**EEPOS - Energy management and decision support systems for energy positive neighbourhoods**

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# EEPOS ICT and decision support systems platform - Specification
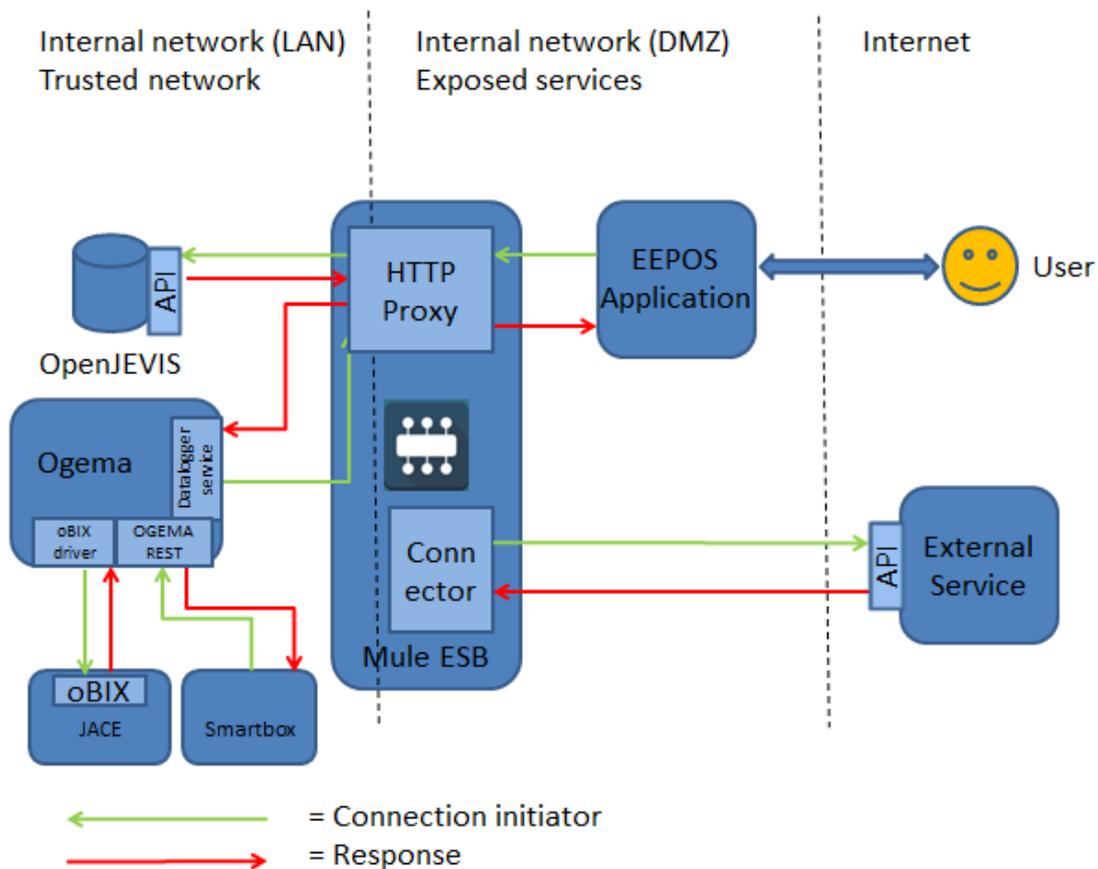


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# 1. PUBLISHABLE EXECUTIVE SUMMARY

Overall project mission: contribute to increased energy efficiency by neighbourhood management and control systems capable to optimize, in near-real time, the local generation-consumption without compromising the comfort or performance of the buildings and neighbourhoods with the aid of latest ICT developments.

To achieve this goal we need internal tools to ease connectivity between EEPOS internal components and to connect to external services and data sources. Automation platform (WP2) offers solutions to connect to sensors and automation devices. But for the EEPOS to be truly useful for customers we need to build an integrated ICT solution able to connect to SAP and other enterprise resource planning solutions.

ICT platform works as a mediator between EEPOS tools, NEMS (Neighbourhood Energy Management System)  and external services. It offers easy way for EEPOS tools to connect to different data sources. The overall system diagram in *Figure 1* shows how the ICT platform will be structured.
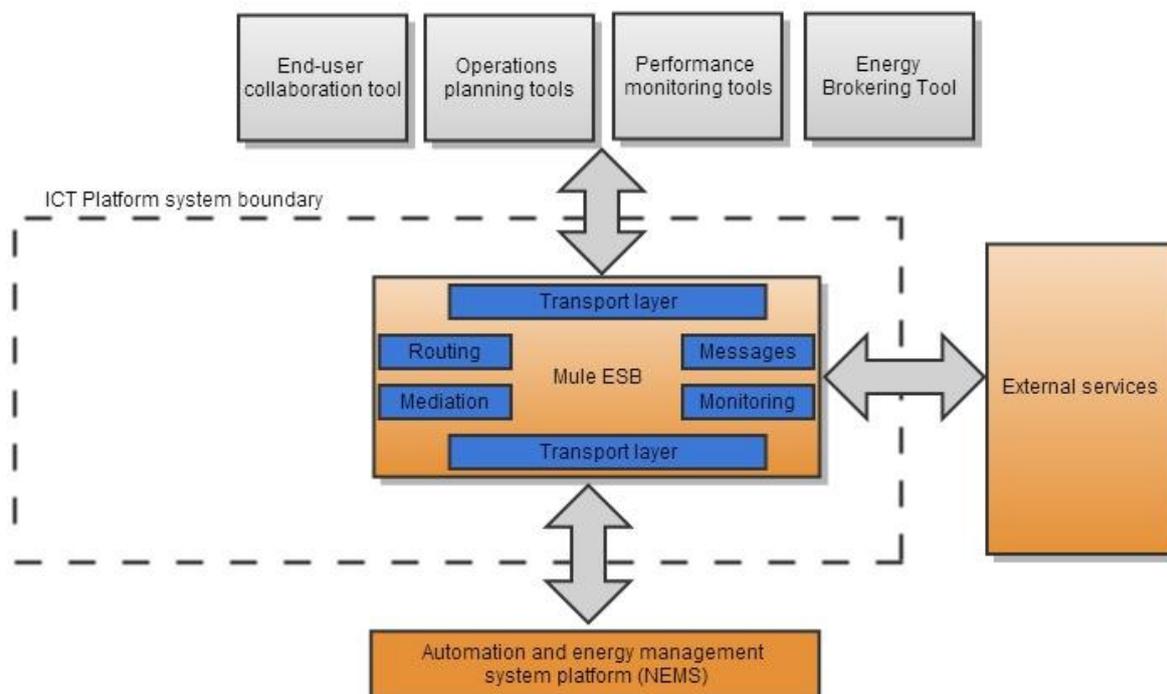


*Figure 1.* System diagram of the ICT platform

After extensive testing we chose Mule ESB (Enterprise Service Bus) as our base platform. Mule offers free to use community edition for non-commercial projects and enterprise edition with proper support for business use. Implementation and prototype is done with the Mule ESB.

# 2. INTRODUCTION

## 2.1 Purpose and target group

This report defines the ICT platform that will be implemented later in this task. Target group is the people who will be doing the actual implementation and also partners from different task that are connected to this one.

Other tasks needs and requirements will be addressed in this report.

## 2.2 Contributions of partners

Fatman Oy (FTM) is the lead contractor and responsible for this report. Other partners have provided information for the use cases, comments and feedback.

| Section / Chapter | Contributor |
|---|---|
| 1, 2, 3, 4, 5, 6, 7 | FTM |
| 4.3.6, 7 | VTT |
| 4.3.3 | DERlab |
| 4.3.2 | ENO |
| 4.3.1 | YIT |
| 4.3.5 | AIT |

*Table 1.* Contributions of partners

## 2.3 Scope

Creating a complex ICT platform can be very long process and since we have limited resources we have to focus on the needs of the demonstrations and take some shortcuts regarding security and other features. Left out features will be addressed in the specification briefly, so it's possible to add these features later.

The ICT platform will provide interfaces for connecting to EEPOS internal interfaces and external third party systems. Platform will not provide any capabilities for data processing, this has to be done in external software (T3.2, T3.3 and T3.4 for example).

Creating the platform from scratch would have been a too big task and a risk regarding the task resources. Various products were considered to be used building the ICT platform. First choice was WSO2 ESB (http://wso2.com/products/enterprise-service-bus/) [1] and it was mentioned on the intermediate specification.  However, during the testing and starting the implementation it proved to be very difficult to use. So during the early implementation choice was made to abandon the WSO2 ESB and start using Mule ESB (http://www.mulesoft.com/platform/soa/mule-esb-open-source-esb) [2]. Mule ESB provided much more user friendly development environment as the other features were almost identical to WSO2 ESB.

Also during the project need for a database in EEPOS was found. Since ICT platform was obvious choice to include this we addressed it briefly during the specification. Since we have very limited resources the database specification and implementation was given to T3.3.

OpenJEVIS (http://openjevis.org/) [3] was chosen for this and it will be described more in the D3.3 and in the D3.1 Prototype documentation.

## 2.4 Relations to other activities
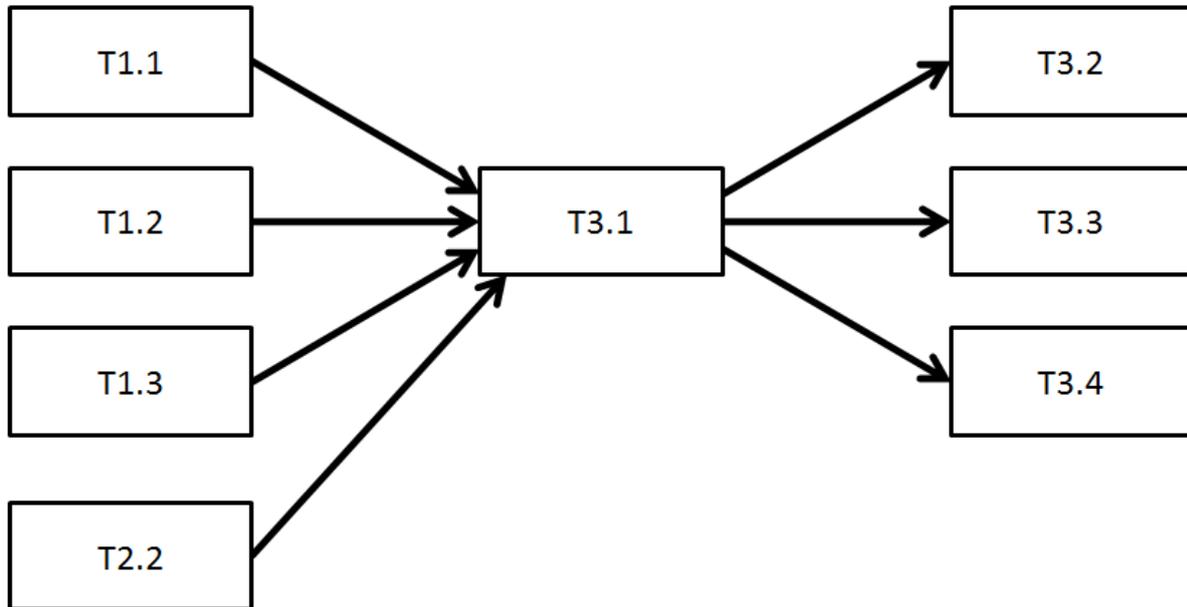


*Figure 2.* Relations to other activities

This specification is based on the information from the WP1 tasks (T1.1, T1.2 and T1.3).

The task using the platform later will provide their requirements as use cases (WP3 tasks T3.2, T3.3 and T3.4).

Use cases specified in chapter 4.3 collect requirements and feature requests from different demonstrations and tasks that will be using the ICT platform.

# 3. ENTERPRISE SERVICE BUS (ESB)

Enterprise service bus (ESB) is a software architecture construct, which lives between the (business) applications and enables communication among them. Ideally, the ESB should be able to replace all direct contacts with the applications on the bus, so that all communication takes place via the ESB.

ESB provides its fundamental services via an event-driven and standards-based messaging engine (the bus). Thanks to ESB, integration architects can exploit the value of messaging without writing any code. Developers typically implement an ESB using technologies found in a category of middleware infrastructure products, usually based on recognized standards.

ESB is a relatively new concept. The term has only been in common use for the last several years. People often associate ESBs and Service Oriented Architecture (SOAs) but they are somewhat orthogonal concerns. However, like SOA, ESB is essentially a collection of enterprise architecture design patterns that is now implemented directly by many enterprise software products.

ESB is the foundation of the ICT platform. Using ESB functionalities we can configure a working setup that will support our EEPOS platform and help us connect different parts together. [1]

Mule ESB is a lightweight Java-based enterprise service bus (ESB) and integration platform that allows developers to connect applications together quickly and easily, enabling them to exchange data. Mule ESB enables easy integration of existing systems, regardless of the different technologies that the applications use, including JMS, Web Services, JDBC, HTTP, and more.

The key advantage of an ESB is that it allows different applications to communicate with each other by acting as a transit system for carrying data between applications within your enterprise or across the Internet. Mule ESB includes powerful capabilities that includes:

- Service creation and hosting — expose and host reusable services, using Mule ESB as a lightweight service container
- Service mediation — shield services from message formats and protocols, separate business logic from messaging, and enable location-independent service calls
- Message routing — route, filter, aggregate, and re-sequence messages based on content and rules
- Data transformation — exchange data across varying formats and transport protocols
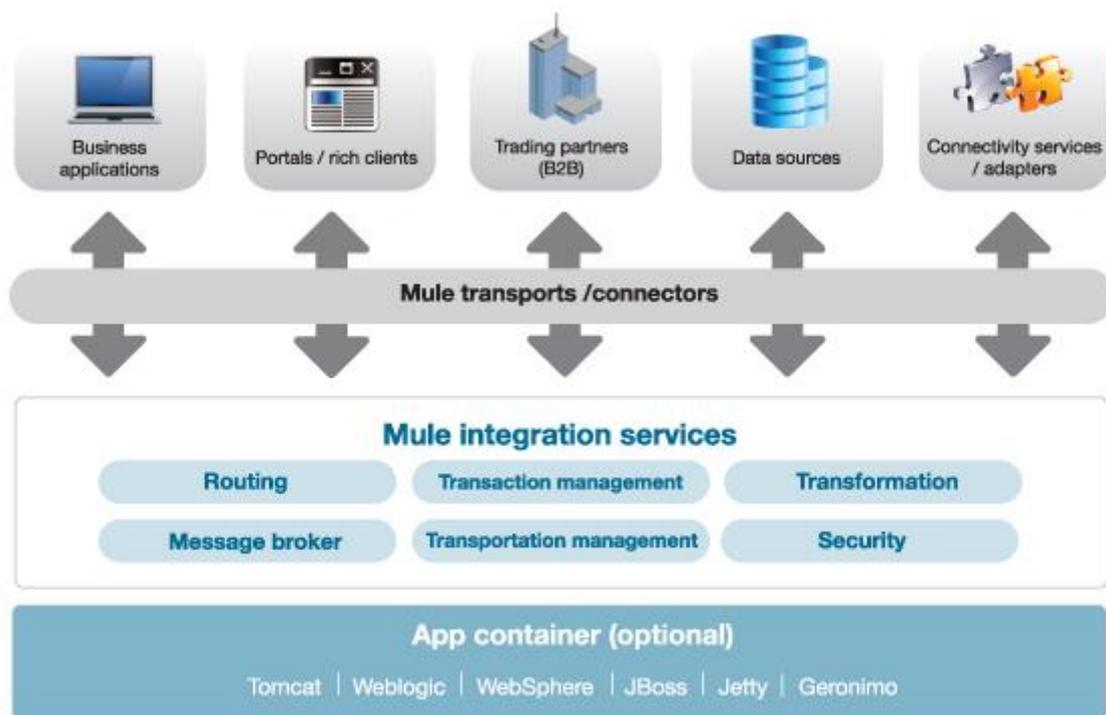
*Figure 3.* Mule ESB Concept

There are two editions of Mule ESB: Community and Enterprise. Mule ESB Enterprise is the enterprise-class version of Mule ESB, with additional features and capabilities that are ideal for production deployments of Mule that have requirements for performance, HA, resiliency, or technical support. Mule ESB Community and Enterprise are built on a common codebase, so it is easy to upgrade from Mule ESB Community to Mule ESB Enterprise. For EEPOS project the Community Edition was used it was valid choice for testing, however for large scale business environments it can easily be upgraded to the Enterprise Edition. (http://www.mulesoft.org/what-mule-esb) [4]

## 3.1 Why we need ESB or ICT platform

Mule and other ESBs offer real value in scenarios where there are at least a few integration points or at least 3 applications to integrate. They are also well suited to scenarios where loose coupling, scalability and robustness are required.
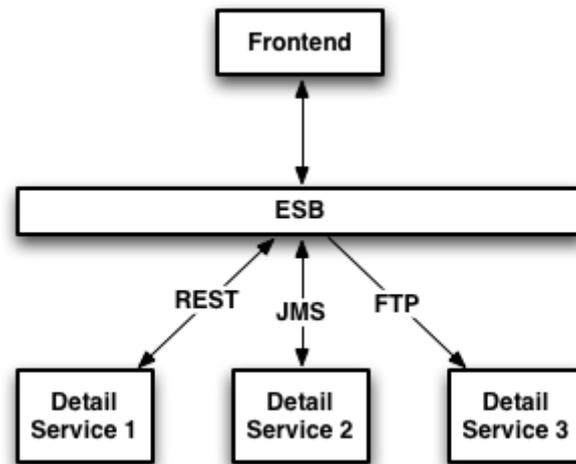
*Figure 4.* Example architecture with multiple integrations

Creating a simple integration point-to-point would be easy to create with almost any tool or programming language. But when you add multiple services to be integrated it gets very complex to manage if each integration is done separately. In cases like presented in figure 4 use of ESB is usually a good fit. It is also much easier to add on new integrations in the future without causing problems to existing ones.

Same ideology also applies to EEPOS architecture. We are creating an neighbourhood level system to integrate local consumers and producers with the main electrical and heating grids. To be able to actually integrate numerous different software platforms and hardware platforms we need very robust platform. This is the reason why ICT platform idea was included in the project. If we want our EEPOS system to be successful it needs be easily expanded and new producers and technologies should be easy to add. If the process is too complex and time consuming it will not attract new producers. For EEPOS to succeed we need to integrate all the key elements in the neighborhood to actually benefit from it's potential.
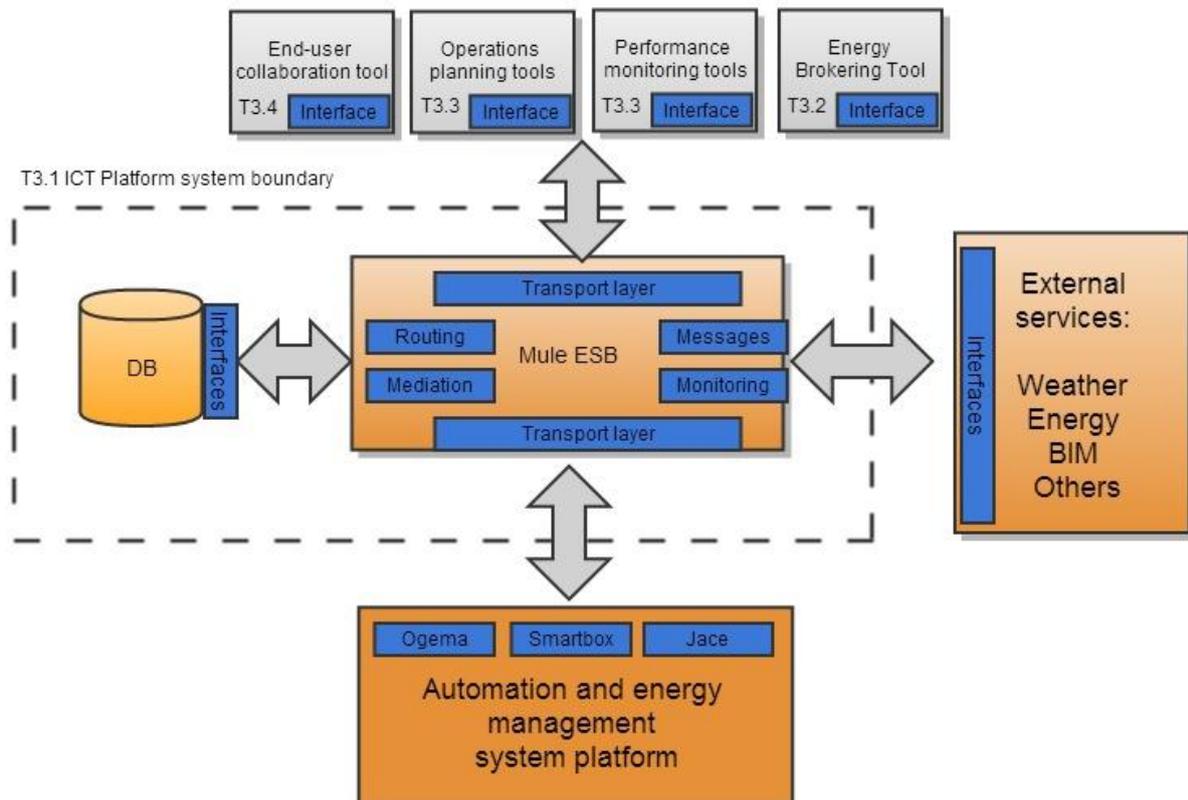
*Figure 5.* EEPOS integration diagram

As we can see in the figure 5, EEPOS consists of numerous integration needs. ICT platform was planned to combine these needs into one package. Doing this simplifies creating of the applications in tasks 3.2-3.4 and connecting external services like weather services. ESB has the ability to work as we planned the ICT platform during the project specification.

## 3.2 ESB Installation prequisitions

ESB needs JAVA environment to run. It can be installed to multiple operating systems including Windows, Linux, Solaris, Mac OS X or anything that can run JDK 1.6.x runtime or newer.

Our installation will be Linux based. Specific distribution will be chosen later when we start the implementing phase. Current test setup is using Ubuntu 64-bit. [3]

Detailed system requirements can be found at:

http://www.mulesoft.org/documentation/display/current/Hardware+and+Software+Requirements

## 3.3 ESB Functions

Demonstrator focused ICT systems architecture is specified covering neighborhood, building and end users ICTs including internal and external data communication interfaces.

## 3.4 User Characteristics

Users of the ICT platform will be all the partners of the EEPOS project. Everyone will use the platform in their own demonstrations and tasks. ICT platform will offer interoperability for the project and make it possible to easily build an ecosystem from all the different parts.
All the requirements are coming from the use cases described in the chapter 4.3 by EEPOS partners.

## 3.5 General Constraints

Possibilities for the platform are clearly very optimistic but we have to keep our scope very focused on the needs of the tasks and demonstrations. Also ICT platform task will not define the data models used between different parts of the EEPOS architecture, task 2.2 will be responsible for that.

# 4. SPECIFIC REQUIREMENTS

This section will specify the ICT platforms functions and interfaces for the implementation phase giving as much as possible detailed information. Most of the information will be derived from the use cases involved partners have specified. However the information is in different formats and some are more detailed than others. More discussions with the other tasks are necessary before it can be successfully implemented.

## 4.1 Interface Requirements

### 4.1.1 User Interfaces

ICT platform itself doesn't have any user interfaces.

### 4.1.2 Hardware Interfaces

ICT platform will be installed on a virtual Linux server. The only hardware interface will be Ethernet port communicating with TCP/IP. No serial ports or propriety interfaces will be used.

### 4.1.3 Software Interfaces

List of the different interfaces needed (derived from the use cases) is shown in *Table 2* below. They will be specified in more detail later during the implementation phase as we get more information and specifications from the other tasks.

| Interface | Type | Needed for |
|---|---|---|
| Automation platform (ogema) | n/a | T2.1, T3.3 |
| Automation platform (jace) | n/a | T2.1, T3.2, T5.1 |
| BIM model server | n/a | T3.4 |
| Energy prices | n/a | T3.2, T3.3, T3.4, T4.2 |
| Weather | n/a | T3.2, T3.3, T3.4, T4.2 |
| Weather forecast | n/a | T3.2, T3.3, T3.4, T4.2 |

*Table 2.* List of the interfaces derived from the use cases

### 4.1.4 Communications Interfaces

ICT platform can send emails and SMS for alarms and notifications. However sending SMS require external service.

## 4.2 Functional Requirements

Main function of the ICT platform will be mediating messages between different tools created during the project, automation platform and specified outside information sources.

Specific requirements will be updated later as the implementation starts and we know better the services and interfaces we are connecting to.

## 4.3 Requirements from EEPOS tools

### 4.3.1 Use Case #1: Demonstration in Finland

For Finnish demonstration the EEPOS platform will be installed into a newly built residential area. This area will be marketed as an ecological and low-energy neighborhood. From YIT point of view, we aim to build good living environments for the residents, thus our need for the EEPOS platform will revolve around making people's lives easier. This also includes establishing lean-procedures for service and maintenance operations. The ICT platform helps us achieve this goal and make it also possible to integrate to our enterprise resource planning (ERP) systems. The EEPOS system is planned to show live for example "how many percent of the cooling is made with seawater-cooling as renewable energy"

The EEPOS platform's End-user collaboration tool should enable the neighborhood form a collective community where the all participants are able to contribute to high energy efficiency, environmental way of living and maximum resource utilization. This means that the end-user collaboration tool could connect all residents with the system through a kind of 'forum square' where the achievements of residents independently or collectively can be highlighted and maybe even discussed. It could provide a certain backbone for decision making regarding renovation, service and maintenance, refurbishment or service procurement issues, as well. There might be a certain kind of volunteered ranking competition listing the top 10% performers.

As a neighbourhood management system, this system should also provide capabilities for incorporating utility billing functionalities and act as a central database for important information regarding the neighbourhood and its principals, systems, agreements etc. It might offer a neighbourhood calendar function for people to mark up relevant events, plan maintenance operations etc. In the demonstration setup, all the buildings use JACE technology for building automation. Initial automation plans will be reviewed and EEPOS requirements are going to be included.

For the professional personnel, the ICT platform should offer through the performance monitoring and operation planning tool the access to the neighbourhood operations efficiency data as well as the service and maintenance information regarding building and neighbourhood level technical systems. The system should provide the historical and real time energy consumption and other relevant operational data as well as standard analytic functionalities so that issues that need attention would become clearly visible without much further effort by the servicing personnel.

### 4.3.2 Use Case #2: Demonstration in Germany

For the German Demonstrator the housing cooperative Bauverein Langenfeld eG (BVL) provided four of its residential buildings. These buildings are equipped with a BEMS based on the Ennovatis Smartbox technology which will be enhanced with additional functionalities and services to fit the EEPOS needs. There will be no direct communication between the BEMS and the ICT platform. The BEMS supports the management of the local grid

(connected devices, energy producers, ...), communicates with the NEMS and uses the offered services. The NEMS (based on OGEMA) communicates with the ICT Platform as described in chapter 4.3.3. The following figure shows the general structure of the communication levels in the German demonstrator:
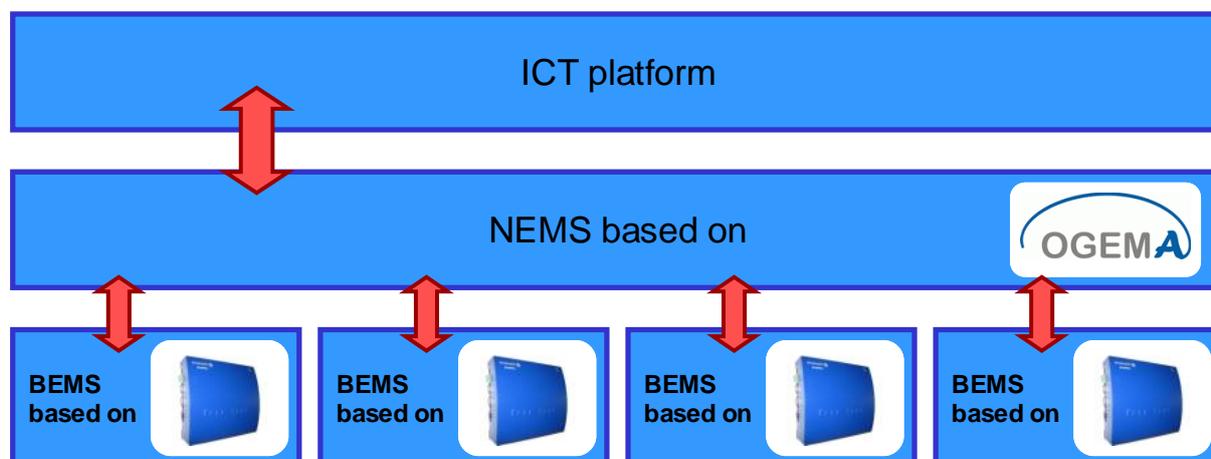


*Figure 6.* General structure of communication levels in German demonstrator

In addition to the general services and functions offered by the ICT platform we need the following data and services to determine the immediate and future optimum actions:

| Service/Data | Source | Description |
|---|---|---|
| customer preferences (continuously) | End-user collaboration tool | preferences for comfort conditions (heating, cooling, ...), sell & buy borders, ... |
| price signals / forecast (at least 24h forecast, updated continuously) | electricity company / energy broker | used to calculate current optimum and to find out when peaks in demand are expected |
| weather conditions and weather forecasts (at least 24h forecast, updated continuously) | meteorological office (e.g. DWD) | predict future energy production (in case of local PV and Wind Turbine) and energy needs |

*Table 3.* Summary of the services needed for german demonstration

### 4.3.3 Use Case #3: Laboratory prototypes

Data communication between NEMS and ICT platforms is required in order (i) to provide NEMS with the needed data for energy management in the neighbourhood and (ii) to provide ICT with a feedback on neighbourhood energy management results and on measured energy consumption/production values.

Addressing the first point, NEMS requires predicted electricity price profile, weather forecast (wind and solar irradiance) profile and demand forecast profile for neighbourhood (further in the text prediction profiles), e.g., for 24 hours in ahead. Price profile is used as an instrument for neighbourhood energy management and should be updated frequently in order to reflect the current situation in electricity market. Weather and neighbourhood demand forecast profiles are additional input data required for efficient energy management in neighbourhood.

Addressing the second point, the feedback to ICT is required in order to inform ICT how efficient was the price profile in load shifting.

| Name | **Required data communication NEMS-ICT** |
|---|---|
| Related scenario | All scenarios in T1.1 |
| Pre-conditions | <ul><li>NEMS based on OGEMA is installed on embedded computer</li><li>NEMS is connected to data communication network</li><li>Data communication between NEMS and ICT is provided</li></ul> |
| Stakeholders | NEMS operator and ICT operator |
| Systems involved | OGEMA, ICT platform |
| Trigger | NEMS is running. NEMS is waiting for prediction profiles. Once at least one of prediction profiles is received, NEMS executes one management cycle. |
| Basic path | After NEMS receives at least one updated prediction profile, it runs one neighbourhood management cycle in order to provide ICT with updated feedback on price influence on load shifting. NEMS executes neighbourhood management algorithm using the updated profile/s. When NEMS receives feedback information from end-energy users/producers, it sends this feedback to ICT. After that NEMS is waiting again for next updated prediction profile and cycle repeats. |
| Post-condition | Neighbourhood management is performed according the updated prediction profiles |
| Exception-path | NEMS operator may involve in NEMS management through HCI. In this case feedback to ICT will include also human factor. |
| Priority | High |

*Table 4.* Summary of the services needed for NEMS-ICT

### 4.3.4 Use Case #4: Energy Brokering Tool

Energy Brokering Tool (EBT) uses ICT platform resources through web interface. Needed resources include sensors and meters from Finnish Demonstration (T5.1) through Automation Platform (T2.1) using Ogema or Jace as a platform.

Additional information needed from weather service (FMI in Finland) and energy prices from Nordpool (Finland). Interfaces those services uses will be researched and implemented if possible. Also the total energy consumption information from energy companies is needed.
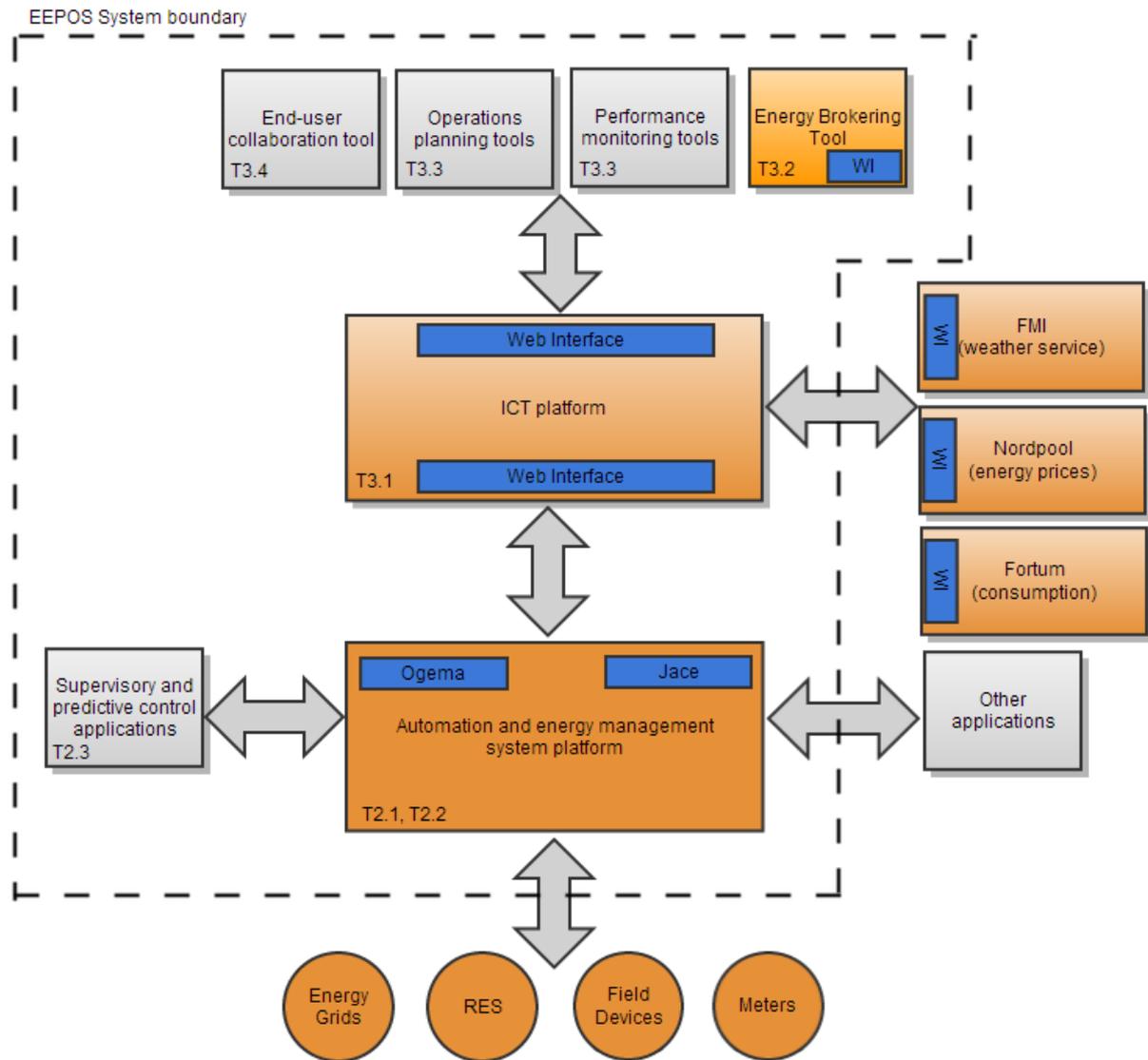
*Figure 7.* Energy Brokering Tool diagram

| Service | What is needed | Interface |
|---|---|---|
| Ogema | Sensors, Meters | Ogema API |
| Jace | Sensors, Meters (if not possible to connect Jace through Oogema) | oBIX |
| Weather | Weather information (FMI or other provider) | Web Service (SOAP) |
| Energy Prices | Energy prices (Nordpool or other provider) | ? |
| Energy Consumption | Energy consumption (Fortum or other provider) | ? |

*Table 5.* Summary of the services needed for EBT

### 4.3.5 Use Case #5: Performance monitoring and operations planning tools

Both the performance monitoring and the operational planning tools will have to connect to the automation and energy management system platform. For proper performance monitoring, the energy consumption data has to be connected to the variables which are controlled by the HVAC components in the individual buildings. Therefore the performance monitoring needs read access to this data. Furthermore, auxiliary data (weather, prices) have to be taken into account as well, which have to be accessed also through the ICT platform. To be able to assess the impact of the other modules on the performance, their influence on the actual consumption should be included as well. It can be concluded that the performance monitoring tool needs read access to almost of the systems components. On the other hand, the end user tool and the operation planning tool may need access to the performance monitoring tool, information included there is needed, in order to reduce duplicated functionality.

The operational planning tool will need access to the supervisory and predictive control applications, which should relay the desired operation to the systems. Furthermore, it should be able to communicate with the energy brokering tool which may give input, as well as the auxiliary data (weather and prices), in case the energy brokering tool either is not present or has no preferences. Furthermore, it should access the performance of the components through the monitoring tool.

### 4.3.6 Use Case #6: End-user collaboration tool

End-user collaboration tool (ECT) uses ICT platform resources through web service interface shown in *Figure 9*. Needed resources includes (note: data varies between demonstrators)

- Apartment level consumption (electricity, heat, gas, water) data.

- Apartment level consumption (electricity, heat, gas, water) data related to other same kind of apartments (reference data).

- Apartment level load shifting data and related costs savings.

- Apartment level load shifting data and related costs savings related to other same kind of apartments (reference data).

- Energy demand and price forecasts.

- Weather data and weather forecast.

- RES related energy production and related impact on $CO_2$ emissions.

- Apartment level purchased, generated (apartment's RES) and sold energy and related cost savings and impact on $CO_2$ emissions.

- Apartment level purchased, generated (apartment's RES) and sold energy and related cost savings and impact on $CO_2$ emissions related to other same kind of apartments (reference data).

- Other available apartment level BAS measurements like inside temperatures, relative humidity, $CO_2$, etc.

- Apartment level average inside temperatures, relative humidity and $CO_2$ related to other same kind of apartments (reference data).

- Easy and secure access to change apartment energy saving mode or set points (for example 1 or 2 hours) in the case of neighbourhood level energy sale.
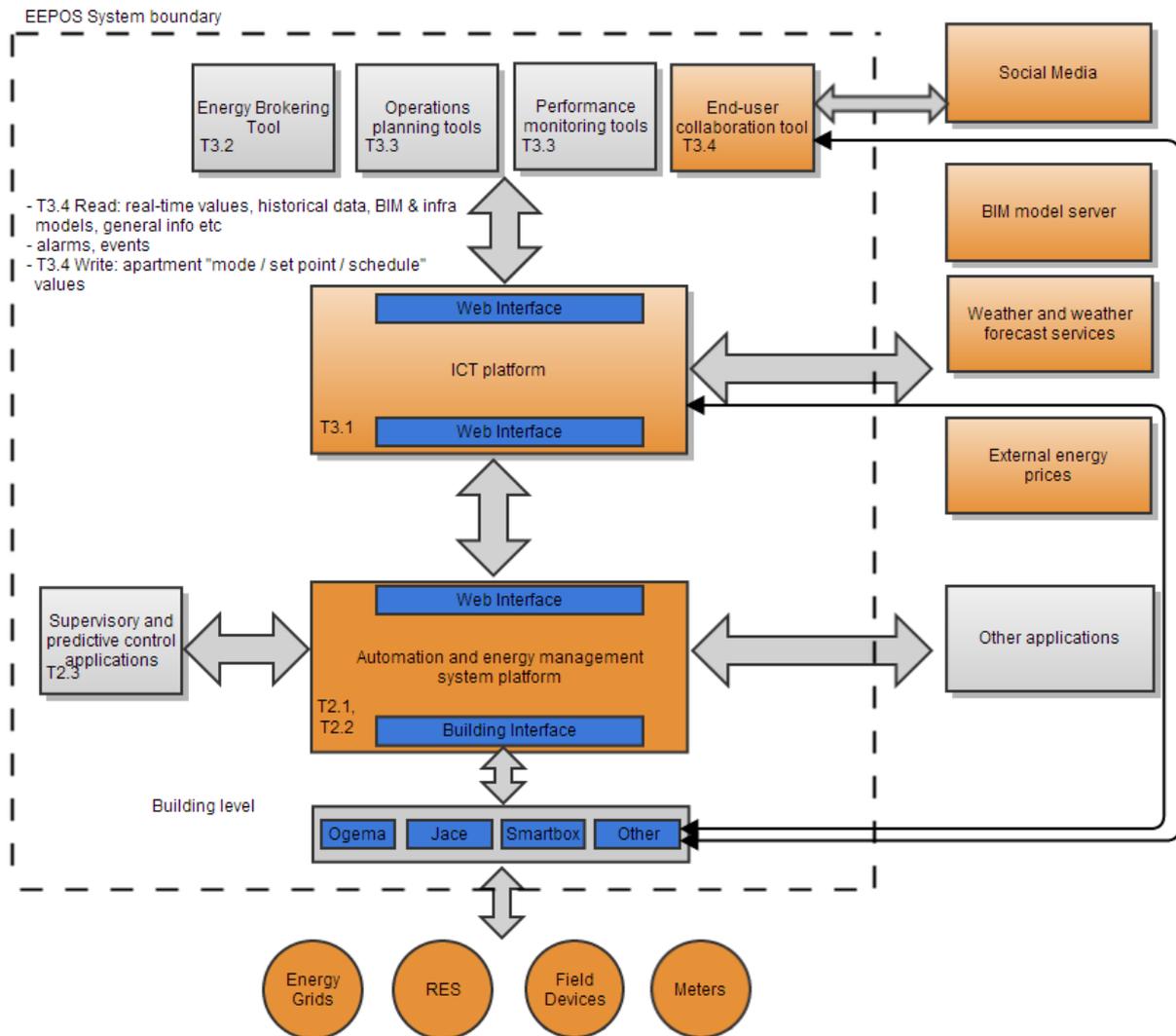
*Figure 8.* End-user collaboration tool diagram

ECT will utilize also some later selectable well known social media platform like Facebook Groups, Twitter, Google+ Pages, LinkedIn Groups or some more suitable solution for supporting collaboration purposes. Additional information needed from BIM model server, infrastructure models, weather and weather forecast service (FMI in Finland) and energy prices from Nordpool (Finland). The application will most likely utilize also some game engine, GPS information and QR code related links to EEPOS web service interface for EEPOS database information.

## 4.4 Non-Functional Requirements

Non-functional requirements may exist for the following attributes.  Often these requirements must be achieved at a system-wide level rather than at a unit level.

### 4.4.1 Performance

The ICT platform will be run as a pilot / demonstration, it should not be considered as production environment. Performance should be in a level that all the aspects of the project

can be demonstrated without problems. Specific details will be updated once the implementation starts and performance can be tested.

### 4.4.2 Reliability

As we are not building an production environment, there is no need for redundant servers and components. However current planned system infrastructure where the ESB will be installed is built for production servers.

### 4.4.3 Availability

Service will be operated as best effort model. It will be monitored and maintained during working hours but it will not have the priorities and SLA of an production site.

### 4.4.4 Security

Site will be published to public web using SSL-certificates (https). Also user interface will require authentication. Any firewall restrictions won't be used as it would be unnecessary layer of security in addition to authentication and SSL.

### 4.4.5 Maintainability

Planning first integrations with ESB carefully and testing thoroughly, we can ease the job on the future integrations. ESB system is built that you can re-use end-point implementations and message mediators. Most of the work is done within graphical user interface, so the developer doing the actual integrating work doesn't have to know Linux operating system or go deep into scripting languages.

## 4.5 Design Constraints

Features that are not possible to implement using ESB will be discussed within the task group: if there is something really needed in the project and if it's possible to implement that in some other way.

## 4.6 Other Requirements

This chapter will include a list of any other requirements and it will be a catchall section for any additional requirements. It will be updated later during the implementation phase.

# 5. CONCLUSIONS

The EEPOS ICT platform will enable the EEPOS neighbourhood energy management platform to easily connect to required data sources. This makes integration to current systems already in use and offers great support for future applications. EEPOS tools (T3.2-T3.4) demonstrate the possibilities and defines which kind of functions and features ICT platform needs to fulfill this support. For this platform to be a success we need to prioritize and focus on the following

- Flexible integration interfaces
- Efficient backend services
- Performance/Quality monitoring of the platform

After numerous tests and plans we decided to use existing OpenJEVIS API in our system. This way we don't have to create new API from scratch. Figure 8 shows planned architecture where Mule ESB works as a proxy service connecting different applications and database together.
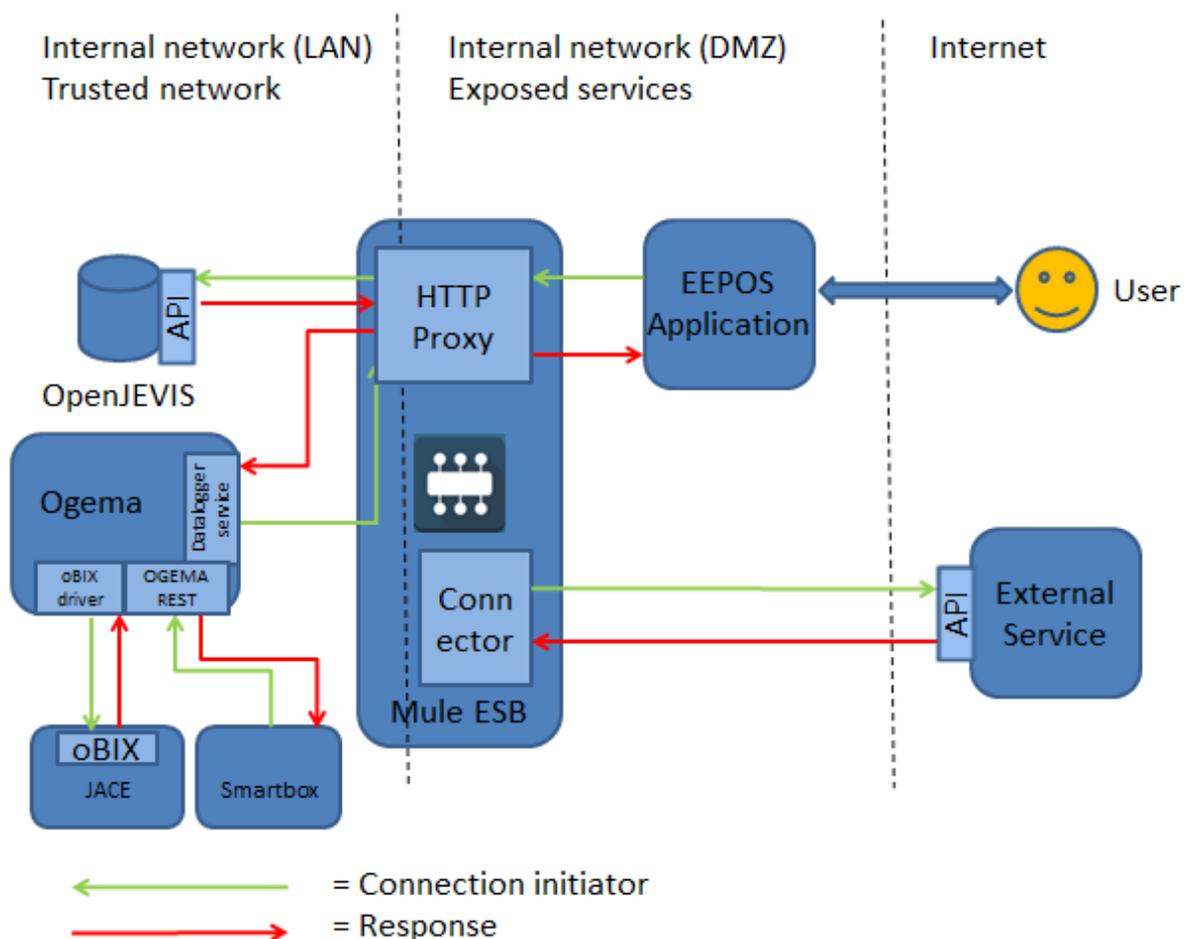


*Figure 9.* Planned proxy solution

Mule ESB also provides possibility to add additional security features later. And the architecture makes it possible to install the system so not all the components are exposed to the public internet.

## 5.1 Summary of achievements

- EEPOS ICT platform role and main function identified
- Suitable tools tested and chosen for the implementation phase – Mule ESB
- External data sources identified
- Main functions and requirements from EEPOS tools for the ICT platform specified
- Need for database solution identified -> moved for the T3.3 to further specify and to implement

## 5.2 Future Work

The tentative schedule for the further work of Task T3.1 is shown in Table 5. The plan will be updated during the project.

| Action | Time | Misc |
|---|---|---|
| Implementation | – May 2014 (m20) | Finishing the implementation phase |
| Task completed | May 2014 (m20) | D3.1 Technical Documentation  D3.1 Prototype |
| Support phase | Jun 2013– Sep 2015 (m21-m36) | Running the ICT platform and giving support to tasks 3.2-3.4 |
| Project completed | Sep 2015 (m36) | |

*Table 6.* Task schedule

We must follow closely the progress of the related other tasks to complete our own tasks according to schedule. Other tasks will lean on this task to provide them with the necessary interfaces and data sources. Interfaces must be done in cooperation with other tasks. T3.1 resources only suffice for the ICT platform's side of the interface, the other tasks must implement their task specific interfaces using their own resources.

# 6. ACRONYMS AND TERMS

BEMS .......................... Building Energy Management System

BIM ............................ Building Information Model

DoW ........................... Description of Work

ECT  ........................... End-user collaboration tool

ERP............................ Enterprise resource planning

ESB............................ Enterprise Service Bus

FMI............................ Finnish Meteorological Institute

GPS............................ Global Positioning System

ICT ............................ Information and Communication Technology

OGEMA ...................... Open Gateway Energy Management Alliance

QR code....................... Quick Response code

NEMS.......................... Neighbourhood Energy Management System

RES............................ Renewable Energy Source

SLA ............................ Service Level Agreement

SMS............................ Short Message Service

SOA............................ Service Oriented Architecture

SOAP.......................... Simple Object Access Protocol

XML........................... Extensible Markup Language

WSO2.......................... Company name (www.wso2.com)

# 7. REFERENCES

[1]   http://wso2.com/products/enterprise-service-bus/

[2]   http://www.mulesoft.com/platform/soa/mule-esb-open-source-esb

[3]   http://www.openjevis.org

[4]   http://www.mulesoft.org/what-mule-esb

# 8. APPENDICES

Additional information is described in related background documents:

Appendix 1: Validation strategy and application scenarios (D1.1; publicly available on the project website).

Appendix 2: Stakeholder requirements (D1.2; publicly available on the project website).

Appendix 3: Overall architecture specification (D1.3; publicly available on the project website).