked to other modules in order to submit or retrieve information. In some cases the information is being fed into the platform from the energy gateways deployed on energy nodes of a neighbourhood, or from external providers like the weather forecast or the energy tariffs.

And finally, the external components, like the concept introduced by this project, holistic Energy Management Solution (hEMS), are described in the form of the functionality being offered to end users (i.e., human stakeholders like city energy managers, building facility managers, etc.) and other relevant actors for both scenarios (Rome and Manchester). The hEMS can be seen as an external solution being plugged to the framework for exposing functionalities and different views of the value added information (KPIs) to the end users for supporting their decision making process.

At the same time, the way these end solutions should connect with the platform to request information for their respective processes is described.

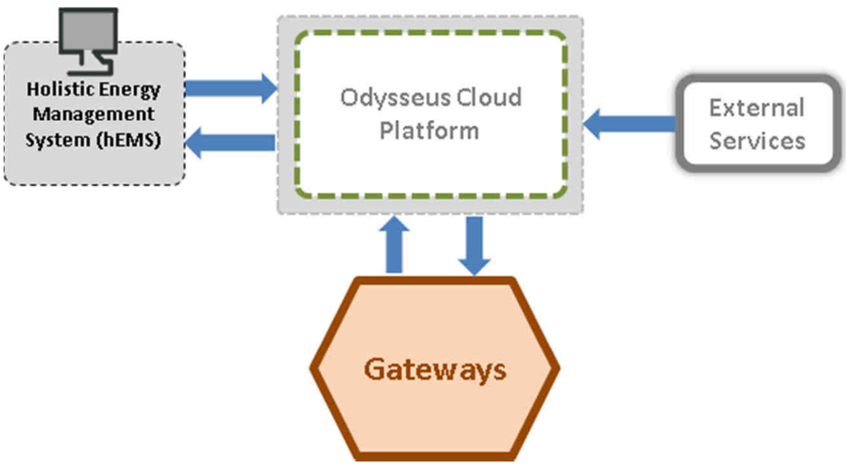


Figure 2 - General Overview of the Logical Architecture

2 Glossary

Term	**Description**
e-Gateway	That part of an E-Node that deals with the communication with other E-Nodes and the Odysseus Cloud Platform (OCP).
E-Network (or Grid)	An energy network containing E-Network Elements being E-Nodes or E-Connections. Network subtypes include electricity, thermal water, thermal air and gas.
E-Node	A node in an energy network that consumes, produces and/or stores energy. E-Nodes can be networks themselves with sub-E-Nodes and sub-eConnections. The Odysseus is concentrated on neighbourhood level E-Nodes like buildings as a whole, street lighting, electric vehicles.
dEPC	The functional and technical description of an E-Node covering both static and dynamic information: properties that are persistent in time and properties that change over time.
District	A district is a type of administrative division, in some countries managed by a local government[1]. From the Odysseus point of view it is an administrative division of the city composed by one or several neighbourhoods of different urban scale.

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

Energy Positive Neighbourhood	A Neighbourhood with an strategic and/or tactical goal focused on sustainability by means of producing more energy than it consumes on a yearly average basis; by 1)using less (direct) non-renewable energy by its energy nodes (E-Nodes), and/or 2) promoting energy exchange and cooperation between surrounding E-Nodes for achieving the goal of self-sustainability (energy island).
Neighbourhood	A group of facilities in an urban area of interest relevant in our case with respect to both a certain set of E-Networks potentially of different types and that represent a measurement boundary at the urban scale.The neighbourhood can include a mix of uses (housing, industry, retail, commerce, etc.), or a collection of facilities for a single use (e.g. an office complex) within a district.
Network	A collection of Nodes linked via Connections to other nodes being of a certain Network Type like traffic, information or energy.
Platform	A server-side ICT software system (data and services) in the cloud for storing and processing the dEPC information for neighbourhoods by means of analytics services. In Odysseus an open cloud-based platform is being developed making use of open interfaces and communications protocols over the internet (import/export, APIs etc.). The platform will support/enable holistic Energy Management Solutions (hEMS) for decision making support based on GIS/Semantic services (via software utilizing the platform).

Table 1 – Odysseus terms/concepts used

3 Introduction

3.1 Purpose, Intended Audience and Scope

The purpose of this deliverable is to define the way of thinking about energy networks in Odysseus. It defines what they are and how the project's planned energy management system fits in. Open, uniform energy node and interconnection information plays an essential role in this.

3.2 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, D1.2 Pilot Integration Scenarios and dEPC Requirements, D5.1 Demonstration Plans provide the top down requirements for our proposed framework.
- Odysseus D2.1 Integration Platform ("The Open GIS Server") & Odysseus D2.2 Extension Approach and Energy ADE ("The Open Semantic Server"), describe two important platform components that feature in the cloud architecture in this deliverable.

3.3 Requirements addressed: Link with Odysseus deliverable D1.2

Odysseus project distinguishes three types of energy considerations involving three different control levels and associated time spans (respectively: long-term, mid-term and short-term):

- The Strategic aspects – long-term: the goals/impacts of the areas/facilities/equipment (energy reduction, cost reduction, enhanced functionalities/comfort etc.)
- The Tactical aspects - mid-term: the static means of the areas/facilities/equipment (like sustainable energy sources, passive isolation, etc.)
- The Operational aspects - short-term: the things that are dynamic and can be changed by 'operational' energy management, including the actual behavior of people and equipment that can be monitored and influenced

All these energy considerations can be for different scale levels (sometimes referred to as Levels of Detail (LoDs)) ranging from geospatial areas like global/worldwide to countries, regions, cities, districts, neighbourhoods to facilities like buildings, electric vehicles down to items of devices/equipment like solar panels, heat pumps, appliances, etc.

In Odysseus we focus in the support for operational and tactical energy decision making for city neighbourhoods and their relevant direct, static and dynamic, E-Nodes.

When considering the Energy Life-cycle we see the following phases:

- Production: Process of generating energy from sources of energy
- Transformation: Change of range of energy. In electrical engineering, converting between AC to DC or changing the voltage or frequency
- Conversion: Change of form of energy, e.g. combined heat power converts natural gas into electricity and hot water
- Transportation: Distribute energy from node to node
- Storage: Transform electrical energy into forms of potential energy to perform useful operation at a later time
- Consumption: Use of energy on different appliances

Within the scope of the Odysseus project we consider the following key phases of the energy lifecycle: production, storage and consumption.

Finally, in the context of Odysseus and the holistic energy management approach we focus on electricity, gas and thermal networks. These networks have a combined influence on the energy production, consumption and storage of a particular E-Node. For instance, an E-Node might use electricity to feed into a heat pump or CHP that warms part of a (green)house and as a consequence a heat-network can deliver less heat.

In appendix 1 the detailed Odysseus requirements described in D1.2 are summarized. Chapter 8 provides a check as to whether the proposed “solution approach” in this deliverable satisfies these requirements.

4 Odysseus Framework

4.1 Design Principles

The following main design principles are defined influencing the specification for the Odysseus Cloud Platform (OCP):

1) Domain Model versus Information Model

The Odysseus project distinguishes between a **Domain Model** and an Information Model such as the **dEPC Ontology** from WP3. The domain model in general gives a complete description of a real world situation where an ontology is an information model to support a certain view and purpose typically describing only a part/aspect of the domain. An alternative way of saying the same is the RS-IS paradigm. Here the objective is to manage, control and/or influence a Real System (RS) supported by an Information System (IS). For that purpose an Information Model of the RS is needed. The total RS can be described in a domain model or alternatively an information model just for a certain purpose w.r.t. a specific part/aspect of the domain.

2) Energy network compared with Internet

An **E-Network** (or Grid) is a set of **E-Nodes** connected by E-Connections where **E-Nodes are** able to communicate and exchange energy. An E-Network always has an "Environment" in which it operates (the local climate and weather conditions like the sun, wind, rain and humidity).

The Internet can be used as a metaphor for an ideal Odysseus energy exchange approach. Note that with the internet all the means are given to communicate but people/machines have full self-control on its use. The initiative is at the internet-nodes not somewhere centrally/globally. The E-Network infrastructure provision can be to some extent compared with internet provision, where data publishers/consumers represent energy producers/consumers. In Odysseus we will focus however on more central control functionalities with neighbourhood overview with varying levels of authority/power compared to an ideal fully distributed E-Node driven exchange. For that ideal most of the current E-Nodes simply lack the adequate local intelligence; also the selected use case types in this project need a more central approach.

3) Boundary conditions

The energy exchange on a grid can be influenced and/or constrained by:

- E-Node activity/initiative (distributed),

- Grid level management or consultancy,
- Law, regulations (it should be possible for an E-Node in an electricity network to sell back locally generated electricity to providers to the same rate at which it was bought earlier).
- Physical characteristics (availability, capacities, losses, failures, etc.) of E-Network elements.

4) Data coverage

dEPC information gives a total picture of all potential E-Node energy-situations: what do they need in time, what can they produce, what can they store etc. but also the actual situation. This information provides the boundaries for exchanges between E-Nodes potentially involving 'contracts' in case of multiple authorities involved. In the latter case (contractually) mutually agreed energy exchange, within the boundaries as specified in the dEPC, is registered and obliged by both parties to the contract. In this way the energy exchange can be realized as planned.

5) Grid infrastructure relevance

Internal grid nodes like that for energy logistics are certainly part of the domain but not of the information model needed for energy management, therefore it is assumed these internal nodes are provided by some grid infra provider. In other words: transport and internal storage are not a part of the information model. Clearly, E-Connection information is in scope, e.g. heat flows where you have less quality (i.e. lower temperature) over larger distances (due to energy loss) or timing aspects have to be taken into account.

6) Central versus de-central dEPC information storage

Each E-Node could in principle have its own data (profiles) located with it (i.e. decentralized 'on location'). That way it could be self-describing and can connect to other E-Nodes and exchange information that is understood because of the common information model (dEPC ontology) known by all. Practically the dEPC information for relevant nodes in our pilot situations will be collected, store and made accessible in the platform by the GIS/semantic server components.

7) Energy Storage

E-Nodes can in general produce, consume or store energy. Network level storage has to be modelled via explicit E-Nodes. E-Node internal storage is in general a 'black box' (we do not have to know how it works externally). *S*torage is seen as just another service next to production and consumption of energy.

If a consumer and/or producer is able to store energy, it could influence its own production/ and/or consumption capabilities.

8) Network abstraction Levels

Three levels involved in energy networks/grids can be identified (in brackets the metaphor comparing to information instead of energy):

1. Usage (compare pragmatics) – flows over E-Connections between E-Nodes represented by energy profiles
2. Logical (compare semantics) – here the 'logical' E-Nodes/E-Connections
3. Physical (compare syntax) – here the physical nodes or P-Nodes/P-Connections as implementations of the E-Nodes/E-Connections such as urban areas/buildings/devices etc.

Our initial dEPC covers all three layers above (figure 3, circles indicating classes, green boxes indicating object properties and blue boxes indicating datatype properties):

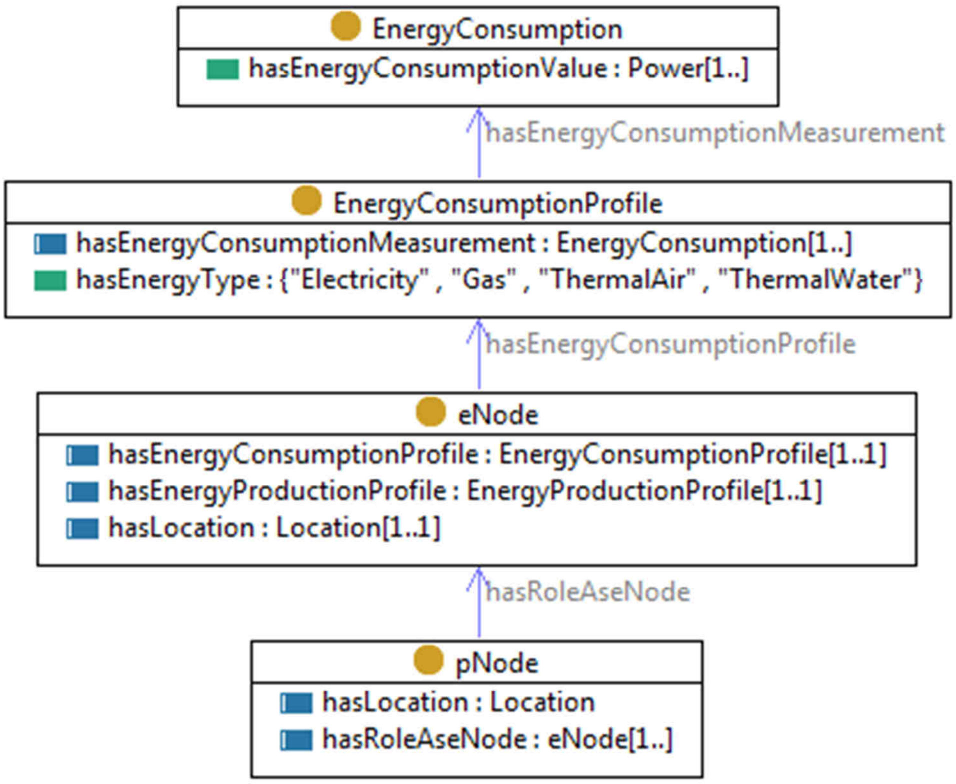


Figure 3 – Top structure dEPC ontology

4.2 Stakeholders selected

Given the scope presented before, the following stakeholders are relevant with respect to (holistic) energy management of E-Nodes.

Stakeholder	Type	Description
Administrator	Organization	The administrator registers the energy production, consumption, transport and does the billing towards the users. Often done by an Energy Utility.
Grid Manager	Organization	The Grid Manager facilitates the trade of goods (in our case "energy") by balancing demand and supply plans by the logistics of the E-Network.
Owner	Person / Organization	The owner facilitates availability of the means of production, consumption or storage and their functions.
Grid User	Person / Organization	The grid user is the user of the grid where energy is bought or sold based on a profile in which demand / supply is determined.
City Energy Agency	Organization	A legal entity or department of a city government (directly or via a spin-off/private company) in charge of energy planning, operations, strategic decision making supported by energy policies and directives (e.g. compliance with the sustainability 202020 paradigm). Usually this city agency owns or is in charge of city assets: facilities (public buildings, schools), street lights, etc..
City Energy Managers	Person	The staff of a city agency that make tactical, strategic and operational energy decision for implementing city policies regarding their assets (e.g. the facilities owned by the municipality).
Building Facility Managers	Person	The staff of a building facility that takes care of the energy efficiency of a building. Usually a building operator which receives energy information (e.g.

		room temperature) and takes control actions (e.g. increase heating temperature of a room).
Energy Utility	Organization	The energy utility usually commercializes and delivers energy through the energy Grid to Grid users by selling energy, charging energy inception on the Grid. The energy utility provides billing services (by an energy tariff) based on energy consumption by grid users.
Aggregator	Organization	Offers services to aggregate energy production from different sources (generators) and acts towards the energy grid as one entity, including local aggregation of demand (Demand Response management) and supply (generation management). In cases where the aggregator is not a supplier, it maintains a contract with the supplier.
Area Energy Service Operator	Organization	A party offering services regarding the energy management of a specific location or geographical area. These services could be dedicated to the charge management of electric vehicles as well as the energy management of the location, like tertiary buildings (in such a case the charging of EVs could be included in a local optimization). An Area Energy Service Operator could, at the same time, offer EV charging Energy (e-Mobility) Services (user profile and billing could be integrated in its service offer). Additional information: an Area Energy Service Operator could be considered as an Aggregator for specific services, linked to the charge management.
Balance Responsible Party	Organization	A party that has a contract on financial security and balance responsibility with the imbalance settlement responsible party. The balance responsible party operates for a set of customers regarding the balance responsibility. This is the only role allowing a party to buy or sell energy on a wholesale level. Additional

		information: the meaning of the word "balance" in this context is an "administrative balance" in the sense that it signifies that the quantity contracted to provide/consume must be equal to the quantity really provided/consumed.
Balance Supplier	Organization	A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the party connected to the grid. In addition the balance supplier markets any difference with the firm energy contract (of the party connected to the grid) and the metered production. There is only one balance supplier for each metering point.
Battery Service Operator	Organization	A party that operates the service for the battery of an electric vehicle. The Battery Service Operator will manage the compromise of usage of the battery between usage for mobility and usage for electricity or grid management services. A Battery Service Operator could for instance subscribe to different services like electricity charging services and electricity delivery services. Additional information: a Battery Service Operator could be considered as an Aggregator for the usage of the battery.
Building Operator	Person / Organization	A consumer of electricity or heat that is a private or business building, may also be involved in contract-based demand response management, e.g. by guiding and steering when electricity is being used or sold back to the smart grid.
Consumer	Person / Organization	End user of electricity, gas, water or heat. **Note:** As the consumer can also generate energy using a Distributed Energy Resource, he is sometimes called the "Prosumer".
Customer Energy Management	Software System	Energy management system for energy customers to optimize the utilization of energy according to supply

System		contracts or other economic targets. It is responsible for gathering flexibilities within the customer premises and providing them to an aggregator, and therefore does not directly participate in flexibility markets
Customer Energy Manager	Software System	The CEM is a logical function optimizing energy consumption and or production based on signals received from the grid, consumers settings and contracts, and energy devices minimum performance standards. The Customer Energy Manager collects messages sent to and received from connected devices; notably in the home/building sector has to be mentioned. It can handle general or dedicated load and generation management commands and then forwards these to the connected devices. It provides vice versa information towards the "grid and/or market". Note that multiple loads/generation resources can be combined in the CEM to be mutually controlled. When the CEM is integrated with communication functionalities it is called a Customer Energy Management System or CEMS.
Flexibility Operator	Organization	A generic role that links the customer and its possibility to provide flexibilities to the market and grid. By aggregating flexibilities of multiple customers and providing that flexibility to the market/grid the balance on the grid can be maintained more easily. It is a generic role that could be taken by many stakeholders, such as a DSO company, an Energy Service Company (ESCO) or an energy supplier.
Producer	Organization	A party that produces electricity or heat. Additional information: This is a type of Party Connected to the Grid.
Weather Forecast Service	Organization	An organization that provides forecasted weather information services for a region or city area (e.g.

		forecast weather, and related conditions, including: temperature, relative humidity, hours of sunshine, sunrise, sunset, precipitation, wind speed and direction, ozone, smog, particulates, allergens, etc.)

Table 2 – Energy stakeholders

Within the scope of the Odysseus project we consider the following key stakeholders in the use cases to be implemented in the cities of Manchester and Rome:

- City energy managers
- Building facility managers
- Energy utility company
- Producer
- Consumer
- Building operator
- Owner
- Grid user
- Provider of weather forecast services

Other potentially relevant stakeholders might be "simulated".

Note: in general the "electricity domain" is more worked out in detail compared to "heat networks" because heat networks are less complex and more easy to maintain. Balancing and flexibility is not a big issue so most of the roles introduced above do not count for heat networks.

4.3 Energy Reduction measures selected

The reduction measures envisaged in the frame of Odysseus platform will rely on services or composition of services provided by the platform itself. They will be adapted according to different roles or profiles of end users / key stakeholders (listed in the previous chapter, section 4.2.1).

These services will be relying on direct information provided by the analytics services as they are defined in D1.2.

Based on the pilot scenarios and expectations, different services needs have been identified:

- Measure, analyze and understand the energy lifecycle of the considered E-Node: This high level need will rely on different kind of services like the ability of the system to measure and store the consumption of different E-Nodes that compose the pilot and also the platform should enable aggregation of the consumptions similar in nature (e.g. Lighting systems, HVAC consumption, etc.).
- Support decisions on managing energy surplus and on reducing E-Node consumption: This will be achieved through composition of services like those dedicated to measurement and aggregation listed above but also with services able to perform simulations based on the past behavior of the E-Node under consideration (past measures and external conditions) and taking into account the forecasted use conditions. This later aspect will be able to deal with weather information and energy cost fluctuations. It is worth mentioning at this stage that the decision making system will consider not only the energy aspect but other KPIs may be taken into account like the Carbon footprint or the energy bill.

From a more generic perspective, there are three main measures to enable a smart management of energy that leads to effective Energy reduction:

- **Load shifting and/or peak shifting**: This measure consist in temporarily reducing the load of an energy network.
- **Energy Trading and/or integration of local production**: One mean to reduce the external demand of an E-Node is to use the energy produced locally that might otherwise go to waste. This new distributed resulting architecture is often called “demand response 2.0”.
- **User awareness:** At the heart of the system, several studies have shown that informing users has an impact on their behaviors. They can (to a certain extent) adapt their energy profile to local conditions and constraints.

All these measures are interrelated as load shifting could rely on the other two options to effectively “shift the load”.

One of the main challenges for the coming years is to develop strategies and corresponding services in order to reduce the consumption peaks. The risk of network collapse is particularly high during peak periods and for identified areas. In order to avoid a global collapse, the current strategy is that load shedding consists in stopping energy supply to identified parts of the network in order to keep the other parts safe. With smart grids, the new strategy, called either “load shifting” or “load shaping”, consists in smoothing the peak loads by steering demand. This load shaping can be seen as a cost-effective alternative to the installation of new production facilities (to supply the peaks) and a response to the difficulty of storing energy for later use. This approach can also be used to offset the intermittent production from renewable energy sources.

The load shaping is already in use in the electricity supply industry on a voluntary basis. When needed, an industrial sector and/or company agrees to erase or decrease its electricity consumption during a certain period, for a fee. It is for the industrial concern to pause some of the electrical equipment, according to the precise terms of its contract.

Now there is another challenge to be tackled i.e. load shaping for citizens.

This is where ICT has a crucial role to play by providing means for a seamless adaptation of buildings energy behaviour following external directives and taking into account local constraints. Based on the four different levels defined in D1.2, the energy systems (at each level) will have to provide comfort to citizens by consuming locally and anticipate external demands based on a computation of various information (local measures, forecast, learned behaviors, external data and constraints, etc.).

This situation is often called “Demand Response 2.0”. It is mainly based on the integration of renewables sources of energy (taking into account their intermittent production capacity) in the “classical” grid composed at its lower level by different energy devices. This is where the mechanism for “Energy Trading” takes place and must be in place within and among E-Nodes in order to make trading decisions automatically available. This mechanism should again rely on ICT at different levels. The data shared must be agreed and understood by all parties and they should be available in real time.

Among the data shared, one point is of key importance and will influence the trading rules. It is important to determine in advance common KPIs that will be used to trade the energy. For instance, the rule could be to minimize the external energy demand of a considered E-Node by using local production first to buy lower priced energy first or look after the lower Carbon footprint production first, etc..

The last but important measure is user awareness. It is often said that good user awareness might reduce energy consumption by 5 to 15 %. This is of particular interest for peak shifting where users (occupants and managers) must be informed of the occurrence of consumption peaks and should be advised to make decisions (e.g. by delaying non vital operations so that they use energy before or after the peak). This could only be done by relying on an ICT system that will be able to display real time measures but also consumption forecast and global energy demand, possible restriction periods and trend advices.

4.4 Logical architecture

The logical architecture is the definition of the detailed structure that supports the several platform processes and services, including the interfaces and flows of information. In this way the Odysseus Logical architecture is a vision of the internal components, services, and the way they communicate.

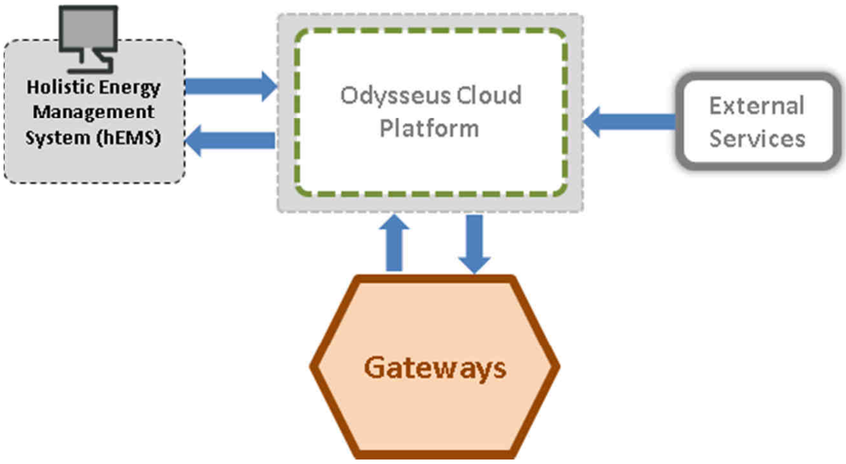


Figure 4 - General Overview of the Logical Architecture

The above figure is a high overview of the architecture where four relevant functional modules can be distinguished:

- **Odysseus Cloud Platform**. This is the central part of the architecture. The place where the business of Odysseus is done. The centralized platform at the cloud offer its services to two other components, the energy gateways at the field level and the information to the holistic Energy Management System (hEMS).
- **Energy gateways**. The energy gateways are placed at field level. They supply the enriched data from "raw data" collected from sensors, devices, etc. in accordance with the proposed dEPC format/structure for the interchange of information (ontology dEPC) over Internet Protocol (IP). This is the main data source of the platform. But at the same time the gateway might receive operations messages from the platform to modify the behavior of the site ("actuation"). In the Odysseus project this level of actuation will be possible for

end-devices like sensors, meters or controllers, but cannot be guaranteed for more complex energy or control devices such energy devices (i.e. HVAC, BMS. etc.) that are part of the legacy ICT infrastructure in the pilot sites, unless interoperability is possible using open communication protocols (i.e. 'modbus', IEEE 802.15.4).

- **External Services**. Another relevant data source of the platform is the external data such as weather forecasting and energy prices. These services offer relevant information to the platform in order to perform analysis, forecasting, simulations, etc.
- **holistic Energy Management System (hEMS)**. This functional module is the real core where the holistic energy management is done, thanks to the services offered by the cloud platform. These modules rely on available services from the Odysseus cloud platform (analysis, prediction, ontology, etc.), based on the information received from gateways and external services.

This overview is explained by Figure 5 - Odysseus Architecture with neighbourhood vision

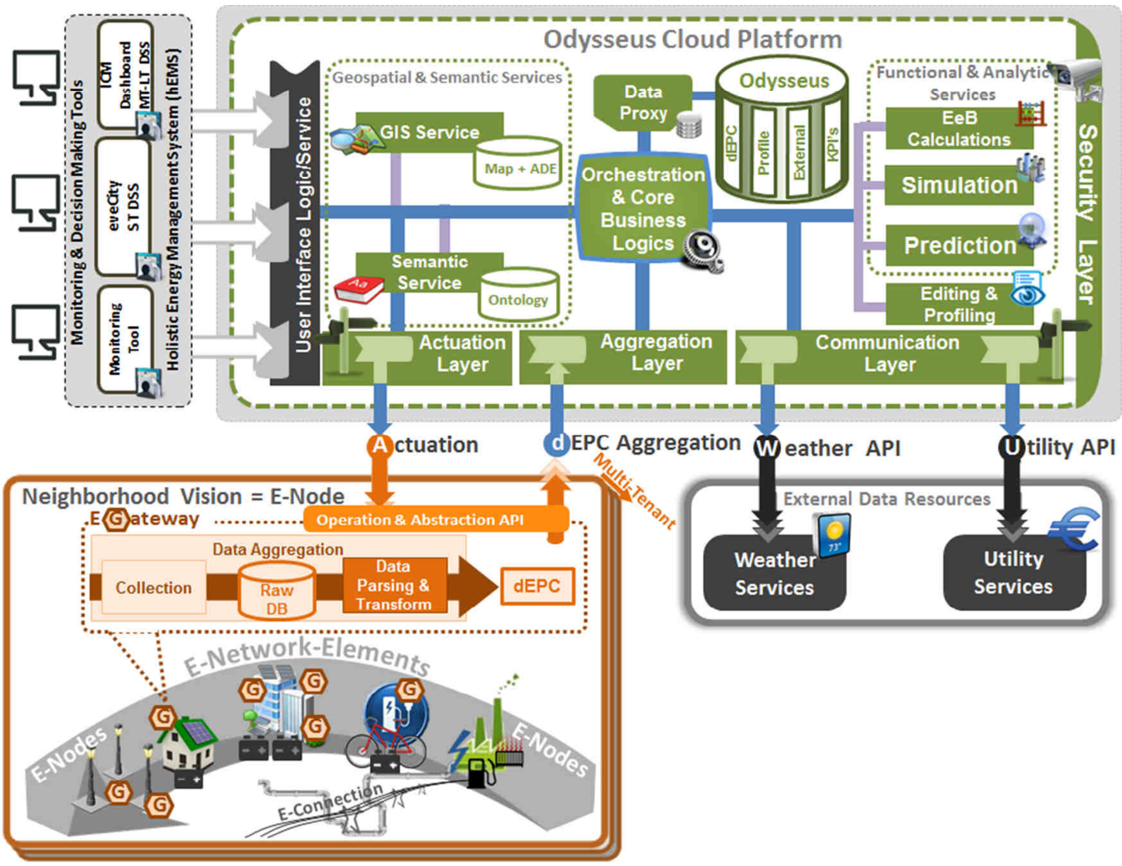


Figure 5 - Odysseus Architecture with neighbourhood vision

This diagram explains a detailed vision of the Odysseus Cloud Platform, e-Gateways, External Services and Holistic Energy Management Systems as previously described. Now that this global vision of the architecture has been introduced, it is time to detail each component. Instead of starting by analyzing the central part of the architecture, which is the cloud platform, a study of the modules from a sequential information flow perspective will be undertaken. From this perspective the e-Gateways at field level are the starting point of the data\information.

4.4.1 *e-Gateways*

In the Odysseus domain the e-gateways deployed on E-Nodes are placed at pilot sites, represented by the scenarios of Rome and Manchester. They aggregate enriched information following the defined dEPC structure by stateless communication between the e-Gateway and the Odysseus Cloud Platform. The Odysseus Cloud Platform has the whole dEPC view while the e-Gateway collects, parses and transforms field data into dEPC functional information.

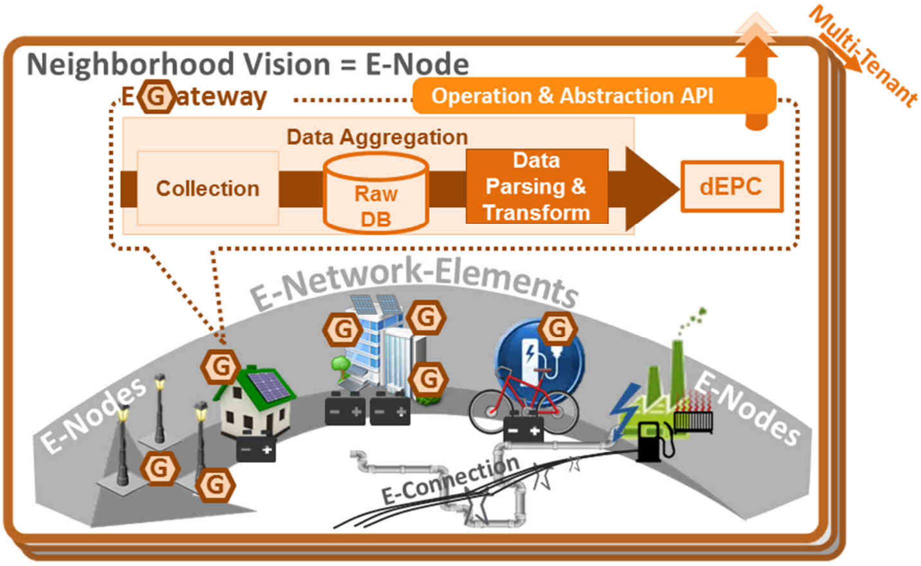


Figure 6 - Energy gateway module definition

At this level Odysseus finds the raw field data from sensors, devices, meters, including smart devices which can perform some kind of actuation from an energy efficiency perspective. This is where the E-Node concept makes appearance. An E-Node follows a "Russian nested doll" approach, where everything (related to energy concept) might be conceptually considered as an E-Node which can contains E-Nodes. An abstract concept which allows reference to several different elements but with a common behavior of functionality linked around the energy efficiency concept.

On the other hand the connections between different E-Nodes are the so called E-Connection. This concept represents the link between the different E-Nodes, establishing and energy connection from an E-Node to another E-Node.

E-Connection = From E-Node to E-Node

And the conjunction of both, E-Nodes and E-Connections forms the E-Network-Elements.

E-Network-Element = E-Node + E-Connection

Figure 6 - Energy gateway module definition illustrates different E-Network-Elements at the pilot site (such as electric bicycle charging, buildings, houses, street lighting, etc.) each one with its own specific characteristics, but all with a common E-Node interface. In some cases the E-Node interface is composed by information provided only by one e-Gateway; in other cases, like in large buildings the E-Node interface is composed by information provided by several on field e-Gateways (e.g. a building might have deployed more than one e-Gateway, the full building will be seen as an E-Node that considers in this case the whole set of information of the deployed e-Gateways).

The e-Gateway is the on field element that submits the information from the pilot site to the Odysseus Cloud Platform (OCP) by means of standard internet protocols. It performs the on field data aggregation by collecting the data, processing and transforming it and finally sending it (following the dEPC information structure schema) to the OCP aggregation layer interface.

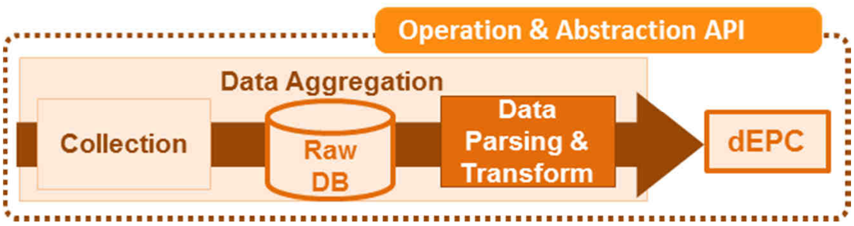


Figure 7 - Energy gateway module definition

One example of this kind of strategies could be the following; the gateway (or gateways if there is more than one assigned to a specific E-Node) collect(s) all the data associated with that E-Node, storing this information immediately at the Raw Database (RAW DB). After that, the gateway in a parallel process finds redundant data and deletes it. At a configured period, the e-gateway prepares the data to send it to the cloud platform. To do so, the gateway parses the information and transforms it into the cloud data model. All this is done at the e-gateway before the cloud platform receives the data. These processes will depend on the target scenario, because it will depend on the kind of information received at the e-gateway, the kind of configuration, the kind of e-gateway, and so on.

So raw data obtained from E-Nodes, is collected firstly at the gateway level. The gateway is a very important element at the pilot site responsible for:

- **Establishing connections** with the low level E-Nodes through different communication protocols (open, non-proprietary standards)
- **Collecting the information** from all E-Nodes defined
- Ensuring the **security and reliability** of the received information
- **Processing and cleansing** the information trying to reduce the problem to the platform.
- **Sending information** to the platform through Aggregation interfaces
- **Receiving Operations** from the platform through Operation interfaces

Now this is when the cloud platform appears. Once the gateway(s) has/have collected, processed, parsed and transformed the gathered data, it is time to send it to the Odysseus Cloud Platform in a structured and standardized way. This is done at gateway level by the Operation & Abstraction API. A module with the capability to:

- **send** information to the platform through the dEPC aggregation interface
- **receive** information from the platform through the actuation interface

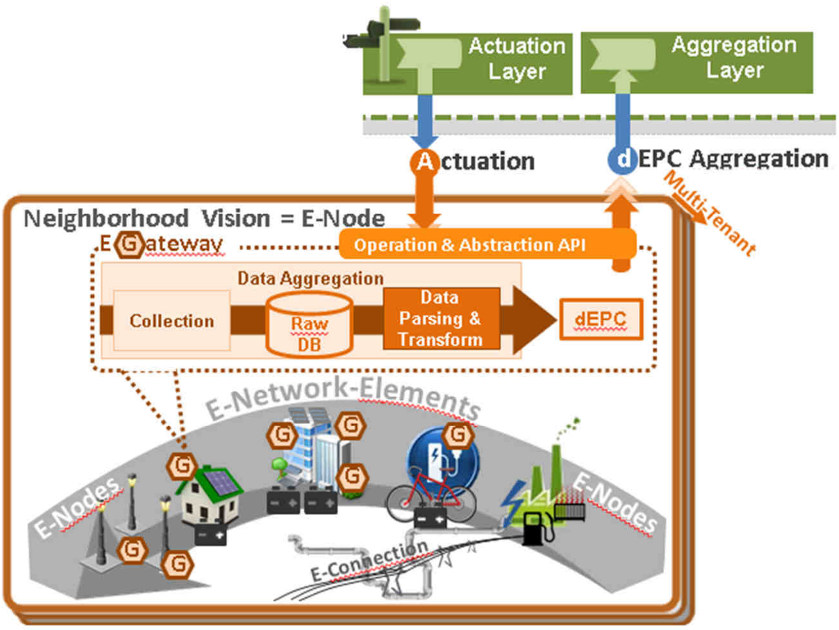


Figure 8 - Gateway communications with the OCP

4.4.2 *Odysseus Cloud Platform*

The Odysseus Cloud Platform (OCP) is the central part of the project using a Service Oriented Architecture (SOA) approach to the business logic responsible for the analysis, predictions, simulations, and so on.

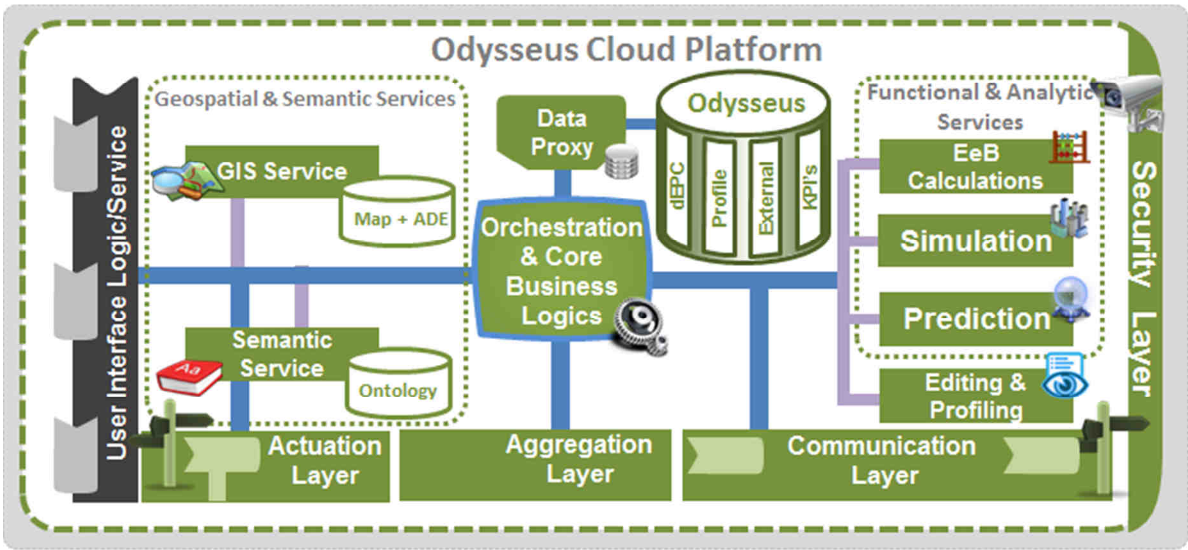


Figure 9 - Odysseus Cloud Platform

The detailed modules inside the OCP can be classified by functional purposes. Therefore we can find communication modules, cross services, and specific modules. All these modules are explored in more detail below.

4.4.2.1 Communication modules

Regarding communication, the Odysseus Cloud Platform offers three different modules to communicate with external consumers and services, the Aggregation Layer, Communication Layer and Actuation Layer.

- **Aggregation Layer**

The aggregation layer is the most important interface of the platform as it is for the communication with the e-gateways and E-Nodes at the pilot site. This layer will expose the necessary aggregation interface that will be the connection end-point of the different gateways at the pilot site level with a REST interface.

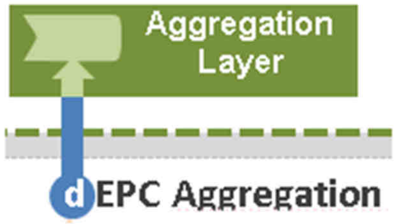


Figure 10 - Aggregation Layer Interfaces

- **Communication Layer**

The communication layer is a generic layer to communicate with externals services not in the control of the Odysseus Architecture. The services are foreseen to communicate with the platform are Weather services, to obtain weather predictions and forecasting, and Utility services, to obtain energy prices and their forecasting.

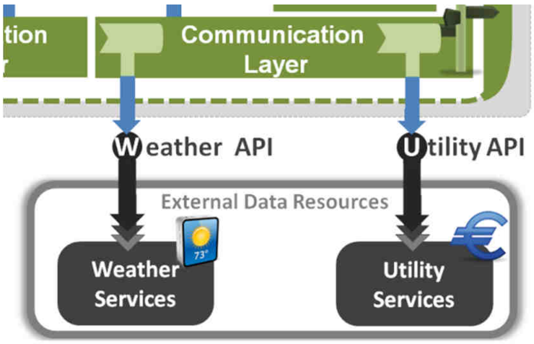


Figure 11 - Communication Layer Interfaces

- **Actuation Layer**

In order to close the loop over the decision making based on the information provided by the OCP to the hEMS tools, an actuation layer has been envisaged that will cause the actuation betweenthe OCP platform towards E-Nodes (energy network element level) at neighbourhood scale (e.g. devices and actuators of a building), which is highly dependent on the IT infrastructure available. This layer will be considered as an optional one and a step forward for supporting the decision making of end users of the hEMS tools provided by Odysseus project. Moreover, automation of some actuations can be envisaged in future development steps based on rules that provide a certain intelligence level to the platform for supporting basic decision making.

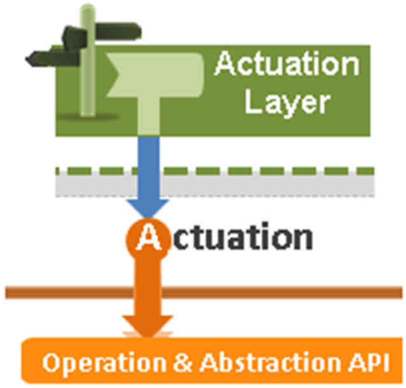


Figure 12 - Actuation Layer

- **User Interface Logics/Service**

The last interface of the platform is the User Interface Logics/Service. These endpoints offer the Odysseus services to external consumers.

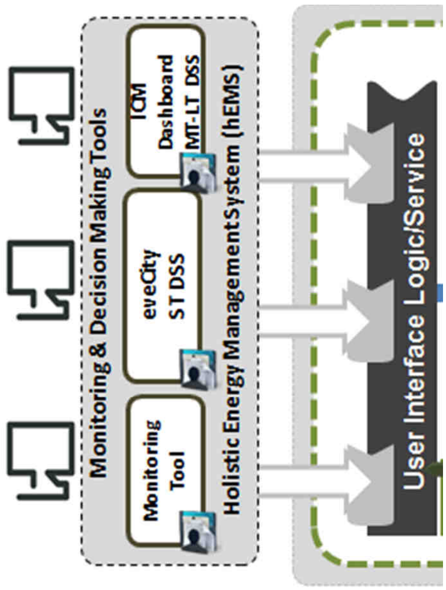


Figure 13 - User Interface Logics/Service interface

These consumers are the Monitoring & Decision Making Tools which need to act as clients of the platform, consuming the services offered by the platform. These will be explored more deeply at the Holistic Energy Management System (hEMS) chapter.

4.4.2.2 Cross services

Cross services are those whose functionality is transversal to the entire platform such as security, orchestration and data proxies.

- **Security Layer**

Security is a must for Odysseus and a basic requirement for the architecture. This service is not only a layer, it is also a set of guidelines to follow inside and outside the platform. Information transmission and storage should be done in a secure way and as well protection against the possibility of attacks to the platform need to be taken into account.

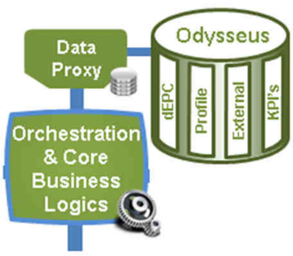
On the other hand, security from the point of view of the access to the platform needs to be addressed at this layer. Who is connected to the platform and its current grants and permissions are under the responsibility of this platform layer.

- **Orchestration & Core Business Logic**

Orchestration & Core Business Logic is the heart of the platform, the module which make sense of the platform and coordinate all the modules inside it.

This module is divided in two main functionalities, orchestration and business logic. Orchestration provides the set of mechanisms at platform level to configure what business process need to be executed at each moment. On the other hand, the Business Logic includes those elements that provides the intelligence of the platform that is responsible for the platform administration, and some other logic that direct the behavior of platform, links the entire platform and is its heart; the difference between just a set of tools or to have an integrated platform.

- **Data Proxy**



Access to the Odysseus database need to be interfaced by the platform, controlling the way the data is stored and retrieved. That is the reason for a Data Proxy, a facade to the data storage at the platform. One of the biggest problems to solve in this module is the need for multi-tenancy, to allow it to service multiple/different tenants in a SaaS way over the internet.

Data Proxy will connect directly to the relational database which will store dEPC data, Profile data, External data, and KPI data.

4.4.2.3 Specific Modules

Specific modules are those services inside the platform which are not transversal at the platform. It is important to define interfaces between these modules and the platform due to the need for the capability to change the implementation of the module easily.

- **Geospatial & Semantic Services**

The GIS and Semantic services interface is for providing data from energy nodes and gathering both semantic and geo-spatial information from energy nodes that will be used by its representation to stakeholders on the holistic Energy Management System (hEMS) provided by the several partners solutions.

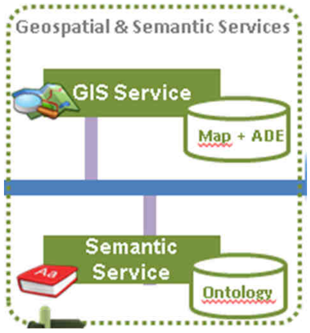


Figure 14 - Geospatial & Semantic Services

These services will match Odysseus semantic concepts with the geo-spatial information based and extending standards when needed, which represent one of the key challenges of the project, and the target of this document (further detailed on next section).

- o **GIS Service**

The GIS Service module provides geo-location capabilities to the data model and map layers to the external UI applications, with the expectation that those applications will provide the necessary user experience that exposes the functionalities. These services are enabled for access over the Web.

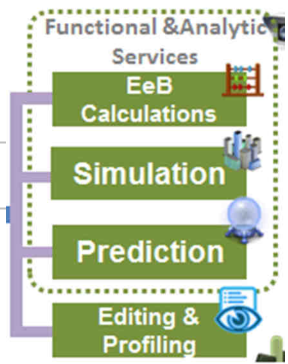
The relation with the semantic service will be thanks to the ADE extension. This semantic data should be compliant to an extension schema to the standard CityGML schema also known as an Application Domain Extension (ADE).

- o **Semantic Service**

The semantic service module gives meaning to the information by linking the data model with the Odysseus proposed ontology. This service will be consumed also from the external Monitoring & Decision Making Tools.

- **Editing and Profiling Module**

The editing and profiling module will manage the energy profiles of the several data instances of the platform. It will provide the editing



capabilities of the several scenarios to be addressed by the Odysseus cloud platform.

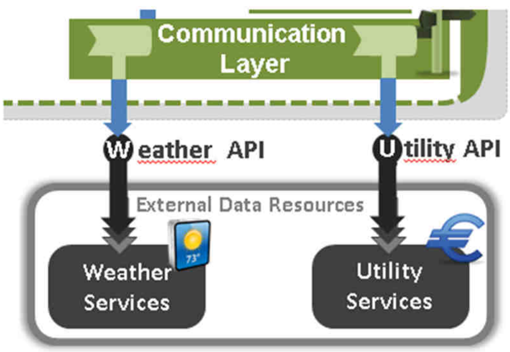
- **EE Functional and Analytics Modules**

The functional and analytics module services aim at providing specific mathematical algorithms for enriching the structured data (from E-Nodes) that follow the dEPC structure. This structured dEPC data is enriched towards more value added information for monitoring and decision support making (like energy alerts, data inconsistency, energy patterns identification, etc.) regarding to energy efficiency (KPIs) at any E-Node level (neighbourhood, facility, etc.).

Based on the focus and purpose of the functional and analytics services, these can be categorised in:

- **Energy efficiency Building (EeB) Calculations,** where basic or elaborated mathematical calculations and algorithms are applied at E-Node level (Average, cumulated, minimum, maximum, standard deviation, etc.) of measured value(s) over a certain time or over a given period of time.
- **Prediction,** in which mathematical calculations and algorithms based on functional models are applied at E-Node level. In this sense external factors like weather forecast, energy tariff or peak demand are relevant ones for obtaining accurate prediction results. Predictions will allow E-Nodes to react and adapt their energy behaviour based on their own interest.
- **Simulation**, in which different energy configurations will be applied based on existing data and models by using existing platform prediction functionalities for making what-if analysis (adding a new E-Node, modifying weather conditions, modifying E-Node energy storage profile, etc.)

4.4.3 *External Services*



The cloud platform will require information from external services. The main services foreseen will be Weather for weather prediction and forecasting and Utility for the energy price forecasting.

These services will be utilized by the platform, taking a client relationship with them. This will be achieved by the communication layer, which is the responsible for communication with external services in a very configurable way.

4.4.4 *Holistic Energy Management System (hEMS)*

These external modules consume the services of the Odysseus cloud platform to support holistic energy management decision making. This is the goal of the platform: to offer services like GIS, semantics, analysis, predictions, and so on to external clients with the expectation that these clients can implement and give to the end-users (city managers, building facility managers, …) a holistic view of the system from an energy efficient point of view.

Three software clients that will use the platform services area foreseen:

- EveCity for the short-term decision support making. EveCity plans to develop an expert module for dealing with dEPC, ICT and smart grids concepts by initially combining a CityGML extraction of the studied zone of a city (neighbourhood), containing GIS and 3D information, and the needed energy data (dEPC) in an Application Domain Extension (ADE) linked with the semantics server. Stakeholders will interoperate in real-time by picking and enriching the energy model and the results can be displayed within a virtual scene in an integrated, interactive and pedagogical way in order to meet the needs and expectations of non-experts.
- ICM Dashboard for the middle-term and long-term decision support making. The provision of a web based dashboard for presenting to stakeholders (city energy manager and facility managers) reports based on several filter selection criteria is envisaged. The energy efficiency dashboard will present reports (in time series or geo-located, historical, actual or forecasted, information based on the existing services of the Odysseus Cloud Platform; which are mainly GIS, semantic functionalities and analytics services.

4.5 Odysseus Cloud Platform: A generic platform

One of the most important strategic objectives of the Odysseus project is to provide a platform that is generic enough to fit a variety of energy efficiency scenarios. For this reason the proposed architecture for the OCP deals with the capability to abstract the problem from the specificity of the case to a more global problem, making valid its solution in a wide range of heterogeneous scopes. This is why the abstract concepts E-Node, E-

Connection and E-NetworkElements are so relevant. Depending on the focus or level of the target problem, the view on the E-Node could be different.

For instance, the same architectural format presented above, can be reformulated with a city viewpoint in figure 15.

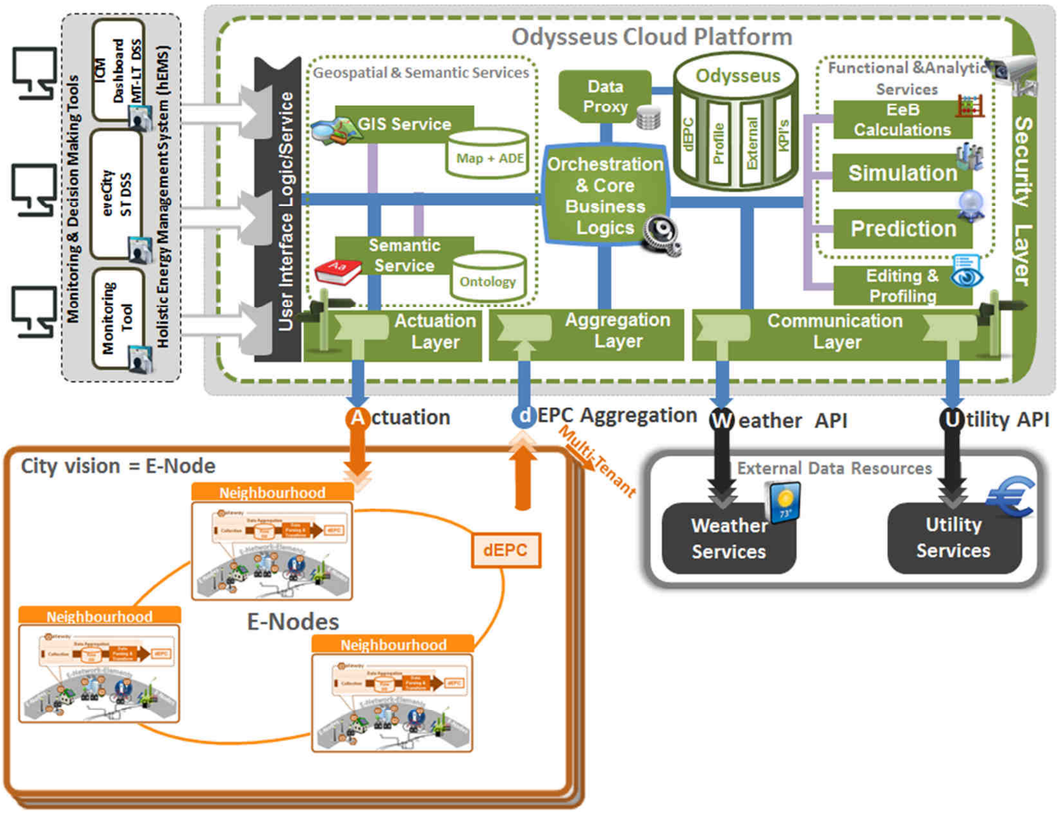


Figure 15 - Odysseus Architecture with City perspective

Here a view is shown where the E-Node is now the neighbourhood, gathering all the information and sending it to the cloud platform. This new higher level view allows an administrator wide control of the city and enables changes at the city level for better global energy management performance.

5 The Odysseus domain: From E-Node to Neighbourhood/District

5.1 Logical approach: E-Nodes (objects) and energy flow (interaction)

From a logical point of view, an E-Node is a basic component in an energy network (E-Network) that can produce, consume or store energy, which the definition of a broad set of components (E-Nodes) within an E-Network. The interaction between E-Nodes defines the energy flow.

The simplicity of the E-Node concept makes it possible to extend the network from a very simple energy system (home appliance) to a neighbourhood or even district level.

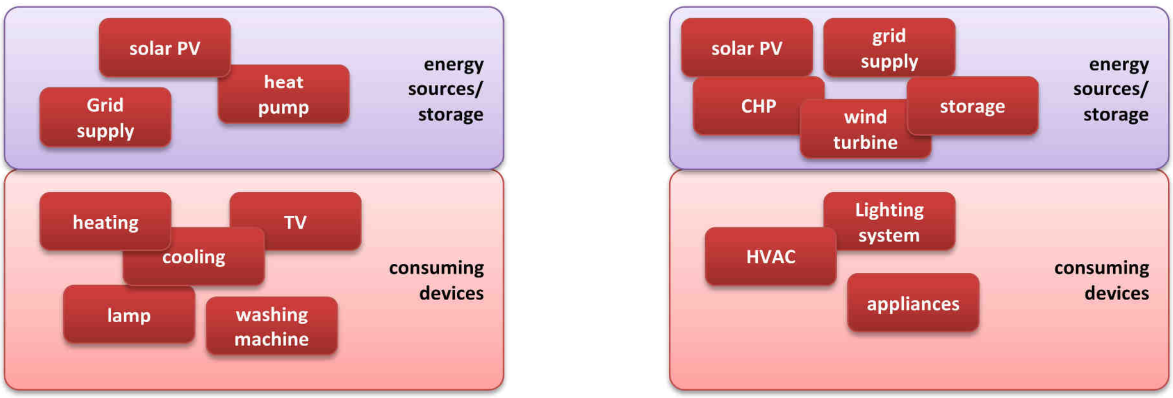


Figure 16 – E-Node: from a home (left) to a building (right)

In essence any energy related system can be defined as an E-Node, characterized by his dynamic Energy Profile Card (dEPC), containing information related to the capacity to produce, consume or store energy.

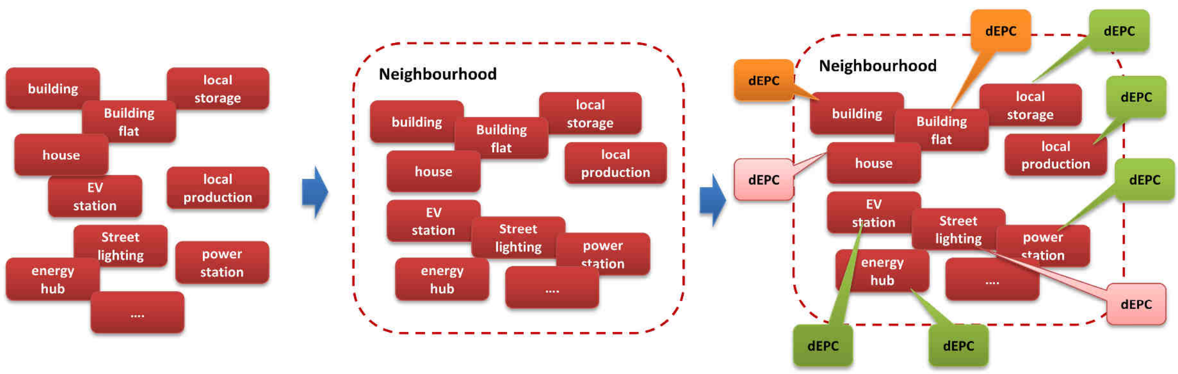


Figure 17- E-Node: from a simple energy system to a neighbourhood

An E-Network can contain very different E-Node types characterized by their dEPC. At urban level within the neighbourhood/district approach, some representative E-Nodes are: buildings, apartments, houses, power stations, street lighting systems, energy hubs, etc.. It is important to stress that an E-Node can be part of another E-Node. This is not an issue because what is really essential, is to know the possible connections between E-Nodes to exchange energy, in other words the energy flow.

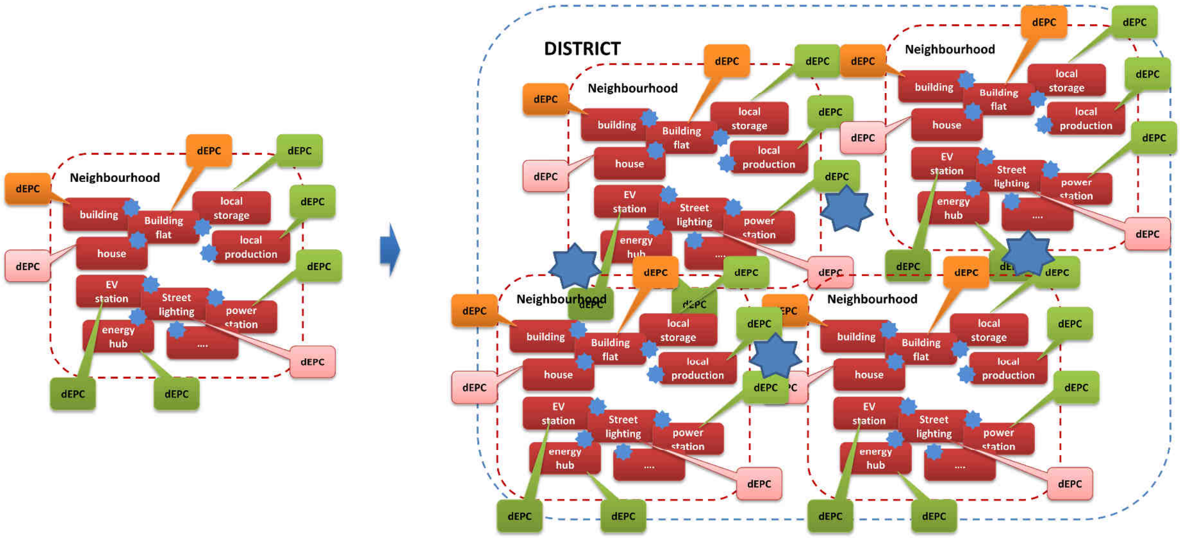


Figure 18 – An E-Node within a district

5.2 Physical approach: data aggregation

Data aggregation is the process that allows measurements from sensors, readings from meters and other data from end devices to be collected through the e-Gateways and exposed to the OCP.

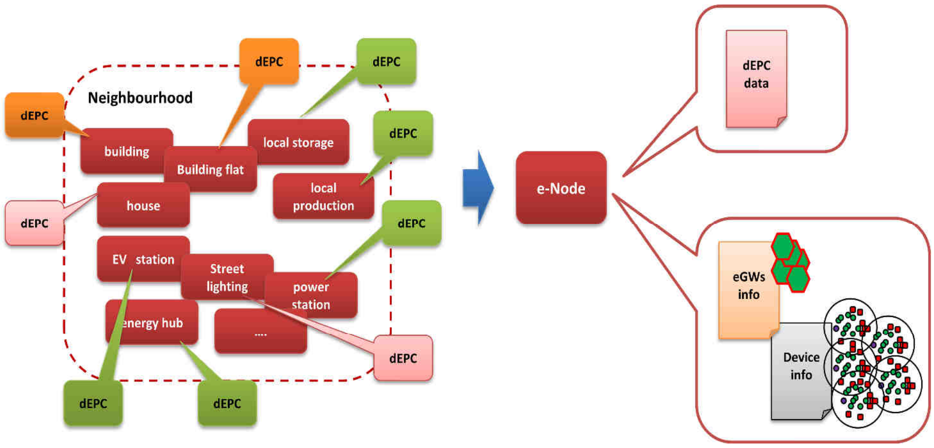


Figure 19 - E-Node data aggregation

Typically it is expected that end devices (sensors, meters, etc.) are connected to the e-Gateway seamlessly. The different technologies (open standards) envisaged to be deployed at the pilot sites (field level) to collect the information necessary will be supported by the e-Gateway, an intermediate abstraction layer to deal with specific data formats and configuration of end devices will be implemented to ensure a smooth integration with the OCP through the e-Gateway. This means that the end devices will be managed at field level by the e-Gateway, configuration (set-up) and monitoring activities will be performed by means of the configuration and monitoring tool to be developed in WP4 Task 4.2 to interact with the e-Gateways.

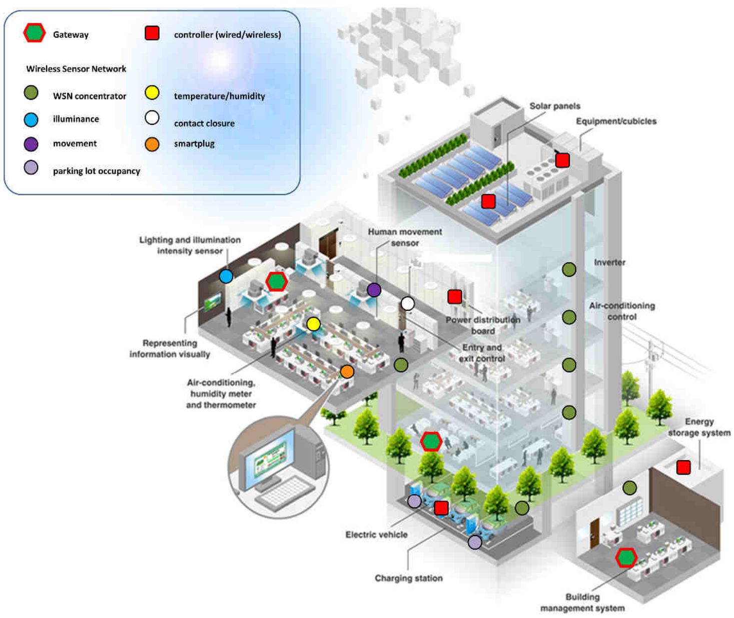


Figure 20 - Example of E-Node definition (building)

Raw data acquired from end devices will be (temporally) stored in the e-Gateways to prevent data loss in case of potential communication failures with the OCP. Raw data will be processed (parsed) and transformed to fit into the data format defined as part of the dEPC structure (mainly dynamic data).

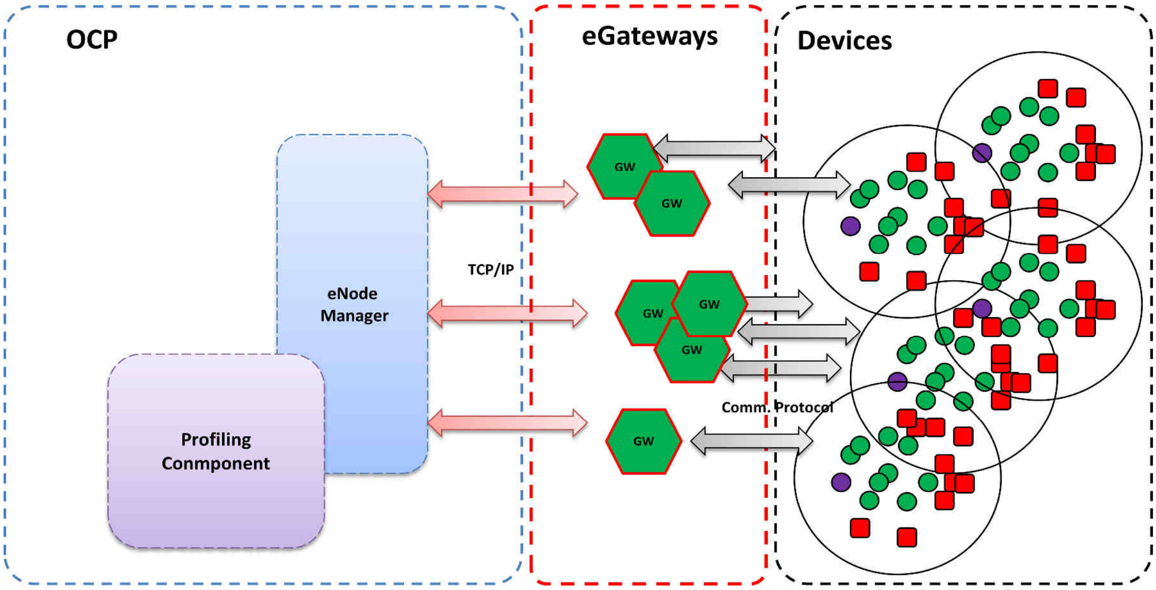


Figure 21 - E-Node definition through OCP profiling service

The definition of an E-Node will be done by the user through the OCP user-interface, the energy systems selected to be part of the E-Node will be assigned to it by selecting the associated gateways and end-devices, mapping the physical layer into the logical layer and defining the granularity and scope of the E-Node.

The operation will be supported mainly by two components of the OCP: the profiling service component and the E-Node Manager. The E-Node manager can be seen as the module of the OCP that has all the information related to the physical components of an E-Node (e-Gateways, sensors, metering devices, actuators, etc.), its hardware infrastructure. It is also expected that the E-Node Manager has part of the dEPC information, but this will be addressed further during the platform implementation process. Figure 17 illustrate graphically the relationship between these concepts.

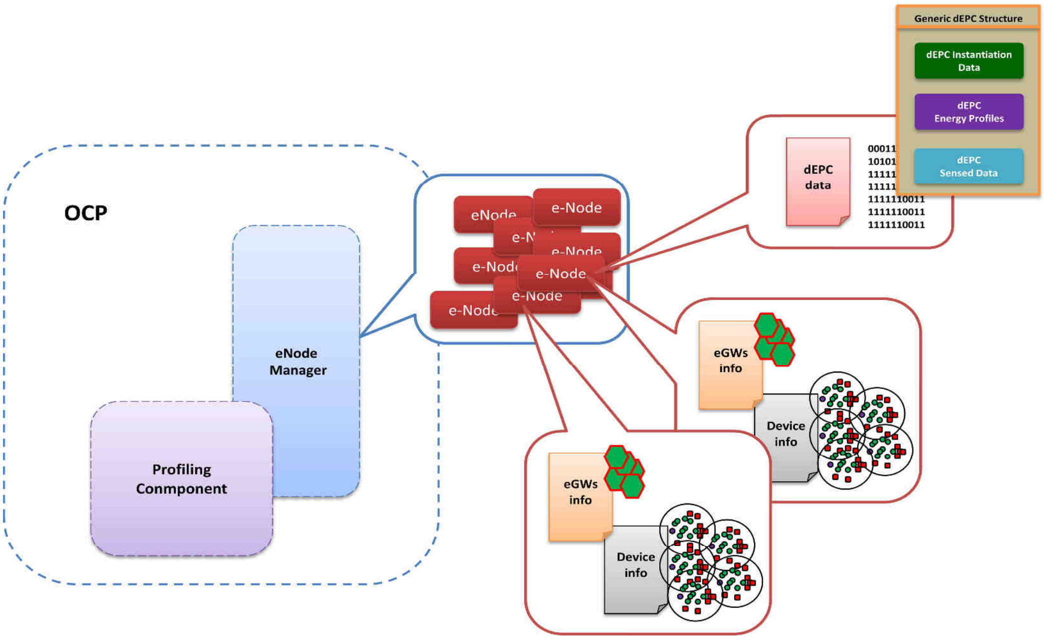


Figure 22 - E-Node and dEPC

5.3 External factors

5.3.1 *Weather*

Predicting weather conditions is an important issue for anticipating energy generation or consumption by some E-Nodes whose performance depends on outside temperature, solar irradiation or wind speed. Several ways are possible to predict weather. Some algorithms allow forecasting weather data from current and historical weather data. For instance, a method is being developed at CSTB to predict the next six hours weather conditions (outside temperature, direct and diffuse solar radiation) using a neural network approach.

Another possible method consists in relying on dedicated services that provide weather forecasts in different locations from some hours to several days ahead. Free websites are commonly providing air temperatures, humidity, and wind speed on an hourly basis for the coming 24 hours and beyond, but only “sky coverage” (like sunny, cloudy, partly cloudy, rainy, etc.) instead of accurate global solar irradiation. In that case, it should be necessary to use a conversion software tool to convert this sky coverage into global irradiation. Weather information can be often accessed through web services, following a custom data structure. A typical example is weather.com. Besides, GRIB format weather information providers allow ftp access to get the necessary information, instead of providing web service access. GRIB is the standard format originated from WMO (World Meteorological Organisation) that is used by the meteorological institutes of the world to exchange weather data. These GRIB weather files (.grib) can be obtained from a worldwide network formed by several sources like the NOAA web site, AEMET, etc. The source or group of sources that will provide the data depend on the location and the information requested.

The ODYSSEUS platform will include a weather service (see figure 23) that will provide other ODYSSEUS services (e.g. analytic services) with such weather forecast data for the neighbourhood location, in particular for the pilot sites. It will basically provide data that may come from different weather forecast providers.

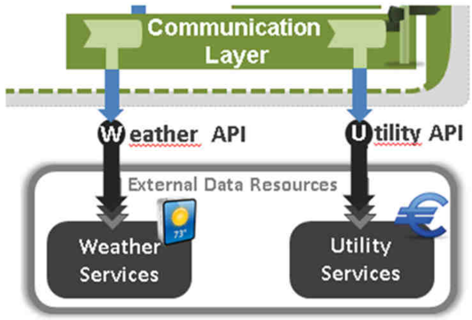


Figure 23 – External Services in architecture

Weather API		
Method	getWeatherForecast	
Expected Input Data	**Expected Output Data**	**Description**
startDate, endDate, location, requestedWeatherDataList	weatherForecast (object)	Request to an external weather service for weather forecast information for a certain location

Table 3 – Weather API

5.3.2 *Energy prices*

The introduction of dynamic pricing for consumers has many advantages both for utilities, since it better reflects the actual variation of energy costs over time, and for consumers because they can then manage their energy consumption more smartly and potentially make savings. Even if dynamic pricing is still not deployed for residential customers (depending on the contract passed with the energy retailer, tariffs may vary from one day to another one and/or from one time slot to another - e.g. day and night tariff, but as yet hourly prices are not used in the residential sector), energy management systems, at level of individual dwellings or global neighbourhood, need to evolve to integrate flexible hourly prices in a smart grid approach.

Today, the wholesale market is the unique reference to track the evolution of energy prices on an hourly basis, depending on the location where transactions are made. In this way several "power spot markets" provide historical data as well as future hourly prices for the day ahead. For instance, figure 24 (below) is a typical chart for day ahead prices on the German Spot Auction as provided by EPEX SPOT, for the 28th of February 2012.

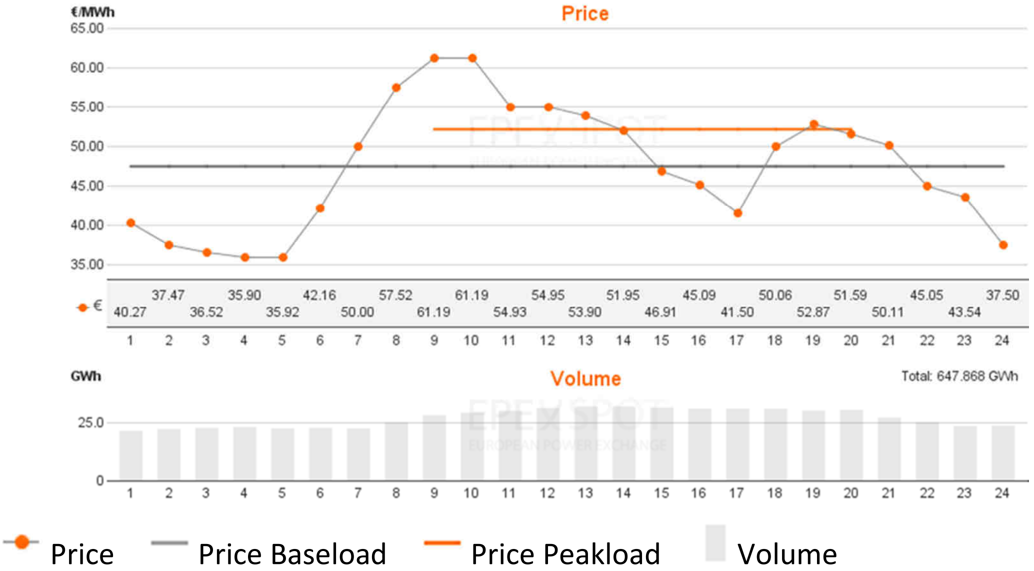


Figure 24 - Example of evolution chart for Day Ahead prices on German market spot (Source EPEX SPOT)

A corrective factor needs to be applied to convert these wholesale market prices into more realistic prices potentially applicable to residential customers. Indeed, those prices are for "the energy bought" only as they don't include additional costs to be paid by the end-users, e.g. for using the distribution and transmission network, or for contracted power. For this reason the wholesale energy market price may increase by 2 or 3 times, or even more, depending on the operating conditions. However the spot prices provide a good indication on the price evolution, and can therefore be used to simulate future flexible prices for end-users by multiplying them with a certain factor depending on the country.

Getting prices from a web site like EPEX SPOT, however, is not straightforward. In order to automatically import such data an ftp account is needed, and this is only available on subscription (around 600 €/year). To (partially) get around this issue, it is possible to use the Spanish electricity spot market Red Electrica (http://www.ree.es). The information is restricted to Spain and Portugal, but the advantage is that energy prices for the day ahead can be freely downloaded in structured files (XML, Excel). However, this can only be done manually since there is no free ftp or web services access. The information is available at http://www.esios.ree.es/web-publica/.

For instance, for the same day, 28th of February (as illustrated in figure 25), the Day Ahead prices given by Red Electra are as shown in figure 25 (prices are given in €/MWh for the first 12 hours):

Country	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12
Spain	51.02	47.69	41.00	39.65	40.93	41.57	49.00	60.68	60.09	60.07	55.52	55.52
Portugal	57.00	47.69	41.00	39.65	40.93	41.57	49.00	60.68	60.09	69.00	71.00	68.45

Figure 25 - Marginal prices in Spain/Portugal Day Ahead Market (€/MWh) – 28/02/2012 (Source Red Electrica)

Energy Prices API		
Method	getDayAheadEnergyPrices	
Expected Input Data	**Expected Output Data**	**Description**
energyType, startDate, endDate, location	energyDayAheadPrices (object)	Request to an external service providing energy prices for the several kind of energies available (electricity, heat, …), for a certain location

Table 4 – Energy Prices API

6 Odysseus Cloud Architecture

6.1 Aggregation layer

The aggregation layer is the responsible for the interface functionality of the cloud platform to insert data from the pilot.

Aggregation API Generic Overview		
Method	aggregatedEPCMessage	
Expected Input Data	**Expected Output Data**	**Description**
dEPC Info, tenantCode	Result	Aggregate a message to the platform at a certain timestamp. A message is a generic abstraction of the dEPC card from an on field E-Network-Node
Method	aggregatedEPCMessages	
Expected Input Data	**Expected Output Data**	**Description**
List<dEPC Info>, tenantCode	Result	Aggregate a set of E-Network-Nodes eEPC messages to the platform.

Table 5 – Aggregation API

Proposed Technologies	
Technology	**Reason**
ESB	One of the most important reasons to propose an Enterprise Service Bus middleware for the aggregation layer is the flexibility to adapt easily to different types of connections.
SOAP	The communication between the E-Nodes and the platform Odysseus could follow the SOAP standards. The main

	reason for this is the better way to expose a contract between the parts (platform and E-Gateway). The security enhancement and transaction extensions are other reasons to prefer it rather than other communication protocols like REST.
REST	The reasons to use the REST guidelines for the communications between the gateways and the cloud platform is its ease of implementation and the low client requirements compared with SOAP. Advanced features (security, traceability, etc.) should be implemented from scratch.

Table 6 – Proposed Technologies

6.2 Actuation layer

The actuation layer is responsible for communicating with each gateway, to send commands from the platform.

Actuation API Generic Overview		
Method	operateOnE-Gateway	
Expected Input Data	**Expected Output Data**	**Description**
List<commands>	Result	Send commands to the gateways to operate from the platform.

Table 7 – Actuation API

Proposed Technologies	
SOAP	The communication between the E-Nodes and the Odysseus platform could follow the SOAP standards. The main reason is the better way to expose a contract between the parts (platform and E-Gateway). The security enhancement and transaction extensions are other reasons

	to prefer it rather than others communication protocols like REST.
REST	The reason to use the REST guidelines for the communications between the gateways and the cloud platform is its ease of implementation and the low client requirements compared with SOAP. Advanced features (security, traceability, etc.) should be implemented from scratch.

Table 8 – Proposed Technologies

6.3 Communication layer

The communication layer has the responsibility to establish connections with the external services of the platform. The services foreseen to connect are Weather services for obtaining weather forecasts and Utility services for obtaining expected energy prices for the several networks.

Communication API Generic Overview		
Method	weatherDataRequest	
Expected Input Data	**Expected Output Data**	**Description**
dataType, dataTypeMode, startDate, endDate, locationRequestList, elementRequestList	weatherDataResponse	Request to an external weather service for weather forecast information for a certain location.
Method	getEnergyPriceCosts	
Expected Input Data	**Expected Output Data**	**Description**
energyType, startDate, endDate, locationRequest	energyDataResponse	Request to an external billing service for energy prices for the several kinds of energy available (electricity, heat, …) for a certain period of time and at a certain location

Table 9 – Communication API

Proposed Technologies	
Technology	**Reason**
ESB	The most important reasons to propose an Enterprise Service Bus middleware for the communication layer is the flexibility to adapt easily to different types of connections.
SOAP	The communication between the E-Nodes and the platform should follow the SOAP standards. The main reason is the better way to expose a contract between the parts. The security enhancement and transaction extensions are other reasons to prefer it rather than others like REST.

Table 10 – Proposed Technologies

6.4 Orchestration & core business logic services

Regarding to the orchestration and core business logic services, the expected functionalities to be provided are related to deal with the control of the platform. In other words, to be the coordinator of the collaboration among services and bricks through service processes within the ´heart´ of the platform. These services provide the ´glue´ to the platform bricks and how they interrelate for the Odysseus Cloud Platform to make sense."

Orchestration & Core Business API Generic Overview		
Method	Aggregate	
Expected Input Data	**Expected Output Data**	**Description**
Message	Result	Aggregate data from the incoming E-Nodes
Method	createTenant	
Expected Input Data	**Expected Output Data**	**Description**
name, code, description, adminTenantUser,	Result	Create a new Tenant

adminTenantPassword		
Method	removeTenant	
Expected Input Data	**Expected Output Data**	**Description**
code	Result	Delete an existing Tenant
Method	login	
Expected Input Data	**Expected Output Data**	**Description**
User, HashPassword	Ticket	Login in the system
Method	Logout	
Expected Input Data	**Expected Output Data**	**Description**
User	Result	Logout
Method	addUser	
Expected Input Data	**Expected Output Data**	**Description**
tenantCode, userID, userPassword, description	User	Create a new User
Method	removeUser	
Expected Input Data	**Expected Output Data**	**Description**
tenantCode, userID	Result	Remove an existing User
Method	editUser	
Expected Input Data	**Expected Output Data**	**Description**
tenantCode, oldUserID, newUserID, newPasswordID, newDescription	User	Edit an existing user

Table 11 – Orchestration and Core Business API

Proposed Technologies	
Technology	**Reason**

Java	Java technology provides a very easy implementations of specifications for the integration with other technologies, provides a proved ecosystem technology implementation, supports multiplatform solutions, and offers a wide set of solutions

Table 12 – Proposed Technologies

6.5 Functional & Analytics services

The analytics services are services that aim at providing the right information and at a level needed to monitor the neighbourhood E-Nodes. As required in the D1.2, these analytics services allow for a given node calculations like:

- Duration of use and duration of no-use (total time / over a given period of time);
- Instant / Average / Cumulated / Min and Max of the measured value(s) (total time / over a given period of time).

These services need to interact at least with a data-service that is able to store and retrieve coupled data (the value of the measure and the time of the measurement).

It is also important to mention higher level services that will ensure other functions based on results provided by the previously mentioned services. For instance, having stored "Average / Cumulated / Min and Max of energy consumption of a given E-Node, it is thus possible to envisage other services like:

- Detection of energy loss by analysing past energy behaviour of the considered E-Node and current values of consumption and alert the users.
- Prediction of future energy behaviour based on past records. Based on these predictions and other external information like weather conditions, peak of demand, energy tariff price, it is possible to determine periods during which there could be energy shortage or a higher price and to alert the end users in order to allow them to react and adapt their behaviour. Information like "Peak of Demand" or "Energy Tariff Curve" are typically data that are external to the system and it is envisaged here that they will be provided to the system by third parties (actors like ESCOs for instance).
- Simulation of energy behaviour. This is very close to the "prediction" services. The simulation will make use of existing data and models to simulate the behaviour of different configurations. For instance the simulation services will be used to answer

the question "what is the new energy behaviour if a new CHP is installed in the considered E-Node?" as the prediction services will focus on future behaviour of existing E-Node taking into account the foreseen / forecasted variability of existing variables (weather conditions, number of occupants, etc.).

This set of services is represented in the in Figure 26 below:

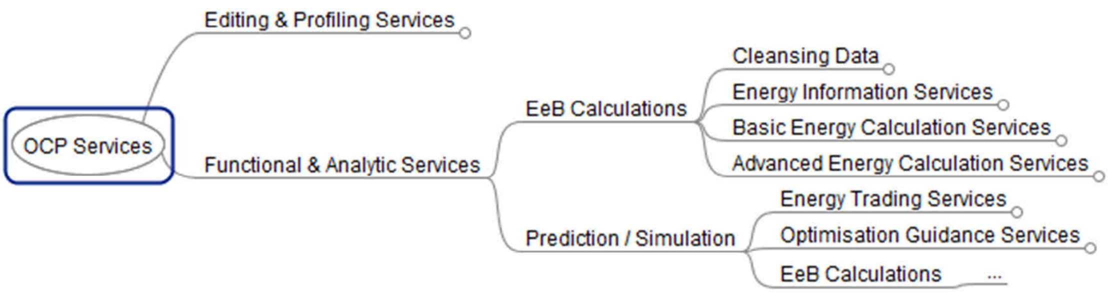


Figure 26 - Taxonomy of analytics and functional services

6.5.1 *EeB Calculation Services*

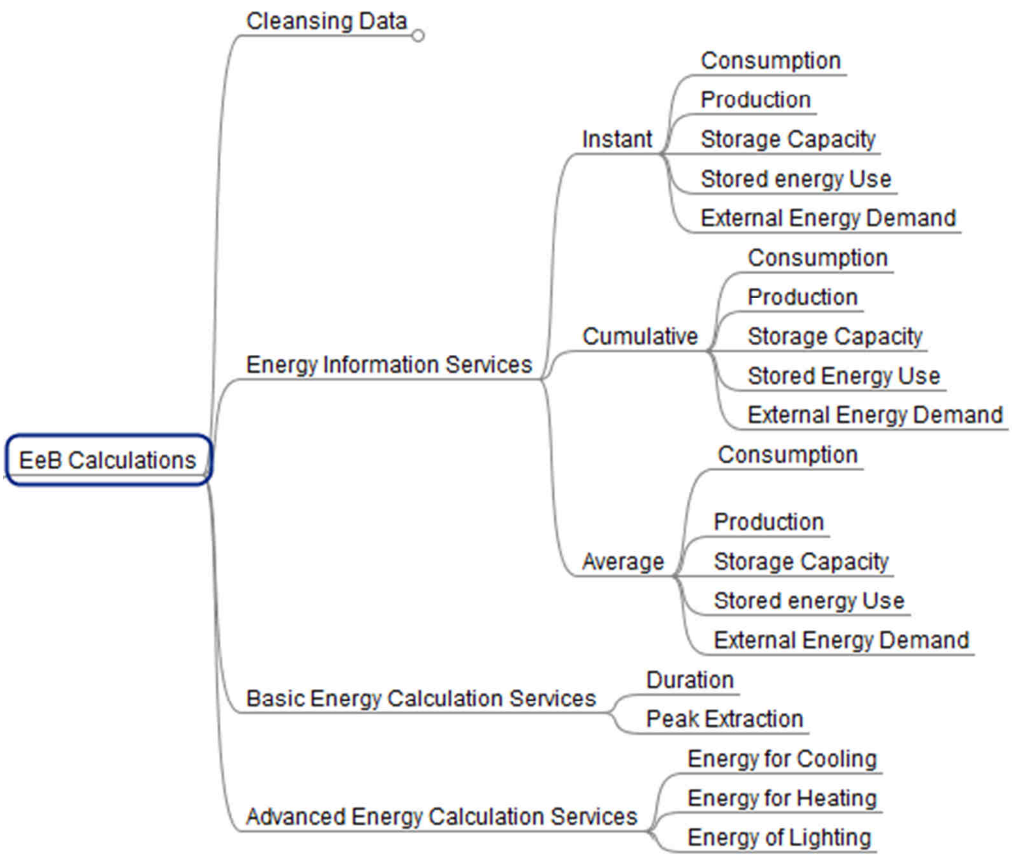


Figure 27 - EeB Calculation services

The cleansing of data service is the first basic service that should be used for cleaning incoming data/information. It covers the detection of errors /artefacts /aberrant values based on the history (already stored values or already defined profile or range of use) of the device. It will allow cleaning the measures by identifying potential artefacts (measurement errors / wrong values) that are out of the normal range of past values.

Cleansing Data Services		
Method	Error_detection	
Expected Input Data	**Expected Output Data**	**Description**
List<StructuredMeasures>	List<StructuredMeasures>	This service is able to detect artifacts / errors of 2 types: - Values that are out of range for the considered E-Node (depend from the configuration of OCP) - Values that are significantly out of the expected range (based on past/learned behavior)
Method	Unit_transformation	
Expected Input Data	**Expected Output Data**	**Description**
List<StructuredMeasures>	List<EnrichedData>	This service transforms the current measure into the corresponding value it is supposed to represent in the appropriate unit.

Table 13 – Cleansing data services

Based on the cleansed data, the Odysseus platform must be able to calculate instantaneous values for energy consumption, production or storage of any network node, as well as energy flows between nodes. These calculations will be done by the "Energy

Information Services" that are designed to provide not only instant values but also cumulative and average values.

Energy information Services		
Method	Instant_Energy_Consumption	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	Result	Gives the total instant value of the energy consumption
Method	Instant_Energy_Production	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	Result	Gives the total instant value of the energy production
Method	Instant_Energy_Storage_Capacity	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	Result	Gives the total instant amount of energy that CAN BE STORED
Method	Instant_Stored_Energy_Use	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	Result	Gives the total instant value of energy that is consumed from a storage element.
Method	Instant_External_Energy_Demand	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	Result	Gives the total instant amount of energy that is demanded by other external E-Nodes.

Table 14 – Energy information services

Long Time Energy information Services

Method	Cumulative_Energy_Consumption	
Method	Cumulative_Energy_Production	
Method	Cumulative_Energy_Storage_Capacity	
Method	Cumulative_Stored_Energy_Use	
Method	Cumulative_External_Energy_Demand	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, startDate, endDate	dEPC	All the above mentioned methods are similar to the "instant" ones, except they express the cumulative value between two dates.
Method	Average_Energy_Consumption	
Method	Average _Energy_Production	
Method	Average _Energy_Storage_Capacity	
Method	Average _Stored_Energy_Use	
Method	Average _External_Energy_Demand	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, startDate, endDate	dEPC	All the above mentioned methods are similar to the "instant" ones, except they express the average value between two dates. These methods may be used by the cleansing service in order to detect malfunctions.

Table 15 – Long time energy information services

The Odysseus solution should also be able to display time-related energy profiles (from historical data), and calculate the average and/or cumulated energy values for any network node, over a given period. Duration of use, min/max values, are also information that can be useful to provide depending on the pilot case. This information is available through the

Basic Energy Calculation Services described below.

Basic Energy Calculation Services		
Method	Duration	
Expected Input Data	**Expected Output Data**	**Description**
boolean	Result (value)	Used at each actuation. This service store for each E-Node the duration of use or no use between two dates. The result is expressed in seconds.
Method	Peak_extraction	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, startDate, endDate	dEPC	This service extracts from any E-Node or series of E-Nodes, the min and max values. It could be coupled with other services in order to extract min instant consumption/max energy storage used etc. (see the other services defined).

Table 16 – Basic energy calculation services

The OCP must also be able to aggregate some measured data according to building partitions (e.g. floors) or types of loads (e.g Lighting, HVAC, etc.). These functionalities are supported by the “Advanced Calculation Services” described below.

Advanced Calculation Services		
Method	Energy_for_Heating	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, startDate, endDate	dEPC	Based on dEPC measures and semantic this service calculates

		the energy used for heating the Node
Method	Energy_for_Cooling	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	dEPC	Based on measures and composition of the E-Node, this service calculates the energy used for cooling the Node
Method	Energy_for_Lighting	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, startDate, endDate	dEPC	Based on measures and composition of the E-Node, this service calculates the energy used for lighting the Node

Table 17 – Advanced energy calculation services

6.5.2 *Prediction & Simulation Services*

Figure 28 – Prediction & simulation services

Energy Optimization Guidance Services		
Method	Energy_Profile_Anomaly_Detection	
Expected Input Data	**Expected Output Data**	**Description**

dEPC	Result (Alert)	Based on the analysis of previous energy behavior and current measures, this service checks if there are some deviation in the energy profile and sends an alert if so
Method	Energy_Optimisation (heating/cooling/lighting)	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, external conditions (weather), number of occupants, energy grid information	dEPC	Based on set points and different variables (number of occupants, weather conditions, energy shortage, etc.), this service is able to propose a solution to adapt the energy profile of the E-Node (i.e. decreasing the temperature set point in order to save energy ; lower the lighting intensity because of fewer occupants in given rooms; etc.)
Method	Peak Alert detection	
Expected Input Data	**Expected Output Data**	**Description**
dEPC, external conditions (weather), energy grid information	dEPC	Based on past / current / future energy consumption, external information (weather forecast, information from other E-Nodes), this service is able to detect an up-coming energy peak and alert the users
Method	Prediction_Simulation_EeB_Calculation	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	dEPC	This service will be available for all previously listed energy calculation

		services (instant/average/cumulative/ production/storage/consumption/etc.). Based on learned behavior, external data (weather for instance), this service will enable forecasting of various energy related scenarios (when used for prediction) or this service will be used to design new solutions when used to simulate new E-Node behavior.

Table 18 – Energy optimization guidance services

6.6 Platform editing and profiling

The users of the platform need different services in order to interact with it and adapt their energy behavior according to the information and advices given by the OCP.

These services are divided into two categories, the services dedicated to the user(s) and the services dedicated to the modeling of the E-Node network (Figure 29).

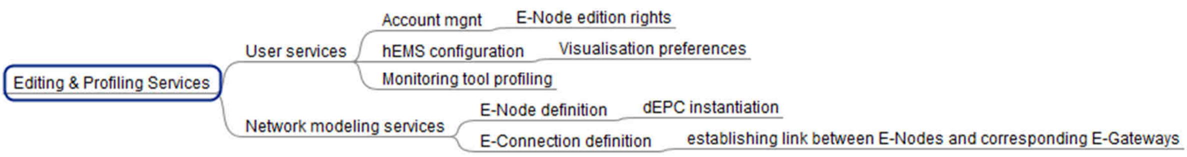


Figure 29 - Taxonomy of Editing & Profiling services

User Services		
Method	Account management	
Expected Input Data	**Expected Output Data**	**Description**
dEPC , user account	DEPC , user account	This service is linked with the "Orchestration & Core business API" described earlier in the document. It allows, according to the account rights to select from a dEPC which information

		the user wants to see. It also aggregates some information together.
Method	hEMS configuration	
Expected Input Data	**Expected Output Data**	**Description**
User access rights, dEPC	dEPC	This service will provide the user with all the required functionalities to set up his/her dashboard with the information s/he wants to have. It could be simple variables (T°, weather forecasts or complex information (like power consumption of the HVAC system). All these combinations will be based on the availability of the services defined in the previous chapter.
Method	MonitoringTools_profiling	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	dEPC	This set of services allows the end users to (pre)define different scenarios, set points, min or max value and behavior in order to enable the system to have predefined reactions according to some situations (i.e generation of an alert when a variable comes above a given value)

Table 19 – User services

Network modeling services

Method	E-Node_Definition	
Expected Input Data	**Expected Output Data**	**Description**
BIM/GIS data, dEPC	dEPC	This service defines how an E-Node is composed and what are the relevant parts in its dEPC to be used and to be combined together (i.e aggregation of zones in a building)
Method	E-Connection_definition	
Expected Input Data	**Expected Output Data**	**Description**
dEPC	dEPC	Beside the previous service, this one allows the creation/definition of links between E-Node and E-gateways in order to connect the OCP to the different sensors, actuators and more generaly to the real elements that compose an E-Node.

Table 20 – Network modelling services

6.7 Data Services (GIS & Semantics)

Two kinds of information are stored in an open structure and format: area maps and E-Node information within those areas. The maps are stored in an open source CityGML server called Deegree3D. The E-Node information is contained in an open source Semantic Server called Fuseki.

This data is available for platform internal and/or external software functionalities via import/export (in cloud terms: upload/download) and via direct access interfaces in the form of web services (WFS/WMS in the case of GIS) or query language (SPARQL in the case of semantics).

Both information structures or the corresponding content can be accessed that way.

Currently the services are running at:

- Deegree3D: http://134.221.193.81/deegree/
- Fuseki: http://vcon2.tno.nl:3030/

Functionally the system needs a fully open semantic database. The platform however also requires an underlying implementing relational database due to requirement for scalability, performance, etc., issues that are historically resolved with relational databases. The ideal situation is a server like D2RQ which provides a semantic view on the relational SQL database, without the need to duplicate the data (and all the synchronization problems). Also solutions will be investigated that map the semantic data to a relational one (requiring the need of synchronization, etc.).

6.8 User interface logic & services

The end user clients of the platform will require the services being offered through the user interface logics and services for visualizing the Odysseus information on graphical user interfaces (GUI). These interfaces will be utilised from the Monitoring & Decision Making Tools for representing the information.

User Interface Logic & Services API Generic Overview	
Method	getKPIList
Description	Obtain the list of available KPIs
Expected Input Data	**Description**
-	-
Expected Output Data	**Description**
KPI List	List of available KPIs
Method	getENodesArea
Description	Obtain the list E-Nodes for a certain Area
Expected Input Data	**Description**
Area	Area to work with
Scope	Scope code to filter

Energy Source	Energy Source filter
Energy Lifecycle List	List of Energy lifecycle to filter
KPI List	List of KPIs to search relative to the E-Nodes found
Period Timeline	Period timeline to filter KPIs information
Expected Output Data	**Description**
eNodesList	List of available E-Nodes on the specified geographic area, filtered by the scope, energy source, energy lifecycle. Each E-Node should have the information of the summarized KPIs at the vision scope. Something like: **<enodes>** **<enode type="house" id="12345" type="consumer" position="x,y">** **<kpis>** **<kpi id="1" description="co2 reduction" value="1"/>** **<kpi id="2" description="Consumption" value="0.5"/>** **</kpis>** **</enode>** **</enodes>**
Method	getDEPCDetailedInfo
Description	Obtain the detailed info for a certain dEPC.
Expected Input Data	**Description**
depcCode	Code of the dEPC to show
Energy Source	Energy Source filter
Energy Lifecycle List	List of Energy lifecycle to filter
KPI List	List of KPIs to search relative to the E-Nodes found
Period Timeline	Period timeline to filter KPIs information.
Expected Output Data	**Description**
depcInfo	Structure with all the relevant data of the dEPC info. This structure needs to fill the dEPC ontology model for an E-Node, by including basic, static information and the

	dynamic one: - KPIs info summarized for the period - List of points for every KPI (for statistical purposes)

Table 21 – User interface services

Proposed Technologies	
Technology	**Reason**
Java Portlets 2.0	Modularity is one of the main reasons to propose Java Portlets as the basic framework to expose the user interface.
Liferay	As a portlet framework portal for publishing them. Liferay is an open source solution, with a great community and integration in other platforms.
Qt/C++	eveCity is a standalone solution that will develop in the same timeframe of Odysseus (see the next section in the document) through a specific module in order to be able to interact with the OCP via SOAP messages (or equivalent). The technologies used to develop this module are Qt/C++.

Table 22 – Proposed technologies

6.9 Security aspects

Security is a must for the OCP platform, and need to be taken into account from different perspectives, always in the direction of a cross non-functional quality attribute that might be implemented on a service approach. These security quality attributes will differ from logical and physical aspects. Only logical ones will be considered in this section.

The OCP platform security must be focused on guaranteeing that Authentication, Authorization and Accounting topics, jointly with Communications among systems and services are being addressed in order to avoid threats (e.g. communication tampering, man in the middle attack, etc.).

Security	
Transport / communication(Confidentiality and integrity)	The transport protocol should always be secured using standards like SSL/TLS that will encrypt communication. The information should not be modified and should not be inspected by third parties, during the transportation. This kind of scenarios doesn't require any additional investment for security. The confidentiality during the process is granted because of the trusted scope between the pilot sites and the OCP (meaning the physical and perimeter security, are out of the scope of this project)
Authentication	Both, client and server should be authenticated in order to ensure that both are known, and are who they say they are (by guaranteeing the trustworthiness of the solution). To ensure this the server should use a server digital certificate with private and public security key to identify it. The client should always check that the certificate is valid. On the other side, when the conversations (interchange of information) are in a machine to machine (M2M) basis, the client should present a certificate to the server, and the server should validate it against a white list of certificates (public/private certificates). In the scope of the project, the platform could generate its own certificates by a custom auto signed PKI and an expiration date for twenty years, avoiding problems for maintenance. In other cases, the end users (physical persons) should authenticate by a user and password in the platform.
Authorization	Authorization should be done at the server side by ensuring that the client has got the grants (proper rights and permissions) for certain actions on the cloud platform. One of the most basics authorization mechanisms that must be guaranteed for multi-tenancy support of the platform is to fit the information showed

	and modified only to the corresponding tenant of the granted user.
Accounting	The server should audit all the actions performed at the server by different users by logging critical actions that might compromise the platform.

Table 23 – Security aspects to cover

Proposed Technologies	
Technology	**Description**
openLDAP	It is an Open Source Software (OSS) implementation of an LDAP server. It provides an organized set of records for managing grants. A common usage of LDAP is to provide a "single sign-on" mechanism between services.
JAAS	Java Authentication and Authorization service is a the de-facto standard when securing applications in the Java world.
Spring Security	Similar to the JAAS implementation, covering all the security aspects for a secure web application.
SSL/TLS	Cryptographic protocols that provide communication security over the internet using asymmetric algorithms by encrypting the communications. It defines how a browser or e-mail client communicates with a server using an

	encrypted connection or data stream.
WSS (Web Service Security)	WS-Security[2] (Web Services Security, short WSS) is an extension to SOAP to apply security to web services. It is a member of the WS-* family of web service specifications and was published by OASIS. The protocol specifies how integrity and confidentiality can be enforced on messages and allows the communication of various security token formats, such as SAML, Kerberos, and X.509. Its main focus is the use of XML Signature and XML Encryption to provide end-to-end security.

Table 24 – Proposed technologies

[2] http://en.wikipedia.org/wiki/WS-Security

7 The Odysseus hEMS solution

7.1 hEMS introduction

As already introduced in chapter 4, the whole sets of services described earlier are designed to enable the management of energy at the neighbourhood level.

A holistic Energy Management System (hEMS) should provide a comprehensible /scalable / configurable user interface in order to help the various potential users (citizens, city managers, ESCOs, Building managers, etc.) to control / monitor / manage the district from an energy point of view.

In the context of the project, two solutions are selected that cover the three time stages envisaged. Namely, the eveCity tool (developed by CSTB) will address the short term aspects and the ICM Dashboard (developed by Advantics) will address both the midterm and the long term aspects.

7.2 Monitoring tools

The monitoring tools (to be developed in T4.2) will provide access to the field devices (e-Gateways, sensors, meters, controllers, etc.) that will be deployed at the pilot sites to support:

- device configuration
- data collection
- potentially local actuation (if supported at the device level)

The set of tools will be developed to allow them to be used in a standalone mode or integrated into the Odysseus Platform Cloud (OPC).

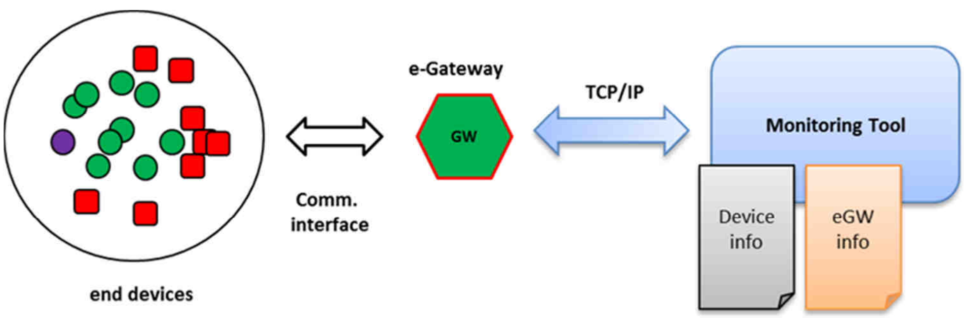


Figure 30 - Monitoring Tool, standalone version

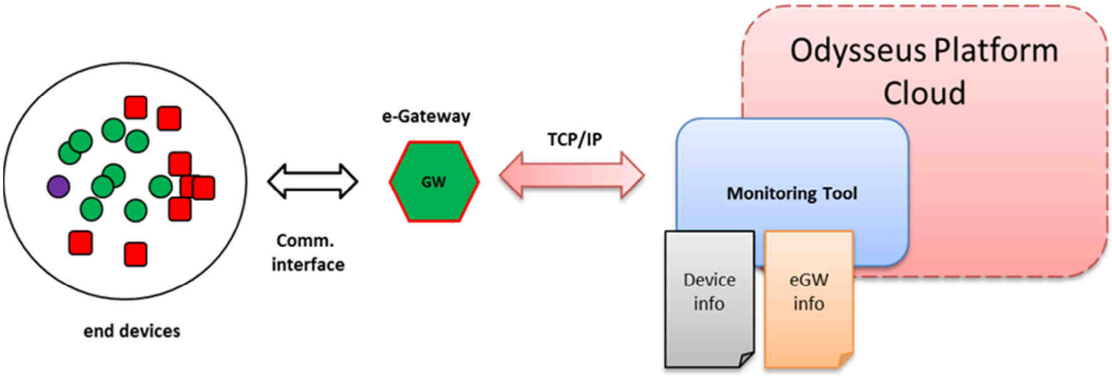


Figure 31 - OPC integrated version

Monitoring tool functionalities will be supported by the e-Gateway. The role of this device is to act as logical and physical bridge between the monitoring tool (standalone or integrated version) and the end devices (meters, sensors, controllers, etc.). According to the architecture proposed, we can see an E-Node associated to a collection of e-Gateways (see Figure 32). The tool will be able provide access to data from end devices (raw) data up to E-Node level aggregation (dEPC data model).

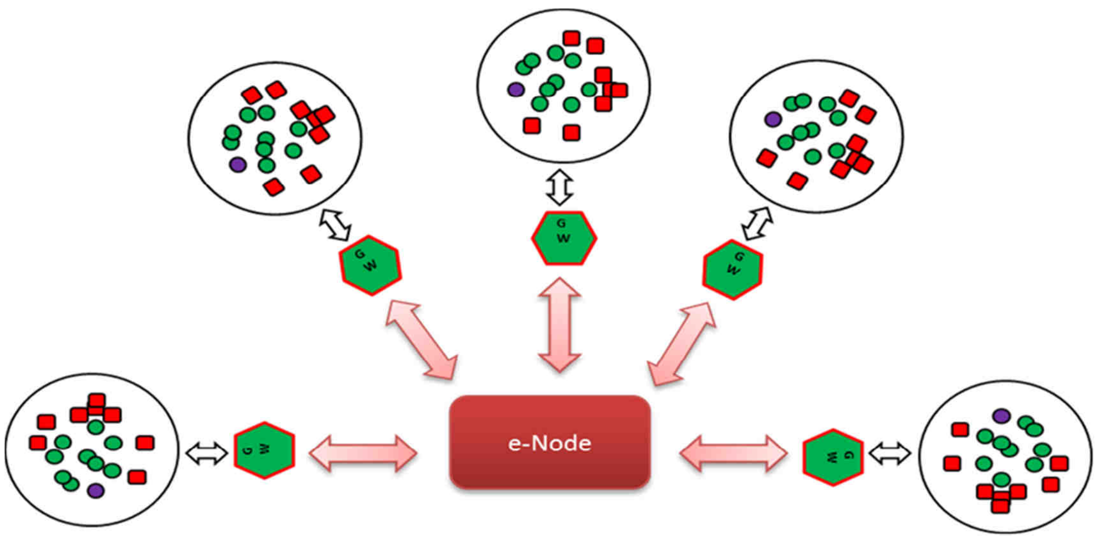


Figure 32 - E-Node associated to a collection of e-Gateways

The configuration of field devices should be handled by the monitoring tool, during the setup of the devices deployed as part of the hardware OPC infrastructure. It will be supported by a user interface to be developed as part of the tool (T4.2). As different (open) technologies will be used (wired and wireless) to articulate the hardware infrastructure for monitoring, a communication abstraction layer will be implemented in the e-Gateways to support widely used open communication protocols (like 'modbus' or 'modbus over 802.15.4').

Figure 33 below shows the main functionalities supported by the e-Gateway and the monitoring tools.

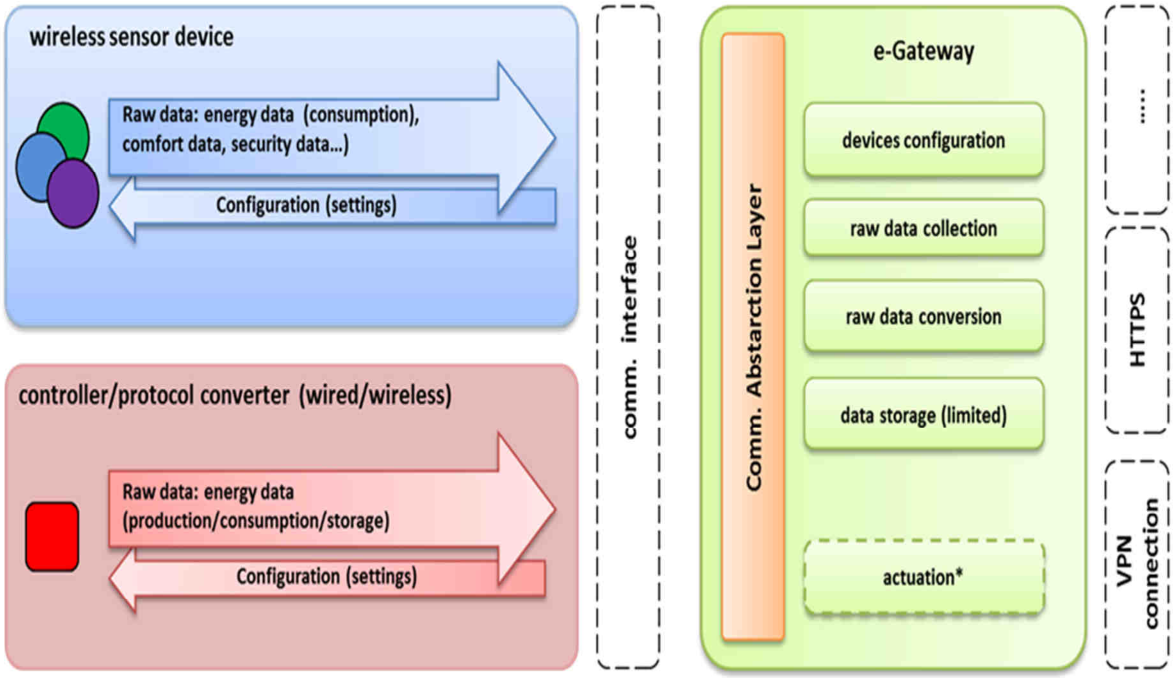


Figure 33 – e-Gateway support functionalities

Raw data collection will mainly include energy measurements, readings from the different meters, sensors and controllers. But also data for device management will be collected, like connectivity, status or configuration.

Monitoring tools will allow to access any device mapped into the hardware infrastructure (from e-Gateways to end devices), to retrieve what is called raw data, information related to energy parameters or device configuration or dEPC information (at E-Node level), raw data processed and presented as partial dEPC information (Figure 34 and Figure 35).

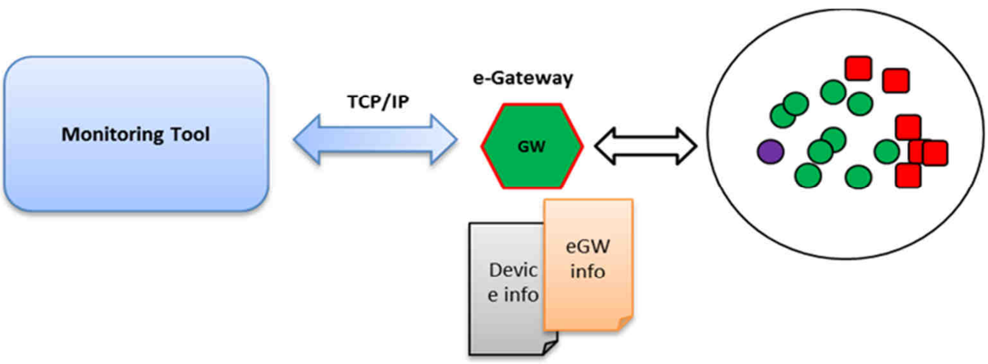


Figure 34 – Access to RAW data

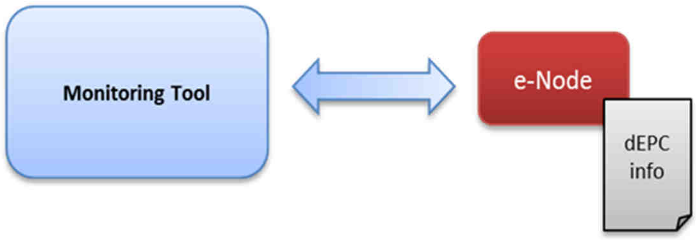


Figure 35 – Access to dEPC information

7.3 Existing decision support tools

7.3.1 *eveCity solution*

CSTB implements CityGML models within a software integrated platform called eveCity (eveCity for "Enriched Virtual Environment for the City") dedicated to research (prototype versions) and/or more operational offers (release versions) for use at the city or district scale. It is based on the Model View Controller architecture, and an Open Source base independent of proprietary technologies. Its main goals are to help and support conception, decision and finally dialogue and communication, for project stakeholders.

To do so, it hosts several "expert modules" that interoperate in real-time by picking and enriching the model. The results can be displayed within a virtual scene in an integrated, interactive and pedagogical way in order to be meaningful to non-experts (Figure 36).

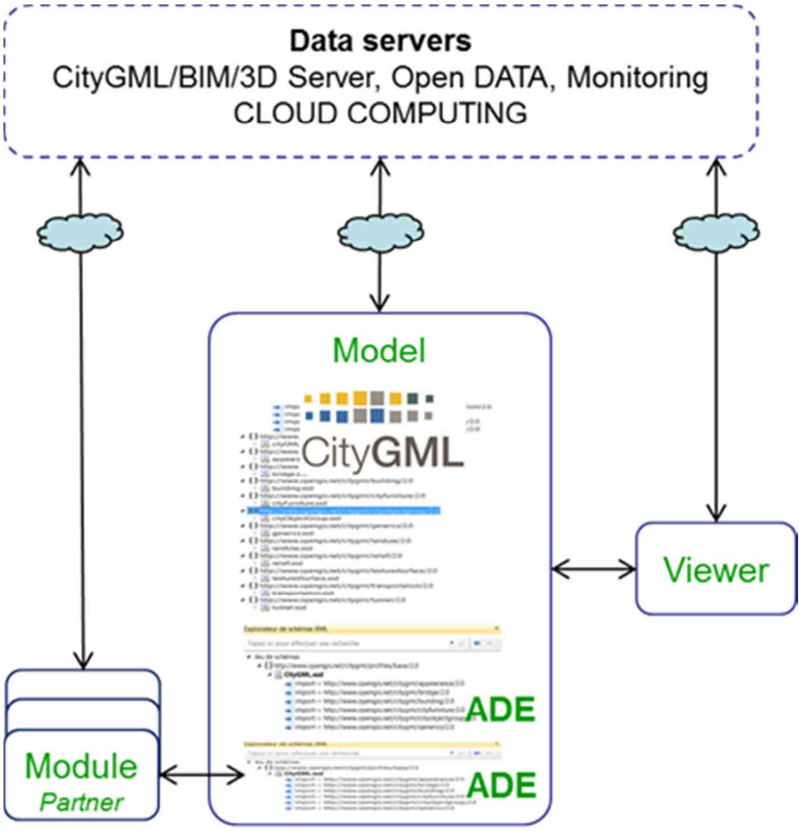


Figure 36 - Main principle of eveCity platform

There are obviously a lot of scientific bottlenecks and issues to address in order to build such an integrated platform. Such challenges constitute a main thematic area of research in the Digital Cities and Territories cluster at CSTB, which includes:

- Hosting and managing a heavy city model on a cloud server: the current work is directly related to the API Degree3D, in the Odysseus scope, to host the CityGML data of experimental pilots (cities). The goal is that eveCity can connect the server to operate on local and smaller data extractions.
  - Automatic generation and validation: the release of CityGML as XML Schema Definition (XSD) is of major interest for software developers and data exchange. Indeed, this formalism can be used to automatically generate APIs, and enables file validation which is of great interest for data exchange to ensure integrity and interoperability.
  - Automatic 3D acquisition thanks to 3D photogrammetry and semantic recognition of those 3D models to enrich the digital mock-up with the data needed for expertise (identify and separate roads for traffic simulation for

example).

- Interoperability between expert modules through digital mock-up to support a multi-criteria analysis essential to reach sustainability (i.e. technical sectors like comfort, health, environment, energy).
- Integrative and harmonious 3D post-treatment representation of model and simulations for non-expert (metaphors like colour maps, 3D strips, immersive or augmented reality, realistic sound).
- Scale compatibility: models have to be consistent especially at their limits to fit the upper or lower scale. The Level Of Detail (LOD) potential of CityGML is then used to ensure a fluid transition between scales.

Focus on Expert modules

EveCity aims to gather and federate the large variability of parameters, and scales for each domain of expertise (like noise, environment, traffic, energy, etc.). Thus it introduces the concept of the "expert module" capable of extending the main model with its specific variables/parameters and sharing them with other subscribing modules. We use the Application Domain Extension (ADE) formalism to describe missing expert data.

Each "expert module" can embed a specific simulation engine led by one of the project partners. To be integrated, this "brick" has to follow some principles of interoperability (a "Digital City Charter" is currently developed to ensure interoperability and coherence between domains and scales of expertise).

Today eveCity manages several prototype expert modules from research, and three operational ones listed here that can interact with each other: (i) Traffic model designed for both macroscopic and microscopic scales, with 3D representation (ii) Noise propagation model with colour map and audio restitution ('auralisation') and (iii) Pollution dispersion with 3D representation (see examples in Figure 37en Figure 38).

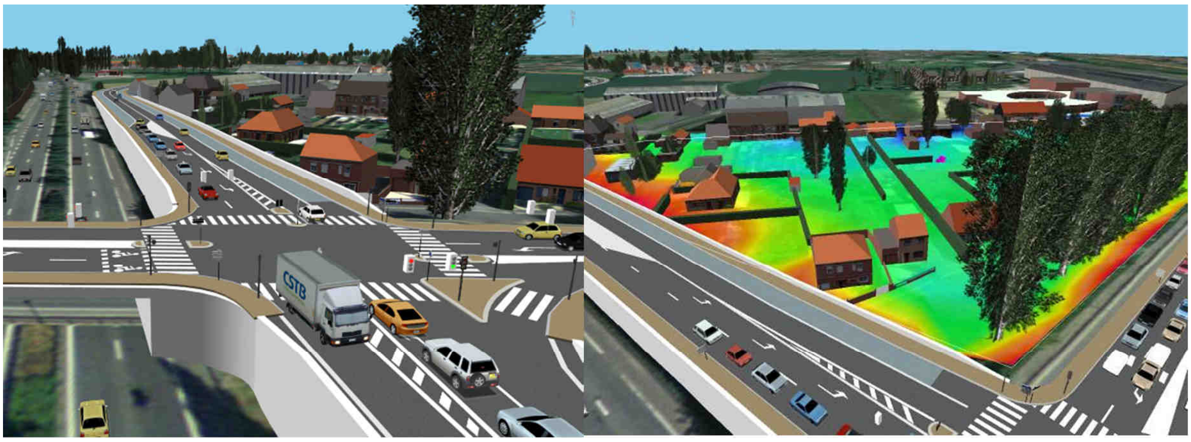


Figure 37 - Example of an eveCity R&D work for local authorities in the north of France (Credentials: Conseil Général du Nord, CSTB). The acoustic impact of traffic on a new road is dynamically rendered both with a colour map and direct audio restitution ('auralisation')

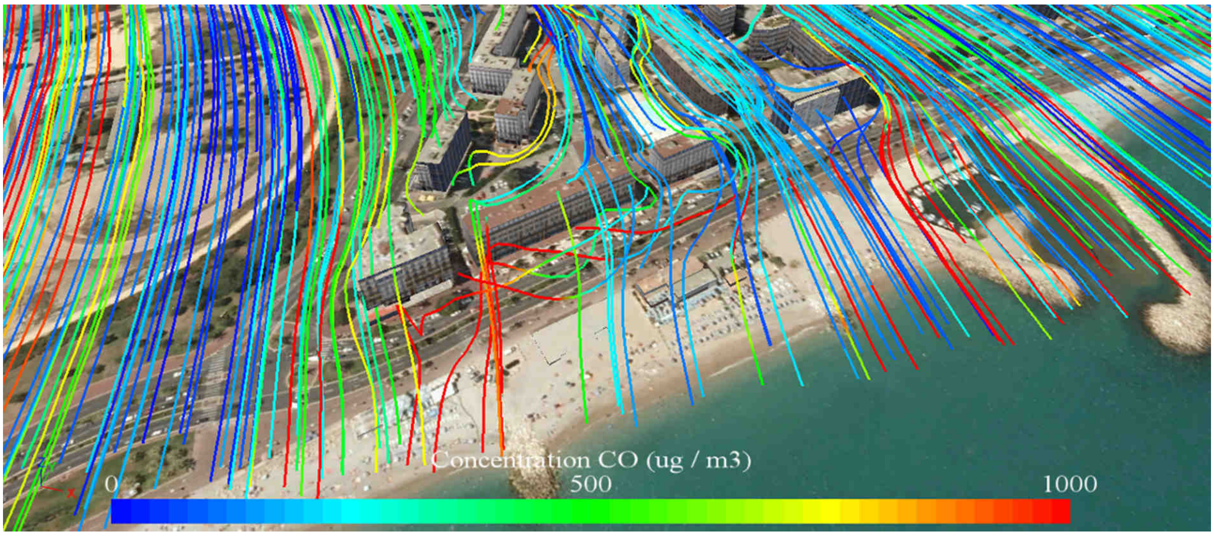


Figure 38 - Example of pollutants propagation through a city digital mock-up (eveCity 2012)

It is worth mentioning the presence of a nearly operational module which aims to evaluate solar energy potential at the district scale. It will help local authorities to map the exact localization of potential solar panels on buildings' roofs. To do so, the module needs an accurate model from 3D photogrammetry representing every detail such as trees, chimneys or dormer windows to take every shadow in account (Figure 39).

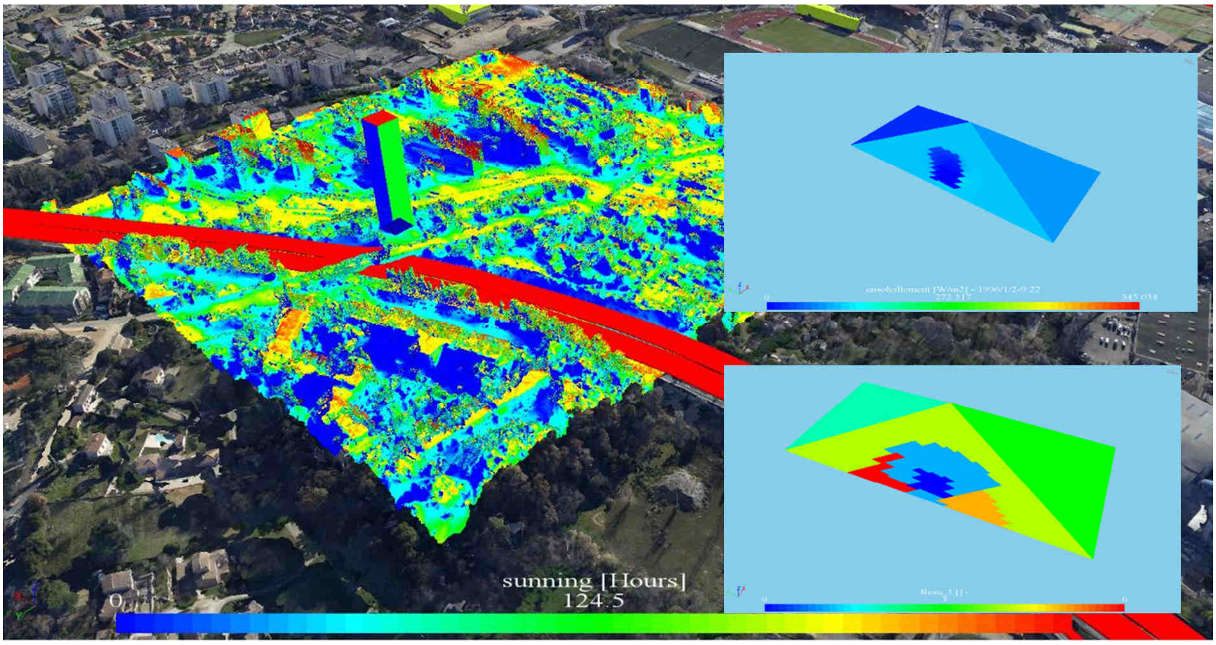


Figure 39 - Example of the use of a 3D photogrammetry mock-up to compute solar potential on a district, and on a specific roof

7.3.1.1 eveCity role

Following this process, it is planned to develop a new expert module dedicated to the Odysseus project, dealing with the dEPC, ICT, and smart grids concepts.

The first idea is to connect the module to the Degree3D to load a CityGML extraction of the studied zone, containing GIS and 3D information, and the necessary energy data (EupP, dEPC, etc.) in a ADE linked with the semantics server.

The module can then deal with the information, share it with other module, and/or compute services based on the Odysseus engine. Several complementary options are considered depending on the evolution of Odysseus platform, and on the time and space scales (short or long term, city or district scale) :

- At first a module can be used to represent the characteristics of every E-Node thanks to an adapted 3D post-treatment superposed on the 3D digital model (ideally in CityGML, if this format is available). This is already a very pedagogical way to enhance information for stakeholders in order to let them take better decisions. This can be done dynamically (even in real-time) if the information is sufficiently updated. In this case, the role of eveCity could be to monitor energy states and represent them as colour maps, labels, or geometrical metaphors (coloured spheres…) as shown in Figure 40.

Figure 40 - Some eveCity ways to represent meta and attribute information within a 3D model

- Following this the module can embed more intelligence to compute some results based on monitored information from the Odysseus architecture: in this case a “smart grid engine” (eventually within the analytics part of the OCP architecture) could analyse energy nodes and propose some solutions or efficiency scenarios to help local authorities in their decision process. This can be done in several ways:
  - a short term approach by monitoring E-Nodes in (almost) real-time, compute some predictions, and propose scenarios to adjust and reorient the Energy Efficiency (EE) strategy. This is linked to a real time management of Energy Efficiency.
  - a middle/long term approach by evaluating and checking assessments, trends, and data collections to propose improvements in the energy efficiency process, and a posteriori evaluate the impact of the new strategy.
- At last, eveCity aims to federate the results of all expert modules, including the Odysseus EE one, in order to propose a global multi-criteria analysis to help and support decision. This will provide a sound way to approach real sustainable energy management.

After that, the module can send dynamically results and/or post-treatment representations to the Odysseus (DEGREE3D and/or SPARQL) server, ensuring an updated GIS/semantic model (frequency to be defined in the interface) useable by experimental city software testers of the involved pilot cities[3].

Note: eveCity is developed in C++ but some elements of ODYSSEUS project are based on Java. To be independent of the software architecture, all connections between ODYSSEUS servers and eveCity module will be based on web services (SOAP 2.0/REST).

To whom is the functionality being provided?

This decision tool is dedicated to stakeholders of local authorities at the city scale.

Indeed a specific public local service could be created, or an existing service adapted like GIS service, sustainable service, energy service where a dedicated agent or a partnership between an agent and the local authority could manage energy efficiency at a district level in real time (as it is already done for other sectors for example traffic management, or crisis management centers).

In the longer term, the decision becomes more political and the scenarios proposed by such an 'eveCity+ODYSSEUS' solution could be used in City councils to illustrate and support global decisions dealing with EE, eventually balanced with other thematic (social, environment, comfort, etc.).

[3] Building and City Energy Managers and technicians as well as members of the Odysseus research team who will together test the use of the Odysseus platform through the respective case studies in each of the pilot cities (Manchester and Rome).

7.3.1.2 eveCity GUI functionalities

The generic GUI functionalities of eveCity are those of a traditional model view controller GUI (see Figure 41 below). These include:

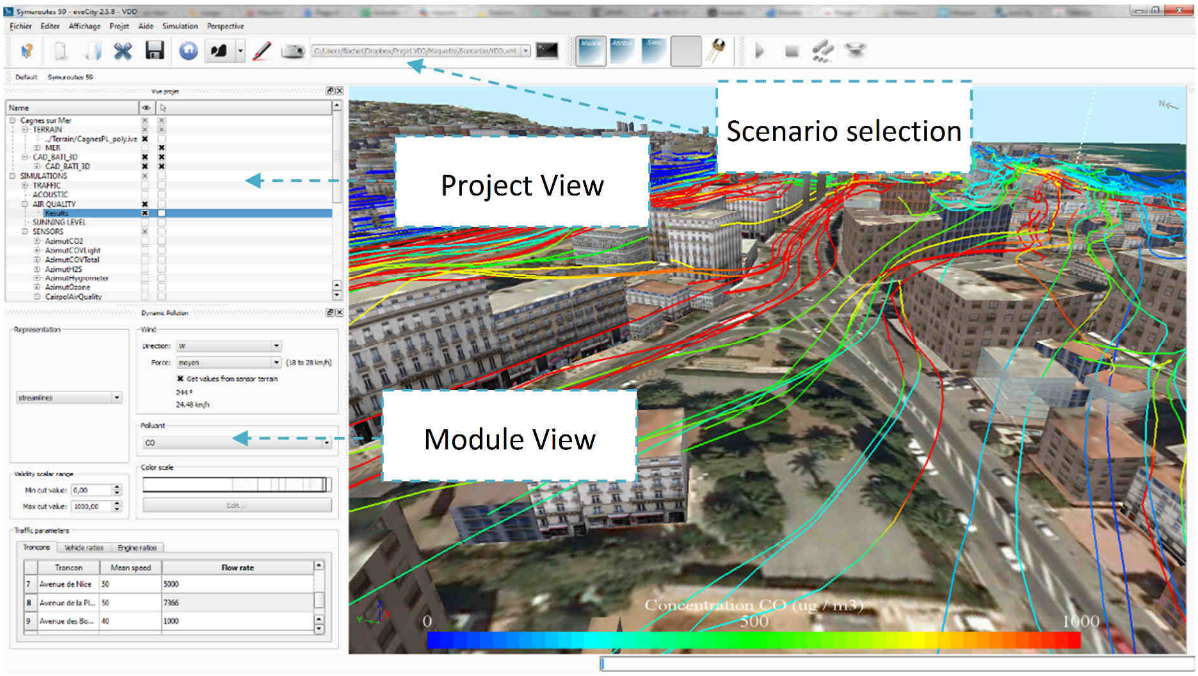


Figure 41 – eveCity GUI

- Project view with all elements,
- Module View with a specific model dedicated to the embedded expertise,
- 3D View with representation of the CityGML model added with 3D metaphors coming from simulation and expertise,
- Scenario selection : we can select a scenario to test, compare or evaluate different parameters, geometries or propositions (for example the noise impact before and after a new infrastructure, with or without noise protections).

However, each module owns its specific GUI, and so for the Odysseus Module, the outcome depends on the developed functionalities (see before). First ideas for GUI/Functionalities include:

- Selection of a 2D zone for CityGML extraction,
- Connection to degree3D with update/refresh capabilities,
- Eventual connection to other monitored E-Nodes,
- Launch / Pause / Stop if we are on a dynamic monitoring,

- Simulation parameters like range, time scale, perimeter,
- Representation parameters like labels, color maps,
- Recording and export capabilities.

7.3.2 *Integrated City Management (ICM)*

7.3.2.1 ICM role

ICM tries to provide an holistic city vision on several domains to city stakeholders in a Smart Cities paradigm. At this time ICM is focused on the provision of mobility information for the transportation domain both at city level and at corridor level among cities. City stakeholders are city managers from city agencies and citizens to which near-real time information is really valuable to their daily lives. In the scope of the Odysseus project the ICM solution will enrich its scenario capabilities by also providing energy efficiency vision of a city to stakeholders (e.g. city energy manager, facility manager, etc.). The proposed energy efficiency dashboard, will provide value added information to stakeholders in order to support their decision making based on information provided by the Odysseus Cloud Platform.

As previously mentioned, the current functionality for the ICM covers the vision for the traffic of a city, including the weather and other data sources. The idea is to improve and expand these functionalities by adding the capability to show to stakeholders the model of the energy efficient city vision proposed by the dEPC concept introduced by Odysseus project with the capacity to make different analysis (supported by the OCP) along the time line for the generated KPIs. On the other hand, the end users stakeholders would be able to request energy predictions from the OCP to be able to envisage what actions from an energy efficient point of view should be taken based on moment by moment indicators. By providing all these functionalities to the application a middle-term/long-term decision support making tool will be provided.

7.3.2.2 ICM Energy Efficient Dashboard GUI prototype

The GUI will be based in portlets, where each zone of functionality will be a portlet, which can be connected to other portlets (Figure 42). A portlet is a pluggable user interface software component, with a lifecycle, that is deployed at a framework portlets. The idea is the reutilization of existing portlets and the possibility to create new ones that could be used in other areas. To do this the dashboard will be deployed in a portlet framework solution like 'Liferay'.

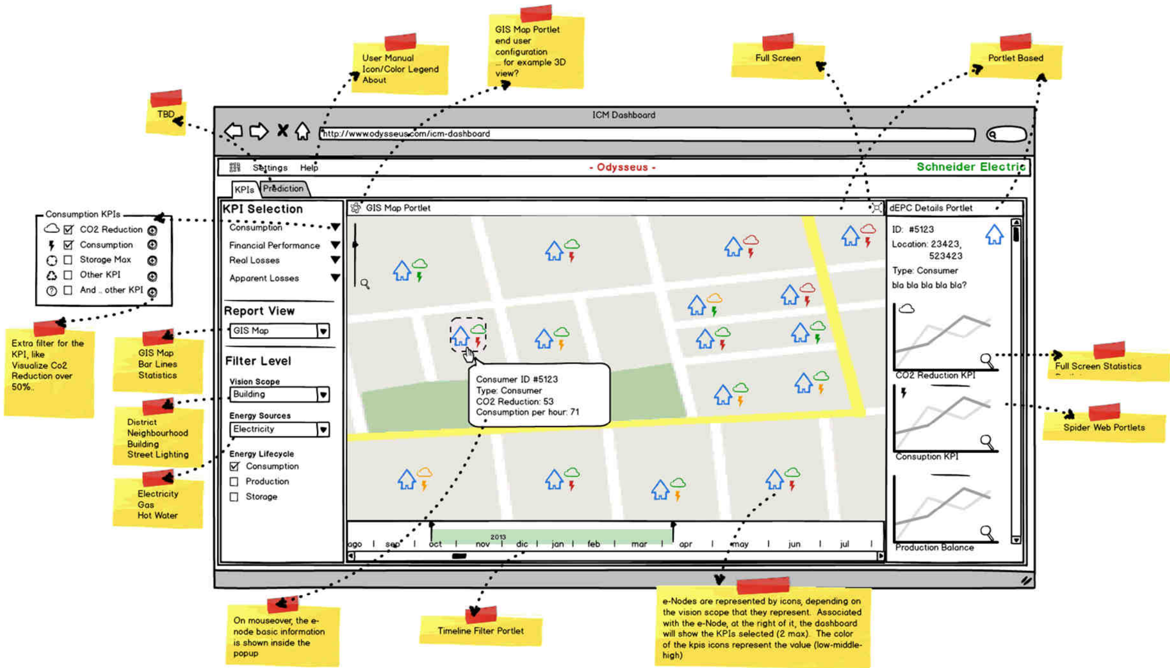


Figure 42 - ICM EE dashboard prototype for decision support making in a middle and long term city vision

7.3.2.3 ICM Energy Efficient GUI functionalities

KPI Selection Filters

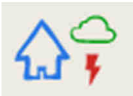
The KPI page for the ICM Energy Efficient Dashboard will deal with the summarized information captured through the specified time. The user (e.g. energy city manager) has the opportunity to select the KPIs to analyze, and filter the information through several fields:

- Vision Scope: District, Neighbourhood, Building, Street Lighting are some of the available filters for this concept. The idea is to summarize the Russian doll dEPC information approach at the level that the user needs, giving to the user a summarized idea of the E-Node vision as district, neighbourhood and so on.
- Energy Sources: Electricity, Gas and Hot Water will be the possible selections for these kinds of energy sources at the vision scope level. The end user will be able to filter the information by selecting what kind of E-Nodes with a specified energy source want to be analyzed.
- Energy Lifecycle: Consumption, Production and Storage are the three key components of the energy lifecycle being considered in the scope of the Odysseus project for the E-Nodes, so this filter criterion is being provided with

multi-selection capabilities by the GUI interface to the end user. The idea is to filter the E-Nodes to show only the component of the energy lifecycle that at a certain filter request are consumers and/or producers and/or storages.

- Timeline Period: The user will check and summarize only the information for a certain time line period, discarding the rest of information on a certain request.

The information will be displayed at the central part of the application in selected format on the Report View combo box, for example a GIS format like in the mock-up of Figure 42. In this case, the user could manage the map zoom, and pan to discover the geo-located information over a GIS map. The specific KPI information of an E-Node (e.g. a building) will be represented at the right side of each E-Node icon with different colors for the high, medium and low values.



In this case, the House represents the vision scope of the E-Node, for example, buildings. At the right we can see two icons representing two different KPIs values, summarized at the building E-Node scope. The first one, the cloud, represents CO_2 reduction, and the green value represents low level values. On the other hand, the thunder represents Energy Consumption KPI. The red color represents high level values.

When the user selects one E-Node, the detailed information will be displayed at the right side, the dEPC details portlets, where static and dynamic information both in text format and graphical style (bar graph, spider wide graph, etc.) are envisaged.

7.3.2.4 ICM Internal Functional Interfaces at GUI Level

Method	getKPIsGroups
Description	Obtain the list of existing Categories of EE KPIs
Expected Input Data	**Description**
-	-
Expected Output Data	**Description**
KPIGroupsList	List of Groups. Each one should have the description and the key code

Method	getKPIsForGroup

Description	Obtain the list of KPIs for an specific category of KPIs
Expected Input Data	**Description**
KPIGroupCode	Code of the group needed
Expected Output Data	**Description**
KPIList	List of KPIs associated with the group code. Each KPI should have the description, if its selected or not and the extra filters

Method	getVisionScopes
Description	Obtain the list of vision Scopes
Expected Input Data	**Description**
-	-
Expected Output Data	**Description**
Vision Scope List	List of available vision scopes. Potential vision scopes considered are one of: - District - Neighbourhood - Building - Street Lighting

Method	getEnergySources
Description	Obtain the list of Energy Sources
Expected Input Data	**Description**
-	-
Expected Output Data	**Description**
Report List	List of available energy sources

8 Validation check

What follows is a short assessment on how the planned ICT functionalities from the previous chapter will support the requirements of pilot case scenarios (see appendix 1) and indirectly make sure energy is reduced at the neighbourhood level.

Therefore a check is made of each identified requirement against the five main logical functionalities of the proposed platform:

1. GIS & Semantic Services
2. Functional, Analytic & Profiling Services
3. Orchestration & Core Business Logic
4. Aggregation, Actuation & External Services
5. GUI & Security

Green means covered, yellow means partly covered, red means not covered.

Requirement	**GIS & Semantic Services**	**Functional, Analytic & Profiling Services**	**Orchestration & Core Business Logic**	**Aggregation, Actuation & External Services**	**GUI & Security**
Business					
Req-1 structure modelling	semantic service				
Req-2 monitoring				aggregation	
Req-3 information integration			orchestration		
Req-4 simulation		analytic services			
Req-5					GUI

informing					
Req-6 automation		Prediction Simulation services		actuation	
Req-7 environment	In dEPC			external services	
Req-8 customization			via orchestration		
Req-9 invariance					
Req-10 scalability	scalable databases / RDBMS links				
Information					
Req-11 granularity	LODs in dEPC				
Req-12 life-cycle	Required, Expected, Measured profiles				
Req-13 exchange	Interconnections , Flows in dEPC				
Req-14 representation	dEPC as concept, static/dynamic				
Req-15 completeness	All this info will be covered by dEPC				

Req-16 genericity	E-Node concept				
Organization					
Req-17 interoperability	interoperable info standards (semweb, open GIS)			Interoperable interfacing standards (IP)	
Req-18 multi-tenancy			Supported by the core business logic in the Relational Data Base		
Req-19 transactions			orchestration aspect		
Req-20 stateless				Stateless aggregation	
Req-21 reprocessing				By e-gateways, Aggregation	
Req-22 filtering					admin
Req-23 gateways					
Req-24 separation	Separate items & CRS choice				
Req-25 applicability	Not too particular info structures	Not too particular services	Not too particular orch./BL		

Req-26 open source	open source servers	Potentially open source services	Based on open source middleware	Based on open source middleware	
Req-27 service integration			orchestration		
Req-28 Communications security					security
Req-29 enrichment		by derivation		by gateways	
Req-30 prediction	modelled in dEPC	calculated or simulated by analytic services			
Req-31 indicators	modelled in dEPC	derived by analytic services			
Req-32 instance modelling		Profiling service			
Req-33 design			Core business logic		
Req-34 energy management			core business logic		
Req-35 user management					security
Req-36 redundancy	Service oriented architecture	Service oriented architecture	Service oriented	Service oriented	

			architecture	architecture	
Req-37 auditing					security

9 Conclusions

This report defines the Odysseus framework for addressing the set of services and functionalities to be provided initially for covering scenarios and use cases in both of the pilot sites in Manchester and Rome, whilst simultaneously proposing a framework definition that takes into consideration a generic approach for the development of a wider holistic energy management solution at the neighbourhood scale.

To address the Odysseus framework definition the requirements identified in D1.2 have been considered from a generic perspective and traced against the key building blocks of the Odysseus framework architecture. Moreover, a set of eight design principles for the definition of the Odysseus platform have been considered. This design principles are of a variable nature and take into consideration issues like:

- a comparison of the energy network with Internet principles,
- how we must relate the domain and the information models of the dEPC ontology,
- what are the boundary conditions regarding grid, regulation or physical characteristics, etc.
- how we will deal with the storage of the information; centralised approach versus de-centralised
- identification of specificities of the energy storage capability of an E-Node versus energy consumption and production capabilities
- what are the required energy network abstraction levels (physical and logical for energy nodes, their profiles, etc.)

Before introducing the logical architecture of the framework and selected stakeholders (i.e. the latest ones identified in the scenarios to be implemented in Manchester and Rome) have been introduced and the so called Demand Response 2.0 challenge has been stated. This Demand Response 2.0 challenge is one of the specific functionalities that will be supported by the Odysseus Cloud Platform and holistic Energy Management Solutions (hEMS) to be implemented within the Odysseus project results.

The logical architecture will be addressed in a SOA (Service Oriented Architecture) over the Internet (and the cloud), where components at pilot site for collecting and parsing and transforming data (e-Gateways) from E-Nodes (e.g. building, building section, etc.) are described and common interfaces have been introduced for pushing data on the so called

Odysseus Cloud Platform.

The Odysseus Cloud Platform is composed of a key set of services (middleware components) that collaborates for the provision of the stakeholders end functionalities. Key building blocks of this Odysseus Cloud Platform architecture are

- the GIS and Semantic services (that will be a result of tasks and activities in WP2)
- the functional and analytics services, where proposed data enrichment will be done based on three kind of approaches: energy efficient building calculations (average, deviations, etc.), predictions and simulation approaches
- platform interfacing layers for dealing with:
    - structured dEPC information from on field E-Nodes (dEPC aggregation layer),
    - third party services that provides the weather and energy tariff information for a certain location (communication layer for external data resources services)
    - user interface logic service for the provision of internet based methods for querying and retrieving information from the platform required for supporting the monitoring and decision making tools
    - various suggestions and advises to E-Nodes and stakeholders, based on KPIs, enriched data from analytics, site profile definition and incoming dEPC data from an E-Node (actuation layer). This actuation layer provides a certain level of intelligence and automation to the Odysseus Cloud platform
- orchestration and core business logics represent the glue for the interchange of data and information among platform services and the data services (relational, semantic and geographical)
- editing and profile modules will be in charge of the definition of the configuration capabilities of the platform, address questions such as what are the energy profiles to be applied for an E-Node, the access grants to data based on stakeholders profiles, etc.

Finally, the envisaged hEMS tools that will utilise the exposed functionalities of the Odysseus Cloud Platform by the user interface logic service will be developed in Task 4.2 Monitoring tool and Task 4.3 Decision making tools have been drafted in this deliverable.

10 Appendix 1: D1.2 Requirements

Introduction

Note: the D2.1 requirements have been generalised, renamed, regrouped and reformulated where possible, abstracting from the particular use case aspects and being easier to validate against the proposed solution in this deliverable. The threefold logic has been kept: business/functionality, information/semantics and organisation/technologies.

A.Business/functionality ("why") - #10

ODYSSEUS-REQ-1	**Title**: Energy Structure Modelling
Explanation	Analyse and understand all types of energy flows (sustainable and non-sustainable) in the whole energy life-cycle including production, consumption and storage on different but interrelated scale levels (devices, rooms, building, neighbourhoods, whole city etc.).
ODYSSEUS-REQ-2	**Title**: Energy Monitoring
Explanation	Being able to measure all kind of energy flows and physical conditions for energy networks (nodes and connections) via sensors/meters.
ODYSSEUS-REQ-3	**Title**: Energy Information Integration
Explanation	Being able to aggregate and integrate various sources of dynamic measurements and existing static information to obtain data that is more useful for holistic energy management.
ODYSSEUS-REQ-4	**Title:** Energy Simulation
Explanation	Being able to, based on the asserted/measured/aggregated/integrated data, derive (calculate, simulated) new information suitable for decision support/taking in energy management.
ODYSSEUS-REQ-5	**Title:** Energy Informing
Explanation	Being able to represent the asserted/measured/derived energy info to a variety of end users involved in the energy management (including balancing, trading, using of equipment etc.) to support their decision making. Typically involving a variety of orchestrated, multi-tenancy, secure services.
ODYSSEUS-REQ-6	**Title:** Energy Automation
Explanation	Being able to automate (via actuation) certain energy management decisions based on all energy information available. (Also(typically involving a variety of orchestrated,

	multi-tenancy, secure services.
ODYSSEUS-REQ-7	**Title:** Energy Environment
Explanation	Being able to take into account environment information like weather and energy prices (via access of existing sources or own measurements).
ODYSSEUS-REQ-8	**Title:** Customization Potential
Explanation	The used ICT platform should provide mechanisms for the customization of processes.
ODYSSEUS-REQ-9	**Title: Time Invariance**
Explanation	The Odysseus platform must provide time-invariant results to allow the reproduction of these results.
ODYSSEUS-REQ-10	**Title: Scalable Solution**
Explanation	The solution must be scalable in order to cover the system grow on the future.

B. Information/semantics ("what") - #6

ODYSSEUS-REQ-11	**Title: E-Node level of granularity**
Explanation	An E-Node represents energy network elements at a district/neighbourhood scale of a city: buildings, dwellings, electrical vehicles, street lights, etc..
ODYSSEUS-REQ-12	**Title: E-Node and energy lifecycle**
Explanation	An E-Node is a component of an energy network that can produce, consume or store energy.
ODYSSEUS-REQ-13	**Title: E-Node energy exchange**
Explanation	An E-Node has possible physical connections with other E-Nodes to exchange energy of different nature (e.g. electricity, heat/cool water, heat air, …).
ODYSSEUS-REQ-14	**Title: E-Node information representation as dEPC**
Explanation	An E-Node has all its energy-related information represented as a dEPC. Information being considered is static or dynamic, depending on how likely to change this information is.
ODYSSEUS-REQ-15	**Title: dEPC Completeness**
Explanation	The dEPC should include all the information needed for energy analysis, performance monitoring, identification of inefficiencies or dysfunctions; optimization of operation conditions at level of the E-Node as an individual component or as a component of network. Initial information to be provided is: static information (like energy characteristics, geo-spatial data, …) and dynamic information (like usage profile, profile of power demand, profile of power charge/discharge, energy exchange strategy,

	sensed data, …). dEPC must also include all the information related to the hardware associated to an E-Node(including device Id, data, associated gateway(s) information, etc.), expose static and dynamic information (dEPC), energy exchange capabilities.
ODYSSEUS-REQ-16	**Title: Generic E-Nodes**
Explanation	The E-Node proposed ontology by the Odysseus project must be generic enough to provide several vision levels: city vision, district vision, neighbourhood vision and energy element vision.

C. Organization/technologies ("how") - #21

ODYSSEUS-REQ-17	**Title:** Interoperability/Openness
Explanation	The information measured/stored/accessed should be conform an agreed open ('standard') information structure or 'ontology' (to be developed in WP3). It's also necessary to use (open) internet standard based communication protocols for connecting to the real world (measuring and/or actuation) and as fundament for all communication aspects. The Odysseus platform must also provide open/standardized mechanisms for dealing with the access to stored data and information on services.
ODYSSEUS-REQ-18	**Title:** Multi-tenancy
Explanation	All services should support multi-tenancy in a cloud based deployment scenario.
ODYSSEUS-REQ-19	**Title:** Transaction Support
Explanation	Aggregation service must support transactionality in all the interchange of data.
ODYSSEUS-REQ-20	**Title:** Stateless communication
Explanation	Aggregation services should be stateless.
ODYSSEUS-REQ-21	**Title:** Reprocess capacity
Explanation	Incoming data must be reprocessed in case of error.
ODYSSEUS-REQ-22	**Title:** Filtering
Explanation	The incoming information can be selectively discarded by admin configuration.
ODYSSEUS-REQ-23	**Title**: Device Gateways
Explanation	The configuration (settings), control and data flow of E-Node associated end devices (gateway, controllers, sensors) must be provided through associated gateway(s).
ODYSSEUS-REQ-24	**Title:** Separation of Concerns
Explanation	Neighbourhood information and energy nodes within neighbourhoods information will be kept separate where an (agreed!) Coordination Reference System (CRS) is the

	interrelating link between these different levels of detail/scale.
ODYSSEUS-REQ-25	**Title:** Balanced Applicability
Explanation	The Odysseus platform should be specific and detailed enough to enable/support the two pilot cases and/but it should be generic and global enough to be relevant for any other future neighbourhood energy management scenario.
ODYSSEUS-REQ-26	**Title:** Open Source
Explanation	The platform and its components should be best implemented in Open Source Software (OSS) that fully complies to the cosen/relevant open standards.
ODYSSEUS-REQ-27	**Title:** Service Integrability
Explanation	It's necessary to use standard technologies whereas is possible in order to increase the interoperability among heterogeneous services. The Odysseus platform must ensure the integrability of the different parts of the system taking into account data-flows and services orchestration relationships.
ODYSSEUS-REQ-28	**Title:** Security on communications
Explanation	The Odysseus platform in general should be secured. All external communications from or to the Odysseus platform should be secured with standard and strong encryptions mechanism. Also the use of digital certificates is suggested in both, client and server sides, in order to authenticate their identities. Finally, services must be provisioned (deployed, installed and configured) in a secured infrastructure to avoid external attacks.
ODYSSEUS-REQ-29	**Title:** Data Enrichment
Explanation	From the raw data collected from sensors at pilot sites, the Odysseus platform must be able to identify irrelevant measures, provide cleansed data, and derive more meaningful data for exploitation. ODYSSEUS should be able to provide (handle/provide) meaningful/semantic energy information related to the production, consumption or storage of every network node.
ODYSSEUS-REQ-30	**Title:** Predictive information
Explanation	The Odysseus platform should provide means to forecast the consumption, production or storage capacities of any network node over a certain period of time ahead.
ODYSSEUS-REQ-31	**Title:** Key Performance Indicators (KPIs)
Explanation	The Odysseus platform should be able to calculate relevant, interrelated KPIs to evaluate the energy efficiency of neighbourhoods.
ODYSSEUS-REQ-32	**Title:** Modeling service
Explanation	The Odysseus platform should provide tools to create/instantiate models/instances of neighbourhoods including all information needed from the energy point of view.

ODYSSEUS-REQ-33	**Title:** Simulation and design service (tactical level)
Explanation	The Odysseus platform should provide a tool to assess the energy performance of district configurations (on an annual basis).
ODYSSEUS-REQ-34	**Title:** Service for near real-time energy management (operational level)
Explanation	The Odysseus platform must provide solutions for optimizing energy management at neighbourhood level.
ODYSSEUS-REQ-35	**Title: (Trusted)** User Management
Explanation	The Odysseus platform should provide mechanisms for managing the trust on valid users and only allow communications from the set of trusted users. Roles should be managed in an accountable way from the Odysseus platform. The platform should control which users have access to which service/module/information. Special care because of multi-tenancy requirements.
ODYSSEUS-REQ-36	**Title:** Redundancy/Robustness
Explanation	Redundancy networks are necessary to ensure the availability of the services provided by the platform.
ODYSSEUS-REQ-37	**Title:** Auditing
Explanation	The platform should be auditable and admin users can monitor it at real time whenever required.