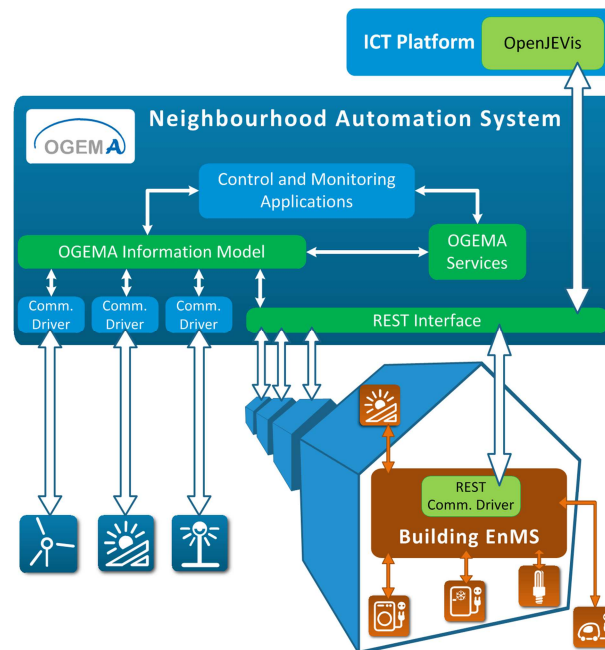


EEPOS automation and energy management platform – Technical documentation of the implemented EEPOS gateway and the related middleware



Authors:

Birthe Klebow..... DERlab e. V. / Fraunhofer IWES
 Arturs Purvins DERlab e. V.
 Jürgen Hubert..... DERlab e. V. / Fraunhofer IWES
 Kaspar Pae..... CAV
 Roland Kopetzky..... ENO
 Kalevi Piira..... VTT

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1. PUBLISHABLE EXECUTIVE SUMMARY

This report provides technical documentation of the implemented EEPOS (Energy management and decision support systems for Energy POSitive neighbourhoods) neighbourhood automation system (NAS) platform. This platform is based on the energy management framework OGEMA software. The core concept of OGEMA is to provide a hardware independent execution environment for energy management applications. The software serves as a base for development of NAS applications which will be developed in T2.3 “Supervisory and predictive control applications” and will be used for (i) energy monitoring and (ii) automated energy management in the neighbourhood. Thus the OGEMA-based software serves as an operation system for neighbourhood level energy management and automation applications.

The NAS platform will be connected with individual grid-users (e.g. buildings) and with Information and Communication Technology (ICT) platform as described in Section 3. The NAS platform should provide the necessary communication among electricity system stakeholders in order to ensure optimal utilisation of controllable loads leading to efficient implementation of the EEPOS tasks:

- Matching of local electricity generation and consumption
- Congestion management in local electricity grids
- Increase of energy efficiency

NAS platform operating system and its stakeholder support services are presented in Section 4. These services are as follows:

- Graphical User Interface (GUI)
- Plug & play functionalities
- User administration, data security
- Modularity
- Application support

Communication interfaces (described in Section 5) are between the following parts of the EEPOS Neighbourhood Energy Management System (EnMS):

1. NAS – Grid-users
2. NAS – ICT platform

The NAS – Grid-users communication is based on a Representational state transfer (REST) software architecture; and the NAS - ICT communication – on OpenJEVis, an open system for energy and operational data storage and monitoring.

2. INTRODUCTION

The main task of the NAS is to monitor and manage energy in a neighbourhood. The NAS platform is based on the energy management framework OGEMA¹ software. This document describes the NAS architecture, the NAS software platform (OGEMA), and means of NAS communications with grid-users and ICT platform.

2.1 Purpose and target group

The aim of Task 2.1 “Automation platform specification and implementation” is to develop the NAS platform which (i) provides a software base for NAS applications and (ii) ensures communication between grid-users (in Finnish and German field demonstrations) and the ICT platform. The NAS platform should be in line with the application scenarios for the EEPOS platform studied in Task 1.1 “Validation strategy and application scenarios” (see Deliverable 1.1 “[Validation strategy and application scenarios](#)”).

The target group of this report includes the EEPOS project consortium and all the relevant stakeholders identified in Task 1.2 “Stakeholder requirements” (see Deliverable 1.2 “[Stakeholders requirements](#)”). This report describes in detail the design process of the NAS platform architecture addressing the role of energy management at the the neighbourhood level. Provisional benefits for the targeted stakeholders are analysed in detail in the business models developed in Task 1.4 “Business Models”.

2.2 Contributions of partners

Contribution of each partner in this report is listed in Table 1.

Table 1. Contribution of partners in this report

Partner	Section
DERlab	All
CAV	5.1
ENO	5.1
VTT	2

2.3 Baseline

The EEPOS energy management platform will provide a contribution to the on-going automation of distribution grids by providing an energy management (load shifting) solution at the neighbourhood level in a semi-centralised way. The energy management will be performed on two levels: neighbourhood (centralised) and household (decentralised). The centralised energy management is performed in order to enable efficient utilisation of local distributed energy resources (DER) and support the local electricity grid (e.g. peak load shaving). Thus, the central energy management system will provide households with additional information on energy situation in a whole neighbourhood. Energy management at the household level allows maximizing the utilisation of flexible demand resources in the neighbourhood since it has direct access to controllable household appliances. Such semi-

¹ Open Gateway Energy Management Alliance, www.ogema.org

centralised management combines benefits of centralised and decentralised systems: Maximum utilisation of load shifting resources in a neighbourhood supportive way. This combination may increase the feasibility of ‘smart’ grids.

2.4 Links to other activities

The specification of the NAS platform architecture is mainly based on Task 1.3: “Overall architecture specification”. Other tasks of Work package 1 (“Requirements, specifications and business model”) are closely related and are in a line with the architecture specification:

- Application scenarios (Task 1.1 “Validation strategy and application scenarios”, Deliverable 1.1 “[Validation strategy and application scenarios](#)”)
- Stakeholders requirements (Task 1.2 “Stakeholder requirements”, Deliverable 1.2 “[Stakeholder requirements](#)”)
- Business models (Task 1.4 “Business Models”, Deliverable 1.4 “[Business Models, first version](#)”).

This report will be used further in building the NAS, particularly in other tasks of Work package 2 (“Neighbourhood automation and management system”)

- Neighbourhood energy grids information models (Task 2.2 “Neighbourhood Energy Grids Information Models”, Deliverable D2.2 “Information models for neighbourhood energy management”)
- Supervisory and predictive controls (Task 2.3 “Supervisory and predictive control applications”, Deliverable “Supervisory and predictive control methods and applications”)

NAS will be tested in the laboratory prototype (Task 4.2 “Laboratory prototypes”) and will be applied and validated in the field tests (Work package 5 “Demonstration”).

3. THE ARCHITECTURE OF THE NEIGHBOURHOOD AUTOMATION SYSTEM

EEPOS EnMS is the central energy management system at the neighbourhood level. It consists of two subsystems: (i) the Information and Decision Support System, which supports stakeholders with additional management tools (like Energy brokering tool), and (ii) the NAS for automated control and management of loads (cf. Figure 1). Figure 1. EEPOS Neighbourhood EnMS architecture. integrates also the grid-users interaction with the overall system. Grid-users are energy consumers or generators in the neighbourhood, i.e. DER and households.

The houses within the neighbourhood are equipped with decentralised energy management systems at the building level (Building EnMS) which communicate with the NAS. In the EEPOS demonstrations in Finland and in Germany (Work package 5 “Demonstration”), the households will be equipped with Java Application Control Engine (JACE) and Smartbox², respectively. In the Laboratory prototype developed in Task 4.2 “Laboratory prototypes”, households controlled by the NAS will be simulated. The laboratory prototype will be used to test NAS system in simulated environment in order to evaluate the performance of supervisory and predictive control applications (like load shifting application). After that the NAS system will be applied in demonstration field tests.

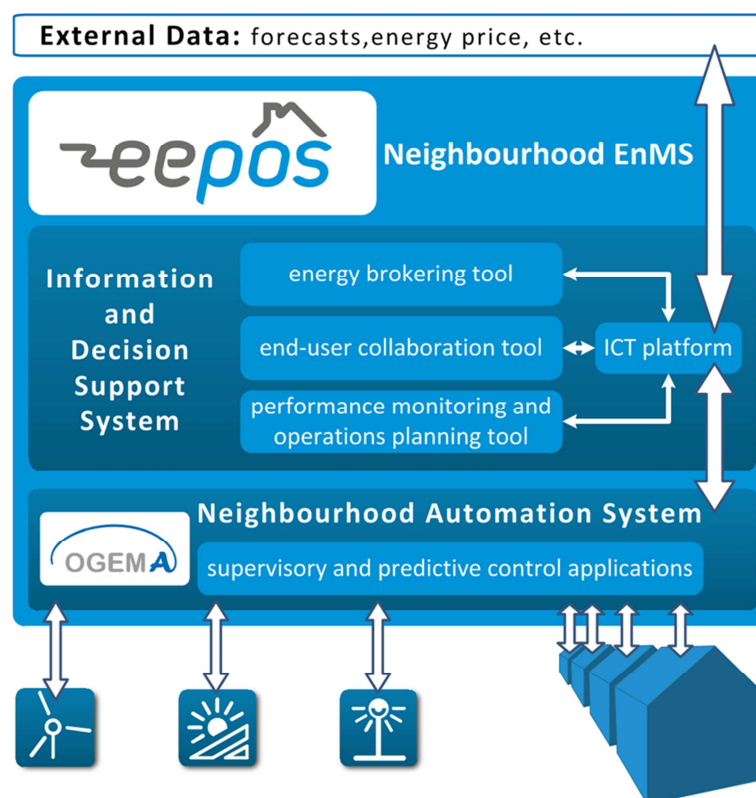


Figure 1. EEPOS Neighbourhood EnMS architecture.

² <http://ennovatis.de/index.php?id=116>

. OGEMA serves as a software gateway ensuring the interaction of four elements: the building/house level energy management systems, the EEPOS software applications – both Supervisory and Predictive Control Applications (developed in Task 2.3 “Supervisory and predictive control applications”) and the Information and Decision Support System tools (Work package 3 “Information and decision support system”) – as well as the external grid and external service providers. The NAS Platform can furthermore be seen as an upper layer operating system on top of which the Supervisory and Predictive Control Applications which are developed in Task 2.3 of the EEPOS project will run.

The NAS platform offers bidirectional communication interfaces to the building level energy management systems as well as to the EEPOS ICT Platform (Task 3.1 “ICT platform specification and implementation”) (see Figure 1). The ICT platform is a mediator between the NAS, the EEPOS information and decision support system and the external data sources (like predicted electricity price profile and weather forecast required for efficient neighbourhood energy management). Furthermore, neighbourhood level loads and generators can be connected to the EEPOS automation system and directly be controlled by Supervisory and Predictive Control Applications (Task 2.3).

The EEPOS NAS consisting of the OGEMA-based NAS platform equipped with the Supervisory and Predictive Control Applications developed in Task 2.3 will perform energy management in a neighbourhood supportive way (supporting EEPOS tasks, see Section 1) through communication with grid-users within the neighbourhood, and with the EEPOS ICT platform.

4. THE NAS PLATFORM OPERATING SYSTEM AND SERVICES

4.1 The NAS Platform Operating System

The EEPOS NAS platform is based on the OGEMA framework as explained before.. The core concept of OGEMA is to provide a hardware independent execution environment for energy management applications. As an essential requirement, a computer system on which the OGEMA framework and accordingly the EEPOS NAS will run is needed. OGEMA implementations can run on a large variety of devices, including PCs and embedded computers with low energy consumption.

The OGEMA framework is Java based and requires a Java Virtual Machine (JVM) to run on the underlying platform (see Figure 2). The application life cycle management is based on an OSGi³-Framework, which shall be included in each OGEMA installation and allows different energy management, control and monitoring applications to run in parallel and to be started, updated or stopped at runtime.

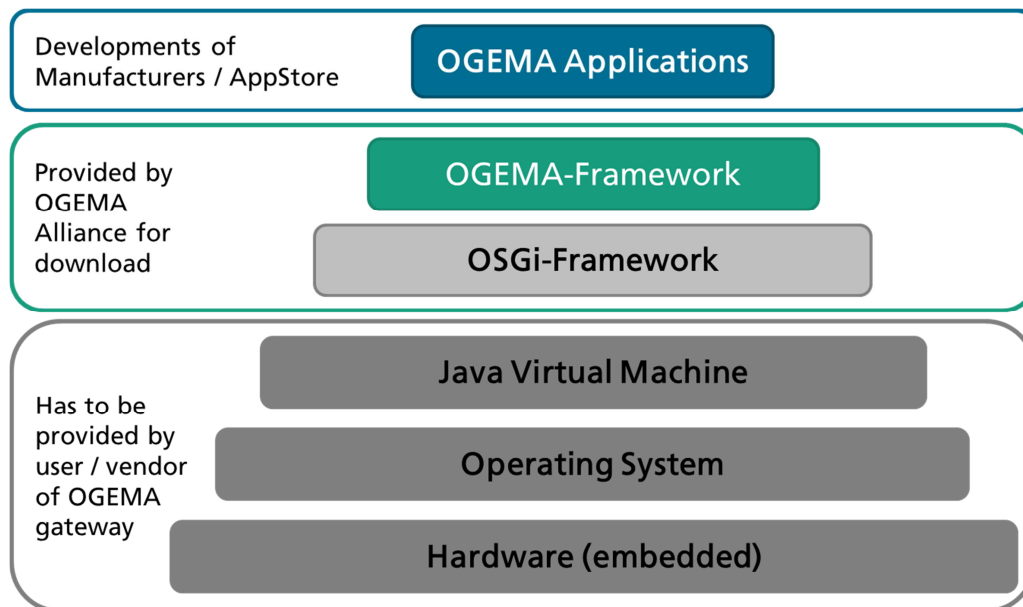


Figure 2. OGEMA Scheme

The OGEMA software acts as an operating system that allows applications to access different types of connected hardware and remote service providers without having to care about the actual physical realization of the connection. The framework itself implements basic functionalities such as management of communication drivers, standardized data elements (resources), user administration and a web-based user interface. However, the real value for the customer comes with add-on applications that perform services related to energy management and home automation.

³ Open Services Gateway initiative, www.osgi.org

The OGEMA energy management framework exhibits a modular structure consisting of the following layers (see Figure 3):

- **Applications** supporting, for instance, least cost routing or emergency power reduction functions
- **Communication drivers**, which enable the communication with field devices
- **Resources**, with individual elements for data storage being defined by the standardized OGEMA data model
- **Services** like resource administration, device management, data storage or a user web interface

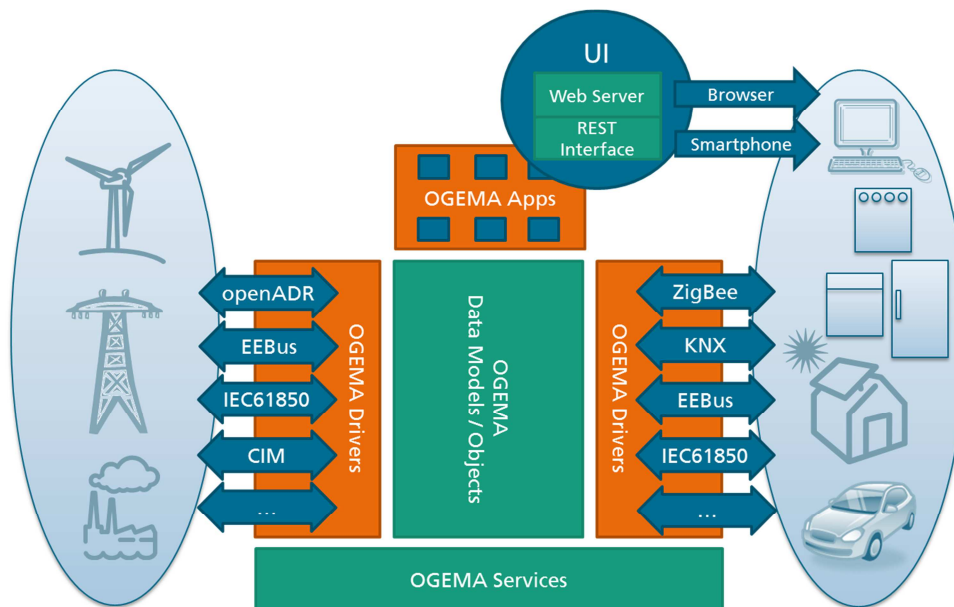


Figure 3. System architecture of the OGEMA framework

For further information on the OGEMA framework, please refer to the OGEMA 2.0 specification [1].

Supervisory and Predictive Control Applications for the EEPOS NAS are developed in Task 2.3 “Supervisory and predictive control applications” of the EEPOS project and will later be documented in detail in Deliverable 2.3: “Supervisory and predictive control methods and applications”. This report will also define performance criteria regarding energy efficiency, energy management/integration capabilities, usability, IT-system integration etc. that will be evaluated in the laboratory tests (Task 4.2 “Laboratory prototypes”). Communication drivers are for instance needed for a direct connection of neighbourhood level loads or generators to the NAS platform. The interfaces of the NAS platform are described in detail in section 5 of this report. Those parts of the OGEMA data model which are of relevance for the EEPOS project will be described in detail Deliverable 2.2: “Neighbourhood Energy Grids Information Models”. OGEMA services relevant for the EEPOS NAS platform are described in the following section.

For each neighbourhood to be controlled, an individual instance of an EEPOS NAS is recommended. Thus, in each EEPOS demonstration as well as in the laboratory tests, an individual computer with an OGEMA framework running on top on its operating system will be deployed.

4.2 NAS Platform Services

Graphical User Interface (GUI)

The EEPOS NAS will provide a GUI for the system operator to perform such operations as connection of new grid-users, setting of management / automation parameters, management / automation application control, monitoring of the current energy situation in the neighbourhood as well as predicted generation and demand profiles. OGEMA is realised such that each application running on the framework can bring its own GUI. A basic GUI functionality based on Wicket is provided by the OGEMA framework; each application programmer can then modify this basic functionality for application specific purposes. In the frame of Task 2.3 “Supervisory and predictive control applications” a specific application, the NAS management application, is currently being implemented which will take care of these aforementioned tasks. Via the GUI, the system operator can modify neighbourhood specific settings (e.g. changing the focus of neighbourhood level automation from congestion management to any other aim). These setting possibilities will be described in the documentation of the respective supervisory and predictive control applications in Deliverable 2.3 (“Supervisory and predictive control methods and applications”).

Plug and Play functionality

The EEPOS system operator can administer the players of the neighbourhood. Adding/deleting of new participants to/from can be carried out using the above described GUI of the NAS management application. The NAS management application will then create/delete the required OGEMA resources such that afterwards the respective Building EnMS, can connect to the NAS and directly start their participation in neighbourhood level energy management. For security reasons, only the EEPOS system operator shall be allowed to add/delete players. Accordingly the possibility for players to create/delete OGEMA resources themselves is neither foreseen nor implemented.

User Administration, data security, security of data communication

Only those grid users can connect to the EEPOS NAS which have in beforehand been registered by the system operator. The system operator can define to which OGEMA resources the individual grid users may have access, normally this should be those resources related to the grid user itself and not to other grid users.

Furthermore, the NAS platform supports the definition of priorities and specific access rights and permissions for different supervisory and predictive control applications which can be managed by the grid operator via the GUI.

Modularity

The EEPOS NAS is designed to be modular. Thus, it offers replacing of specific parts (modules) of the system by other systems/ modules. So, for instance on the household level, the potential stakeholders (end-users) are free to choose which Building EnMS they want to use (e.g. JACE or Smartbox as in the EEPOS demonstrations). This aim has been considered for the design of the external interfaces of the NAS platform (cf. section 5.1). Any grid-user supporting the kind of data communication specified there is compatible with the EEPOS NAS.

Furthermore, being an OGEMA system, the EEPOS NAS provides the possibility of installing various monitoring, control, automation and energy management applications. The NAS

operator has the opportunity to decide which applications he needs and wants to use. In Task 2.3 a first set of supervisory and predictive control applications is developed. The system operator has the possibility to decide which of these applications he wants to use and furthermore can develop and implement additional applications for site specific monitoring / control / automation / management purposes. In such a way, more freedom is given to potential stakeholders for using the EEPOS system and adjusting it to their specific needs. Applications can be installed and deleted during system runtime.

Application support

OGEMA supports logging of data and evaluation of text log messages as well as of measurement data series. Thus, the NAS can persistently store e.g. preferences, application data or structures that are commonly needed by the running monitoring / control / automation / management applications. This means that this persistently stored data will for instance still be accessible after a restart or an unintended shutdown of the system. OGEMA furthermore cares for Application Administration and Time Control: Administration of applications, the system time they are using and the way they are executed.

5. COMMUNICATION INTERFACES

The EEPOS NAS exhibits the following external communication interfaces (cf. Figure 4):

- Interfaces to Building Energy Management System (EnMS)
- An Interface to the EEPOS ICT platform
- Interfaces to neighbourhood level DER, loads or meters which are directly connected to and controlled by the NAS

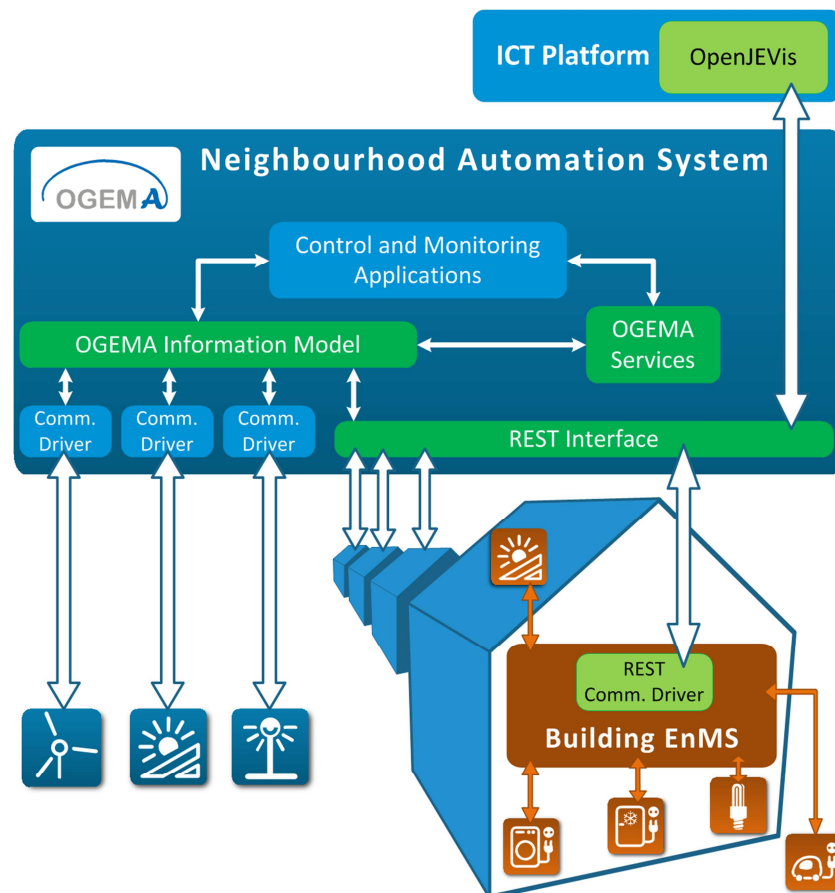


Figure 4. EEPOS neighbourhood automation system architecture.

The figure shows the modules of the neighbourhood automation system in detail: EEPOS control and monitoring applications, OGEMA information model, OGEMA services, OGEMA REST interface as well as optional communication drivers. Furthermore, the system's communication interfaces to the building energy management systems, the ICT platform as well as further distribution grid level generators and loads are shown.

All communication between the players of the neighbourhood and the NAS will be realised as TCP/IP based communication through the Internet. Thus, a basic requirement for data communication within the system is the connection of all players of the system to the Internet.

The interfaces to the Building EnMS and to the ICT platform will be described in the following subsections. Neighbourhood level DER, loads or meters can be connected to the NAS either via the OGEMA REST interface or through the provision of device specific communication drivers are required. For the two EEPOS demonstration sites as well as for the laboratory tests, device specific drivers won't be required. Accordingly, this category interfaces won't be described in detail here.

5.1 Interfaces OGEMA – grid-user

The communication of information between the NAS and the building level EnMSs will be realised using the OGEMA REST interface. This decision has been taken considering the following design concepts: The interfaces between the NAS and Building EnMS shall be designed such that

- new Building EnMS not used in EEPOS yet, can easily implement this interface, and thus become “EEPOS compatible”.
- the provision of a communication driver for a new Building EnMS shall be possible without the installation of additional software on the NAS.
- not only individual values but also time series (e.g. energy production or consumption forecasts) can be communicated.
- shall support multi user access and user roles. This means that different parties (grid-users, ICT platform) connected to the NAS should not have access to all OGEMA resources but only to a certain subset of them relevant for the respective level.
- shall support encrypted data transfer.

The REST interface of the OGEMA framework will offer a common solution for these challenges. In section 4 of this report, the OGEMA is described. Which data exactly will be communicated through the interfaces will be documented in Deliverable 2.2: “Information model for neighbourhood energy management”.

- The Building EnMSs connect to OGEMA via the OGEMA REST interface (see example in Figure 5). OGEMA doesn't actively send data but the Building EnMSs have to fetch and send data themselves.
- Building EnMS must be known by OGEMA (thus NAS management application creates resources for the building EnMS).

```

1  #!/bin/bash
2
3  IP="rev2020.iwes.fraunhofer.de"
4  PORT="1700"
5  NAS=$IP":"$PORT
6
7  # Gets $2 from NAS using format $1.
8  REST_GET() {
9      url=$NAS"$2"
10     curl -X GET -H "Accept: application/"$1 $url
11 }
12
13 if [ ! -d "output" ]; then
14     mkdir output
15 fi
16
17 # Get building information.
18 echo $(REST_GET xml /rest/resources/testBuilding) > output/building.xml
19 echo $(REST_GET json /rest/resources/testBuilding) > output/building.json
20
21 # Get production forecast (similarly for adaption requests, of course).
22 forecast="conn/powerSens/mmx/forecast"
23 echo $(REST_GET xml /rest/resources/testBuildingMeter/"$forecast) > output/forecast_building.xml
24 echo $(REST_GET json /rest/resources/testBuildingMeter/"$forecast) > output/forecast_building.json
25
26 # Get adaption request (single value)
27 echo $(REST_GET xml /rest/resources/testBuildingMeter/conn/powerSens/adaptionRequest) > output/building_adaption_req.xml
28 echo $(REST_GET json /rest/resources/testBuildingMeter/conn/powerSens/adaptionRequest) > output/building_adaption_req.json
29
30 # Get adaption request (schedule)
31 echo $(REST_GET xml /rest/resources/testBuildingMeter/conn/powerSens/adaptionRequest/values) > output/building_adaption_req_sched.xml
32 echo $(REST_GET json /rest/resources/testBuildingMeter/conn/powerSens/adaptionRequest/values) > output/building_adaption_req_sched.json
33
34 # Get mmx of neighborhood plant
35 resourceLocation="NeighborhoodPlant/e1Connection/powerSens/mmx"
36 echo $(REST_GET xml /rest/resources/$resourceLocation) > output/neighborhood_plant_mmx.xml
37 echo $(REST_GET json /rest/resources/$resourceLocation) > output/neighborhood_plant_mmx.json

```

Figure 5. Sample script for retrieving information from OGEMA

5.2 Interface OGEMA – ICT Platform

To send and receive data, OGEMA will actively connect to the ICT platform which is based on OpenJEVis, an open system for energy and operational data storage and monitoring. In this way, information can be immediately forwarded to the ICT platform as soon as received by the NAS.

First, all relevant resources are registered within the OGEMA framework. Then the framework connects to a specified OpenJEVis instance containing/requiring the information, retrieving the information or submitting it. This must be an ongoing process or daemon which retrieves or pushes the data at regular time intervals.

6. CONCLUSIONS

The Neighbourhood Automation System (NAS) platform provides a software base for development of supervisory and predictive control applications in EEPOS Neighbourhood energy management system. In this report, a provisional architecture of NAS platform and its communications with ICT and grid-users is developed. This is the first step in the NAS development.

6.1 Summary of achievements

1. Provisional NAS platform architecture has been developed based on OGEMA.
2. Communication NAS – grid-user has been developed through REST interface. Communication NAS – ICT will be based on OpenJEVis. For this communication a driver needs to be developed in OGEMA.
3. Automated registration of new grid-users will be supported by application running on OGEMA. This and all other required applications will be developed in Task 2.3 “Supervisory and predictive control applications” and described in Deliverable 2.3 “Supervisory and predictive control methods and applications”.
4. First version of data models will be developed in Task 2.2 “Neighbourhood Energy Grids Information Models”. Data models may change during development process of OGEMA applications.
5. Standard services of OGEMA framework have been described in Section 4.1.
6. The following stakeholder functions offered by OGEMA have been described: Graphical User Interface, Plug & play, User administration, security of data, Modularity, Application support.
7. Performance criteria of the NAS platform will be addressed in other tasks as described in the next subsection.

6.2 Relation to continued developments

Data models for the communication on the neighbourhood level will be developed in Task 2.2 “Neighbourhood Energy Grids Information Models” of the EEPOS project. OGEMA (supervisory and predictive control) applications for the NAS will be developed in Task 2.3 “Supervisory and predictive control applications” of the EEPOS project. NAS energy performance criteria firstly will be described and evaluated theoretically during validation of OGEMA applications within Task 2.3, and then in field tests within Work package 5 “Demonstration”. The usability of OGEMA platform will be assessed within Task 4.5 “Usability study”. Data communication testing is foreseen to be performed within Task 4.2 “Laboratory prototypes”.

7. ACRONYMS AND TERMS

DER	Distributed Energy Resources
EEPOS.....	Energy management and decision support systems for Energy POSitive neighbourhoods
EnMS.....	Energy Management System
GUI.....	Graphical User Interface
ICT	Information and Communication Technology
JACE	Java Application Control Engine
JVM.....	Java Virtual Machine
NAS.....	Neighbourhood Automation System
OGEMA	Open Gateway Energy Management Alliance
OSGi.....	Open Services Gateway initiative
REST	Representation State Transfer
TCP/IP.....	Transmission Control Protocol / Internet Protocol

8. REFERENCES

- [1] Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., institutes IIS, ISE, IWES, OGEMA 2.0 - Framework and API Specification, unpublished, publication on OGEMA-Wiki (www.ogema-source.net/wiki) planned by 2014.