Deliverable 2.2

Information models for neighbourhood energy management

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1. EXECUTIVE SUMMARY

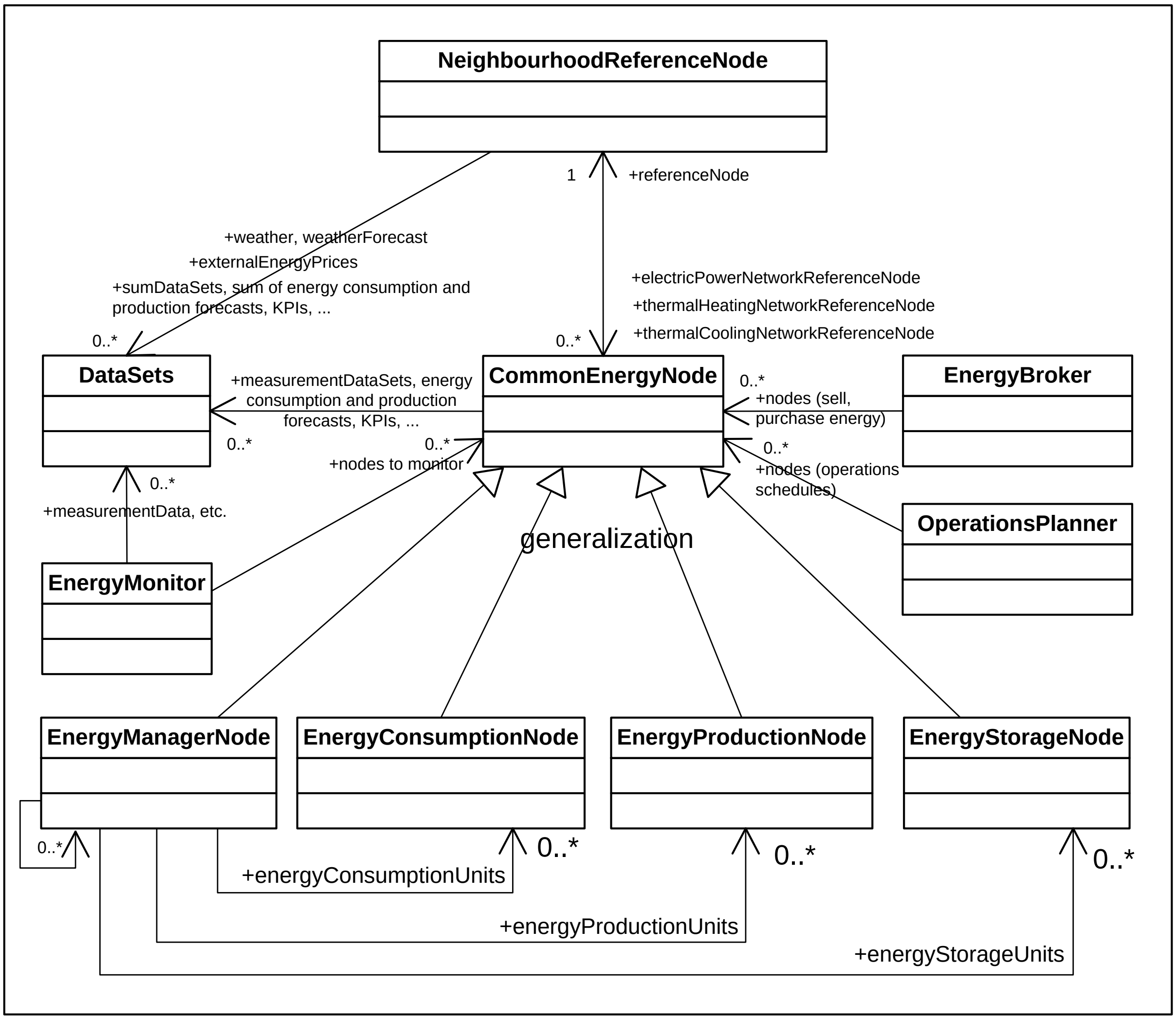
This deliverable defines the EEPOS neighbourhood energy grid information model for neighbourhood energy management including the information modelling approach, the requirements for the information models and the EEPOS use cases and related use case analysis.

The information modelling approach includes use case templates provided by CEN/CENELEC/ETSI. Some of these templates have been left out and some of these templates have been further developed.

The requirement specification includes a listing of standards which should be considered when developing the EEPOS information models. Furthermore, concept of the OGEMA data model as relevant for EEPOS, EEPOS relevant communication between building and neighbourhood level and communication between the EEPOS Neighbourhood Automation System and the EEPOS ICT platform are described.

In addition, this document describes several use cases and related use case analysis which should be considered when developing the EEPOS information models.

The main result presented in this report is the EEPOS neighbourhood energy grid information model for neighbourhood energy management.



A total of 13 EEPOS use cases and related use case analyses are described:

- UC1: Automatic consumption cut off
  An automatic consumption cut-off of certain loads can reduce energy costs or system maintenance costs, in case of extremely high electricity cost or unstable grid status.
- UC2: Energy brokering tool
  The Energy Brokering tool enables real estate managers to measure, calculate and monitor energy consumption and production and sell energy to tenants.
- UC3: Utilising the energy performance monitoring tool in Finnish demonstration
  Use case is based on visualized 3D virtual neighbourhood including the landscape, buildings and energy production units with navigation, online monitoring, historical data visualisation, benchmarking, and fault detection support.
- UC4: Utilising the energy performance monitoring tool in German demonstration
  The energy manager can use energy performance monitoring tool for data management, assessment and further processing.
- UC5: Integration of consumers / non-automatized loads
  Based on the prediction of the Network Energy Management System, the tenants get recommendations when the use of energy is most beneficial or least detrimental to the neighbourhood energy grid. Based on these recommendations, the tenants operate their non-automatized loads, e.g. white goods, leading to a more grid friendly behaviour.
- UC6: Heating grid optimisation in German demonstration
  The production of heat is optimized based on the production profile of the local heating plant and data from the heating grid and the individual substations.
- UC7: Saving energy by end-user collaboration
  The target of this use case is to support building end users (tenant, owners of the apartment) to save energy by means of visualized 3D virtual neighbourhood (landscape, buildings and energy production units) with navigation and limited social media and reporting support.
- UC8: The Trading (Agent-Based) approach
  The general target is the architecture with a high level of surplus which ensures that transmission lines are never overloaded.
- UC9: Calculation of neighbourhood level PV generation by the Neighbourhood Automation System
  The PV generation forecast application calculates generation forecast profiles for PV systems in the neighbourhood. The valuated generation forecast profiles for the PV systems serve as input data for other applications of the Automation Platform.
- UC10: Optimal load shifting planning on the neighbourhood level by the Neighbourhood Automation System
  The Load shifting planning application calculates optimal load shifting profiles for grid user.
- UC11: Storage of neighbourhood level historic electric energy consumption and generation rates
  A data storage solution supporting storing and querying of neighbourhood level electric energy consumption and generation rates.
- UC12: Operations planning supported by performance monitoring
  Performance monitoring based dynamic operating plan for neighbourhood and related buildings. This use case is described in more details in appendix 2.

2. INTRODUCTION

2.1 Purpose and target group

This document describes the final EEPOS neighbourhood energy grid information model for neighbourhood energy management.

Target group for this document are the software developers of the EEPOS consortium and in general level all those modellers who are developing models for neighbourhood energy grid ICT based management.

Most of the partners have participated in this work and they all had possibility to contribute their ideas and wishes they want to the basis of the EEPOS information model.

2.2 Contributions of partners

Partners' contributions are shown in the table below.

Section / Chapter	Contributor
1, 2, 3, 4.1.1, 5.3, 5.7, 6, 7, 8, Appendix 1: chapters UC3, UC7	VTT Technical Research Centre of Finland (VTT)
4.1.1, 4.1.2, 4.2, 4.3, 5.9, 5.10, Appendix 1: chapters UC9, UC10	European Distributed Energy Resources Laboratories e.V. (DERlab)
4.1.2	Fraunhofer IWES (IWES)
5.4, 5.8, Appendix 1: chapters UC4, UC7, UC8	ENNOVATIS GMBH (ENO)
5.5, 5.6, 5.11, Appendix 1: chapters UC5, UC6, UC11	AIT Austrian Institute of Technology GmbH (AIT)
5.2, Appendix 1: chapter UC2	FATMAN OY (FTM)
5.1, Appendix 1: chapter UC1, Appendix 2	Caverion Suomi Oy (CAV)

2.3 Baseline

State of the art / available technologies - information model standards for EEPOS:

- Intensive standardisation is going on, covering areas of smart grids, smart metering, energy management etc. on European and international level. Relevant standards, existing and under development, are e.g. IEC 61970 - Common Information Model (CIM) / Energy Management, IEC 61968 - CIM / Distribution Management, IEC 61850, OpenADR and ASHRAE SPC 201P.
- OGEMA uses standardised resource types for modelling of application data.

State of the art / available technologies – information modelling approach:

- Existing Use Case Templates are provided by CEN/CENELEC/ETSI.

Related other (EU) projects:

Odysseus project organised a round table workshop on Energy Efficiency at District Scale Level in Nice on the 12th of September 2013. The members of Ambassador, IDEAS, EEPOS and INTrEPID projects were invited to join to the discussion among others information model related ICT semantics (e.g. ontologies for energy networks). In the workshop the participants decided to keep in touch and to consider information exchange at least related to information modelling.

2.4 Relations to other activities

The work described here is mainly based on the results of the WP1 (scenarios, actors, etc.). In addition the intermediate inputs from tasks T2.3, T3.2, T3.3 and T3.4 have also been utilised.

The development of EEPOS tools in tasks T2.3, T3.2, T3.3 and T3.4 are carried out in close collaboration with this task and related OGEMA information models.

3. MODELLING APPROACH

3.1 EEPOS information model development

The EEPOS information model development approach is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

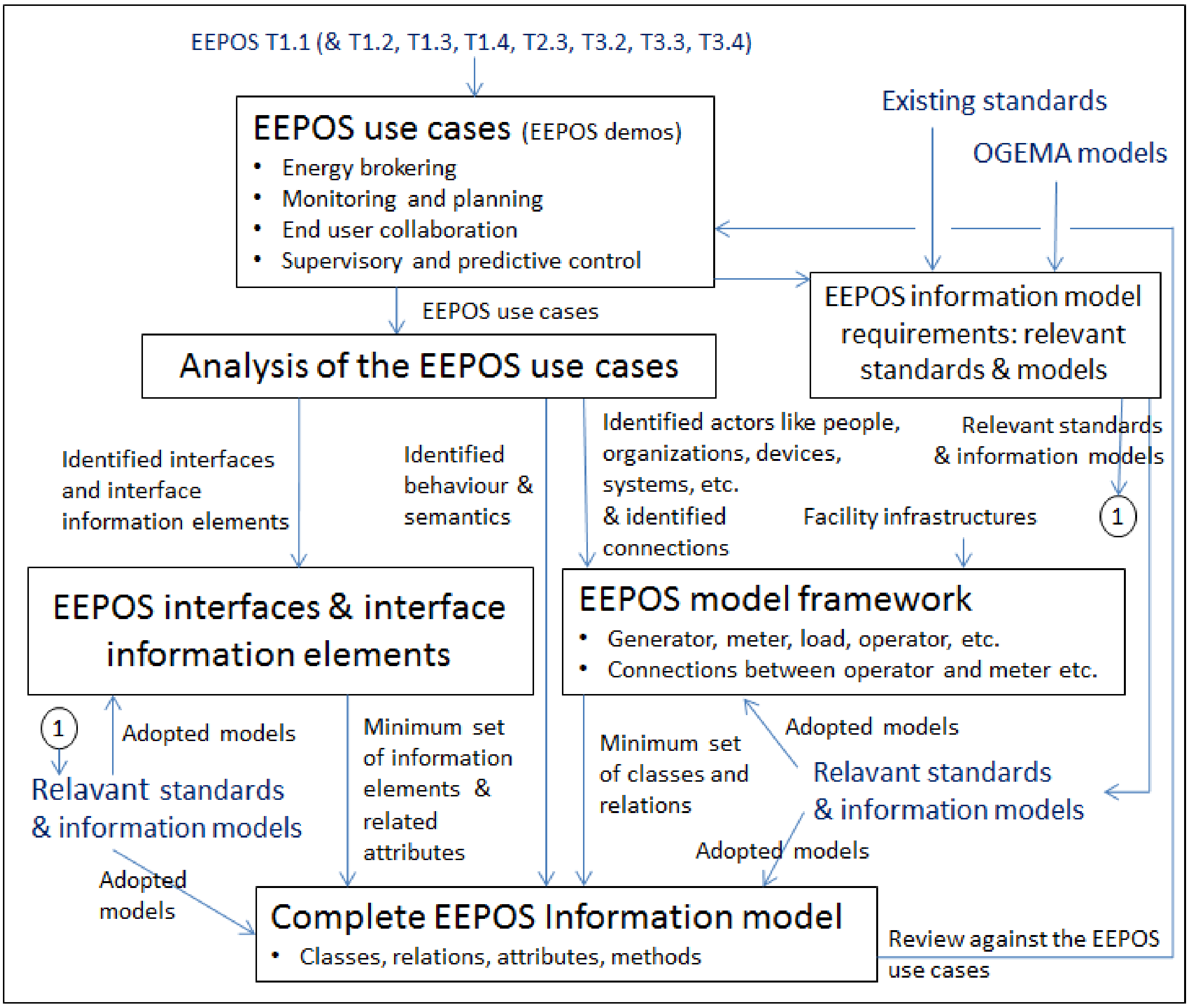


Figure 1. The EEPOS information model development approach

The main result of this task is the complete EEPOS information model. The modelling scope (**Fehler! Verweisquelle konnte nicht gefunden werden.**) includes the needed information model elements for EEPOS relevant in-house communication and especially the information model elements for EEPOS neighbourhood energy grids covering the basic neighbourhood energy grid topology, node entities like buildings and production units and node profiles like consumption and production components and information elements for communication between them.

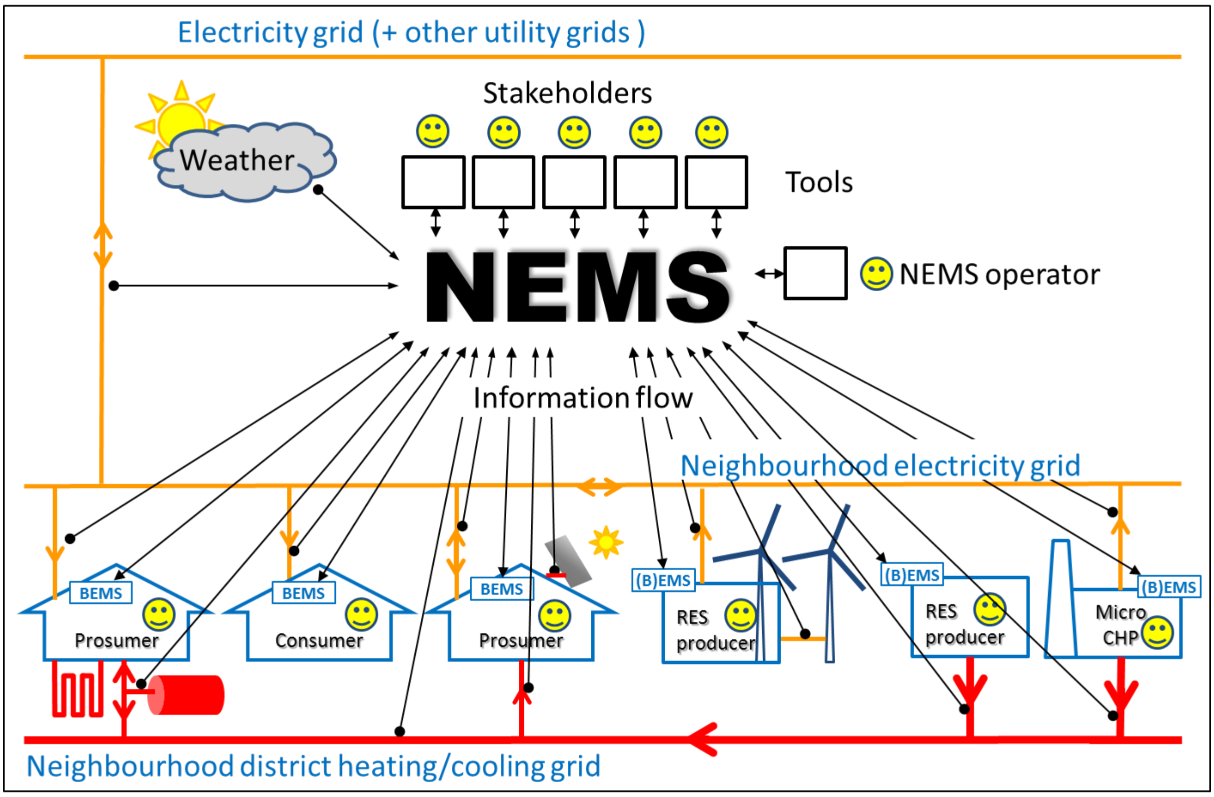


Figure 2. The scope of the EEPOS information model (black coloured lines)

The modelling approach includes the description of the most relevant EEPOS use cases and the analyses of these use cases including the identification of the needed actors, information elements between the actors, the use case related behaviours / semantics and related requirements for the information model. The approach includes that the existing standards including OGEMA models will be utilised if available.

The EEPOS actors are the participants in EEPOS applications. They may be e.g. persons, organisations, devices, computer systems or software programs. Actors can make decisions and exchange information with other actors through interfaces. The EEPOS interface information elements are data elements (single value, collection of data items etc.) which are sent from a source entity to a destination entity.

The EEPOS model framework describes a generalized neighbourhood level energy grid model associating the identified EEPOS devices and system actors and the main connections between them. In other words, the EEPOS framework defines an abstract representation of neighbourhood level energy consumption, production, and storage systems.

The complete EEPOS information model includes classes derived from EEPOS model framework and related attributes based on EEPOS use case related interface information elements.

In the following sections, templates (provided by CEN/CENELEC/ETSI **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**) and methods (Unified Modeling Language, UML **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**) for use case definition, related data analysis (CEN/CENELEC/ETSI) and the EEPOS information model related modelling (UML) are utilised.

3.2 Template and methods for the description of EEPOS use cases

The main target of the use case templates is to describe the requirements, functionalities and applications for the EEPOS information modelling and related EEPOS tool development purposes.

The templates are based on the use case templates provided by CEN/CENELEC/ETSI **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**. Some of these CEN templates have been left out and some of these templates have been further developed but the basic idea has not changed.

The first template is for the narrative description of the use case (**Fehler! Verweisquelle konnte nicht gefunden werden.**). To avoid duplicate work utilise EEPOS T1.1 as a background document.

Table 1. Template for the narrative description of a use case ***Fehler! Verweisquelle konnte nicht gefunden werden.***

Narrative description of the use case
Short description
Write a short description (max 3 sentences) of the EEPOS use case.
Complete description
Write the complete description of the EEPOS use case.

The second template is for the description of the use case related actors (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The column named "Actor Type" can be a person, organisation, system (more detailed application, function, database, device, system), role or generic role. The role is used if more than one actor is capable of fulfilling the function. For example an energy management system, an ESCO, an energy information provider or an energy supplier can do benchmarking so the actor benchmarker is an example of actor which type is role.

A complete description of the use case should include narrative description of the function from a domain expert user's point of view. It should describe what happens, when it happens, why it happens and with what expectation and under what conditions it happens.

Table 2. Template for the list of the use case related actors ***Fehler! Verweisquelle konnte nicht gefunden werden.***

Actor name	Actor Type	Actor Description	Further information specific to this Use Case	Source
Actor name	Actor type (e.g. Person)	Write a short description of the Actor	Write specific information for the use case (if needed)	EEPOS or standard x, …
…	…	…	…	…

The third template is for the use case related preconditions, events and assumptions (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Table 3. Template for the use case related preconditions, events and assumptions ***Fehler! Verweisquelle konnte nicht gefunden werden.***

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Describe which actor(s) trigger(s) this use case	Describe what event(s) trigger(s) this use case	Describe what condition(s) should have been met before this use case happens	Possible assumptions
…	…	…	…

The fourth utilised template is a UML use case diagram (**Fehler! Verweisquelle konnte nicht gefunden werden.**). UML is a standard (ISO/IEC 19501:2005) based general purpose modelling language for software engineering. The UML based use case diagram describes in a technology neutral way what the system must do. In other words the diagram includes the studied EEPOS use case related actors, goals and dependencies by means of graphical presentation.

EEPOS use case related actors, goals and dependencies

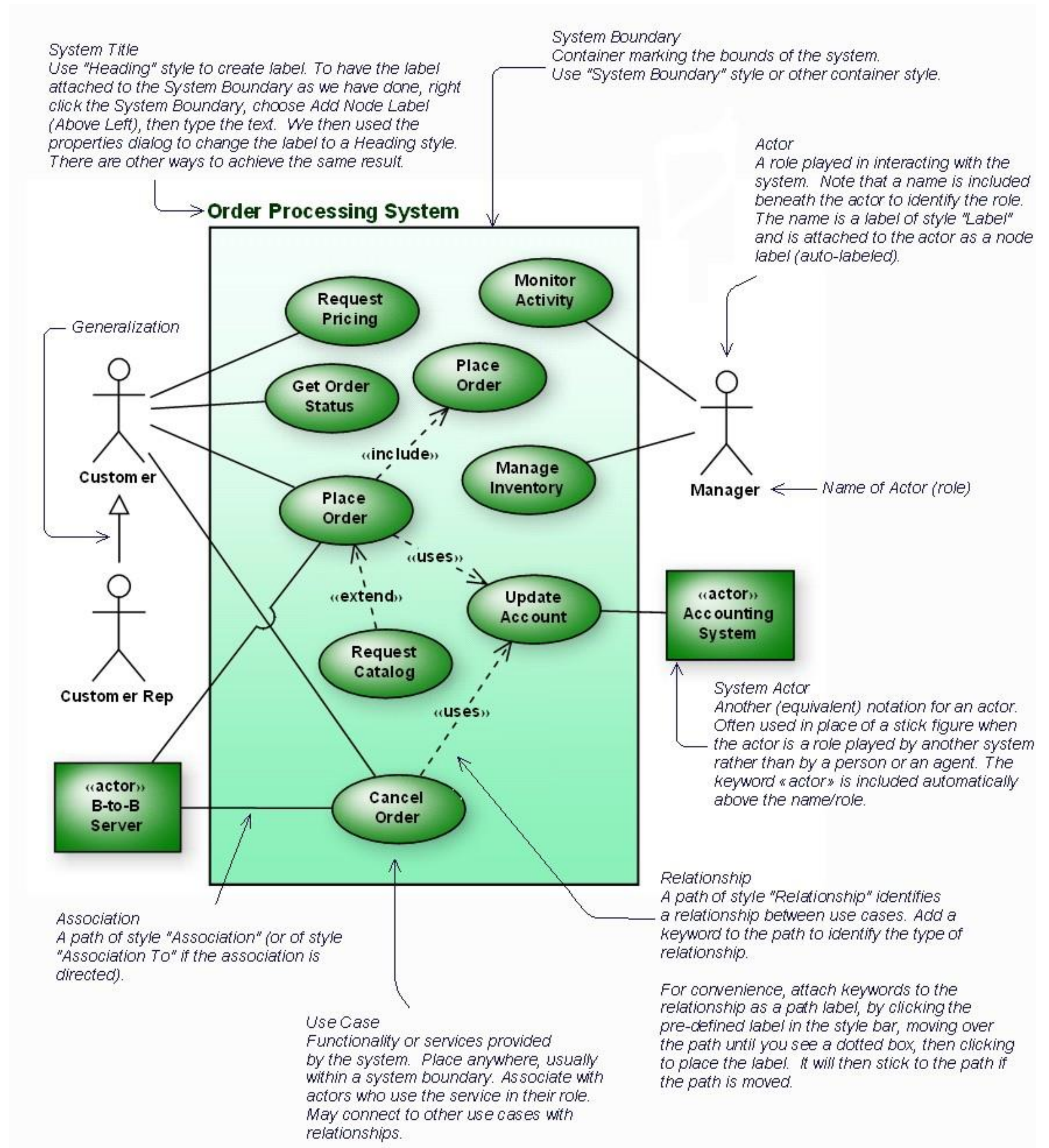


Figure 3. An example based template for UML based use case diagram [5]

Examples of the software which can be used to create UML based use case diagram are e.g. Enterprise architect **Fehler! Verweisquelle konnte nicht gefunden werden.**, Microsoft Office Visio (UML Model Diagram template) **Fehler! Verweisquelle konnte nicht gefunden werden.** or free open source UMLet **Fehler! Verweisquelle konnte nicht gefunden werden.** including Eclipse plugin.

3.3 Template for use case analysis

The templates for use case analysis are provided now, but the analysis will be documented in the final version of the deliverable.

The main focus of the use case analysis is to find out the minimum set of actors and the information elements needed to build EEPOS information model.

The use case analysis includes five different types of templates which are mainly based on the use case template provided by CEN/CENELEC/ETSI **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**. The first template is for summarising all studied EEPOS use case's primary scenarios (named PS1, PS2, ...) and related alternative scenarios (named AS1, AS2, …) for the situation that primary scenarios do not succeed (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

*Table 4. Template for all the different scenarios of the studied EEPOS use case **Fehler! Verweisquelle konnte nicht gefunden werden.***

Use case's scenario number	Primary Actor	Triggering Event	Pre-conditions	Post-Condition
PS1	Describe which actor(s) trigger(s) this scenario	Describe what event(s) trigger(s) this scenario	Describe what condition(s) should have been met before this use case happens	Describe what condition(s) should prevail after this scenario happens. The post conditions may also define "success" or "failure" conditions for each use case.
PS2 or AS1	…	…	…	…

The second template is for describing all the steps (list of events) and related information elements for the studied use case scenario (**Fehler! Verweisquelle konnte nicht gefunden werden.**). This template can be used also for failure (alternative, error management and/or maintenance/backup) related scenario. The column named "Sending actor" is the actor who sends the information to the actor named in the column "Receiving actor".

Table 5. Template for the use case scenario (list of events) and related information elements

Use case's scenario						
Step no.	**Event**	**Description of Process/Activity**	**Sending actor**	**Receiving actor**	**Information exchanged**	**Req. id**
1	The event that starts the step	What action takes place in this step	Actor name	Actor name	List the information elements to be exchanged	Possible req. id
2 etc.	…	…	…	…	…	…

The template for the summary of all the identified actors in all the EEPOS use cases is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 6. Template for summary of all the needed actors

Actor name	Actor Type	Actor Description	Parent Actor	Possible Roles / Functions	Source
Actor name	Actor type	Description of the Actor	Parent actor name	List of actor names (0…N)	EEPOS or standard x, …
…	…	…	…	…	…

The template for the summary of all needed information elements in EEPOS use cases is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. The column named "Sending actor" is the actor who sends the information element to the actor named in the column "Receiving actor". The information element is the information structure name which describes the sent information content (e.g. energy tariff).

Table 7. Template for summary of all needed information elements

Information element name	Sending actor	Receiving actor	Description	Information exchanged	Requirement id
Information element name	Actor name	Actor name	Description of the Information element	Detailed information content of the information element	Possible requirement id.
…	…		…	…	…

If there are some additional requirements for the EEPOS information model, the next template can be used (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Table 8. Template for requirements

Requirement ID	Relevance	Specification
Requirement id	High/must/compulsory/low/option/	Specification of the requirement
…	…	…

3.4 Template for the model framework

There are no exact templates for the EEPOS model framework diagram. This diagram should include the main components and the connections between them (see an example in **Fehler! Verweisquelle konnte nicht gefunden werden.**).

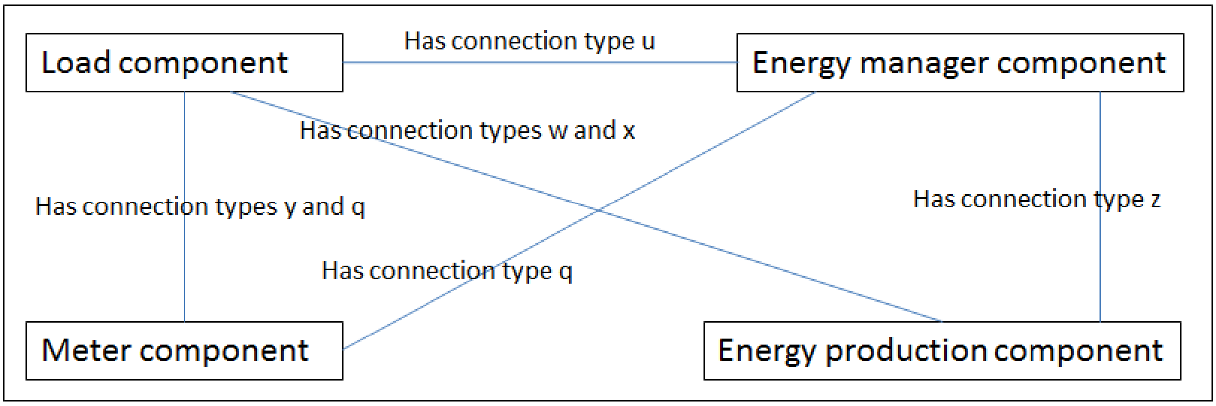


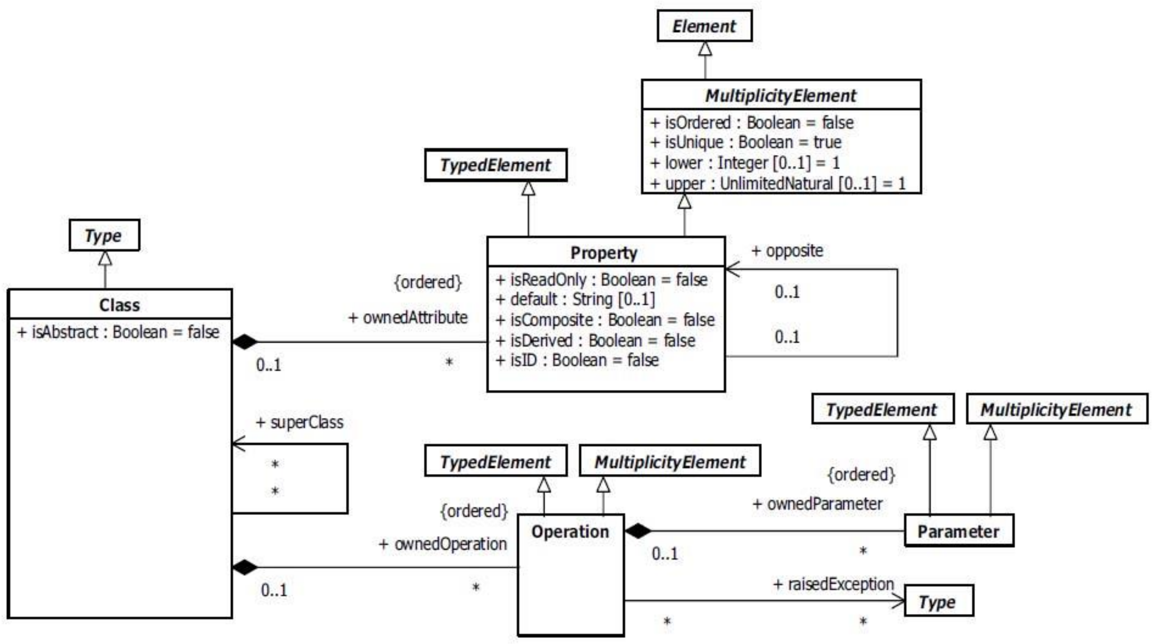
Figure 4. An example based template for the model framework

The basic idea is to describe so general level components that the other components can be presented by combining them. For example energy storage can be presented using energy production and load components. And load component can be building, electric car, HVAC system, end user's device etc.

3.5 Template and methods for EEPOS information models

The final EEPOS information model will be realised using the UML based classes diagram (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The diagram defines the constructs for class-based modelling (system's classes, attributes and the relationships to other classes).

Example of UML based classes diagram



Source of the example diagram **Fehler! Verweisquelle konnte nicht gefunden werden.**

Figure 5. Template for UML based classes diagram **Fehler! Verweisquelle konnte nicht gefunden werden.**

The other UML diagrams are e.g. activity (visualizing a sequence of activities), component (how the software is divided into components and the dependencies between the components), deployment (describes the implementation related hardware and the execution environments), interaction (visualizing a sequence of activities), package (how software is divided into logical groups and the dependencies between the software logical groups) and state machine (the sequence of events relating single object lifetime). If these templates are needed, those diagrams related documentation can be found from the UML specification **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**.

4. General requirements for EEPOS information models

4.1 State-of-the-Art

4.1.1 Standards for the EEPOS related information

The baseline will be the state-of-the-art information models on related domains such as smart grid, building and home automation, building and neighbourhood energy systems, building energy performance metrics, etc. Ongoing standardisation activities within ISO, IEC, CEN and CENELEC as well as within industrial organisations such as buildingSMART, ASHRAE (BACnet, FSGIM), or OASIS (oBIX) will be followed and taken into account:

- IEC 62056 (DLMS/COSEM): Data exchange for electricity meter reading, tariff and load control
- IEC 61850: Design of electrical substation automation
- IEC 61970: Series of standards for the application program interfaces for energy management systems including the Common Information Model (CIM)
- OpenADR: Market communication, load/generation management
- EN 50491: General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS)
- EN 13757 (M-Bus): Communication system for meters and remote reading of meters
- IEC 62746: System interfaces and communication protocol profiles relevant for systems connected to the Smart Grid
- MSCONS
- Z-Wave
- ZigBee
- BACnet
- FSGIM
- oBIX
- LON
- SunSpec
- WAGO-I/O
- EEBus: Commodity prices, load/generation management

As described in EEPOS D1.3 and in the introduction of chapter 4.1 of this document there are a lot of building communication/control network protocols, smart consumption meters and related smart grid standards and building and neighbourhood related information models (Figure 6). The big challenge is how to build the neighbourhood level energy management system and related ICT tools and fully integrate them without considerable effort. This means uniform EEPOS information model and related APIs which should utilise as much as possible existing standards.

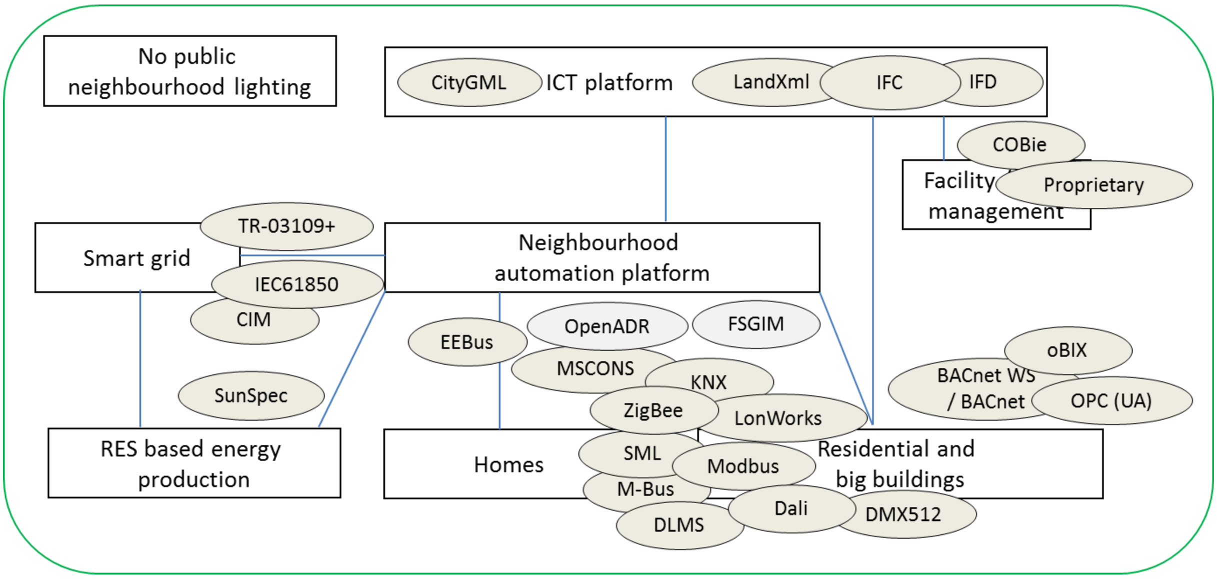


Figure 6. Examples of existing standards and technologies relating EEPOS scope

From EEPOS information model development point of view the most important energy grid related standards are

- IEC 61968 - CIM / Distribution Management
- ASHRAE / NEMA 201 (Facility Smart Grid Information Model **Fehler! Verweisquelle konnte nicht gefunden werden.**)
- OpenADR
- IEC 62056 (DLMS/COSEM): Data exchange for electricity meter reading, tariff and load control
- EN 50491-11: A metering data model for a simple external consumer display [10]
- prEN 50491-12: Neutral API for connecting different Home and Building Electronic Systems (HBES) / smart devices to the smart grid [11]

It is also important to notice general level issues from *IEC 61970 - Common Information Model (CIM) / Energy Management*. *IEC 61970 - Common Information Model (CIM) / Energy Management* was initially developed for generation and transmission problems. The CIM information model describes the electrical network, the connected electrical components, the additional elements and the data needed for network operation and the relations between these elements. The CIM model related packages are basic elements, topology, generation, load model, measurement values and protection. An important feature from EEPOS point of view is that the CIM relations between classes may extend beyond the boundaries of packages. This means that it is possible to extend this model with EEPOS relevant features.

IEC 61968 - CIM / Distribution Management is an extension to the CIM model. It defines needed information models for electrical distribution from substation to the customer meter. It includes network topology models and models for distribution lines, distribution loads, voltage regulators, and distribution feeders.

The ASHRAE/NEMA 201 standard defines an abstract, object-oriented information model to enable appliances and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a "smart" electrical grid and to communicate information about those electrical loads to utility and other electrical service providers. **Fehler! Verweisquelle konnte nicht gefunden werden.**

The ASHRAE/NEMA 201 model provides communication protocol independent basis for common information exchange between control systems and end use devices in buildings.

The model defines data objects and actions for energy management applications and electrical service provider interactions including

- On-site generation
- Demand response
- Electrical storage
- Peak demand management
- Forward power usage estimation
- Load shedding capability estimation
- End load monitoring (sub metering)
- Power quality of service monitoring
- Utilization of historical energy consumption data
- Direct load control

Open Automated Demand Response (OpenADR) is a research and standards development effort for energy management led by North American research labs and companies. It is typically applied to send information and signals to cause electrical power-using devices to be turned off during periods of high demand. **Fehler! Verweisquelle konnte nicht gefunden werden.**

In addition IEC technical committee PC 118 (Smart grid user interface) is planning to use OpenADR documents and publish related API specifications as a technical report. On the other hand IEC TC 57/WG10 specialists have been commented that OpenADR is not compatible with IEC 61850 and CIM-models.

It is also important to notify the new work item proposal IEC/TS 62056-6-9, Mapping between the Common Information Model CIM (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and message profiles. [14]

In addition it is very important to notify the ongoing standardization work in CENELEC TC 205 WG18 related to the defining a neutral layer for connecting different Home and Building Electronic Systems (HBES) / smart devices to the smart grid (prEN 50491-12). The ongoing work includes related data models, data structures and data types and how to addressing the devices. The planned future work (50491-12-xx) includes the definition of the minimum requirements for Customer Energy Manager (CEM), commissioning / discovery / management, dataflow between CEM / mapping, message exchange protocol, encoding of information (e.g. XML / JSON) and security. [11]

The CEM is planned to be an element (specifications not yet available in any standard), which is between smart grid and the installed devices in the building. It will typically utilise smart grid inputs and optionally inputs from other sources (e.g. energy availability and related forecast, energy demand and related forecast) for managing the devices installed in the building. The CEM can also provide feedback to the smart grid, e.g. in forms of load forecasts etc. The interoperability between CEM and the Smart Grid can be ensured by using the IEC 62746.

On the other hand there is a competing CEN TC 247 project for prEN 50491-12. The CEN TC 247 project utilise ISO 17800 for connecting smart buildings to smart grid.

EN 50491-11 specifies a metering data model for a simple external consumer display. The same data model can be used also in interfaces between Meter Communication Functions (MCF) and the Local Network Access Point (LNAP) or Neighbourhood Network Access Point (NNAP) and related interfaces to the HBES devices. [10]

It is also important to notify BACnet etc. standards related smart grid activities and IEEE 1377 version 2 (flexible metering data and information models) and IEC 62056 standard series (Data exchange for meter reading, tariff and load control) when developing the EEPOS information model.

4.1.2 Concept of the OGEMA data model as relevant for EEPOS

In a neighbourhood which is equipped with an EEPOS Energy management system, all communication between buildings and the neighbourhood level will go through the Neighbourhood Automation System which is based on OGEMA (cf.**Fehler! Verweisquelle konnte nicht gefunden werden.**). Accordingly, to enable the communication between the OGEMA-based Neighbourhood Automation System and other players of the EEPOS system, the EEPOS information model elements need to be integrated into the OGEMA data model.

The aim of the OGEMA data model is to be able to represent all kinds of data that need to be exchanged between applications, drivers and user interface applications in the fields of smart grid and smart building. For this, the OGEMA data model defines standardized resource types for modelling of application data **Fehler! Verweisquelle konnte nicht gefunden werden.**. Thanks to this resource based approach, OGEMA realizes an interface-less interoperability of the different players: To facilitate the communication with other applications or the communication with partners outside of an OGEMA system, OGEMA applications write/read their output/input into/from data containers with a tree-like structure, so called resources. These resources are administered by the OGEMA framework and shared with the other applications or, via the REST interface, with external communication partners – provided that they have been granted the appropriate access permissions.

The structure of the resource trees in an OGEMA framework is determined by the standardized resource types. Each resource has an associated standard resource type that defines what type of information the resource represents and what its possibly expected sub-resources (child nodes) are. The resource type does not define a resource's possible parent resources or their type. Instead, the OGEMA data model defines many generic resource types that are intended to appear as sub-resources of a variety of other resource types. For example, a sub-resource of the type ElectricalConnection is defined for all resource types representing a device that consumes or produces electrical energy. As an example, excerpts of the representation of a combined heat and power generator by the OGEMA data model are shown in Figure 7.

Many resource types merely define structure, i.e. a set of possible sub-resources. For storing values describing the current state of a system, special resource types are defined: the simple resource types. These types like FloatResource, IntegerResource and StringResource store a value of the respective type (a floating-point value, an integer value or a piece of text in this case). Their respective array resource type counterparts store arrays of the respective types. Simple resource types and array resource types do not define the meaning of their values stored. The values' meanings are entirely determined by their parent resources, i.e. by how the resources are arranged in the structure of data elements.

Except for the values contained in simple resource types and their arrays, all elements defined in the OGEMA data model's resource types are optional. This means that applications wanting to operate on a resource's field must either ensure its availability or add the entry themselves. Due to this flexibility of the resources, applications should be able to work with a minimum set of input data points, while exposing as much information back to the framework as possible. In order to ensure interoperability between applications and drivers, each physical or abstract value that could be exchanged, e.g., between two OGEMA applications or with external players, must be unambiguously identifiable within the OGEMA data model.

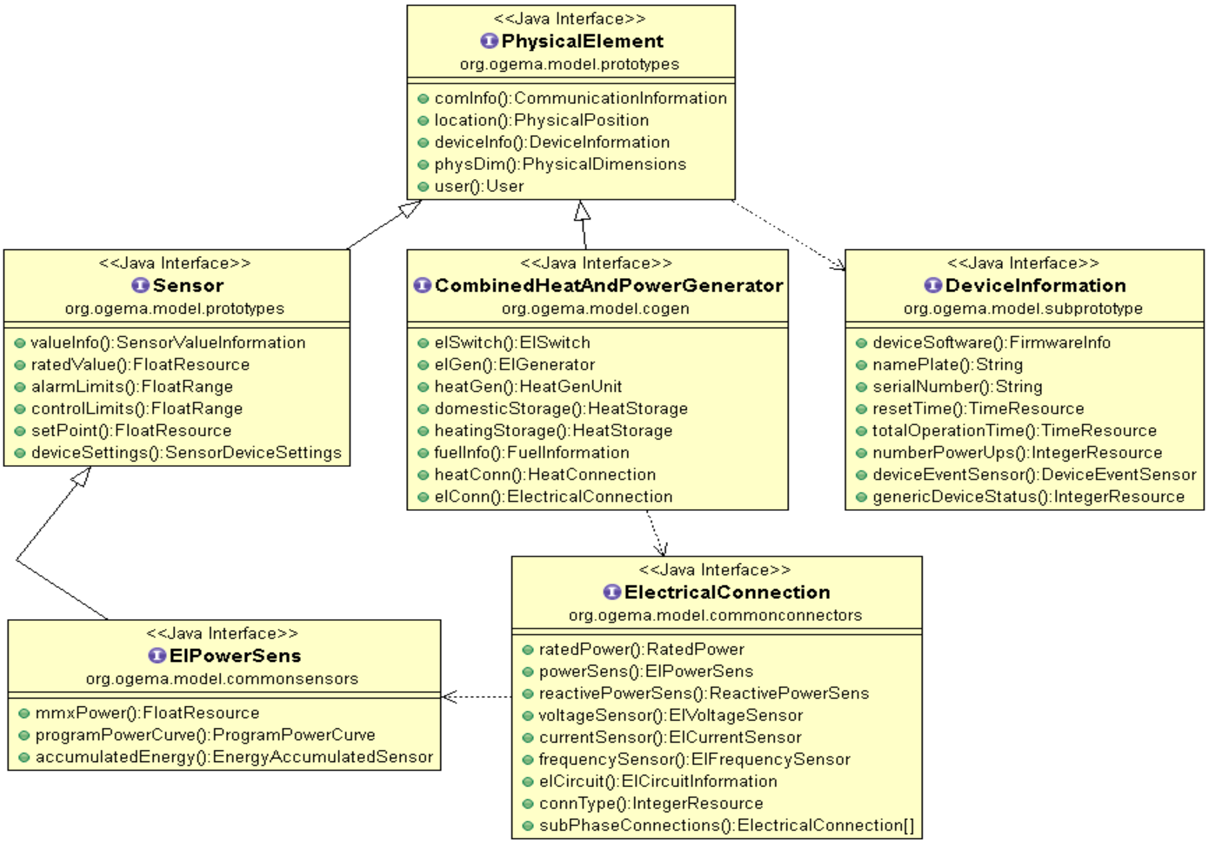


Figure 7. Example of the representation of a combined heat and power generator by the OGEMA data model. For clarity of the representation, only selected paths are shown, e.g., all child resource types of the generator's ElectricalConnection are hidden

As a consequence of the aim to be able to represent all kinds of data that need to be exchanged between applications, drivers and user interface applications in the fields of smart grid and smart building, the OGEMA data model exhibits a rather complex and extensive structure. That is why the formal structure of its elements, the standardized resource types, is determined by modelling rules and not according to certain use cases or existing domain standards. A model which claims to represent all that might be exchanged in a certain field can hardly ever be complete: It is very likely that it will encounter cases in which an initially unexpected energy management service requires an extension. Hence, the OGEMA Data Model is designed to be growing. It is foreseen that it will be extended constantly when new applications and drivers are developed and new use cases and device types are considered. The OGEMA modelling rules are the guidelines for the definition of new resource types when extending the OGEMA data model ("modelling process") as well as for the usage of already available resource types ("usage"). These modelling rules will be part of the OGEMA 2.0 Framework and API Specification **Fehler! Verweisquelle konnte nicht gefunden werden.**. The complete structure of the data model of the OGEMA 1.1 framework is documented and provided to the public in form of a Javadoc at www.ogema-source.net. The Javadoc for the OGEMA 2.0 framework, which will be employed as software platform for the EEPOS Automation System.

In addition to extending the data model when no suitable defined resource type is available in the OGEMA data model, it is possible to locally add custom resource types to a specific

OGEMA framework. However, the design of such new resource types should strictly be carried out according to the modelling rules. Alternatively, sub-resources that are not defined by the OGEMA data model can be added to a resource via the decorator mechanism (for further information see **Fehler! Verweisquelle konnte nicht gefunden werden.**). Both, using custom resource types and using decorators should be avoided since they tend to break the aims of interoperability and unambiguous identifiability of data elements for which the resource-type approach was chosen in the first place. Hence, the EEPOS consortium will strive to incorporate the whole EEPOS information model into the OGEMA data model without the definition of EEPOS specific custom resource types.

4.2 EEPOS relevant communication between building and neighbourhood level

From the EEPOS perspective, models for in-house communication are of interest as far as they concern the communication between the building and the neighbourhood level. This means that on the building level itself, e.g., for communication between a building energy management system and controlled devices like white goods, different information models may be used by different manufacturers of building level energy management systems. However, to ensure communication between building and neighbourhood level and functioning of the EEPOS energy management system, the energy management systems employed on the building level need to support the EEPOS communication model as developed in this task.

This subsection describes the required data communications between the Neighbourhood Automation System and grid users. Here grid users are seen as energy consumers or producers connected to the electricity grid being buildings (represented by building energy management or automation systems), neighbourhood level electricity generation systems or consumers. The term grid user also refers to thermal systems like CHP plants and heat pumps, which generate electric power as by-product or use electricity to pump heat respectively. Aforementioned grid users independently of their characteristics and functions are able to adapt their electricity consumption or generation patterns up to some grade when necessary. This adaption of energy patterns should be able to be automatized and doing so, the quality of life of the neighbourhood inhabitants should not be reduced.

The communication between the Neighbourhood Automation System and grid users has to be bidirectional. The Neighbourhood Automation System will for instance make available updated price forecasts and optimal load shifting planning profiles (e.g. 24 hours in ahead updated every 15 min) to the end users. End users will recalculate their load adaption planning profiles after reading the updated load shifting planning profiles and will send feedback of planned load shifting to the Neighbourhood Automation System. Such data communication is required for efficient load management within the neighbourhood. Examples for data communication between the Neighbourhood Automation System and grid users are listed in are listed in the Tables 9 and 10.

Table 9 Examples of Neighbourhood Automation System to grid user communication

Information element	Data type	Description
Price forecast	Array of real values with time stamp	Price forecast for at least one day in ahead every 15 min in €/kWh. Each forecasted value is paired with a time value. In Nordic electricity market the time interval is one hour. One hour time interval is used also in Nord pool prices. This means that EEPOS system should adapt to different price forecast time interval.
Optimal load shifting planning	Array of integer values with time stamp	Optimal load shifting planning for at least one day in ahead indicating times at which load shifting is required (i) for cost effective load shifting following electricity price and (ii) for peak load shaving in electricity grid. For example, “-1” indicating times from which load is suggested to be shifted; “1” indicating times to which load is suggested to be shifted. “0” indicates a neutral time period without suggestions for load shifting. Each profile value is paired with a time value.

Table 10 Examples of Grid user to Neighbourhood Automation System communication

Information element	Data type	Description
Residual load forecast (grid user #1, grid user #2, …, grid user #n)	Array of real values with time stamp	Residual load forecast profile of grid users for at least one day in ahead every 15 min in kW. Each predicted value is paired with a time value. Profiles should be saved temporary

In EEPOS, price forecasts will be provided to the Neighbourhood Automation System by the ICT platform. The optimal load shifting planning calculation is described in Deliverable 2.3 **Fehler! Verweisquelle konnte nicht gefunden werden.**.

In the German EEPOS demonstration, the communication between the Neighbourhood Automation System and the grid users will be the communication between an OGEMA system and the ennovatis Smartbox. In the German EEPOS demonstration, it will be the communication between an OGEMA system and the Niagara JACE system. In the laboratory prototypes, the communication between building and neighbourhood level will the communication between two OGEMA systems. Communication with any other building level management system provided by any other manufacturer will be performed on the same level and in the same way.

To ensure data privacy, detailed information on specific appliances in the end user systems will not be required and will not be provided to the Neighbourhood Automation System.

4.3 Communication between the Neighbourhood Automation System and the ICT platform

The Neighbourhood Automation System requires information from external data sources in order to manage neighbourhood load shifting efficiently. Furthermore, it will provide information to the different software tools developed in WP3. The ICT platform will serve as a mediator between WP3 tools, external data sources and the Neighbourhood Automation System. For instance, the Neighbourhood Automation System expects to be provided by the ICT platform with updated information on the electricity price, weather forecast and load forecast for the neighbourhood. Here, the required weather forecast depends on the neighbourhood where the Neighbourhood Automation System will be applied as well as on the complexity of the load management applications. Here, we assume that the neighbourhood equipped with the EEPOS system has neighbourhood level PV systems installed. Accordingly, the application for calculating generation forecast of PV systems which is developed in Task 2.3 **Fehler! Verweisquelle konnte nicht gefunden werden.** requires weather forecast information on solar irradiance and ambient temperature. Examples for data required from the ICT platform by a Neighbourhood Automation System applied in a neighbourhood with photovoltaic systems is listed in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 11 Examples for communication between the ICT platform and the Neighbourhood Automation System

Information element	Data type	Description
Price forecast	Array of real values with time stamp	Price forecast profile for at least one day in ahead every 15 min in €/kWh. Each predicted value is paired with a time value.
Solar irradiance forecast	Array of real values with time stamp	Solar irradiance (the solar radiation measured perpendicular to the sun, $S_{incident}$) forecast for at least 24 hours in ahead every 1 min in W/m2. Each forecast value is paired with a time value.
Ambient temperature forecast	Array of real values with time stamp	Ambient temperature forecast for at least 24 hours in ahead every 15 min in °C. Each forecast value is paired with a time value.
Neighbourhood load forecast	Array of real values with time stamp	Load forecast profile of the neighbourhood load for at least one day in ahead every 15 min in kW. Each predicted value is paired with a time value.

Predicted load of the neighbourhood is an important input in the Neighbourhood Automation System. It gives the information on the total load forecast in the neighbourhood needed to identify peak loads and to calculate residual load (load minus generation).

The Neighbourhood Automation System to ICT platform communication includes all the necessary data communication for energy management feedback, and on current and historical energy data. Depending on the feedback needed and data needed for energy monitoring, the required communication towards ICT platform may differ. From the viewpoint of the Neighbourhood Automation System, this data communication is only for monitoring and feedback purposes. The example of the communication of historical data of the electricity consumption for one building is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 12 Example for Neighbourhood Automation System to ICT platform communication

Information element	Data type	Description
Residual load (grid user #1, grid user #2, …, grid user #n)	Real value	Residual electricity consumption of grid users for last 15 min in €/kWh paired with a time value.

5. REQUIREMENT SPECIFICATION - EEPOS USE CASES

The selection of relevant uses cases for the development of the EEPOS information model is based on the need of the EEPOS demonstrations related tools (supervisory and predictive control, energy brokering, monitoring and planning and end user collaboration). The next list (**Fehler! Verweisquelle konnte nicht gefunden werden.**) of use case candidates is based on the EEPOS scenarios documented in deliverable D1.1. The Table contains also information on which use cases will be included in the EEPOS information model development and which not.

Table 13. Selection of the use cases for EEPOS information model development

Use Case candidate	Will be included in the model
Integration of Consumers / non-automatized loads	x
Operations planning supported by performance monitoring (based on D1.1 scenario "Optimisation of heating grid")	x
Activities delayed by end-user	x
Saving energy by end-user collaboration	x
End-user balance card	x
Energy Brokering Tool	x
Automatic consumption cut off	x
Utilising energy performance monitoring tool	x
The Trading (Agent-Based) Approach	x
Considering Power and Heat	x
Optimal load shifting planning on the neighbourhood level by the Neighbourhood Automation System (based on D1.1 scenario Automated Demand Side Management within the Neighbourhood)	x

The next list of the use case candidates shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** are based on the input of other EEPOS WPs.

Table 14. Additional use cases for EEPOS information model development

Additional EEPOS Use Case candidates	Will be included in the model
Collection and management of current electric energy consumption and generation rates within the neighbourhood	Covered by the other use cases
Storage of neighbourhood level historic electric energy consumption and generation rates	x
Calculation of neighbourhood level PV generation by the Neighbourhood Automation System	x
Planning of optimal load shifting on the neighbourhood level by the Neighbourhood Automation System	x
Use cases for additional OGEMA Applications which are not yet	x

specified	
Use cases with respect to heating grid optimisation	x
Neighbourhood can assign a single broker to buy all energy needed – allowing procuring energy in bulk thus receiving better price conditions	x

The next list of the use case candidates (**Fehler! Verweisquelle konnte nicht gefunden werden.**) are based on ASHRAE SPC 201P. Only the EEPOS relevant validation use cases are listed with minor modifications. If the use case will be used in the EEPOS demonstration then it will be studied more in this document by adding it to use case descriptions related chapter.

Table 15. Possible additional use cases (mainly ASHRAE 201 based) for EEPOS information model development

Additional Use Case candidate
Minimize customers energy costs by managing power demand by contracts and tariffs
Manage neighbourhood level energy production
Forecast customers energy demand
Buy and sell energy
Social, environmental, and regulatory related information for customers who wants to control related aspects of their energy consumption
Customers can buy energy from different energy producers
Balance power purchases between utility and on-site generation
Measure detail level power (e.g. heating, cooling, outdoor lighting, washing machine, selected plug) to calculate related cost and consumption
Measure energy cost, emissions and consumption for online and historical data (e.g. daily, monthly and yearly) reports
Measure energy cost, emissions and consumption for accounting
Measure energy cost, emissions and consumption for benchmarking (comparing against similar buildings, certificate, etc.)
Measure energy cost, emissions and consumption for validating (e.g. using temporary measurement equipment)
Generation for grid maintenance and planning (e.g. when the distribution system maintenance should do etc.)
Receive instantaneous power quality information to validate power service level agreement
Historical energy information for forecasting future use
Defining the customers power demand target (low target -> possible penalties, high target -> no savings)
Neighbourhood operator or energy broker is able to see customer's load shifting parameter setup (e.g. which energy price means lower power consumption)
Direct load control by an external source
Get information of onsite generation capacity
Get information of onsite storage capacity

Get information of weather forecast

The list of the harmonized description of all EEPOS use cases related actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 16. List of the EEPOS use cases related actors

Actor name	Actor Type	Actor Description	Source
Automatic consumption cut off application	«Software»	A computer program which sends energy consumption related cut off decision for execution.	EEPOS
Automation Platform	«System»	The EEPOS Automation Platform is a hardware independent execution environment for neighbourhood related energy management applications. It will provide means to access different devices and meters and provides interfaces for control applications as well as to the EEPOS ICT platform.	EEPOS
Buyer	«Person»	A person who purchases something.	EEPOS
Benchmarker	«Role»	A generalized description for an entity that performs cross-building analysis and defines the energy usage and efficiency of one building in relation to other buildings. This could be an Energy Management System, by an ESCO, by an Energy Information Provider or by an Energy Supplier. **Fehler! Verweisquelle konnte nicht gefunden werden.**	ASHRAE 201
BIM service	«Software»	An existing web service APIs and related existing Building Information Model (BIM) related software(s).	EEPOS
Building Management	«Role»	Building Management is a meta-role within a facility that encompasses various personnel concerned with managing a building. This includes but is not limited to the Facility Manager, the Operations Manager, the Environmental Manager and the Financial Manager. **Fehler! Verweisquelle konnte nicht gefunden werden.**	ASHRAE 201
Building Owner	«Role»	The Building Owner is a meta-role within a facility that defines a Landlord for a leased entity or a Home Owner for residential application. **Fehler! Verweisquelle konnte nicht gefunden werden.**	ASHRAE 201
Energy brokering tool	«Software»	A tool providing a platform for the EEPOS System operators to participate in energy trading on external energy markets on behalf of the members of the neighbourhood.	EEPOS
Energy grid	«System»	A network for delivering electricity or thermal energy from suppliers to consumers.	EEPOS

End user	«Person»	A person who uses the application.	EEPOS
End user collaboration tool	«Software»	An EEPOS software tool for motivating end users to save energy.	EEPOS
Energy consumption component	«System»	A device or system (e.g. building, electric car) that use locally produced energy.	EEPOS
Energy manager	«Person»	A person who analyse the energy data with the objective to optimize the functions of the building automation systems to save energy.	EEPOS
Energy Services Company (ESCO)	«Organization»	A business providing energy savings, efficiency and generation solutions. **Fehler! Verweisquelle konnte nicht gefunden werden.**	ASHRAE 201
EnMS Operator	«Role»	EnMS operator is the party that combines the neighbourhood into a single entity to participate in the energy market (buy heat and fuels and trade electricity), procures the necessary resources and services and ensures the optimum operations of the neighbourhood.	EEPOS
Ennovatis Controlling	«Software»	A software by Ennovatis for data storage and monitoring of EEPOS information.	Ennovatis
Facility manager	«Person»	The person responsible for the maintenance and operation of the facility. In the Residential market, this is the home owner, landlord, or building superintendent. **Fehler! Verweisquelle konnte nicht gefunden werden.**	ASHRAE 201
Fault detection service	«Software»	An existing web service APIs and related existing fault detection software(s).	EEPOS
ICT platform	«System»	The ICT platform is a mediator between the Automation Platform and the Information and Decision Support System (and external data sources).	EEPOS
Local energy production unit	«System»	A device or system that can create energy from local energy source (solar, wind, geothermal, biomass, etc.).	EEPOS
Main grid	«System»	Energy network outside the neighbourhood.	EEPOS
Meter	«Device»	A device that measures physical quantity.	EEPOS
Neighbourhood level energy supplier	«Organization»	A company that delivers energy to customers.	EEPOS
Operations planning tool	«Software»	The operations planning part of the performance monitoring and operations planning tool developed in EEPOS.	EEPOS

Optimal load shifting planning application	«Software»	An application for calculating optimal load shifting profiles for the grid users.	EEPOS
Performance monitoring tool	«Software»	The monitoring part of the performance monitoring and operations planning tool developed in EEPOS.	EEPOS
Performance monitoring and operations planning tool	«Software»	A software for monitoring EEPOS information including related operations planning.	EEPOS
Performance monitoring tool's database	«Software»	A software for saving EEPOS measurement data.	EEPOS
Price forecast service	«Organization»	An organisation or a service providing electricity price forecast.	EEPOS
PV generation forecast application	«Software»	An application for calculating the PV generation forecast profiles.	EEPOS
Seller	«Person»	A person who sells something.	EEPOS
Service Provider	«Organization»	A company providing services to other organisations.	EEPOS
Simulation service	«Software»	An existing web service APIs and related existing building simulation software(s).	EEPOS
Social media	«Software»	An existing social media platform.	EEPOS
Tenant	«Person»	A person who lives in the neighbourhood.	EEPOS
Weather forecast service	«Organization»	An organization providing weather forecasts as well as current and historical weather information. [8]	ASHRAE 201

The EEPOS use cases are described in the following chapters.

5.1 UC1: Automatic consumption cut off

The narrative description of the monitoring tool related use case "automatic consumption cut off" is shown on **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 17. Narrative description of the use case "Automatic consumption cut off"

Narrative description of the use case
Short description
Automatic consumption cut off (CAV)
Complete description
In cases of extremely high electricity cost or unstable grid status, an automatic cut-off of

certain loads can reduce energy costs or system maintenance costs. In this use case, the limits for power consumption, electricity price as well as suitable loads to cut off are defined. When one or many preset condition is met, the cut-off program is executed. The limits are set to the equipment that is in common use and outdoor areas (equipment that is not controlled by individual inhabitants) or to the equipment that longer operational buffer, e.g. Air handling units and ventilation system Heating and air conditioning system Electric car charge Outdoor lighting (dimming/switch-off) Lighting of common spaces (dimming, color adjustment, shorter delay of switch-off timer) De-icing applications

The list of the use case related possible actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 18. List of the use case "Automatic consumption cut off" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
End-user	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Person, service provider or other decision maker who defines what systems to regulate, define the limiting variables and define allowed compromise. This may be private of indoor conditions (other than regulations derived).
Performance monitoring and operations planning tool	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	To acquire needed variables (electricity price, consumption amounts etc.), a performance monitoring tool is needed. Performance monitoring and operations planning tool also calculates relevant variables, based on which the decisions would be made.
Automation platform	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Cut off commands are executed.

Automatic consumption cut off application	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Building owner	«Role»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 19. Use case "Automatic consumption cut off" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Performance monitoring and operations planning tool	Continuous data logging	Performance as well as other relevant (electricity price etc.) data collection in sufficient level of details.	
End user or service company	Set limits for performance or indoor climate conditions	Possibility to define relevant limits for performance or indoor climate conditions, with explanations regarding the effect of the set limits on overall result. Automatic consumption cut off tool is installed and running.	Tenant is participant of the EEPOS network
Automation platform	Maximum limit is reached	End-users have set the suitable limits to compromise as well as defined the maximum energy costs. The building systems are defined that can be controlled by this application.	
Automatic consumption cut off application	Send cut off decision for execution	Automation platform should be able to execute the cut of commands	

The UML based diagram for the use case "Automatic consumption cut off" is shown in Figure 8.

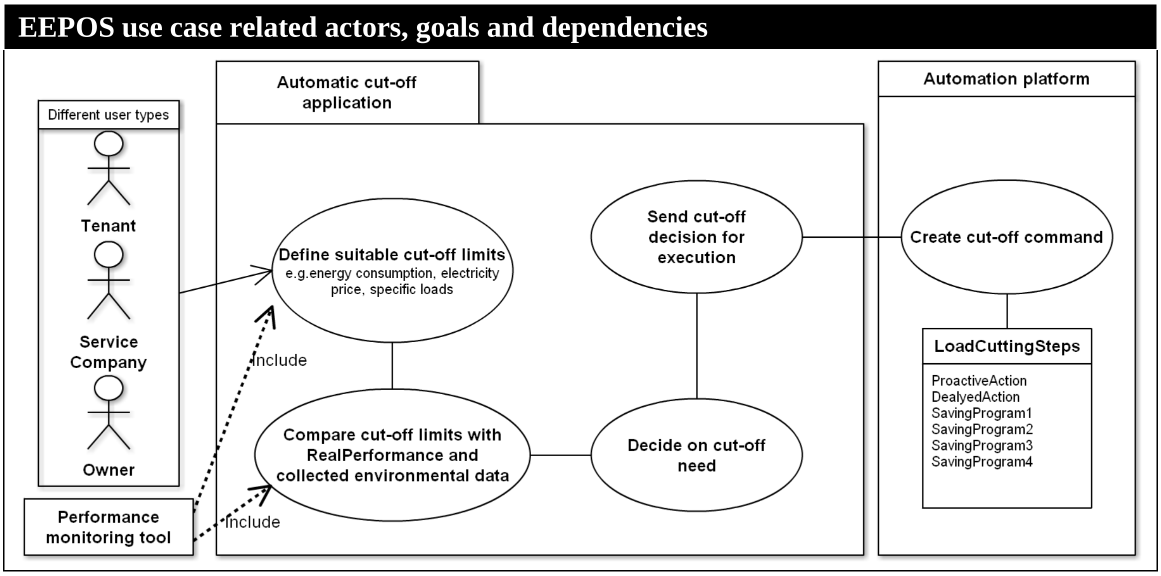


Figure 8. UML based diagram for related use case "*Automatic consumption cut off*"

5.2 UC2: Energy brokering tool

The narrative description of the monitoring tool related use case "energy brokering" is shown on **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 20. Narrative description of the EEPOS use case "energy brokering"

Narrative description of the use case
Short description
Energy Brokering (FTM)
Complete description
The Energy Brokering Tool (EBT) enables managers who manage the real estate with its own energy production ("EnMS operator") to measure, calculate and monitor energy consumption and production. EnMS operator can sell energy to tenants by creating a contract within the system with the tenant. End-user/tenant itself isn't using the software but receives reports and bills generated by it. Selling energy back to the grid is left out for this use case. Key functions The Software enables the EnMS operator: • to manage the energy consumption data • to monitor the energy consumption, peak loads and energy output • to monitor competitive sales and purchasing prices of the energy • to anticipate sales and purchasing activities according to consumption and forecast • to monitor the activities realizations • to transfer the anticipated supply requirements to sales and purchasing activities • to perform sales and purchasing of energy • to perform actual cost calculation

The list of the use case related actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 21. List of the use case "Energy brokering" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
Facility Manager	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional
Building Owner	«Role»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional
Neighbourhood level energy Supplier	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional
Energy Services Company (ESCO)	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional
EnMS Operator	«Role»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 22. Use case "Energy brokering" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
EBT	Calculate production/ consumption	Relevant meters available	
EBT	Fetch prices and usage forecast	EEPOS System installed with related components	Pricing/forecast information to be available
EnMS Operator	Buy energy	Relevant contracts in place to by energy from the grid	
EnMS Operator	Sell energy	Sell energy produced on site or purchased from the grid to end-users	
End user	Buy energy	Purchase energy from the EEPOS system	Relevant contracts in place

The UML diagram for the use case is shown in Figure 9.

EEPOS use case related actors, goals and dependencies

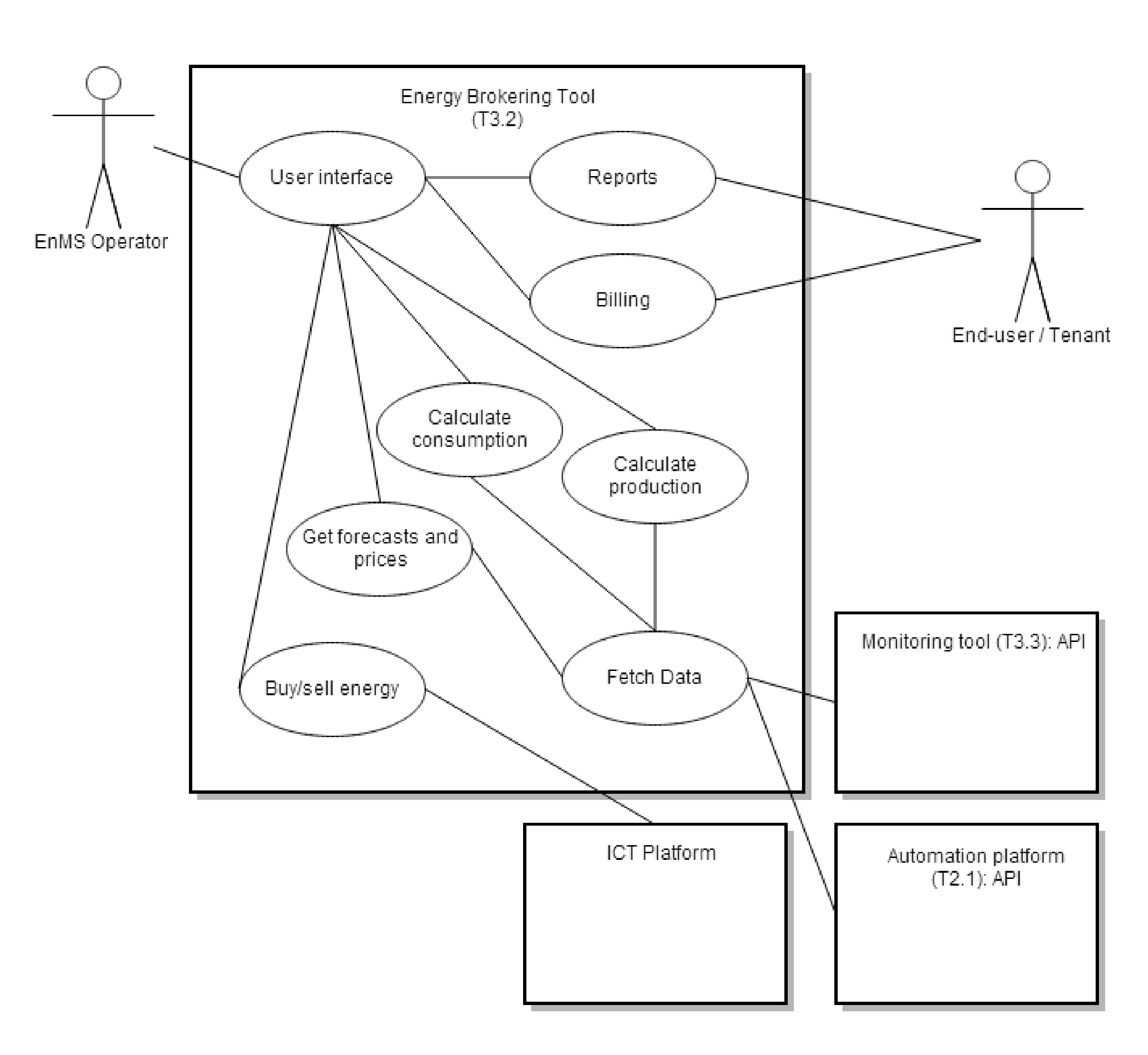


Figure 9. UML diagram for use case "Energy brokering"

5.3 UC3: Utilising the energy performance monitoring tool in Finnish demonstration

The narrative description of the "utilising energy performance monitoring tool" use case for Finnish demonstration is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 23. Narrative description of the Finnish demonstration use case "utilising energy performance monitoring tool"

Narrative description of the use case
Short description
Utilising the energy performance monitoring tool (VTT)
Complete description
The utilising the energy performance monitoring tool use case is based on visualized 3D virtual neighbourhood including the landscape, buildings and energy production units with navigation, online monitoring, historical data visualisation, benchmarking, and fault

detection support. The flesh out use case from the D1.1 scenario is as follows. The user can navigate in this 3D game engine based neighbourhood and start real time monitoring by clicking the item (building, energy production unit, energy grid component, etc.) and selecting the monitored variable (e.g. available measurements, calculated KPIs etc.). Example of the possible monitoring variables are index of energy positive neighbourhood, neighbourhood level energy reduction, neighbourhood and building level energy performance index, neighbourhood and building level energy consumption and power (heat and electricity), neighbourhood and building level energy production and power (heat and electricity), related costs, RES part of the used energy and load shifting done (moved demand from peak hours to off-peak hours of the day). Almost identical sub use case is the visualizing historical data. In that case the user must also give the start time and the end time. The user can also do benchmarking between buildings. The results can be shown by colouring the most energy efficient items by green and the least energy efficient ones by red. The tool can also detect some energy consumptions related faults and show the target item(s) in virtual neighbourhood by colouring it red and by linking it. **Fehler! Verweisquelle konnte nicht gefunden werden.**

The list of the use case related possible actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 24. List of the Finnish demonstration use case "utilising energy performance monitoring tool" related actors ***Fehler! Verweisquelle konnte nicht gefunden werden.***

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
Benchmarker	«Role»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Building Management	«Role»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Tenant	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
EnMS Operator	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Optional
Weather forecast service	«Software»	See **Fehler! Verweisquelle konnte nicht**	

		gefunden werden.	
BIM service	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Existing VTT's BIM service based on open source BIMserver [19]
Simulation service	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Existing simulation service(s) developed by VTT
Fault detection service	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Existing fault detection service(s) developed by VTT

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 25. Finnish demonstration use case "utilising energy performance monitoring tool" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Performance monitoring and operations planning tool	Command "Get data"	EEPOS monitoring system "core" with relevant API's must be installed and working.	
Different types of end users (tenant, building management, etc.)	Navigation and selecting items in 3D virtual neighbourhood	3D model of the neighbourhood must be installed.	Landscape and building 3D models must exist.

The UML based diagram for the use case "utilising energy performance monitoring tools" is shown in Figure 10.

EEPOS use case related actors, goals and dependencies

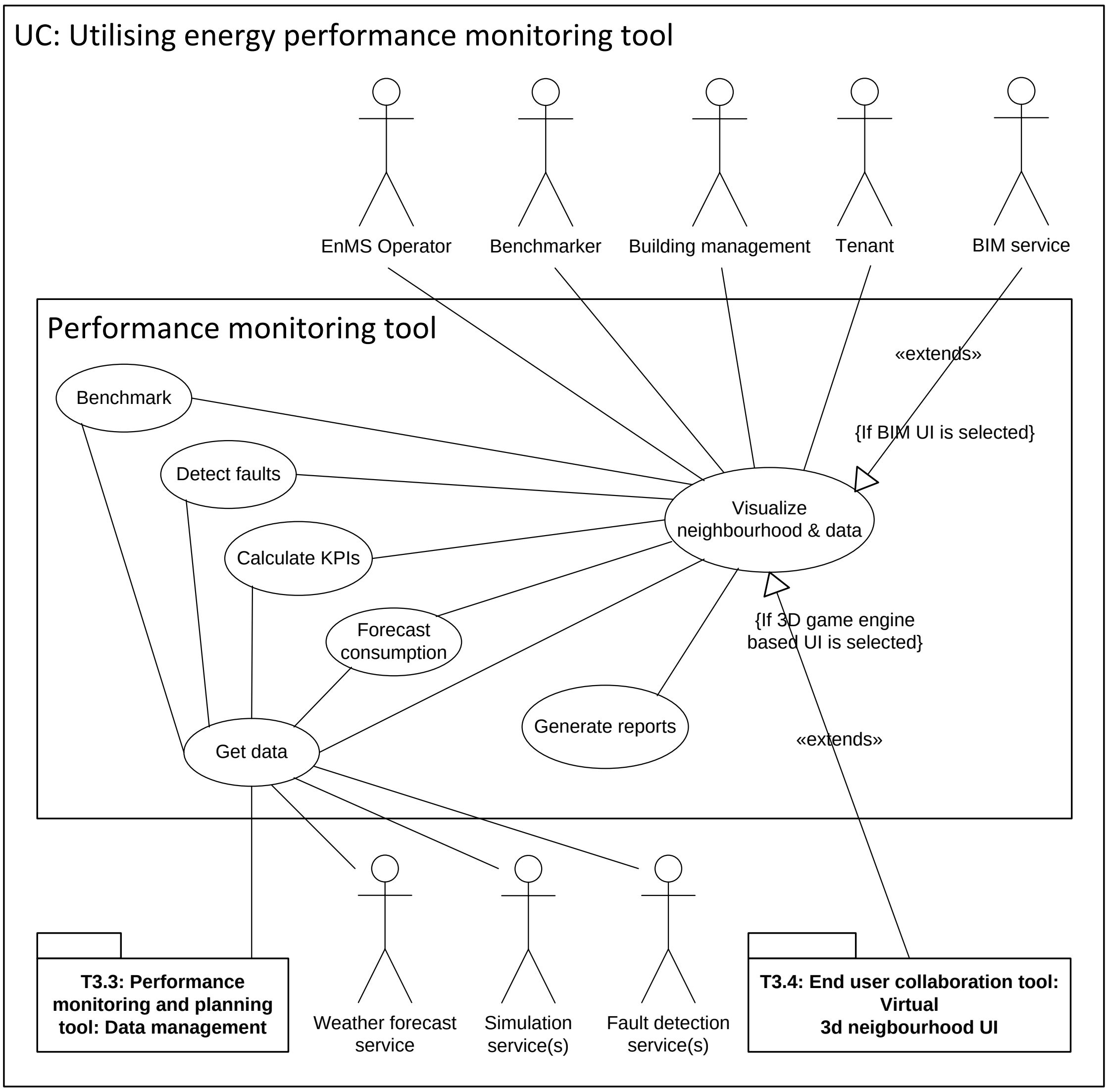


Figure 10. UML based diagram for Finnish demonstration related use case "utilising energy performance monitoring tools"

5.4 UC4: Utilising the energy performance monitoring tool in German demonstration

The narrative description of the German demonstration use case "utilising monitoring and planning tool" is shown on **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 26. Narrative description of the German demonstration related use case "utilising monitoring and planning tool"

Narrative description of the use case
Short description
Utilising monitoring and planning tool (ENO)
Complete description
Ennovatis and the building owner of the buildings in the German field test site will use in this use case the ennovatis Controlling Energy Management software. The energy manager can use the software Ennovatis Controlling for data management, assessment and further processing. The user of the software can create benchmarking reports or other types of reports, which can be created customized. To maintain the recorded data each data file can be opened and edited separately e.g. for the inclusion of a meter change. The software user can also use the graphical data analyser (GDA) which provides great opportunities to visualize and compare the recorded data like RES energy production versus energy consumption in the neighbourhood in different ways, such as scatter graphs and other types of diagrams. For the analysis tasks the ennovatis Controlling provides for the user a powerful software solution enabling individual collection, analysis and administration of different types of measurement data. Automatically and permanently recorded data (e.g. weather, water, heat, electricity consumption and temperature) will be stored via distance reading (GSM or TCP/IP) in the database of the software. The following features of Ennovatis Controlling will be used: • Data collection • Data administration • Data analysing • Load profiles • Forecasting • Benchmarks • Saving potential • Web-based reports Key functions The key functions of the energy performance monitoring and planning tool are historical and real-time trend data monitoring, different kinds of statistical data analysis, calculation of duration curves and dependencies between different monitored values, neighbourhood level benchmarking, value based automatic fault detection and related basic level fault diagnostics. In the user interface of the tool BIM and the neighbourhood map will be utilised for visualising the NEMS status.

The list of the use case related actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 27. List of the German demonstration use case "utilising monitoring and planning tool" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
Ennovatis Controlling	«Software»	See **Fehler! Verweisquelle konnte nicht**	A software that monitors and performs cross-building analysis and defines the energy usage and efficiency related KPI's of one apartment / building in relation to

		gefunden werden.	other apartments / buildings.
Energy manager	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Weather forecast service	«Organisation»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Meter	«Device»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 28. German demonstration use case "utilising monitoring and planning tool" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Energy manager	In case of recognized mal functions or over consumptions of energy.	Existing metering data with at least 15-min reading cycles of all energy consuming devices in the household/building .	Technical systems are not yet optimised.

The UML based diagram for the use case is shown in Figure 11.

EEPOS use case related actors, goals and dependencies

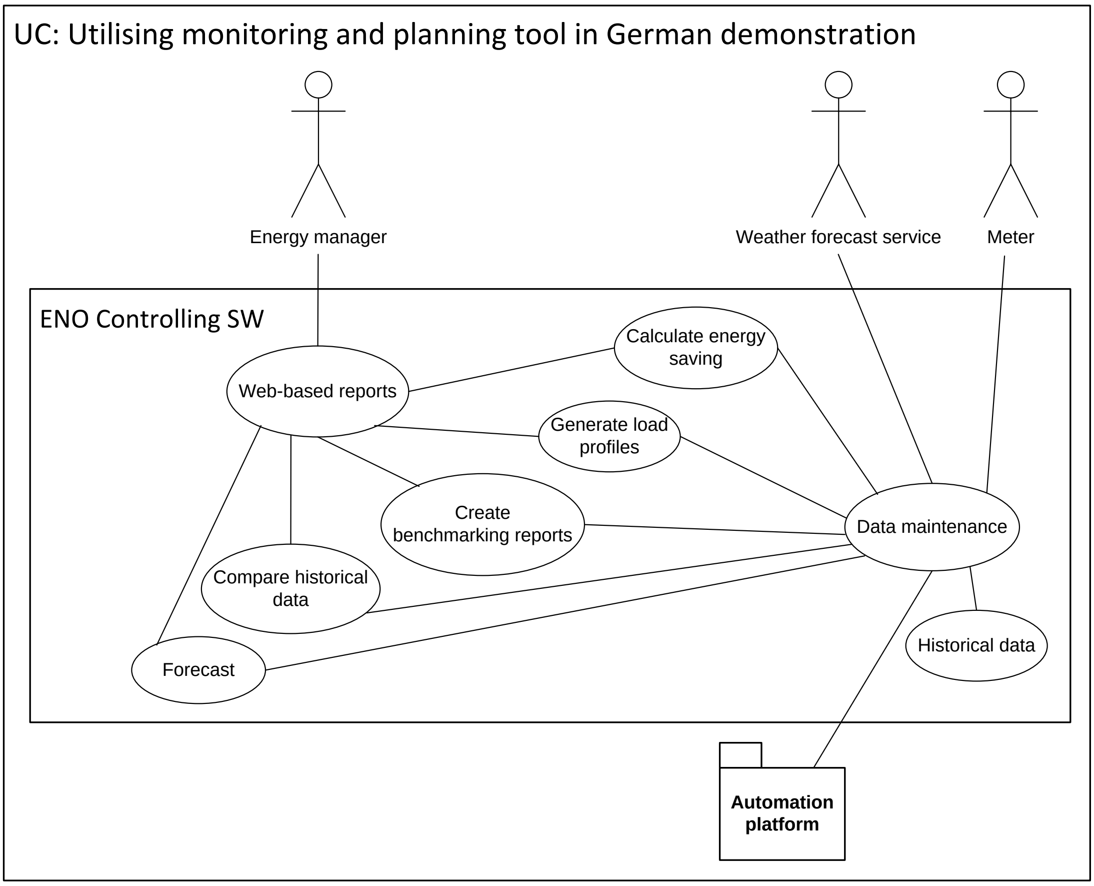


Figure 11. German demonstration related use case "utilising monitoring and planning tool"

5.5 UC5: Integration of consumers / non-automatized loads

The narrative description of the use case "Integration of consumers / non-automatized loads" is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 29. Narrative description of the use case "Integration of consumers / non-automatized loads"

Narrative description of the use case
Short description
"Integration of consumers / non-automatized loads" (AIT)
Complete description
Based on the prediction of the NEMS, the tenants get recommendations when the use of energy (mainly electric) is most beneficial or least detrimental to the neighbourhood energy grid. Based on these recommendations, the tenants then operate their non-automatized loads, e.g. white goods, leading to a more grid friendly behaviour.

The list of the use case related actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 30. List of the use case "Integration of consumers / non-automatized loads" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
End user	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Automation platform	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Energy grid	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 31. Use case "Integration of consumers / non-automatized loads" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Automation platform	Grid status forecast	Grid status must be available in NEMS. Feedback device must be connected to NEMS.	

The diagram for the use case is shown in Figure 12.

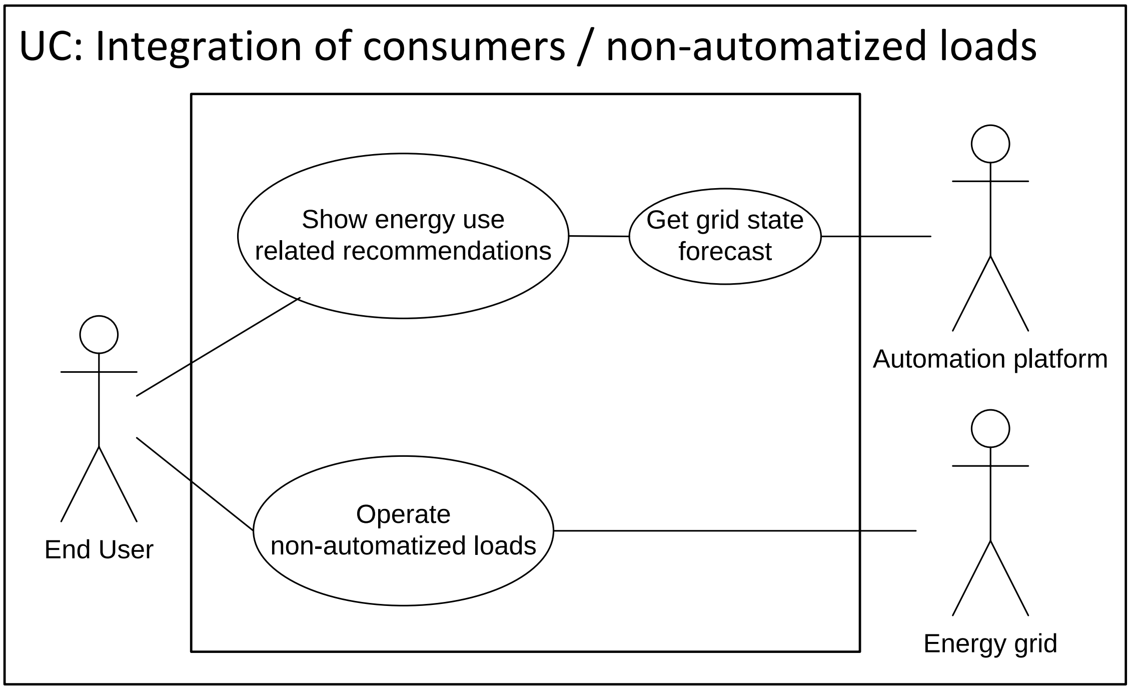
EEPOS use case related actors, goals and dependencies


Figure 12. Use case "Integration of consumers / non-automatized loads"

5.6 UC6: Heating grid optimisation in German demonstration

The narrative description of the use case "heating grid optimisation in German demonstration" is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 32. Narrative description of the use case "heating grid optimisation in German demonstration"

Narrative description of the use case
Short description
Heating grid optimisation in German demonstration (AIT)
Complete description
Based on the production profile of the local heating plant – most often a CHP unit – and data from the heating grid and the individual substations. The production of heat is optimized by employing one or both of the following optimization methods. One possibility is to use the entire heating network as temporary heat storage, raising the desired temperatures to the upper limit before the end of the usual night setback period, allowing the substations to draw from this storage when heating up the dwellings in the morning. On the other hand, using data from the heat meters, average profiles for the individual substations can be identified, and the substations can be controlled in a way that their profiles are combined to a smoother profile by shifting the end of their night set in time, up to certain limits given by the end user.

The list of the use case related possible actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 33. List of the use case "heating grid optimisation in German demonstration" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
End user	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Sets limits to time shift.
Automation platform	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Ennovatis Controlling	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Controls substation.

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 34. Use case "heating grid optimisation in German demonstration" related preconditions, events and assumptions

Actor/System/ Information/ Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
End user	Feels need to adjust time shifting limits		Included in demand response program.
Ennovatis Controlling	Load shift requested	Connections established, limits set	
Automation platform	Load shift needed	Connections established	Data available

The UML based diagram for the use case "heating grid optimisation in German demonstration" is shown in Figure 13.

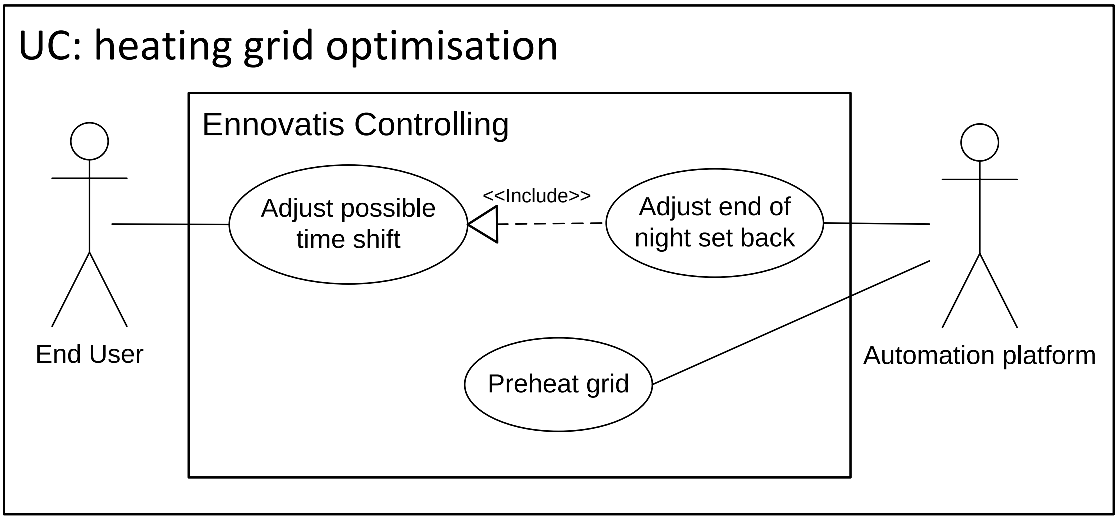
EEPOS use case related actors, goals and dependencies


Figure 13. UML based diagram for related use case "*heating grid optimisation in German demonstration*"

5.7 UC7: Saving energy by end-user collaboration

The common main use case in Finnish and German demonstration for end user collaboration tool is "saving energy by end-user collaboration". The narrative description of the use case is shown on **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 35. Narrative description of the use case "saving energy by end-user collaboration"

Narrative description of the use case
Short description
Saving energy by end-user collaboration (VTT)
Complete description
The saving energy by end-user collaboration use case is based on visualized 3D virtual neighbourhood including the landscape, buildings and energy production units with navigation and limited social media and reporting support. The flesh out use case from D1.1 scenario is as follows. The end user/tenant can navigate and click target entities in this 3D game engine based neighbourhood and get related energy use reports (by means of performance monitoring and operations planning tool) including main KPI's like energy consumption (heat and electricity), costs, RES part of the used energy and load shifting (moved demand from peak hours to off-peak hours of the day) relating year, month, week and day level. Optionally the user can access the right information / feedback without navigation by QR code based smart phone application. The user can also do benchmarking (by means of performance monitoring and operations planning tool) between his / hers apartment / building level KPI's to the corresponding KPI's of other end users. This KPI benchmarking allows the end user gets information of the energy saving issues (KPI's) which are not as good as others. The end-user collaboration tool can be used for asking advice from those whose KPI's are the best. And the improvement on energy saving (apartment / building related KPI's) can be published with few comments (how this was done) in the end-user collaboration tool related forum.

The list of the use case related actors are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 36. List of the Finnish demonstration use case "saving energy by end-user collaboration" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
End user	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	In most cases the end user is tenant.
End user collaboration tool	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	3D game engine based UI which can visualize 3D virtual neighbourhood including the landscape and buildings with navigation, social media and reporting support.
Performance monitoring and operations planning tool	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	A software that monitors and performs cross-building analysis and defines the energy usage and efficiency related KPI's of one apartment / building in relation to other apartments / buildings.
Social media	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Software platform for discussion and publishing the personal energy saving results.

The use case related preconditions, events and assumptions are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 37. Finnish demonstration use case "saving energy by end-user collaboration" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
End user collaboration tool	Command "Get KPI's"	Performance monitoring and operations planning tool with relevant API's must be installed and running.	
End user / tenant	Navigation and selecting items in the 3D virtual neighbourhood	3D model of the neighbourhood must be installed.	Landscape and building 3D models exist. End user is participant of the EEPOS network.

End user collaboration tool	Command "publish in social media" or "read/write comment in social media"	Social media must have suitable API and support for creating social media based groups for people living in the neighbourhood.	

The UML based diagram for the use case is shown in Figure 14.

EEPOS use case related actors, goals and dependencies

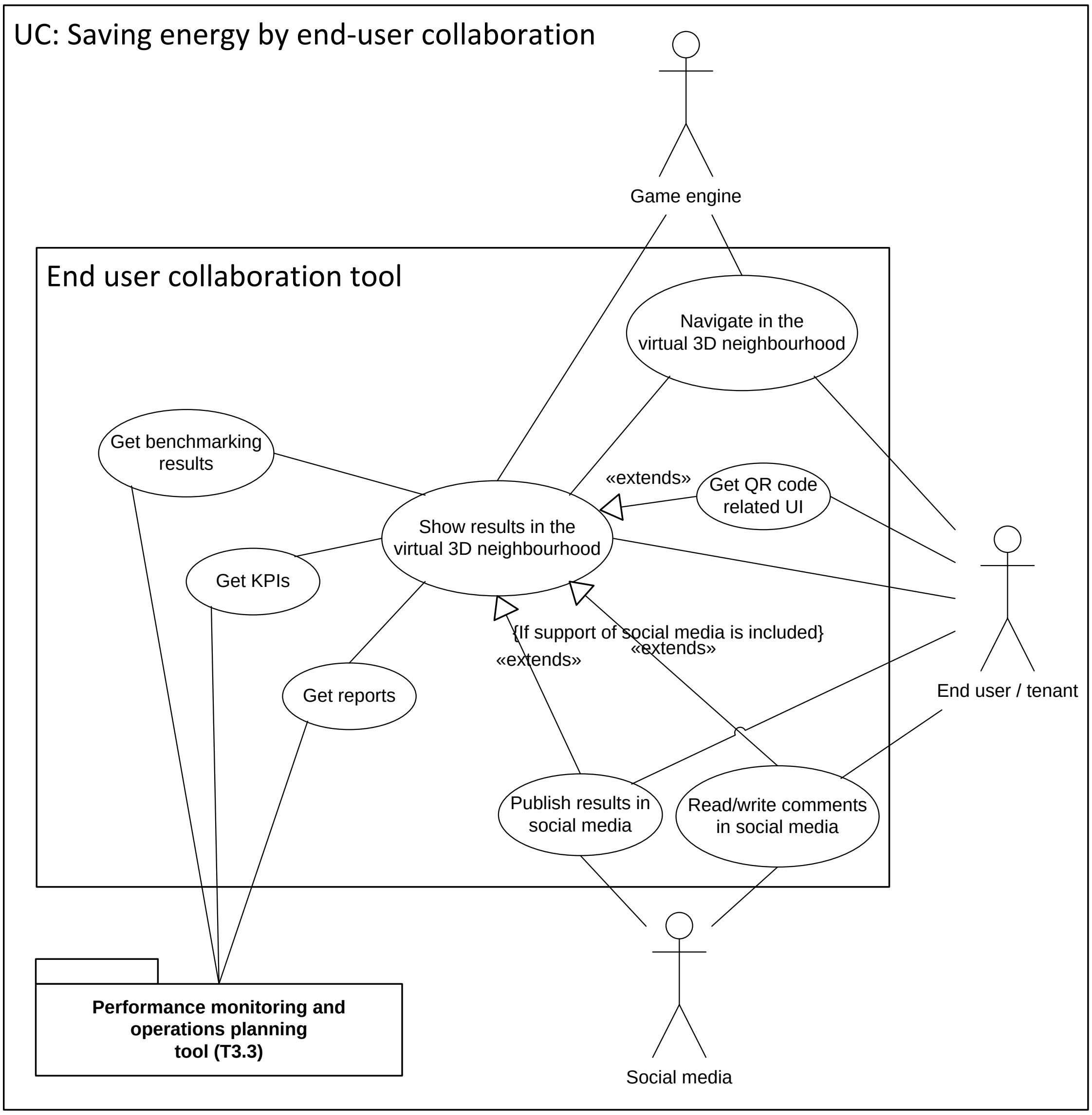


Figure 14. UML based diagram for the Finnish demonstration related use case "saving energy by end-user collaboration"

5.8 UC8: The Trading (Agent-Based) approach

The narrative description of the use case "The Trading (Agent-Based) approach" is shown in *Table 38.*

Table 38. Narrative description of the use case "The Trading (Agent-Based) approach"

Narrative description of the use case
Short description
"The Trading (Agent-Based) approach" (ENO)
Complete description
With more and more PROSUMER try to deliver energy to the Main Grid (MAG) it is especially a critical task to consider the limited capacity of transmission lines. When these lines are overloaded, they may break down and cause, in the best case, damage to the system and a minor blackout or, in the worst case, a massive blackout. These significant challenges call for the need to build decentralized autonomous systems that are self-organizing and achieve high levels of efficiency. We call such a decentralized autonomous system a "Neighbourhood Area Grid" (NAG). The general target is an architecture with a high level of surplus which ensures that transmission lines are never overloaded. The flesh out use case from the D1.1 scenario is as follows. Each Energy PROsumer (EPRO) is represented by an agent who manages the self-interested actions of the EPRO. In this context "self-interested" means, that the agent represents the individual interest of the EPRO and not the interests of the complete neighbourhood in general which can be quite different. The NAG offers a balancing mechanism in form of a market place, where buyers and sellers of energy do the trading. The trading is limited to a given trading period which is divided into time frames.

The list of the use case related actors are shown in *Table 39*.

Table 39. List of the use case "The Trading (Agent-Based) approach" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
End user	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	End user shall be a "prosumer"
Buyers	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	End user shall be a "prosumer"
Sellers	«Person»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	End user shall be a "prosumer"
Service Provider	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden**	Manages the relation between the main grid and the EEPOS system.

		werden.	
EnMS operator	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Manages the relationships of the energy traders (buyers, sellers) in the EEPOS system especially with the end-user (prosumer).
Main grid	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Local energy production unit	«Device»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	
Energy consumption component	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	e.g. building

The use case related preconditions, events and assumptions are shown in *Table 40*.

Table 40. use case "The Trading (Agent-Based) approach" related preconditions, events and assumptions

Actor/System/Information/Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
End user	End user interactions	Participant of the EEPOS system (network)	End user shall be a "prosumer"
Performance monitoring and operations planning tool	Get data	Performance monitoring and operations planning tool software must be up and running	
Buyers (at the market place)	Signal buy (e.g. email)	Byers are registered in EEPOS system	B, !S
Sellers (at the market place)	Signal sell (e.g. email)	Sellers are registered in EEPOS system	S, !B
Local energy production unit	Signal "more electricity to sell" (e.g. email)	Metering of energy production	$E_{Sellers} > E_{Buyers}$ at a given time frame
Energy	Signal "more	Metering of energy consumption	$E_{Sellers} < E_{Buyers}$

consumption component	electricity to buy" (e.g. email)		at a given time frame

The diagram for the use case is shown in Figure 15.

EEPOS use case related actors, goals and dependencies

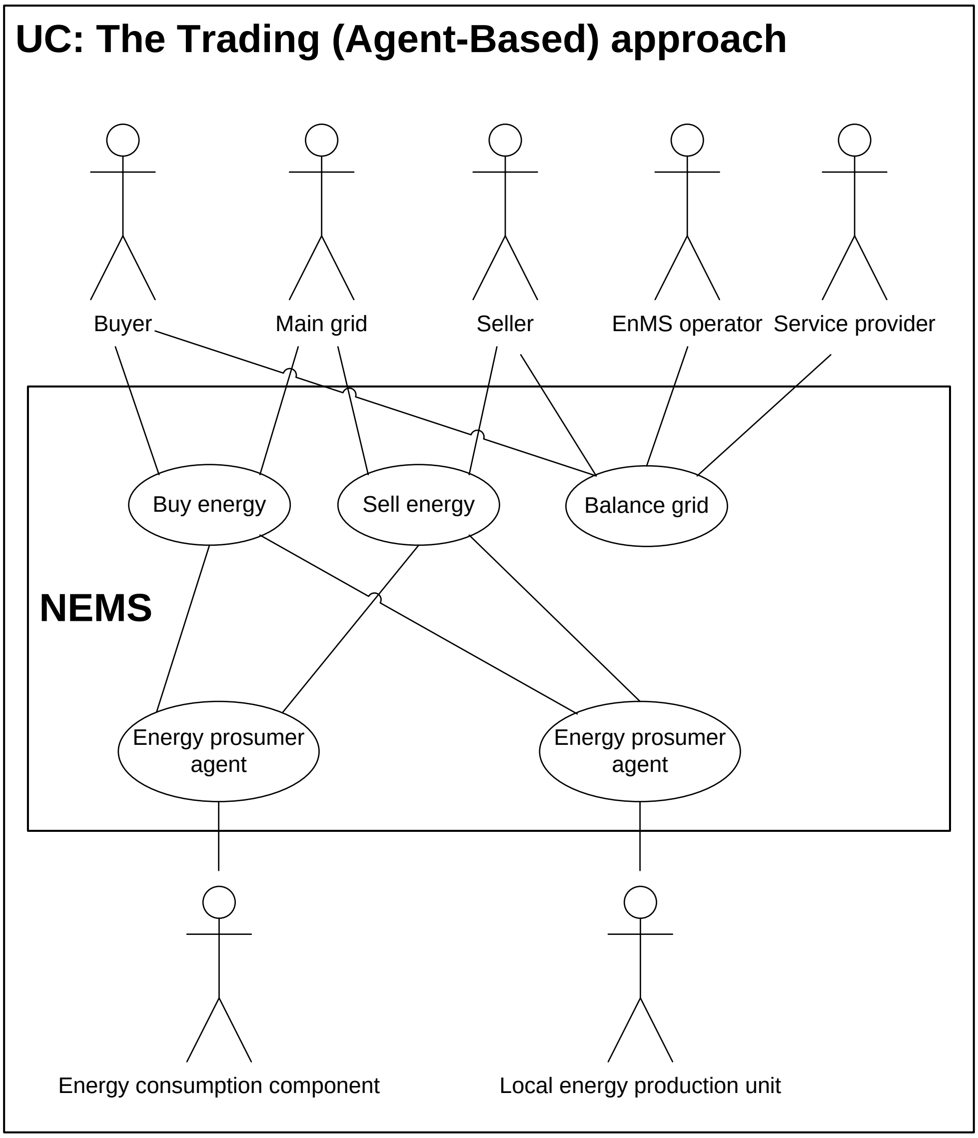


Figure 15. Use case *"The Trading (Agent-Based) approach"*

5.9 UC9: Calculation of neighbourhood level PV generation by the Neighbourhood Automation System

The narrative description of the monitoring tool related use case "PV generation forecast calculation" is shown in *Table 41*.

Table 41. Narrative description of the use case "PV generation forecast calculation"

Narrative description of the use case
Short description
PV generation forecast calculation by the Neighbourhood Automation System (DERlab)
Complete description
The PV generation forecast application runs on the Neighbourhood Automation System (Automation Platform) which is a part of the EEPOS Neighbourhood EnMS. It calculates generation forecast profiles for those PV systems in the neighbourhood, which are not controlled by individual Building EnMS. The calculated generation forecast profiles for the PV systems serve as input data for other applications of the Automation Platform (e.g. the optimal load shifting planning application) or EEPOS tools (e.g. energy brokering tool).

A list of the use case related possible actors is shown in *Table 42*.

Table 42. List of the use case "PV generation forecast calculation" related actors

Actor name	**Actor Type**	**Actor Description**	**Further information specific to this Use Case**
Weather forecast service	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	External data source provides the ICT platform with solar irradiance forecast and ambient temperature forecast. Solar irradiance and ambient temperature forecast is required as input data for the PV generation forecast application of the Automation Platform.
ICT platform	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	The ICT platform provides the Automation Platform with (i) solar irradiance forecast and (ii) ambient temperature forecast update.
Automation Platform	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	The Automation Platform informs the PV generation forecast application about updates in (i) solar irradiance forecast and (ii) ambient temperature forecast. Update in solar irradiance or ambient temperature forecast triggers the execution of PV generation forecast application.
PV	«Software	See	The PV generation forecast application runs on top of

generation forecast application	»	**Fehler! Verweisquelle konnte nicht gefunden werden.**	the Automation Platform. The application calculates the PV generation forecast profiles for those PV systems in the neighbourhood, which are not controlled by individual Building EnMS. The outcome of the application is required input data for Optimal load shifting planning application and Energy brokering tool. The PV generation forecast application updates PV generation forecast in the Automation Platform.

The use case related preconditions, events and assumptions are shown in *Table 43*.

Table 43. Use case "PV generation forecast calculation" related preconditions, events and assumptions

Actor/System/ Information/ Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Weather forecast service	Solar irradiance forecast update is provided or ambient temperature forecast update is provided	EEPOS Neighbourhood EnMS is running	

The UML based diagram for the use case "PV generation forecast calculation" is shown in Figure 16.

EEPOS use case related actors, goals and dependencies

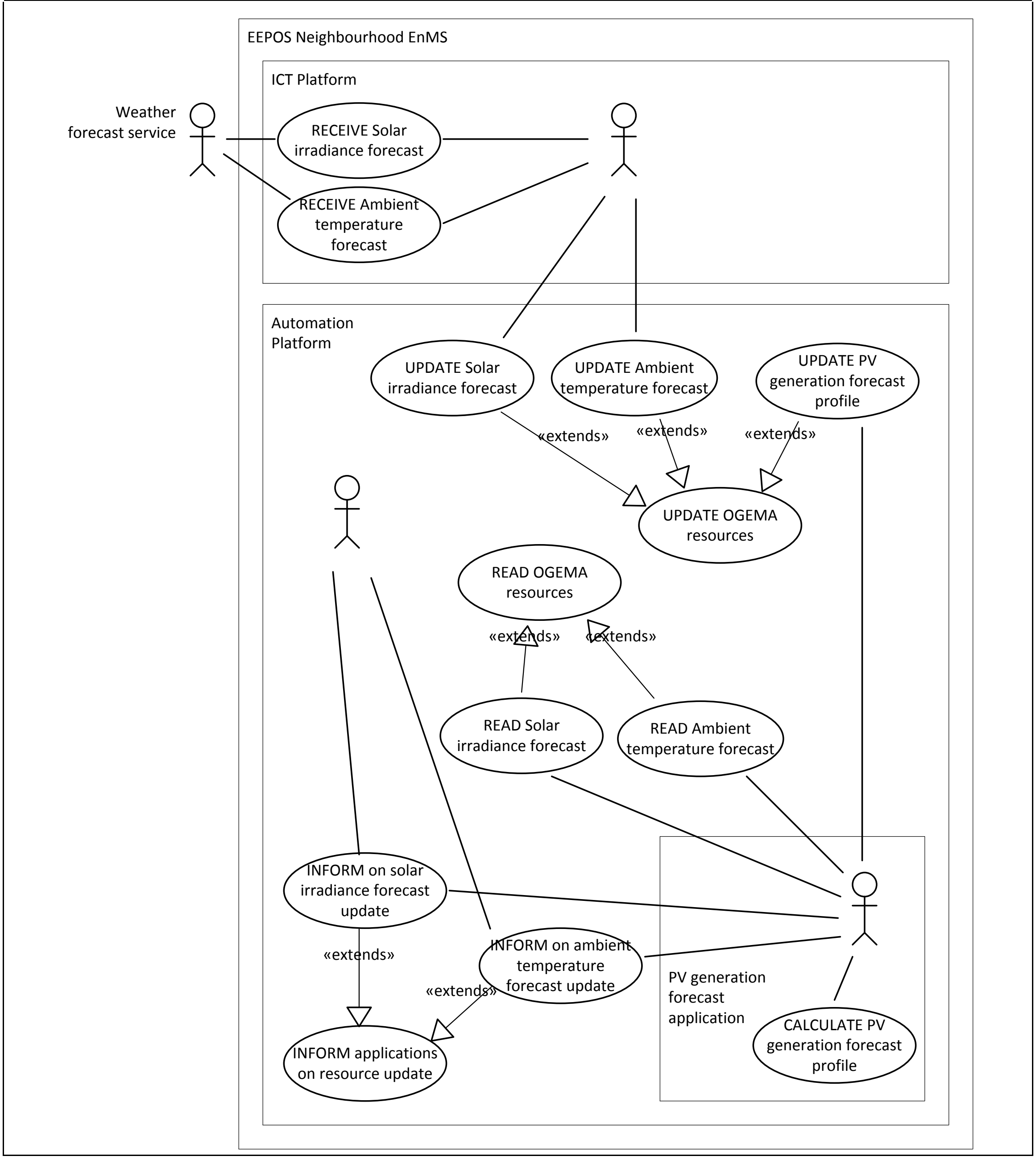


Figure 16. UML based diagram for related use case "*PV generation forecast calculation*"

5.10 UC10: Optimal load shifting planning on the neighbourhood level by the Neighbourhood Automation System

The narrative description of the monitoring tool related use case "Optimal load shifting planning" is shown in *Table 44.*

Table 44. Narrative description of the use case "Optimal load shifting planning"

Narrative description of the use case
Short description
Optimal load shifting planning on the neighbourhood level (DERlab)

Complete description
The load shifting planning application runs on the Neighbourhood Automation System (Automation Platform) which is a part of the EEPOS Neighbourhood EnMS. It calculates optimal load shifting profiles for grid user EnMS following management priorities: 1) local DER surplus compensation in the neighbourhood, 2) cost effective load shifting following electricity price and 3) peak load shaving in the local electricity grid.

The list of the use case related possible actors are shown in *Table 45*.

Table 45. List of the use case "Optimal load shifting planning" related actors

Actor name	**Actor Type**	**Actor Description**	**Further information specific to this Use Case**
Price forecast service	«Organization»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Electricity price forecast (by means of ICT platform) is required as input data for the optimal load shifting planning application of the Automation Platform.
PV generation forecast application	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	The PV generation forecast application runs on top of the Automation Platform. PV generation forecast is required as input data for the optimal load shifting planning application.
Energy brokering tool	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Electricity load forecast on the neighbourhood level is required as input data for the optimal load shifting planning application.
ICT platform	«System»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	The ICT platform provides the Automation Platform with (i) electricity price forecast and (ii) electricity load forecast on the neighbourhood level. Electricity price forecast and electricity load forecast on the neighbourhood level are required as input data for the optimal load shifting planning application of the Automation Platform.
Automation Platform	«System»	See **Fehler! Verweisquelle konnte nicht gefunden**	The Automation Platform informs the optimal load shifting planning application about updates in (i) electricity price forecast, (ii) PV generation forecast and (iii) electricity load forecast.

		werden.	Update in electricity price, PV generation or electricity load forecast trigger the execution of optimal load shifting planning application.
Optimal load shifting planning application	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	The optimal load shifting planning application runs on top of the Automation Platform. The outcome of the optimal load shifting planning application is required as input data for grid users equipped with EnMS and connected to the EEPOS Neighbourhood EnMS. Such grid users can be electricity consumers as well as electricity generators with ability to change their electricity consumption/generation patterns up to some grade.

The use case related preconditions, events and assumptions are shown in *Table 46*.

Table 46. Use case "Optimal load shifting planning" related preconditions, events and assumptions

Actor/System/ Information/ Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Price forecast service	Electricity price forecast update is provided	EEPOS Neighbourhood EnMS is running	
PV generation forecast application	PV generation forecast is updated	EEPOS Neighbourhood EnMS is running	
Energy brokering tool	Electricity load forecast on the neighbourhood level is provided	EEPOS Neighbourhood EnMS is running	

The UML based diagram for the use case "Optimal load shifting planning" is shown in Figure 17.

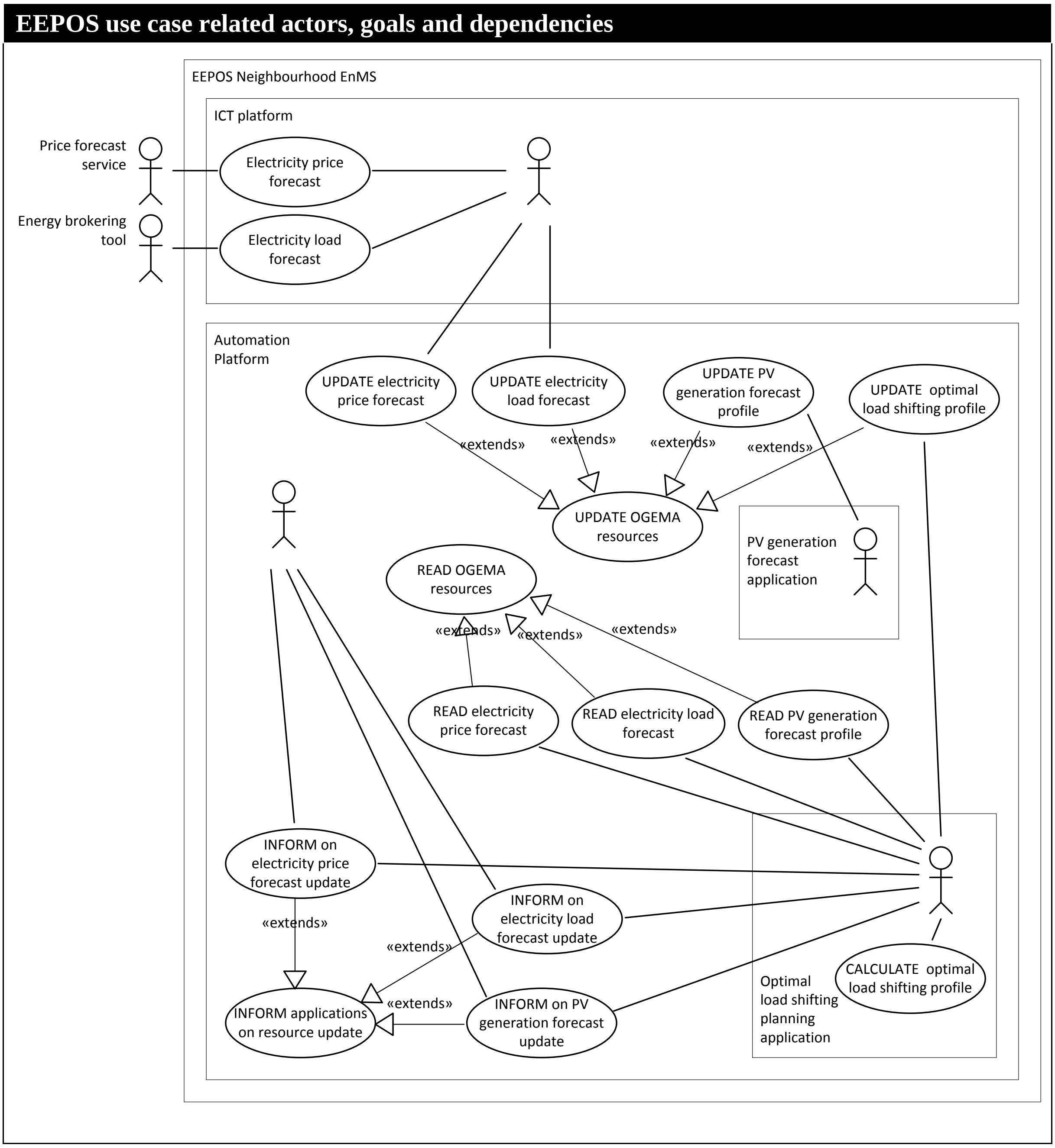


Figure 17. UML based diagram for related use case "*Optimal load shifting planning*"

5.11 UC11: Storage of neighbourhood level historic electric energy consumption and generation rates

The narrative description of the use case "storage of neighbourhood level historic electric energy consumption and generation rates" is shown in Table 47.

Table 47. Narrative description of the use case "*storage of neighbourhood level historic electric energy consumption and generation rates*"

Narrative description of the use case
Short description
Storage of neighbourhood level historic electric energy consumption and generation rates (AIT)
Complete description
Various components of the NEMS rely on forecasts of the behaviour of the neighbourhood for controlling various systems present in the neighbourhood. This forecast need historic data to be computed, which may also be pseudonymized for privacy reasons.

The list of the use case related possible actors are shown in *Table 48*.

Table 48. List of the use case "storage of neighbourhood level historic electric energy consumption and generation rates" related actors

Actor name	Actor Type	Actor Description	Further information specific to this Use Case
Meter	«Device»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	Energy meter
Automation platform	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	API for reading/receiving any form of energy data must exists.
ICT platform	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	API for reading/receiving any form of energy data must exists.
Performance monitoring tool's database	«Software»	See **Fehler! Verweisquelle konnte nicht gefunden werden.**	

The use case related preconditions, events and assumptions are shown in *Table 49*.

Table 49. Use case "storage of neighbourhood level historic electric energy consumption and generation rates" related preconditions, events and assumptions

Actor/System/Information/ Contract triggering the use case	Triggering Event	Pre-conditions	Assumption
Meter	Meter has measurements and data transfer is needed.	Meter structure created and linked.	Measurements are performed periodically.

Performance monitoring tool's database	Data is transferred.		
Performance monitoring tool's database	New building/meter/etc. is registered -> new meter needs to create according structure in monitoring database.	Resource provides KPI such as SPF dependant on class.	Deletion of resources disables datapoint but data remains.
Performance monitoring tool's database	New monitoring data -> aggregations and dependant values require updating.	Dependant resources available.	If not event based updating at least regular updating.

The UML based diagram for the use case "storage of neighbourhood level historic electric energy consumption and generation rates" is shown in Figure 18.

EEPOS use case related actors, goals and dependencies

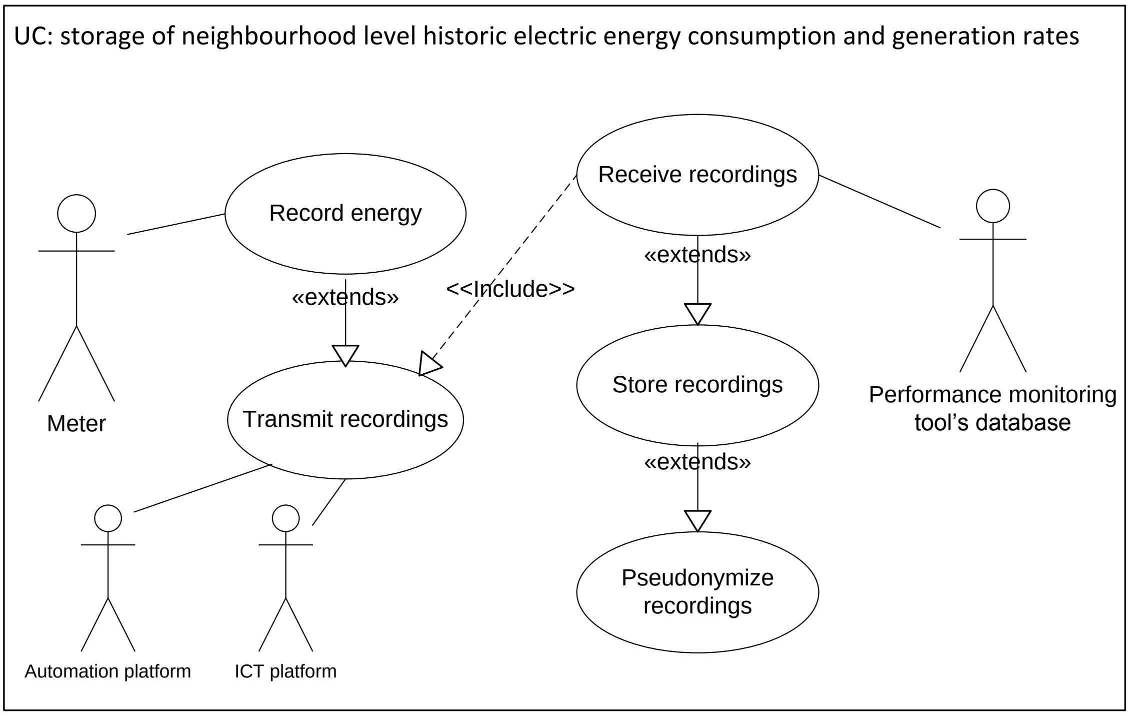


Figure 18. UML based diagram for related use case "storage of neighbourhood level historic electric energy consumption and generation rates"

5.12 UC12: Operations planning supported by performance monitoring

The use case description and related analysis is described in non-public appendix 2.

6. EEPOS USE CASE ANALYSIS

A detailed level use case analysis are presented in the appendix 1. Every use case includes primary-, alternative- and extended scenarios and every use case scenario is opened to steps how information is exchanged through interfaces. Based on these use case analysis the summary of the use case analysis is presented as follows.

6.1 Summary of the use case analysis

The summary of the use case analysis includes EEPOS interfaces related information elements and EEPOS model framework.

6.1.1 EEPOS interfaces related information elements

The results presented in this chapter are EEPOS platform interfaces and detailed data streaming through EEPOS platform interfaces. EEPOS platform interfaces (described more detailed in the EEPOS deliverable D4.1) are shown in the Figure 19.

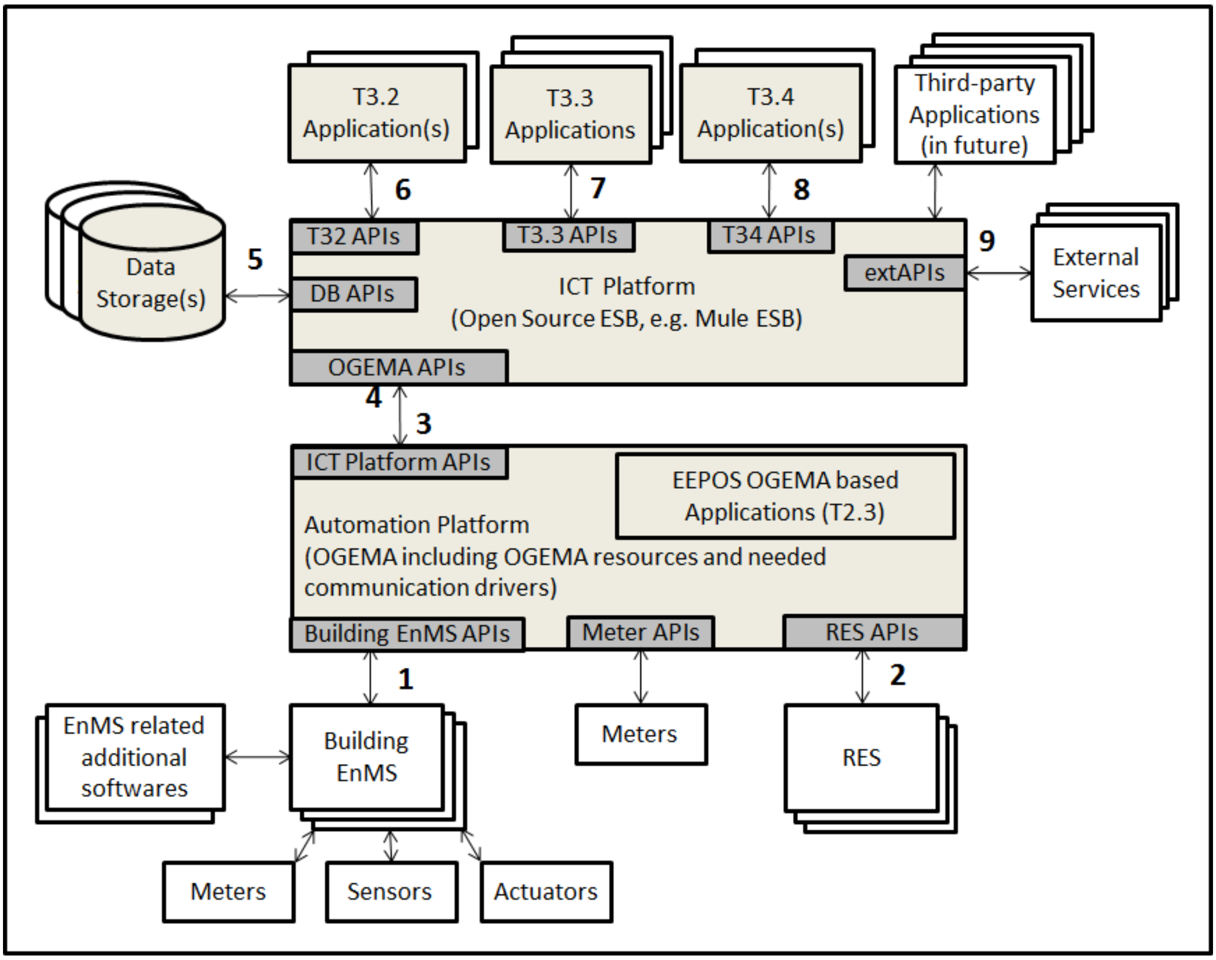


Figure 19. Platform interfaces

Detailed data streaming through EEPOS platform interfaces are described in following tables 102 - 111. More detailed use case information though the interfaces can be found from appendix 1 - *EEPOS Use Case Analysis*.

Use cases information exchanged through interface 1 are shown in Table 50.

Table 50. Information exchanged through platform interface 1

Interface number	**(1)**
UC number	**Information exchanged**
UC5	Grid status (String)
UC1	Cut-off execution (String)
UC3, UC7, UC4	Energy consumption and load data (Array of real values with time stamp)
UC4	Water consumption data (Array of real values with time stamp)
UC4, UC3	Temperatures etc. BAS measurements (Array of real values with time stamp)
OGEMA	Current electricity presumption adaption requests, Electricity Prices?
OGEMA	Information on current electricity generation, Information on electricity generation forecast

Use cases information exchanged through interface 2 are shown in Table 51.

Table 51. Information exchanged through platform interface 2

Interface number	**(2)**
UC number	**Information exchanged**
UC6	Energy production related operation schedule
UC3, UC7	Energy and average power production data (Array of real values with time stamp)

Use cases information exchanged through interface 3 are shown in Table 52.

Table 52. Information exchanged through platform interface 3

Interface number	**(3)**
UC number	**Information exchanged**
UC9	Solar irradiance forecast (Array of real values with time stamp)
UC9	Ambient temperature forecast (Array of real values with time stamp)
UC10	Energy price forecast (Array of real values with time stamp)
UC10	Electricity load forecast (Array of real values with time stamp)
UC10	PV generation forecast (Array of real values with time stamp)
UC12	Operating plan (String)
OGEMA	Smart Meter Data, Sum of Smart Meter Data, PV production forecast, Past BAS electricity prosumption forecasts
OGEMA	Weather forecast, Consumption forecasts for the neighbourhood, Electricity Prices

Use cases information exchanged through interface 4 are shown in Table 53.

Table 53. Information exchanged through platform interface 4

Interface number	**(4)**
UC number	**Information exchanged**
UC3, UC7	Energy consumption and load data (Array of real values with time stamp)
UC3, UC7	Energy production and average produced power data (Array of real values with time stamp)
UC3, UC7	Load shifting done and related savings (Array of real values with time stamp)

UC3, UC4	Status signals (Array of real values with time stamp)
UC4	Water consumption data (Array of real values with time stamp)
UC4, UC3	Temperatures etc. BAS measurements (Array of real values with time stamp)
UC7	Feedback data (Integer)

Use cases information exchanged through interface 5 are shown in Table 54.

Table 54. Information exchanged through platform interface 5

Interface number	**(5)**
UC number	**Information exchanged**
All UCs related to APIs 4 – 8 (and 3, 9)	Data needed in interfaces 6, 7, 8 (and 3, 4)

Use cases information exchanged through interface 6 are shown in Table 55.

Table 55. Information exchanged through platform interface 6

Interface number	**(6)**
UC number	**Information exchanged**
UC2	Energy consumption data (Array of real values with time stamp)
UC2	Energy production data (Array of real values with time stamp)
UC2	Weather information (Array of real values with time stamp)
UC2	List of energy providers (Array of strings) and related energy price information (Array of real values with time stamp)
UC2	Energy price (Array of real values with time stamp)

Use cases information exchanged through interface 7 are shown in Table 56.

Table 56. Information exchanged through platform interface 7

Interface number	**(7)**
UC number	**Information exchanged**
UC3, UC7	Weather data (Array of real values with time stamp)
UC3, UC7	Weather forecast data (Array of real values with time stamp)
UC3, UC7, UC4	Energy consumption and load data (Array of real values with time stamp)
UC3, UC7	Energy consumption and load related forecast data (Array of real values with time stamp)
UC3, UC7	Energy and average power production data (Array of real values with time stamp)
UC3	Energy and average power production related forecast data (Array of real values with time stamp)
UC3, UC7	Load shifting done and related savings (Array of real values with time stamp)
UC3, UC7	Energy price/tariff information (Array of real values with time stamp)
UC3	Simulation data (Array of real values with time stamp)
UC3	Fault data (Boolean)
UC3	Calculated solar panel area (Integer), investments costs (Integer) and ROI (Integer)
UC3, UC7	3D model (BIM model, 3D model supported by Unity game engine)
UC3, UC4, UC6, UC7	Grid status (Array of real values with time stamp)

UC3	KPIs (Array of real values with time stamp)
UC4	Water consumption data (Array of real values with time stamp)
UC4, UC3	Temperatures etc. BAS measurements (Array of real values with time stamp)
UC7	Reports (File or string)
UC12	Operating plan (String)

Use cases information exchanged through interface 8 are shown in Table 57.

Table 57. Information exchanged through platform interface 8

Interface number	**(8)**
UC number	**Information exchanged**
UC3, UC7	Weather data (Array of real values with time stamp)
UC3, UC7	Weather forecast data (Array of real values with time stamp)
UC3, UC7, UC4	Energy consumption data (Array of real values with time stamp)
UC3, UC7	Energy consumption forecast data (Array of real values with time stamp)
UC3, UC7	Energy production data (Array of real values with time stamp)
UC3, UC7	Energy price information (Array of real values with time stamp)
UC3, UC7	Load shifting done and related savings (Array of real values with time stamp)
UC3, UC4, UC6, UC7	Grid status (String)
UC3, UC7	3D model (BIM model, 3D model supported by Unity game engine)
UC7	Reports (File or string)
UC7	Comments from neighbourhood (String)

Use cases information exchanged through interface 9 are shown in Table 58.

Table 58. Information exchanged through platform interface 9

Interface number	**(9)**
UC number	**Information exchanged**
UC3, UC7	Weather data (Array of real values with time stamp)
UC3, UC7, UC9	Weather forecast including solar irradians and ambient temperature (Array of real values with time stamp)
UC3, UC7	Energy consumption forecast data (Array of real values with time stamp)
UC3	Energy production forecast data (Array of real values with time stamp)
UC3, UC7	External energy price/tariff (Array of real values with time stamp)
UC3	Simulation data (Array of real values with time stamp)
UC3	Fault data (Boolean)
UC3	Calculated solar panel area (Integer), investments costs (Integer) and ROI (Integer)
UC3, UC7	3D model (BIM model, 3D model supported by Unity game engine)
UC10	Energy price forecast (Array of real values with time stamp)
UC10	Electricity load forecast (Array of real values with time stamp)
UC10	PV generation forecast (Array of real values with time stamp)
UC6	Optimized schedule (Array of real values with time stamp)

6.1.2 EEPOS model framework

Based on the use case definitions and related use case analysis the challenges for the EEPOS information modelling are as follows:

- The information model should support ICT based energy management of three different types energy networks (electric power, thermal heating, thermal cooling) including the optimised use (buy and sell energy) of the external energy networks.
- The information model should include a building model (load node) that includes at least information of heating, cooling and electric power network related loads, energy consumption and optionally also building level RES based energy production. In addition it would be useful if the generic information model could support also the energy management of different building sub-systems (e.g. heating, air conditioning, electric, lighting) or even devices.
- The information model should also support the optimised energy production control of CHP which includes both electric power and thermal heat production.
- There is also need to analyse and monitor huge amount of many different type of data (e.g. real-time values, peak values, average values, historical data, forecast data, faults) of many different types of variable (e.g. energy consumption, energy production, loads, load shifting done, energy savings, produced power, weather, internal/external energy prices/tariffs, KPIs) in many different levels (energy network, neighbourhood, building and optionally building sub-system, apartment and space/device).

On the other hand the final goal of this information modelling is to create a simple and generic EEPOS use cases and related analysis based information model for ICT based management of neighbourhood energy grid and related facilities. The basic approach for that is to define so few general level components that the other same type of components can be presented by them or by combining and extending them.

The summary of the all EEPOS use case related actors are listed in **Fehler! Verweisquelle konnte nicht gefunden werden.** but based on the use case analysis not all of them are really needed. According this analysis the most important actors are EEPOS automation platform, energy consumption unit (building), energy production unit, different types of users (e.g. energy broker) and EEPOS ICT platform including database and end user applications like energy performance monitoring and operations planning. These components can be modelled as nodes (and related datasets) in the ICT based energy management network as follows:

- Building → Energy consumption node
- Energy production unit → Energy production node
- EEPOS automation platform → Energy manager node
- EEPOS ICT platform including databases and different types of end users and tools → Energy broker, operations planner, energy performance monitor and related data sets

Using these main components the neighbourhood energy grid information model can be modelled as shown in Figure 20.

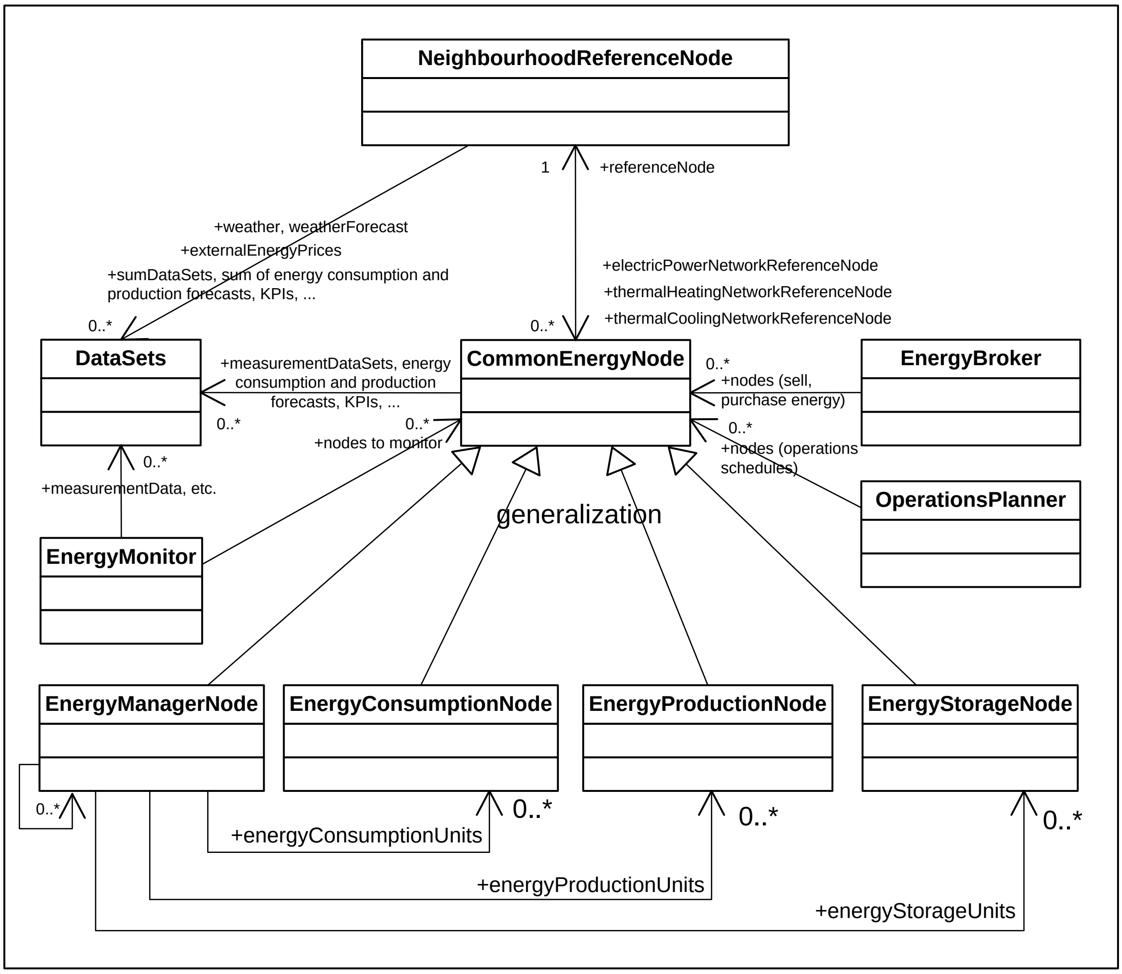


Figure 20. EEPOS modelling framework - main components and connections of the neighbourhood energy grid information model

The basic idea is that the NeigbourhoodReferenceNode includes all neighbourhood level general values (e.g. weather data, weather forecast, external energy price and target and realized KPIs) for electric power network, thermal heating network and thermal cooling network nodes.

The CommonEnergyNode is an abstract class which includes information for all other type of energy nodes. The EnergyConsumptionNode includes information related to energy consumption node (e.g. buildings, building sub-systems, street lighting and electric car charging point). The EnergyProductionNode includes information of energy production units and the optional EnergyStorageNode includes information of energy storages like charging power and discharging power.

From the neighbourhood energy grid information model point of view the most important model component is EnergyManagerNode which has connection to all energy system’s (e.g. local thermal cooling network) related EnergyConsumptionNodes, EnergyProductionNodes and EnergyStorageNodes. It has also connection to optional sub EnergyManagerNodes which make it possible e.g. to use sub energy manager also at building level or even building sub-system level and connect them to the upper level EnergyManagerNodes. The EnergyManagerNode includes also all studied level (e.g. neighbourhood, building, building sub-system) energy system (electric power, heating or cooling) management and summary data like total energy consumption, total energy production, total energy consumption forecast, total energy production forecast etc.

7. EEPOS NEIGHBOURHOOD ENERGY GRID INFORMATION MODEL

The EEPOS neighbourhood energy grid information model is presented as Class Model. The classes are generated using Enterprise Architect (EA) tool which make it possible to publish these models as Java, C++ or C# programming language based classes or as a DDL script for database generation.

The classes and related enumerations of the information model are shown in the Figure 21.

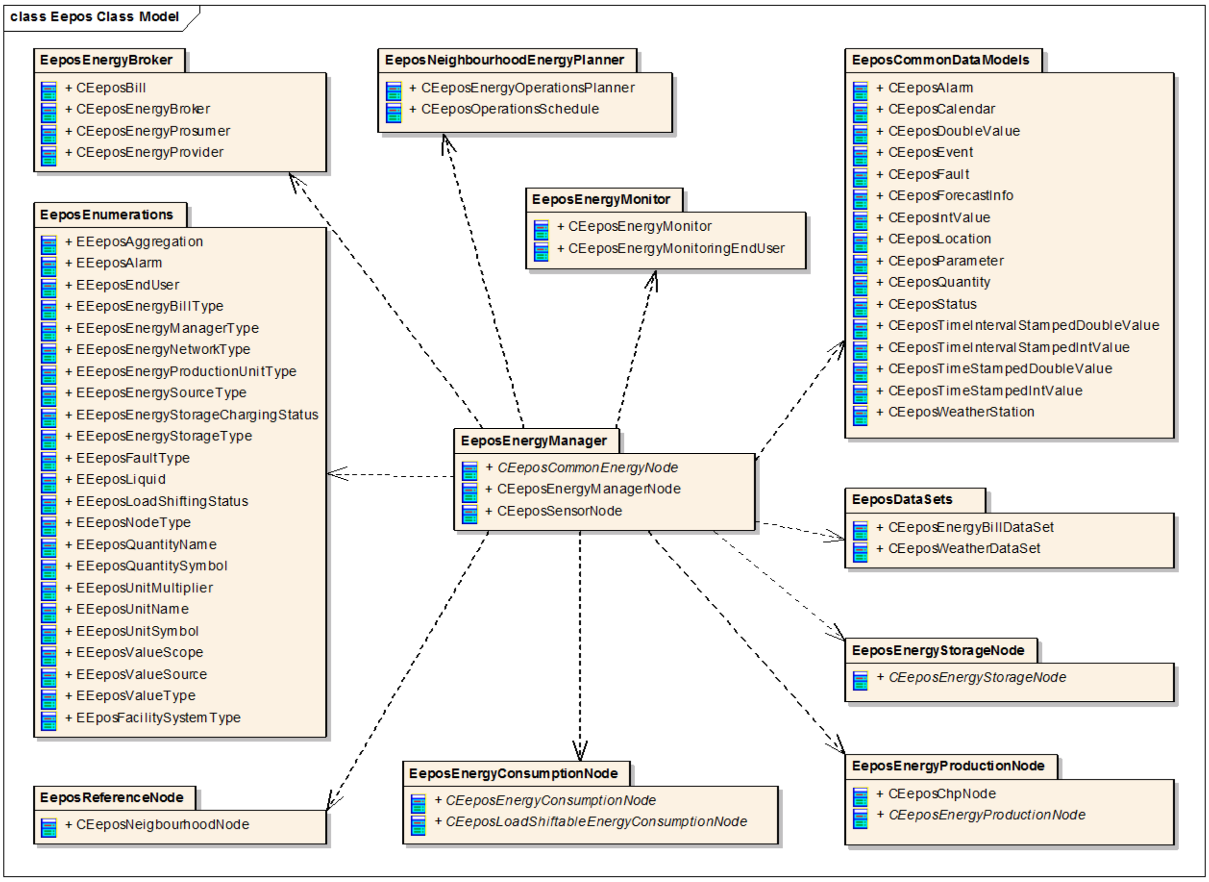


Figure 21. The Class model related components of the EEPOS neighbourhood energy grid information model

The core of the EEPOS neighbourhood energy grid information model are EEPOS energy nodes including CEeposEnergyManagerNode, CEeposEnergyProductionNode, CEepos-EnergyConsumptionNode, CEeposEnergyStorageNode, CEeposSensorNode and CEepos-NeigbourhoodReferenceNode shown in Figure 22.

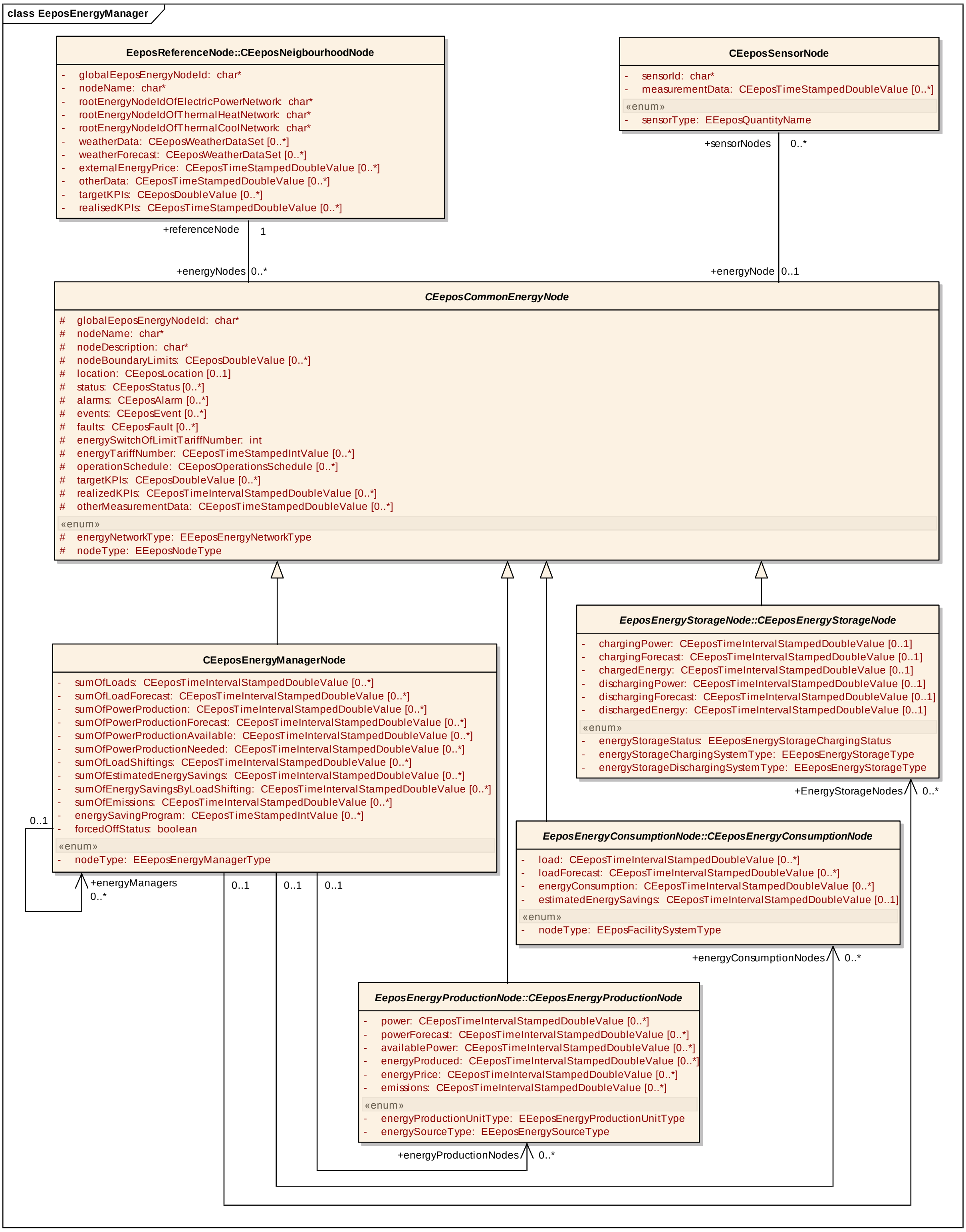


Figure 22. EEPOS neighbourhood energy grid information model related energy nodes

The CEeposEnergyConsumptionNode is shown in more detail in Figure 23.

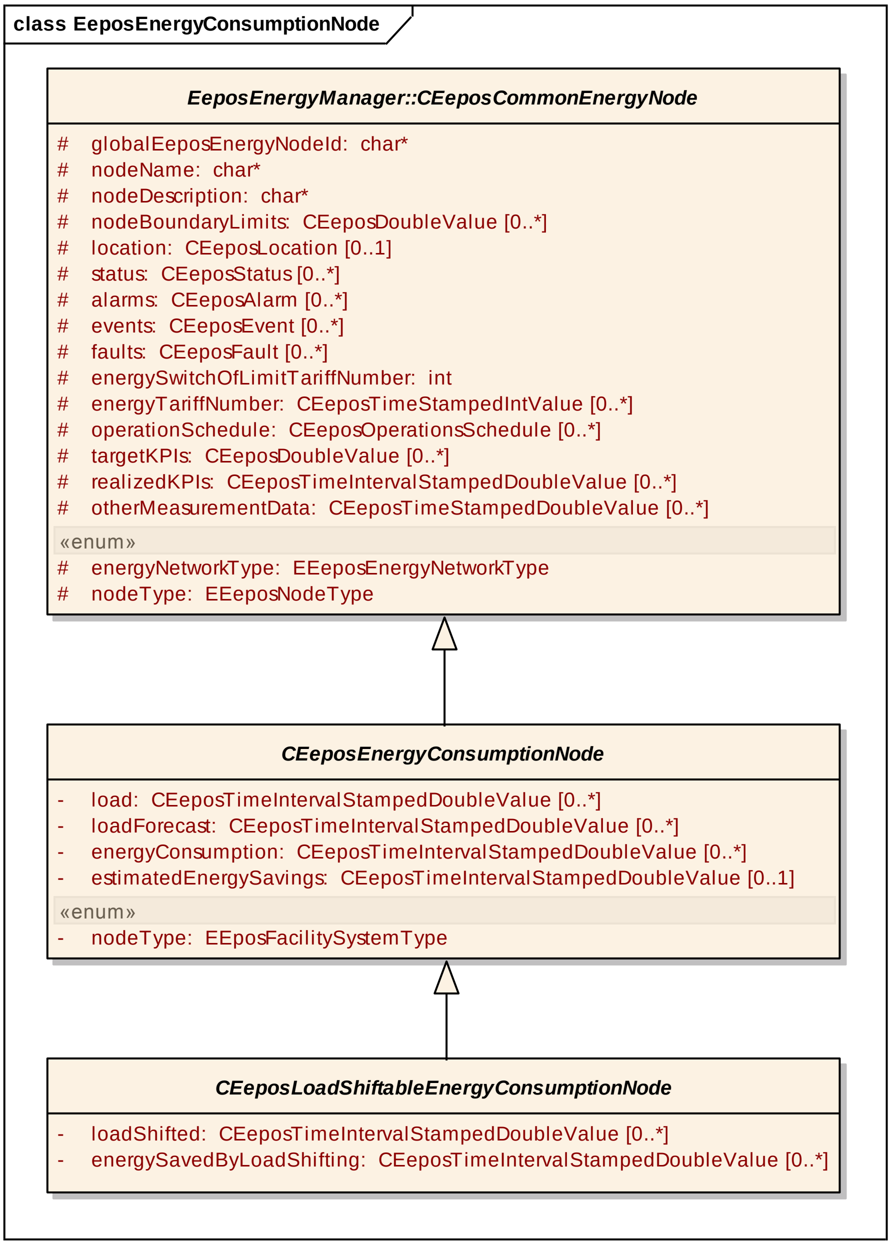


Figure 23. EEPOS neighbourhood energy grid information model related energy consumption nodes

The CEeposEnergyProductionNode is shown in more detail in Figure 24.

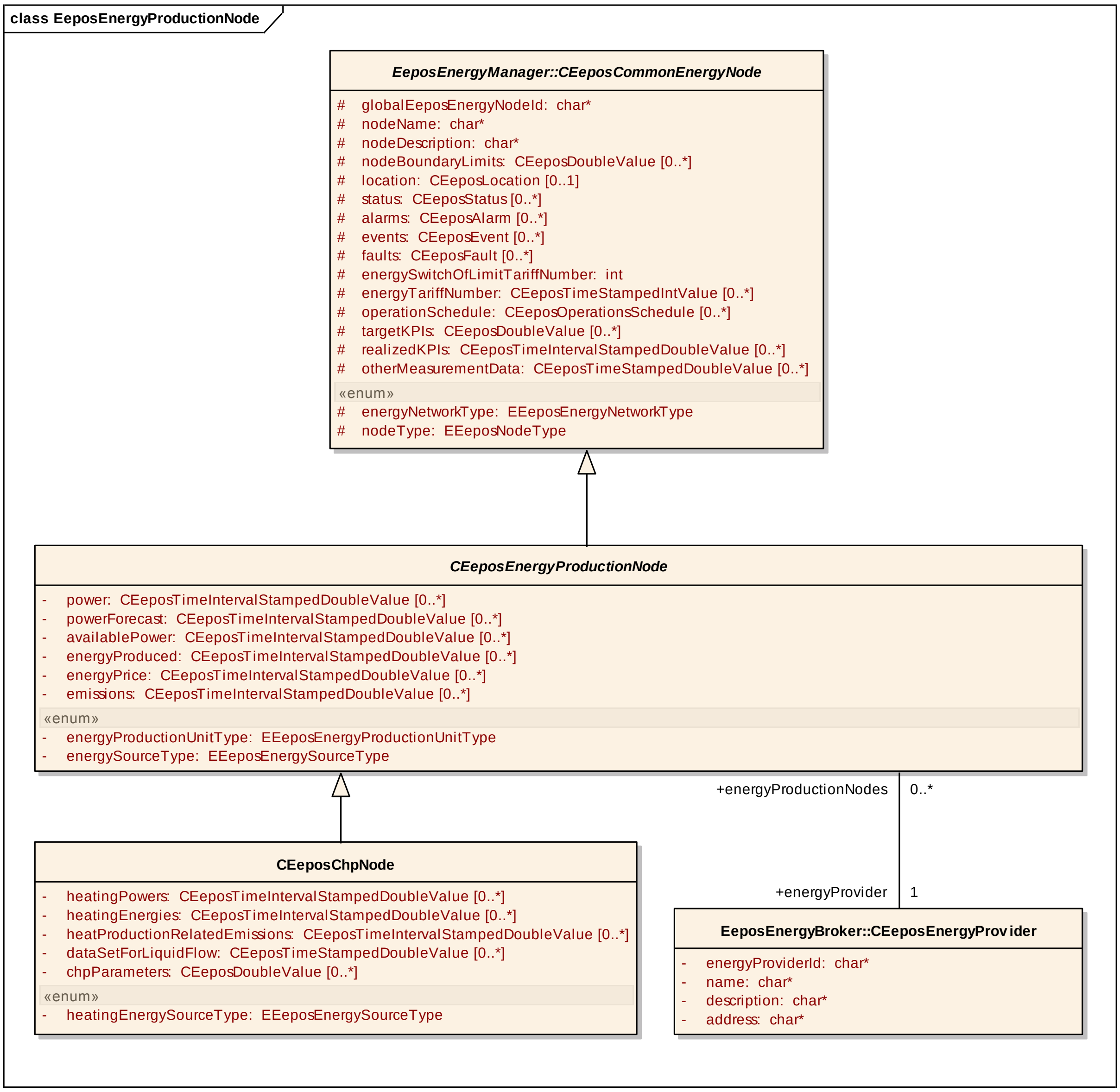


Figure 24. EEPOS neighbourhood energy grid information model related energy production nodes

The CEeposEnergyStorageNode is shown in more detail in Figure 25.

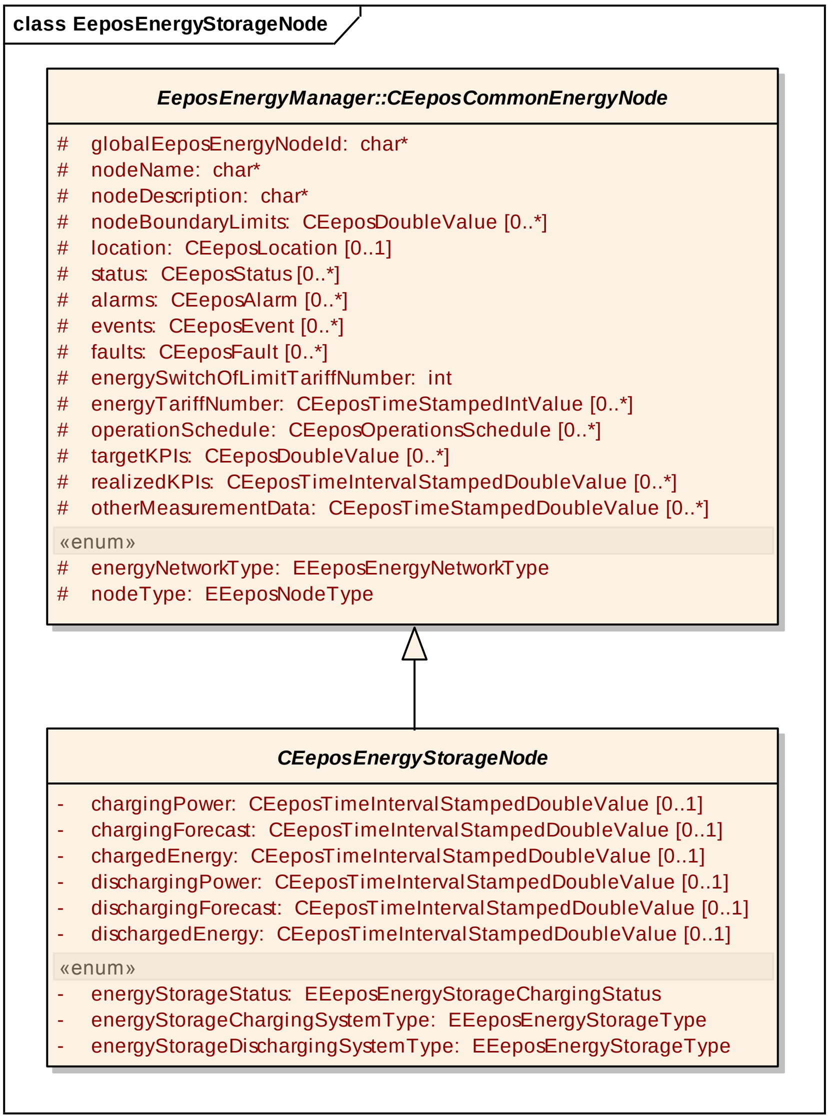


Figure 25. EEPOS neighbourhood energy grid information model related energy storage nodes

The CEeposEnergyBroker is shown in more detail in Figure 26.

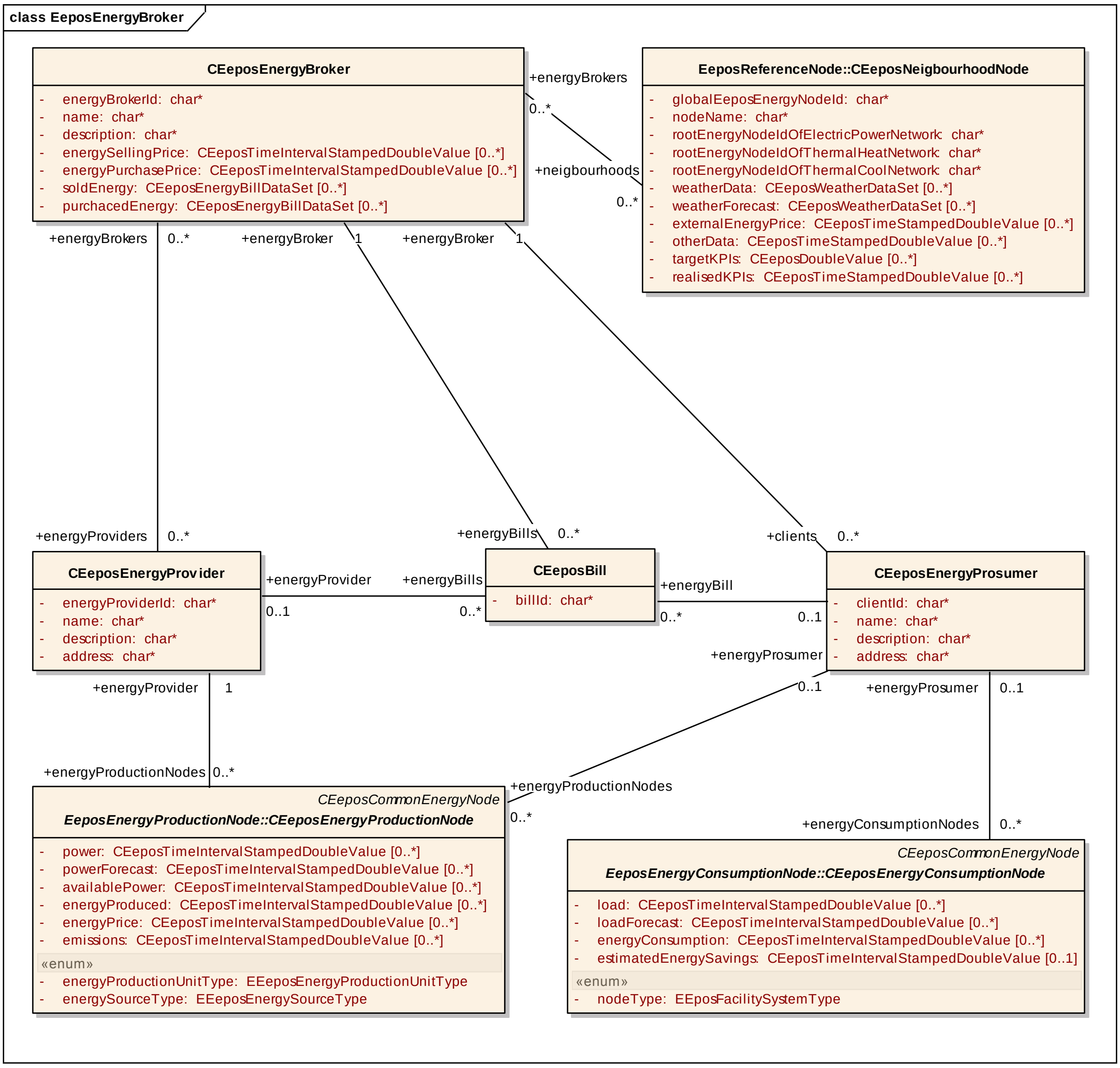


Figure 26. EEPOS neighbourhood energy grid information model related energy broker

The CEeposEnergyMonitor is shown in more detail in Figure 27.

Figure 27. EEPOS neighbourhood energy grid information model related energy monitor

The CEeposEnergyOperationsPlanner is shown in more detail in Figure 28.

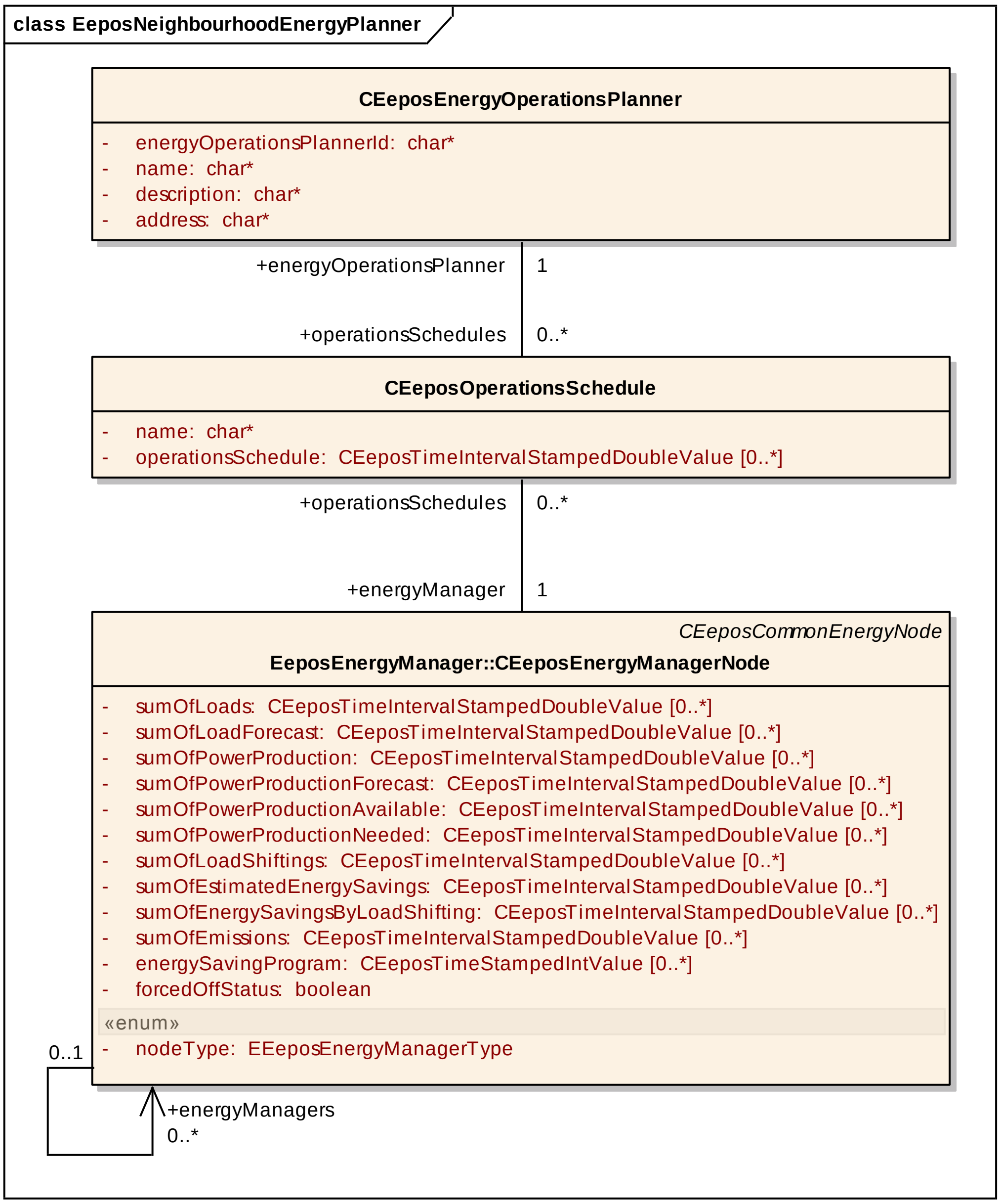


Figure 28. EEPOS neighbourhood energy grid information model related energy operations planner

The CEeposDataSets is shown in more detail in Figure 29.

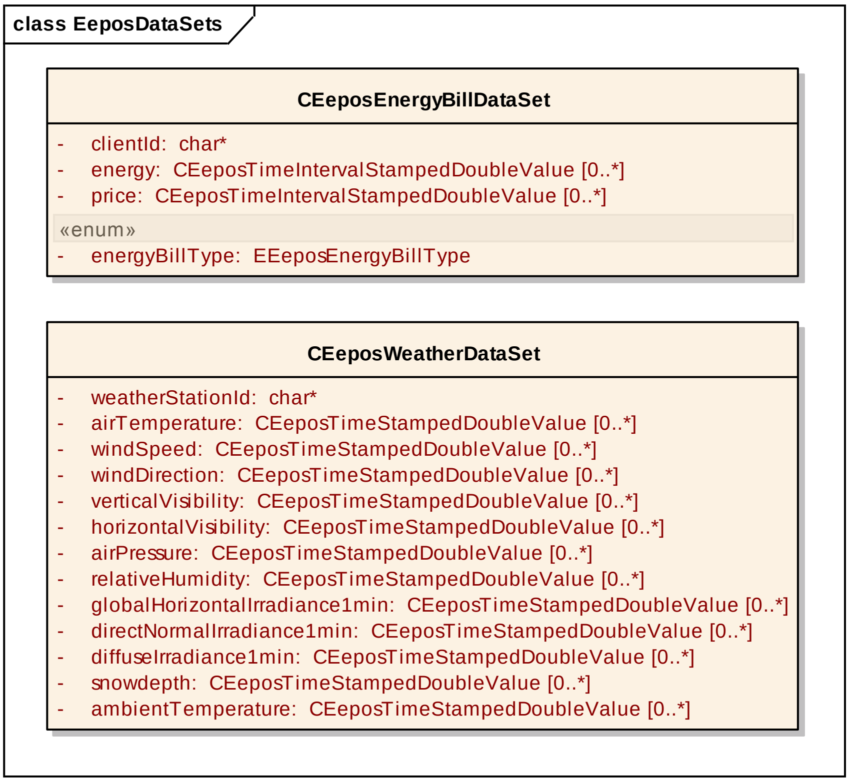


Figure 29. EEPOS neighbourhood energy grid information model related data sets

The CEeposCommonDataModels is shown in more detail in Figure 30.

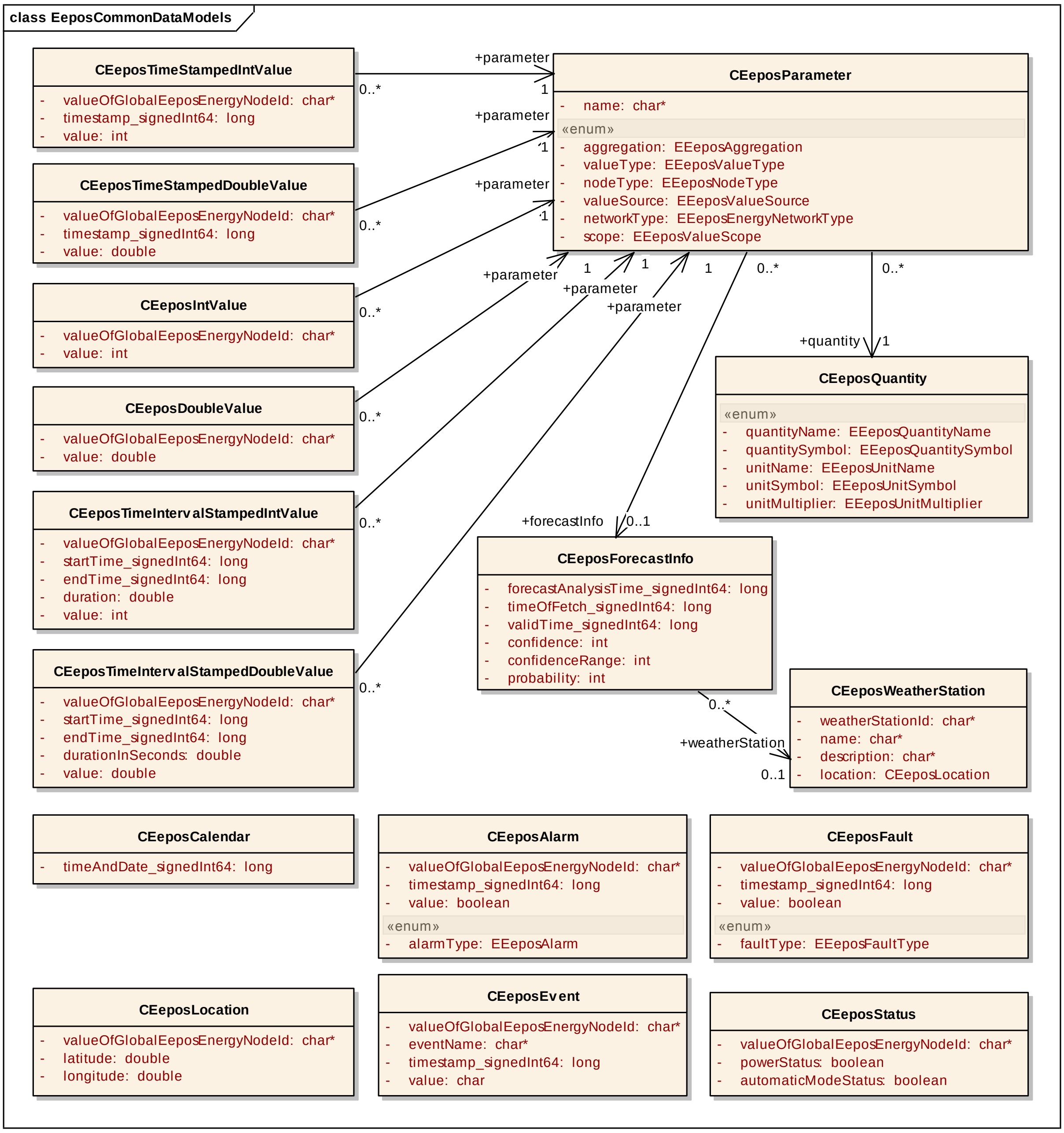


Figure 30. EEPOS neighbourhood energy grid information model related common data models

The enumerations used in the neighbourhood energy grid information model are shown in more detail in Figure 31.

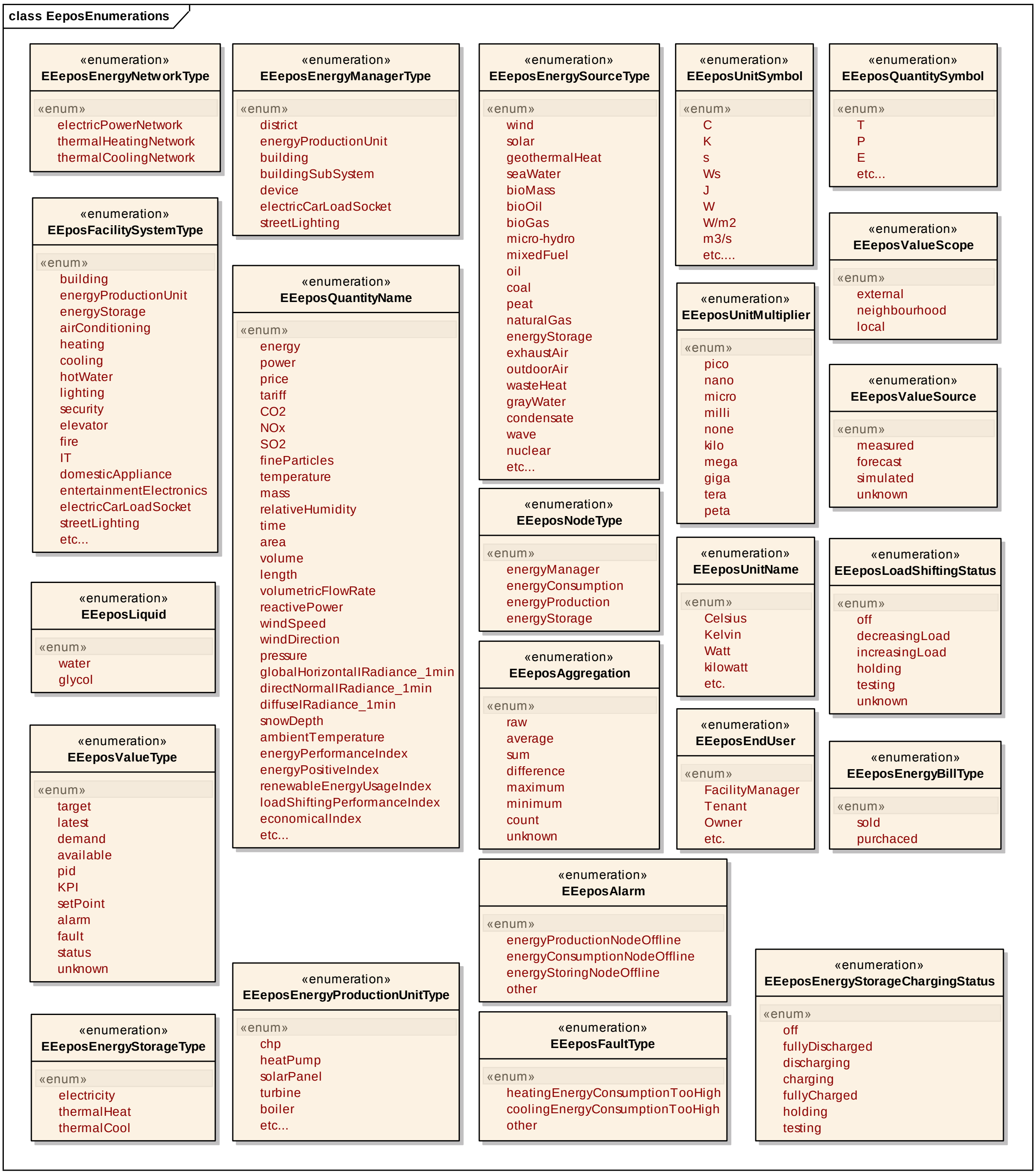


Figure 31. EEPOS neighbourhood energy grid information model related enumerations

8. CONCLUSIONS

The final goal of this task was the EEPOS neighbourhood energy grid information model for neighbourhood energy management. The related sub goals were the description of the modelling approach and the EEPOS use case definitions and related analysis.

The main results are

- Description of the EEPOS information modelling approach
- Requirements for EEPOS information models including EEPOS use case definition
- EEPOS use case analysis including summary of needed actors and information elements
- EEPOS neighbourhood energy grid information model for neighbourhood energy management

The full EEPOS neighbourhood energy grid information model is generated using Enterprise Architect tool which make it possible to publish these models as Java, C++ or C# programming language based classes.

8.1 Summary of achievements

The main results presented in this report are the EEPOS neighbourhood energy grid information model including

- Description of the EEPOS information modelling approach including use case templates based on templates provided by CEN/CENELEC/ETSI
- Listing of the standards which should be considered when developing the EEPOS information models
- Description of the OGEMA data model concept as relevant for EEPOS
- Description of the EEPOS relevant communication between building and neighbourhood levels
- Description of the communication between the EEPOS Neighbourhood Automation System and the EEPOS ICT platform
- Description of the use cases for EEPOS tools by using EEPOS use case templates
- The EEPOS use case analysis including the definitions of the main actors and needed information elements
- The EEPOS neighbourhood energy grid information model for neighbourhood energy management

8.2 Relation to continued developments

This document describes the final EEPOS information model which has output to the OGEMA information model used in T2.3, T3.2, T3.3 and T3.4. And if possible these models can have a role when developing EEPOS related European level information model standards.

8.3 Other conclusions and lessons learned

The using of all CEN/CENELEC/ETSI based use case templates is a rather heavy process and is not very effective in the case when the substance is well known by the information modellers. It is more suitable for standardisation and for very big projects where the domain experts, information modeller and the software developers are different peoples.

9. ACRONYMS AND TERMS

3D .... Three Dimensional.

Actor .... A participants in Application.

Ambassador .... Project name (Autonomous Management System Developed for Building and District Levels, http://ambassador-fp7.eu/).

API .... Application Programming Interface.

AS1.............................. Alternative scenario 1.

AS2.............................. Alternative scenario 2.

ASHRAE .... American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

BACnet .... Building Automation and Controls Networks.

BIM .... Building Information Model.

buildingSMART.......... A neutral, international and unique non for profit organisation supporting open BIM through the life cycle.

C++.............................. C Object-Oriented Programming Language.

C# .... C Sharp (Microsoft programming language).

CEM .... Customer Energy Manager.

CEN .... European Committee for Standardization.

CENELEC .... European Committee for Electrotechnical Standardization.

CHP .... Combined Heat and Power.

CIM .... Common Information Model.

COSEM .... Companion Specification for Energy Metering.

DDL............................. Data Definition Language.

DER .... Distributed Energy Resources.

DLMS .... Device Language Message Specification, originally Distribution Line Message Specification.

DSM .... Demand Side Management.

EA................................ Enterprise Architect.

EBT .... Energy Brokering Tool.

EEBus .... E-Energy Bus (www.eebus.org).

EEPOS .... Energy management and decision support systems for Energy POSitive neighbourhoods.

ESCO .... Energy Service Contractor/Company.

ETSI .... European Telecommunications Standards Institute.

EU................................ European Union.

FSGIM......................... Facility Smart Grid Information Model.

HBES .... Home and Building Electronic Systems.

ICT .... Information and Communication Technology.

IDEAS .... Project name (Intelligent neighbourhooD Energy Allocation & Supervision, http://www.ideasproject.eu/wordpress/).

IEC .... International Electrotechnical Commission.

IEEE .... Institute of Electrical and Electronics Engineers.

INTrEPID .... Project name (INTelligent systems for Energy Prosumer buildIngs at District level, http://www.fp7-intrepid.eu/).

ISO .... International Organization for Standardization.

JACE .... Java Application Control Engine.

Java.............................. A general purpose, high-level, object-oriented, cross-platform programming language developed by Sun Microsystems.

JSON .... JavaScript Object Notation.

KPI .... Key Performance Indicator.

LNAP .... Local Network Access Point.

LON............................. Local Operating Network.

M-BUS .... Meter-Bus.

MCF .... Meter Communication Functions.

MSCONS .... Meter data related messages for market communication.

NEMA .... National Electrical Manufacturers Association.

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

NNAP.......................... Neighbourhood Network Access Point.

OASIS .... Organization for the Advancement of Structured Information Standards.

oBIX............................ Open Building Information Xchange.

Odysseus...................... Project name (Open Dynamic System for Holistic energy Management of the dynamics of energy supply, demand and storage in urban areas, http://www.odysseus-project.eu/).

OGEMA .... Open Gateway Energy Management Alliance.

OpenADR.................... Open Automated Demand Response.

prEN .... Proposed European Standard.

PS1 .... Primary scenario 1.

PS2 .... Primary scenario 2.

PV................................ Photovoltaic.

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

ROI.............................. Return on Investment.

SunSpec....................... Open information standards that solar PV manufacturers use to achieve plug-and-play interoperability between solar PV power plant components and software applications, http://www.sunspec.org/.

UC .... Use Case.

UML .... Unified Modelling Language.

WAGO-I/O .... A modular, fieldbus independent I/O system.

Z-Wave .... A wireless communications protocol designed for home automation (http://www.z-wavealliance.org/).

ZigBee .... A low-cost, low-power, wireless mesh networking standard.

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