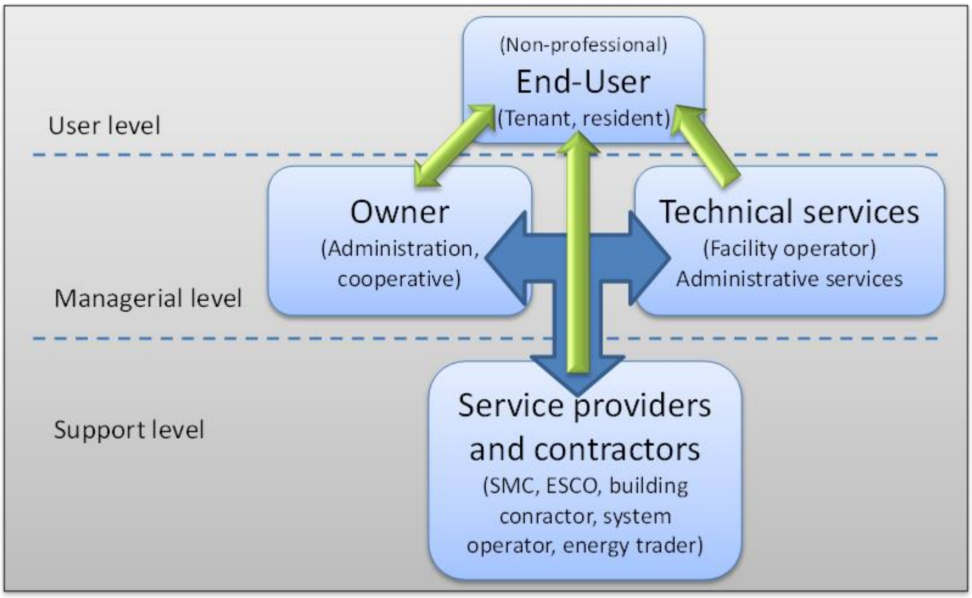
Stakeholders requirements for EEPOS neighbourhood energy management system



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1. PUBLISHABLE EXECUTIVE SUMMARY

Objective of the document is to summarize the results of the work done for stakeholder requirements formulation and to provide further assistance for the development tasks of EEPOS project. This task inquires the requirements most relevant to stakeholders related neighbourhood level energy management activities. The purpose is to capture the stakeholders concerns and needs when developing an automation and energy management system.

In total, 41 experts were interviewed from various domain fields – research organisations specialised in the field of automation, ICT and energy management, energy efficiency and renewable energy utilisation related service providers and consultants, municipalities facility management departments, specific automation and energy management related ICT and hardware developers and also housing companies and cooperatives to depict the stakeholders view. These stakeholders form a wide range of multidiscipline experience, thus it is expected to cover all relevant aspects when discussing about neighbourhood level automation and energy management. Even though the interviewed formed the top of experts from their respected fields, it should be noted that topics such as demand side automation and micro grid possibilities are not widely adopted concepts. There lie many obstructions before such technology could widely be implemented in everyday life.

Potential customers of EEPOS framework are – various service providers (facility managers, energy service companies, housing companies as well as municipalities and building contractors and real estate developers). Some of the interviewed experts (research institutions, energy traders, hardware and ICT developers, building contractors, renewable energy developers etc.) will potentially develop/introduce related products and services on the basis of EEPOS solutions and may adopt EEPOS concepts. EEPOS aims at an emerging future markets which does not exist today. Therefore interviewing experts from relevant domains is justified even if they are not potential customers today.

From the interviews the following top priority areas can be highlighted.

Functional and related requirements

- Ability to define, set limits and monitor key operating parameters and EnPIs,
- Ability to interoperate between different automation systems,
- Ability to develop own solutions with EEPOS framework,
- Ability to optimise energy consumption considering comfort - Adaptive system control,
- Enabled supervisory and predictive control features.

Requirements related to data content presentation and communication

- Ability to present segragated energy flow and duration curve,
- Ability to communicate detailed monitoring of energy consumption,
- Ability to prioritise energy sources,
- Ability to detect and prioritise faults.

Issues related with end-user awareness and their contribution potential

- Means for End-user engagement and motivation,
- Promoting renewable energies and energy efficient technology adaption,
- Supporting End-users in understanding energy saving and behavioural influence potential.

In the document more detailed analysis of the interview results is done.

Based on the results of the interviews, many important conclusions can be drawn. In general, the stakeholders highlighted similar concerns and issues with potential future developments as project consortium has envisioned thus far. This supports the prerequisites project consortium has been taken as a basis for the development work so far and assures that the direction of the development work currently on-going is adequate.

As a result of interviews and the work done in Task 1.2, we recommend to consider 12 top priorities presented in figure above while developing solutions for neighbourhood level energy management. Interoperability is essential while building neighbourhood level energy management system. Raw performance data should be processed and filtered into format understandable for various groups of stakeholders.

Mentioned requirements as well as tools specific requirements in this document contribute to EEPOS neighbourhood energy management system development and help to further the state-of-the-art currently existing. These requirements enable to develop precise and functional neighbourhood level methods and applications to manage the energy flows and take into account not only the consumption of energy but distributed production of energy as well.

2. INTRODUCTION

2.1 Purpose and target group

This report maps relevant stakeholders related to neighbourhood level energy management activities. Based on the results of the work done in Task 1.2 it is possible to focus functionalities of the tools and applications to the relevant end-users. These end-users may be tenants or owners as well as service providers (e.g. facility managers, service and maintenance companies, ESCO, housing companies and cooperatives). Also necessary focus has been turned to the implementation of the envisioned solution which includes the viewpoints of hardware and ICT developers as well as building contractors and other technical consultation companies specialised in energy efficiency solutions.

The requirements are used to develop tools and application for the neighbourhood level energy management that relate to real stakeholder needs. To capture user's need expert interviews were conducted. The results of the interviews were then mapped with technical specifications for neighbourhood energy management system. The results of the work are also used to validate the project team's ideas and assumptions, thus making sure that applications are addressing real world issues. The identification of these issues helps to improve the quality of neighbourhood energy management system with smart grid applications.

2.2 Contributions of partners

The task leader of T1.2 with the help of task leaders of other tasks has compiled a generic interview template as well as online survey form. All task participants have conducted interviews. The summary of partner contribution is as follows.

Table 1 Number of interviews conducted by each partner

Number of interviews per partner	
Araia	5
Caverion	9
DERlab	5
Ennovatis	5
Fatman	5
Solintel	5
VTT	7
Total	41

Consolidation and analysis of the interview results was done by task leader.

2.3 Scope

Novel applications, such as neighbourhood energy management and automated demand response, have not generated widely known requirements or available data. However, building level automation and energy management solutions are well known and the extensive combined experience of project partners and working together with stakeholders has allowed to assume certain general requirements.

This task is one of the first tasks of the EEPOS project and provides necessary input for the development work in technology development work packages.

2.4 Relations to other activities

The work in this task has been done in two phases. Initial environment mapping and stakeholder identification as well as tool features formulation and stakeholder requirements provided input for architecture creation. At this stage of the project preliminary solutions have been mapped but detailed tool and application specifications have been created in parallel with requirement formulation. The work in this task has enabled to create general framework and specific functionality depends on the specific requirements. The functionality of the tools can now be adjusted to the requirements formulated according to collected stakeholder viewpoints. Up to this point the automation and energy management process has been designed and the configuration of the application is now done.

Also Work Package 2, 3 and 4 contents have contributed to more specific stakeholder requirement formulation. Based on the decisions on the final architecture as well as data flows it was possible to compile relevant interview template as well as survey form.

3. METHODOLOGY

This document maps stakeholder interests with solutions and tools that realise neighbourhood level energy management. In the process of formulating requirements that various stakeholders have towards neighbourhood level energy management, firstly the stakeholder groups are identified based on the scope of EEPOS project as well as taking into account the environment in which the stakeholders operate in relation to managing end-user energy consumption and energy supply. After initial identification of stakeholder groups, the stakeholders are grouped and categorized based on the type and access levels of their activities related to neighbourhood energy management. This will enable to define necessary user levels for the application development.

The actual formulation of requirements for the functionality and validation of the formulated principles are made on the basis of the results received through 1-on-1 interviews (template added in annex 1) with various stakeholders and experts of the field e.g. housing cooperatives, service providers, research institutions, hardware and ICT developers etc. They were selected on the basis of country coverage as well as expertise field and relevance regarding the EEPOS project.

The interview was compiled to be non-directive so that interviewees are able give open answers regarding their top priorities for ICT solutions on energy management. During an interview the project partner is able to deepen the discussion after main issues have been listed.

In addition to 1-on-1 interviews also online survey (template added in appendix 2) has been set up. The survey will continue to be accessible also after this task has finished, thus providing valuable feedback when adjusting the applications. The possibility of participating in the online survey is disseminated through various channels e.g. EEPOS project website, social media (LinkedIn etc.), project consortiums contacts as well as during workshops and conferences.

Based on the results of the interviews main focus points for functionality development are formulated and mapped with task specific requirements.

In the table below, the number of interviews conducted per each stakeholder group is presented.

Table 2 Number of interviews conducted per each expert organisation group

Number of interviews per stakeholder group	
Service provider - Energy consultants – ESCO	6
Research organisation or university	9
Hardware developer	5
Housing cooperative / housing company	4
Municipality	4
ICT developer	3
Service and maintenance company	3
Facility manager / technical operator	3
Building contractor (construction or building technical system)	3
Energy trader	1
Total	41

3.1 EEPOS environment

In order to give context for the following interview results analysis the EEPOS operating environment is explained.

The EEPOS environment comprises of the neighbourhood and relevant stakeholders that act either as receivers or providers of services and benefits. The primary focus is to create sustainable, comfortable and efficient living, working and operating environment for end-users. End-users in the context of EEPOS project take the role of ‘prosumer’ (producer and consumer). The end-users (residential, commercial, industrial and public) are grouped into a neighbourhood around which various services and processes are constructed in order to enable the needed operations of end-users. How different roles conform to provide necessary services for end-users are presented in the figure 1. Thin green arrows show the movement of services and/or information, whereas thick blue arrows represent cooperation relations between owners and service providers.

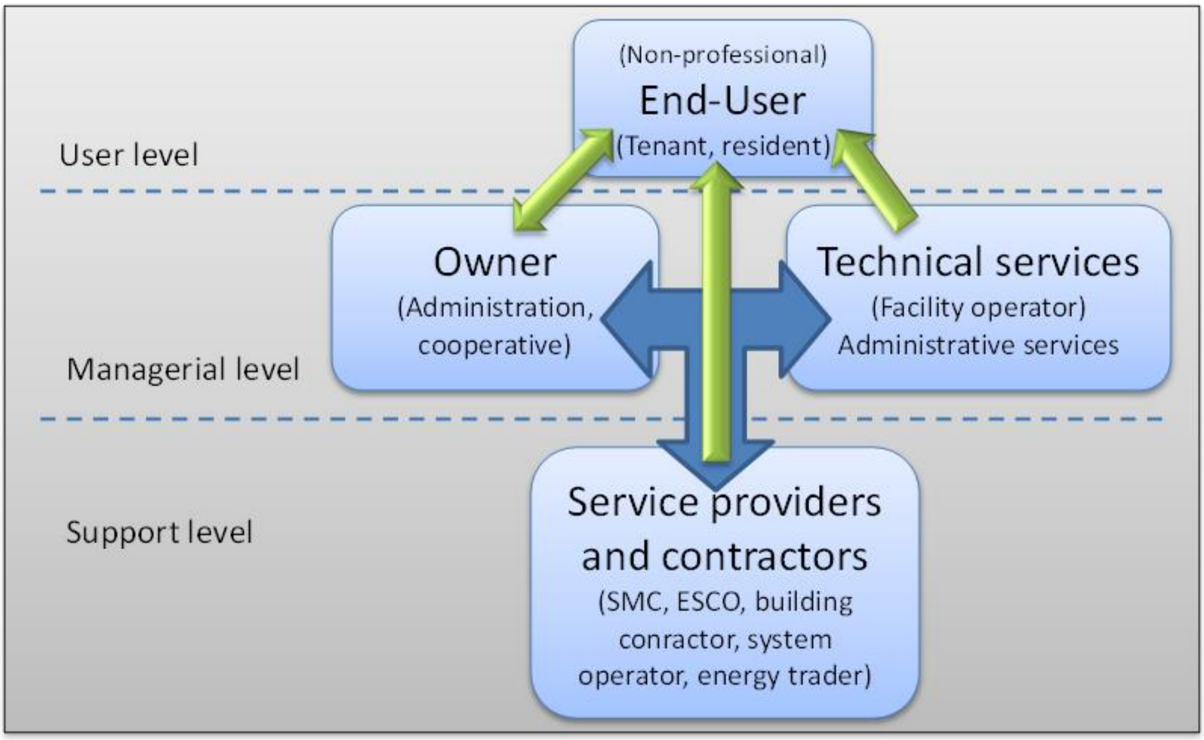

Figure 1 - User categorization according to roles and activities

The interactions of various stakeholders are described and pictured in the section below and figure 2.

Firstly the energy supply chain is considered. Several forms of energy are provided through open energy markets. Distributors transfer energy from producers via energy grid to the end-users. In the context of EEPOS NEMS (Neighbourhood Energy Management System) a neighbourhood operator will be responsible for adequate energy supply, thus making sure that enough energy is provided at best available prices. Additionally, the energy needed might be produced also within the neighbourhood. With the help of EEPOS NEMS the owners and operators of the neighbourhood are able to evaluate the optimal mix of renewable energy production as well as prioritize between local intermittent (wind, solar) and controllable (CHP, heat pump etc.) sources for the best result. With the help of EEPOS NEMS, there might be separate energy production company who invests in the neighbourhood grid as well as renewable energy production capacity and is then able to realise produced energy in more optimum way.

The supply-chain of energy, however, does not consider the efficient use of energy. For such purposes the NEMS Operator will utilise the EEPOS NEMS ICT platform to ensure the optimum operations of the real-estate and building technical systems.

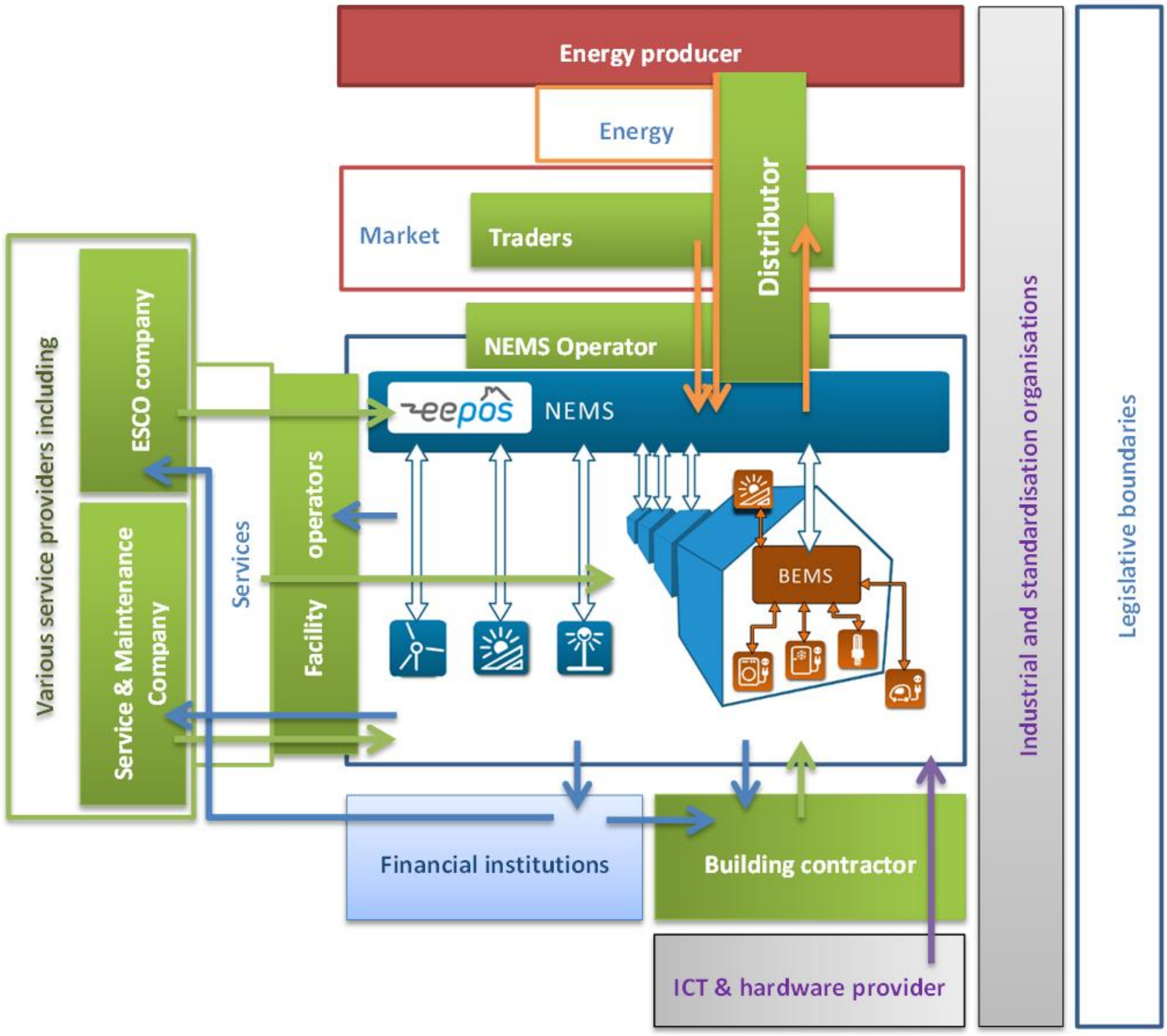

Figure 2 – EEPOS neighbourhood energy management environment

Over the life-cycle of multitude of technical systems installed within a neighbourhood it is necessary to monitor and maintain the technical equipment. The NEMS operator is not required to have capability of the servicing and maintaining the heating or electrical grid with related devices. Generally a technical facility operator is hired for such responsibilities. The responsibilities of a facility operator are to ensure the continuous operations of the technical system. A monitoring system might be used for such purposes. If service or maintenance need is detected, a service and maintenance company is hired (or alerted, in case of continuous contract) which will resolve the malfunction issue. In the case of less complicated systems NEMS operator may be able to evaluate and decide on the need for service and maintenance activities with the help of ICT platform, thus separate facility operator is not required.

With the help of performance analytics tools and supervisory and predictive control applications NEMS operator is able to ensure maximum energy efficiency (EE) of the neighbourhood. In the case of technical system renovation energy service company (ESCO) services might be required. NEMS operator could represent the neighbourhood in hiring suitable company for energy saving activities, as it incorporates necessary technical competence and tools to evaluate the value offering by the ESCO.

EEPOS platform is built to comply with the relevant standards by the international standardization and industrial bodies. System architecture as well as Application Programming Interface (API) is provided for the manufacturing sector to create new operating applications and improvements.

4. RESULTS OF EXPERT INTERVIEWS

In this chapter all interview results are presented.

The table below summarises how interviews have distributed according to the organisation of the experts that were interviewed.

Table 3 Distribution of expert interviews according to organisations of the interviewed experts

Number of interviews per stakeholder group	
Service provider - Energy consultants – ESCO	6
Research organisation or university	9
Hardware developer	5
Housing cooperative / housing company (managerial end-user)	4
Municipality	4
ICT developer	3
Service and maintenance company	3
Facility manager / technical operator	3
Building contractor (construction or building technical system)	3
Energy trader	1
Total	41

Section 3.1 summarises all results acquired from expert interviews.

Each following section begins with the list of contributing (interviewed) stakeholders and task partner who conducted the interview.

In the Annex II all direct interview results are presented. The interview results are summarised in 3.1 and further analysed in section 3.2.

Potential customers of EEPOS framework are – various service providers (facility managers, energy service companies, housing companies as well as municipalities and building contractors and real estate developers)

Some of the interviewed experts (research institutions, energy traders, hardware and ICT developers, building contractors, renewable energy developers etc.) will potentially develop/introduce related products and services on the basis of EEPOS solutions and may adopt EEPOS concepts.

EEPOS aims at an emerging future markets which does not exist today. Therefore interviewing experts from relevant domains is justified even if they are not potential customers today.

The answers from the interviews mainly cover the scope of building level, but as buildings form part of the neighbourhood it is possible to extend topics to neighbourhood level. Even if some expert feedback is not strictly limited to neighbourhood level, it is still relevant in developing solutions aiming at integrating buildings into neighbourhood. Technical requirements such as e.g. interoperability of different building automation systems apply to neighbourhood level the same way as building level.

4.1 Top requirements

Current section highlights most relevant requirements of the results from expert interviews. More detailed explanation can be found from subsections 3.1.1-3.1.3 as well as section 3.2. The direct results from the expert interviews can be found in Annex II.

Figure 5 lists requirements that experts from various domains have highlighted during the interviews. The listed top priorities indicate where the development work of tools and application should focus on.

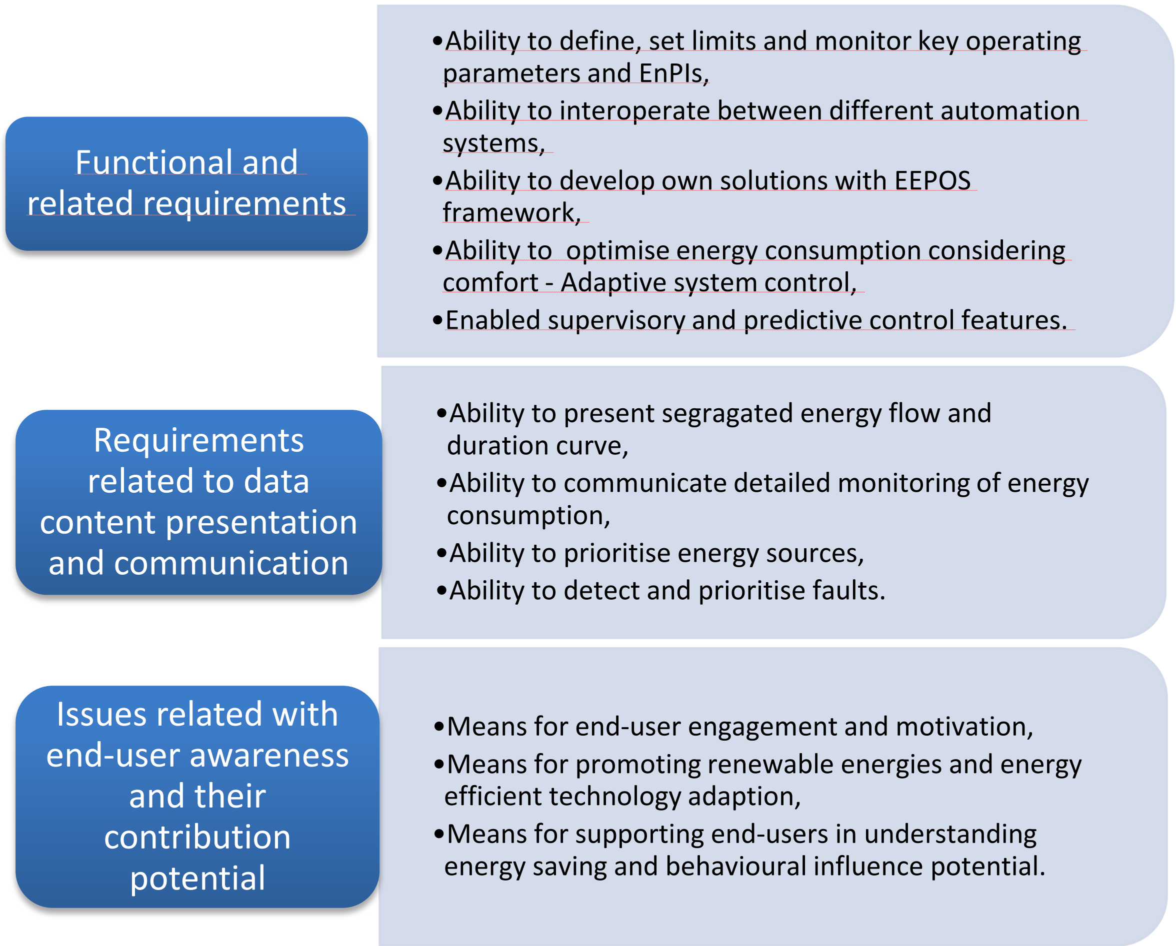

Figure 3 – Top stakeholder requirements

4.1.1 Functional and related requirements

4.1.1.1 Ability to define, set limits and monitor key operating parameters and Energy Performance Indicators (EnPIs) including the following features:

- Built environment characteristics
- Building parameters
- Envelope properties (thermal and physical)
- Energy production and consumption + forecast
- Indoor climate conditions and comfort levels
- Degree of utilisation – intensity of use
- Weather data and
- Energy price information
- Real-time data comparison with history data accompanied with

- Economic and ecological gains
- Duration curve with various resolutions (hour, day, week, month, year)
- Energy saving potential
- Saved energy amount

4.1.1.2 Interoperability and compatibility

The key focus points that should be addressed are the following:

- **Interoperability** between different building automation systems that may be connected below the same neighbourhood management system.
  The use of Open Platforms, Standards, Interfaces and Protocols is preferred – this would allow minimising future compatibility issues. Most of these issues are regarded resulting from corporations' proprietary technologies and closed systems which are unable effectively communicating with one another. The use of open solutions would enable feasible mapping of data model elements with standard interfaces as well as contributions and support by the community and technology enthusiasts.
- **Interoperability** with other related ICT platforms (e.g. ERP solutions) to enable multidisciplinary information exchange.
- **Tools for interoperability**
  - Tools for mapping the communication between different data models.
  - Graphical mapper for non-programmers

4.1.1.3 Developing own solutions with developed framework

- Generic open frameworks utilising common programming methods and languages to enable to operate with multiple hardware solutions.

4.1.1.4 Energy consumption optimisation considering comfort - Adaptive system control

- Principle of minimising the amount of energy consumed in order to achieve certain comfort levels.
- The automation system regulating the building system in a way that comfort is reached at minimal cost.
- Data collection and subsequent processing and analysis to understand energy behaviour of (i) buildings and (ii) its subsystems.
- Followed by contextualising the energy consumption (the effect = amount of energy) and reporting the cause for monitored result (effect). This is possible with precise reproduction of energy flows within a system (e.g. utilising Sankey chart).
- Advanced systems allowing the active configuration and reconfiguration taking into account system boundaries, operating environment as well as historical performance.

4.1.1.5 Supervisory and predictive control

Those applications should allow

- Energy consumption optimisation considering end-user comfort minimising the amount if consumed energy to achieve certain comfort levels.
- Understand energy behaviour of (i) buildings and (ii) its subsystems

- Demand side management applications where devices and boundary conditions can be defined
- Expanding existing system and including new units
- Active configuration and reconfiguration of technical systems taking into account system boundaries, operating environment as well as historical performance
- Use of performance data to understand changes in operating environment and be able to adapt to dynamic operating parameters

4.1.2 Requirements related to data content presentation and communication

4.1.2.1 Data presentation

When developing tools and creating the data model

- Information needs for decision making for various user levels should be defined.
- Real-time data comparison with history data accompanied with economic and ecological gains.
- Browsing and comparison of collected data should be effortless and easily understandable also for non-technical users.
- Consumption, production, weather and energy price data
- Duration curves with various resolutions (hour, day, week, month, year) for analysing energy saving potential.
- Ability to clearly evaluate energy savings as well as costs of saving energy (energy consumed by operating the system itself) that can be achieved with any given technology.
- Visualisation of technology and solutions for non-technical users
  - Utilising graphical 3D building information modelling technologies

4.1.2.2 Monitoring energy consumption

- Constant operating parameters and EnPI monitoring
- Device level consumption monitoring, if possible.
- Segregated (system level, device level) consumption data provision (e.g. with sankey diagram and duration curve)

4.1.2.3 Prioritisation of energy sources

- In order to realise the concept of energy positive neighbourhoods and maximise local renewable energy utilisation, it is necessary to be able to differentiate various energy sources and prioritise the use of those sources.

4.1.2.4 Fault detection

- Prioritisation of alarm types
- Control methods to detect faulty sensors

4.1.3 Issues related with end-user awareness and their contribution potential

4.1.3.1 End-user engagement and motivation

- The following topics are suggested to be considered to increase end-user engagement
  - Utilising social features of energy saving

  - Comparison with top performers
  - Encouraging and motivating of underperformers
  - Energy saving competitions – strong community plays an important role
  - Gaming
  - Energy saving steps are suggested to be built into daily routines
  - Benefits of each activity should be highlighted (saved money, competing and comparison with other neighbourhood members, being environmentally friendly etc.)

4.1.3.2 Promoting renewable energies and energy efficient technology adaption

The following aspects help to raise end-user awareness and assist in decision making

- Raising awareness of end-users and decision makers about such solutions if
- General knowledge about available technology, its benefits and feasibility in given environment
- Making preliminary suggestions about standard solutions as well as
- Providing implementation potential taking into account the system parameters and past performance. For example, based on the weather data and consumption characteristics and end-user collaboration tool could suggest a suitable size of solar panel installation along with potential savings and other benefits that could results from installation.

4.2 Results from expert interviews

Below are listed the organisations of experts which have contributed to stakeholder requirement formulation. Interviews have been personal interviews and may not depict the organisations views and some interviewees have requested that their contribution remains anonymous.

	Contributions	**Interviewed by**
1	CSTB	VTT
2	Materials Testing Instutute University of Stuttgart	Solintel
3	Tampere University of Applied Sciences	Fatman
4	University of Applied Sciences Leipzig	Ennovatis
5	VITO	DERlab
6	Instytut Energetyki Oddział Gdańsk	DERlab
7	Technical University of Denmark, Department of Electrical Engineering	DERlab
8	*Research institution X from South Europe*	DERlab
9	Soluciones Energeticas Inteligentes S.L.	Solintel
10	Symelec Renovables S.L.	Solintel
11	EnergyStar OÜ	Caverion
12	Profener OÜ	Caverion
13	Estonian Energy Saving Association MTÜ	Caverion
14	Cuadrilla of Agurain-Salvatierra	Araia
15	San Juan Grupo Servicios Empresariales, S.L.	Araia
16	City of Kerava, Technical services	Fatman
17	*City X from Germany*	Ennovatis
18	Energy agency of the Basque Country	Araia
19	City of Helsinki	VTT
20	SAP	VTT
21	Granlund Oy	VTT
22	IBM	VTT
23	Advantic SYS	DERlab
24	Energest OÜ	Caverion
25	*Hardware manufacturer X*	VTT
26	Asema Electronics	Fatman
27	Ouman Oy	Caverion
28	*Housing company X from Germany*	Ennovatis
29	*Housing company Y from Germany*	Ennovatis

30	Real estate investment company	Fatman
31	Sõpruse pst 202 – housing cooperative	Caverion
32	Aalto Yliopistokiinteistöt Oy	VTT
33	Isännöitsijätoimisto Vuori Oy	Fatman
34	Musterknaben eG	Ennovatis
35	Delap & Waller EcoCo	Solintel
36	LKS Ingeniería	Araia
37	Telur Geotermia y Aqua S.A.	Araia
38	Ancodarq S.L	Solintel
39	Helioest OÜ	Caverion
40	YIT Corporation	Caverion
41	Nordic Power Management OÜ	Caverion

4.2.1 Main recommendations and top priorities from experts obtained through interviews

Detailed stakeholders issues and priorities regarding neighbourhood level energy management are presented in the table of Annex II.

The experts consider important that an energy management system would allow defining, setting limits and monitoring **key operating parameters** and **Energy Performance Indicators (EnPIs)**:

- Characterisation of built environment,
- Easy inclusion of building parameters, envelope properties (thermal and physical) and materials used as well as changes in the system over time
- Energy production and consumption with forecasts
- Indoor climate conditions and comfort levels
- Weather data and energy price information

Energy consumption optimisation considering comfort [comfort vs. energy] should follow the principle of minimising the amount of energy consumed in order to achieve certain comfort levels. The automation system would regulate the building system in a way that comfort is reached at minimal cost. Currently automation system control principles rarely consider energy consumption or costs.

For this purpose data collection and subsequent processing and analysis is needed to understand energy behaviour of (i) buildings and (ii) its subsystems. This should be done by contextualising the energy consumption and reporting the cause for monitored consumption. This is possible with precise visual representation of energy flows within a system (e.g. utilising Sankey chart). Further processing of this data combined with raw consumption data allow to define energy performance indicators**.** Of course, these indicators can also be defined by the users themselves.

Centrally coordinated adaptive system control

Currently automation systems are programmed utilising static control logic. Neighbourhood level energy management systems should allow active configuration and reconfiguration of building technical system (i.e. consumers) operation taking into account system boundaries, operating environment as well as historical performance.

Interoperability issues are mentioned by almost all interviewed stakeholders. The key focus points that should be addressed are the following:

- Interoperability between different building automation systems that may be connected below the same neighbourhood management system.
  Stakeholders see important that drivers that consider most common and well established standards and protocols should be available (or capability of creating such drivers and interfaces).
  The use of open platforms, standards, interfaces and protocols is preferred – this would allow minimising future compatibility issues. Most of these issues are regarded resulting from corporations' proprietary technologies and closed systems which are unable effectively communicating with one another. The use of open solutions would enable feasible mapping of data model elements with standard interfaces as well as contributions and support by the community and technology enthusiasts. The achievements of open source communities are acknowledged and principles seen as potential direction to follow when developing new solutions.
- Interoperability with other related ICT platforms (e.g. ERP solutions) to enable multidisciplinary information exchange.

Data model creation taking into account user levels

When developing tools and creating the data model, various user level information needs for decision making should be defined. In addition to operating parameters and EnPIs visualisation, an energy management system should allow real-time data comparison with history data accompanied with economic and ecological gains. It is important that browsing and comparison of collected data is effortless and easily understandable also for non-technical users.

Along with afore mentioned aspects stakeholders see the need of being able to clearly evaluate the energy savings as well as costs of saving energy (energy consumed by operating the system itself) that can be achieved with any given technology.

Level of detail of monitored energy consumption

In addition to operating parameters and EnPI related aspects mentioned in previous section, experts find it relevant (for meaningful performance analysis) that data model could be capable of device level consumption monitoring. Furthermore, the interview results show that current energy management systems support mostly aggregated energy balance view, as opposed to detailed consumption data presentation.

The utilisation of Sankey diagram as well as duration curve analysis and more detailed consumption data would allow better identification of saving potential and efficiency improvements. Advanced energy consumption analysis should allow segregating the consumption by energy types and system as well as device level.

Reliability and security of monitoring, transferring and storing data

The reliability of data collection should be ensured by utilising high quality sensors and meters which ensure uninterrupted data collection and allow to detect interruptions in monitoring activities (e.g. by automated notification of abnormal interruptions in data stream).
The data communication should be encrypted and each device(node) could have a unique encryption key.

Installation of the system

Experts find that installation of energy management systems are resource heavy and often not feasible (into existing buildings), thus ways to lower this barrier should be a priority. In tasks 2.1 and 3.1 of EEPOS project the requirements and details for installation of the system into (i) new developments and (ii) existing neighbourhoods will be addressed.

End-user engagement and motivation

The following topics are suggested to be consider

- Utilising social features of energy saving,
- Comparison with top performers,
- Encouraging and motivating of underperformers,
- Energy saving competitions – strong community plays an important role,
- Gaming,
- Energy saving steps are suggested to be built into daily routines of tenants of the neighbourhood,
- Benefits of each activity should be highlighted (saved money, competing and comparison with other neighbourhood members, being environmentally friendly etc.).

Experts highlight the importance of reliability of wireless sensor and actuator network. Measures that would ensure sufficient coverage of wireless sensors should be developed.

Performance reliability of the energy management and decision support system

The performance reliability of the energy management and decision support system is considered important. Experience shows that the performance of energy management systems decreases over time, thus making it important to find solutions that evaluate the energy management system performance – either so that the system is always accurate or so that system evaluation reveals inaccuracies enabling the system to be re-configured.
The installation of energy management and automation system into existing buildings is difficult, thus it is important to find solutions that enable easy installation.

Expanding existing system and including new units

Currently expansion of already existing system requires manual labour for installation, setup and configuration. It is noted that detection as well as standard configuration of new units could be automated and therefore appropriate methods and data communication elements should be included into data model.

Prioritisation of energy sources

Generally energy management systems do not differentiate between various energy sources. In order to realise the concept of energy positive neighbourhoods and maximise local renewable energy utilisation, it is necessary to be able to differentiate various energy sources and prioritise the use of those sources.

Feasibility issues of utilisation of high level automation, control and energy management

To facilitate decision making whether or not to adapt various systems involving high investments, the benefits as well as feasibility of such systems should be well understood and validated.

Supporting End-users in understanding energy saving and behavioural influence potential

Interviews have revealed that end-users often lack knowledge about consequences of their behaviour as well as influence potential on overall energy consumption.
Automated load control can be feasible up to certain limits, but the end result (and costs of energy use) can better be affected by conscious behaviour. As there are methods and technology for automated energy consumption control the biggest challenge lies in improving users' behaviour.

Educating the end-users (in this context tenants and residents without technical background) about energy efficiency reveals the biggest potential. Basic energy efficiency principles (e.g. reduction of indoor temperature 1°C could lower energy consumption total of 5%) could effectively be disseminated through decision support system.

Promoting renewable energies and energy efficient technology adaption

Along with the lack of knowledge by non-technical users, also deciding on suitable renewable energy solutions pose challenges without the help of third party consultation. It would be possible to raise awareness of end-users and decision makers about such solutions if general knowledge about available technology, its benefits and feasibility in given environment would be provided.

In addition, a decision support system could make preliminary suggestion about standard solutions as well as implementation potential taking into account the system parameters and past performance. For example, based on the weather data and consumption characteristics and end-user collaboration tool could suggest a suitable size of solar panel installation along with potential savings and other benefits that could results from installation.

Furthermore decision support system could provide the contacts of certified local service providers or technology vendors.

The resolution of data metering

Metered data that is generally available has low resolution (e.g. only monthly resolution) which makes evaluation of energy saving potential challenging. Energy consumption should be metered at least with **hourly resolution**, but actual **real-time** data offers the best evaluation means.
Additionally one potentially effective method for energy saving potential evaluation is the use of **daily duration curve** method. If there is high consumption over a long period

of time during the day, one could conclude that there might be potential to save energy (e.g. by adjusting time schedules or improving ones behaviour etc.)

User friendliness and self-management

The importance of potential of ICT solutions is acknowledged however stakeholders have faced issues with **user friendliness**. Future developments should offer the necessary information for the end-users to **allow self-management** options without involvement of third parties. The final objective should be enabling to make good decision regarding energy consumption and production. It is important that users have access to information such as energy demand, energy prices and the origin of the energy.

Such system should allow:

- Monitoring the energy consumption over the internet
- Train local personnel about energy efficiency actions
- Help to implement energy saving actions

Software and device management

Without well designed software architecture improving and updating the software could be challenging. Modular architecture which allows evolving over time would ensure minimal effort while keeping software updated (safety, security, reliability etc.)

Also updates in devices firmware pose similar challenges along with widely implemented static and outdated service models. M2M platform for devices lifecycle management enables the evaluation and updating the system over devices' life cycle.

Usability of automation and energy management system

Usability has been deemed as poor for automation and energy management systems. User interfaces are generally designed for knowledge heavy engineering processes that require strong technical background. The usability of the systems should be made simple and understandable for non-technical users.

Tools for interoperability

Currently to enable interoperability between different automation and ICT systems a gateway interface has to be created (programmed) for each communication case. This requires considerable resources and constant updating. This issue could be solved by developing tools for mapping the communication between different data models.

Furthermore, graphical mapper would enable also automation and other field specialists (non-programmers) to create those connections and separate programming support would not be needed.

Forecasting of consumption and production

Currently the existing solutions lack of appropriate algorithms for energy forecasting. This issue could be solved by developing standard data model for forecasting.

Possibilities of visualisation of technology and solutions for non-technical users

Explaining the technical operating environment as well as energy saving possibilities to non-technical users is currently done with technical drawings and schematics. Generally

persons with non-technical background are unable to comprehend the context and scope of the system.
Utilising graphical 3D building information modelling technologies could help understanding and ease following decision making.

Locating relevant metering points

Depending on the size of the building (or buildings within a neighbourhood) locating and accessing relevant metering points can be challenging. With the help of flexible metering devices and up to date BIM model which includes all necessary cabling and thermal network paths it would make installation more efficient and lower implementation costs.

Promoting wider technology adaption

Building owners lack resources to make expensive investments into building operation optimisation. To better promote and enhance wider adoption of developed solution, tha value of energy management services should inarguably be presented and demonstrated. Benefits could arise from lowered costs due to energy savings, work load reduction or improved fault detection and continuous commissioning resulting in more optimal maintenance and servicing expenses.

Developing own solutions with developed framework

The problem of such systems generally in use is either high cost (capability to operate with multitude of hardware vendors) or requires skillset specific to one particular solution. The issues could be solved by developing open frameworks that are generic enough so that programmers would easily be able to operate with the solution and that it would enable to operate with multiple hardware solutions.

Considering the allocation of heating costs

People in centrally heated apartment buildings generally do not care about how their behaviour influences heating need. This is mainly due to the fact that in many apartment buildings heating energy consumption in not separately metered for each single apartment and costs are evenly distributed among all tenants. The utilisation of heating cost allocators help to divide heating costs in relation to actual consumption. Data models should be able to consider the use of heating cost allocators.

Operations of automation and energy management system over time

When programming automation controls, it is difficult to capture the real building behaviour as well as users' needs. With static control logic the system is unable to follow the operating environment changes.

It would be an asset if automation system could use performance data and understand changes in operating environment and be able to adapt to dynamic operating parameters.

Conducting an energy review at system changes (and at defined intervals) and taking the energy baseline as basis in building system control could enable solving this issue.

Fault detection

From the results of the interview in can be found that prioritisation of alarms on detected faults is not working properly. Either the system sends the alarm at wrong detected event (some event can occur multiple times without serious reason) or the system cannot differentiate more acute faults from less acute.
Better prioritisation of alarm types and deliberated definition of alarm events could help solving this issue.
Additionally developing control methods to detect faulty sensors will help to reduce incorrect alarms.

Demand side management

The importance of demand side management needs to be clearly explained. This means that benefits as well as saving potential due to such activity should be presented.
Stakeholders see that it is crucial that end-users can specify in detail the individual devices that could be submitted to automated demand side management as well as acceptable boundary conditions for compliance.
Many of interviewees mention to study the end-user acceptance of automated control. Based in their experience power switching by third party is generally not accepted and that end-users feel the need to be able to fully control the process.
However these aspects cover mainly the loads directly within end-user premises, and conforming to automated control could be feasible to implement for building system operations taken that user comfort and regulations are not compromised.

Enabling of energy selling/trading

The trading within a neighbourhood clearly needs further investigation as such solutions are not in use today. Furthermore, current legislative environment may not support energy trading within a neighbourhood.
There are certain aspects that are needed to be considered when designing a system for renewable energy selling within and without the neighbourhood.

- What are the exact legislative boundaries at each country where such solutions would be implemented?
- What are the technical boundaries?
- Studying in detail of various possible business cases that would enable such activities. This means investigating the needs of systems operators, energy traders and service providers in multiple contexts. Such study, however, falls beyond the resources and scope of this particular project.

Suggestions for functionality

- Web user-interface utilisation for easy access irrelevant from the device used (pc, tablet, smartphone etc.
- Users should be able to define and activate preset modes (e.g. home/away/night etc.)
- High level operator features should be enabled (e.g. grouping and analysis by various characteristics)

5. Conclusions

The main purpose of work done in Task 1.2 was to capture stakeholders' needs and requirements for a neighbourhood level energy management system. The requirements were formulated from the interviews conducted with 41 different stakeholders (service companies, research institutions, ICT and hardware developers, municipalities etc.).

Based on the results of the interviews, many important conclusions can be drawn. In general, the stakeholders highlighted similar concerns and issues with potential future developments as project consortium has envisioned thus far. This supports the prerequisites project consortium has been taken as a basis for the development work so far and assures that the direction of the development work currently on-going is adequate.

From the interviews the following priority areas can be highlighted.

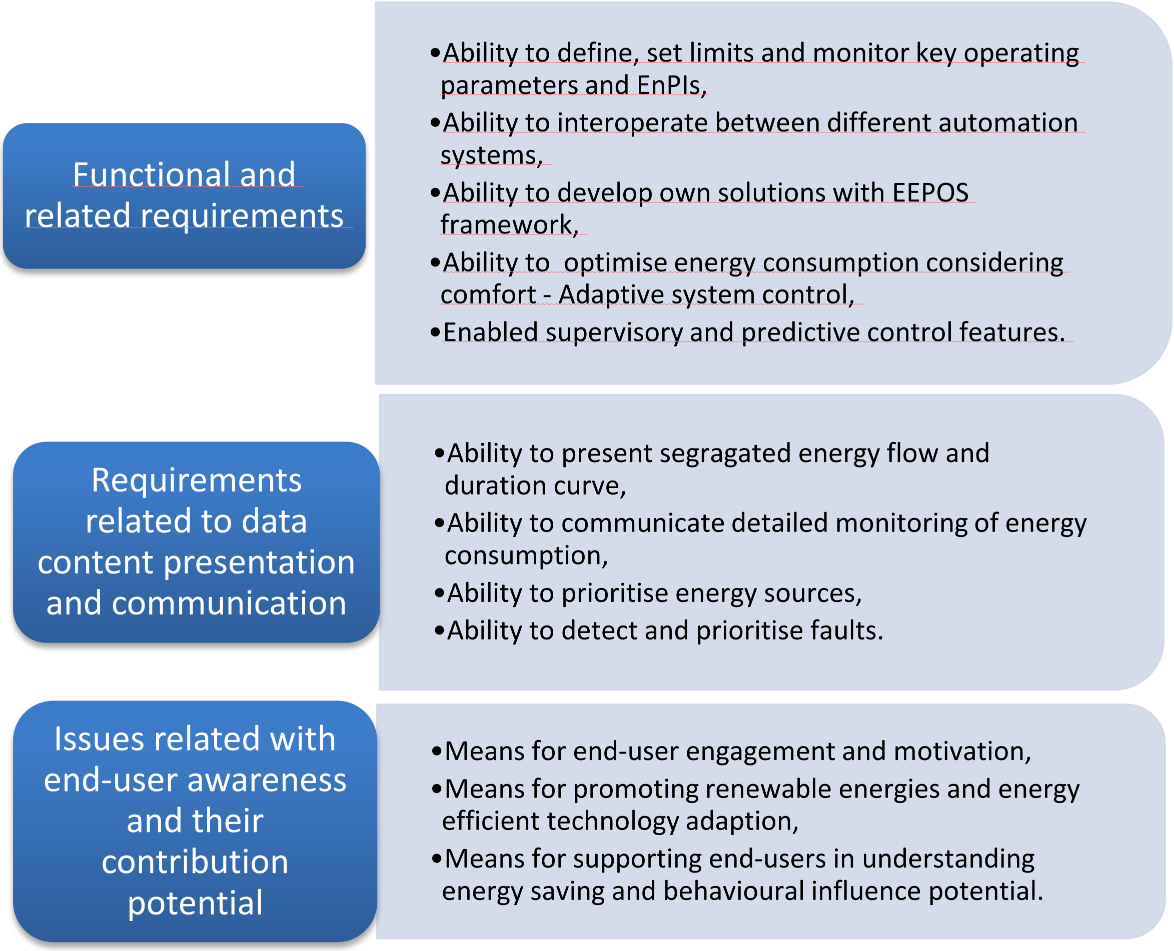

Figure 4 - 12 top requirements obtained from expert interviews

As a result of interviews and the work done in Task 1.2, we recommend to consider 12 top priorities presented in figure 4 while developing solutions for neighbourhood level energy management. Interoperability is essential while building neighbourhood level energy management system. Raw performance data should be processed and filtered into format understandable for various groups of stakeholders.

In the document more detailed analysis of the interview results is done.

6. ACRONYMS AND TERMS

API .... Application Programming Interface
BEMS .... Building Energy Management System
CHP .... Combined heat and power
DER .... Distributed Energy Resources
EBT .... Energy Brokering Tool
EE .... Energy Efficiency
EnPI .... Energy Performance Indicator
EnMS .... Energy Management System
ERP .... Enterprise Resource Planning
ESCO .... Energy Service Company
FM .... Facility Manager
HAM .... Heat, air and moisture
HC .... Housing Company
HVAC .... Heating, Ventilation and Air Conditioning
ICT .... Information and Communication Technology
KPI .... Key Performance Indicator
NEMS .... Neighbourhood Energy Management System
RE .... Renewable Energy
RES .... Renewable Energy Source
SMC .... Service and Maintenance Company

7. APPENDICES

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7.1 Annex I - List of interview participants (confidential)

Available for project partners and European Commission

7.2 Annex II – Direct feedback from expert interviews

7.2.1 Direct feedback from interviews

The priorities and issues in the first column are that of those highlighted by the experts during the interviews. The second column of interview result tables addresses possibilities to influence the mentioned priority or issue (future developments – possibilities to solve the issue). The table in section 6.1.2 presents topics that are relevant but fall out of the current project scope.

Problem	**How could EEPOS project address this issue**
It is difficult to evaluate the actual energy savings with specific technologies	Energy savings evaluation capability supported by ICT platform
Reliability of data collected with sensors	Data transfer should ensure reliable sensor data from sensors to database
Energy demand and consumption including built environment characteristics (HAM modelling – heat, air and moisture modelling)	Actual energy demand and consumption Easy inclusion of buildings to the system Easy inclusion of building paratmeters (building envelope + materials used) Comfort optimisation considering energy consumption Data analysis capability to understand energy behaviour of buildings Fast detection of energy losses
Understanding and reporting of energy consumption	Precise(detailed) reproduction of energy flows and consumption
Difficult to compare the context of consumption data	Calculation of specific comparable values that describe and characterise consumption and associated costs Explaining of cause and effect of energy consumption
Interoperability	Open Platforms and open standards
Security and privacy of data collected	Visibility of the data flows
Costs of energy saving	Evaluate the energy consumption of the energy management system
Stability of the system and correctness of collected data	Stable and correct data measurement and calculation
Energy consumption data presentation	Meaningful data cosidering end-users needs (e.g. detailed consumption measurements, history data, comparison with history data, comparison between economic and ecological gains)

Importance of demand side management	The benefits of demand side management should be clearly explained - who benefits and how
Business cases of selling energy are not clear - what are preconditions to enable energy brokering	Regulations in different countries should be considered
Automation and control of individual devices by the neighbourhood level system	Functionality of controlling individual devices should be considered
Interoperability. Ability to remotely control hardware, among others also window openers, light detectors etc. *Specific modules to control different hardware from different manufacturers should be developed	Developing drivers considering most common and well established standards and protocols (proprietary as well as open standards)
Installation to existing buildings - wiring for communication bus	Consider wireless communication technologies, enable distributed sensor networks
Suggestions for functionality	-web user-interface utilisation -users can define and set different preset modes (e.g. night mode); control different devices(switch on/off); define devices that may be controlled from outside or only in the houses -higher level operator features (such as enable grouping by various characteristics - e.g. same street)
Security issues in data transfer	Use encrypted (wireless) communication (every device has unique encryption key, control/deactivate any device at any time e.g. if stolen). Public key infrastructure used for encryption key distribution and management
End-user acceptance for automated demand response	*Power switching by third party generally not accepted *Control within the building - as long as end-user can fully control the process themselves *The demand response settings should be configured by the end-user at system installation
Motivating the end-users in energy saving	Consider (experimental state – more research needed on the best solutions) • Social features • Compare individual end-users with neighbourhood average, top 10% etc • Encourage those who perform at top 10% level to stay on that level • Encourage underperformers to reach top10% levels
Active end-user involvement Experience - After up to 3 months people lose their interest.	Build the system into daily routine without extra effort (save money, feel more secure, be more environmentally friendly)
Comfort vs. energy saving	Optimization aims: minimize the amount of energy that you need to achieve a certain comfort level. Automatic control system should solve this problem: an automatic control system does the regulation (e.g. air condition) in a way that comfort is reached at minimal costs

With wireless monitoring network, there is a problem with maintaining full coverage of the monitoring area	System could ensure that transmission area is always larger than sensing area
Signal transfer from sensing nodes to central station and back	The use of sufficiently powerful wireless transceivers
Serious problem between calculated(simulated) and monitored energy performance	Reliable calculation of energy consumption taking into account affecting parameters and losses of the system
Sensor network	Reliable monitoring sensors – uninterrupted data transfer and measures against interruptions
Retrofitting impact evaluation	Reliable performance assessment before and after the retrofit project
Complicated installation of energy management and automation system into existing buildings	Find solutions that address system installation into existing buildings
The performance reliability of energy management system - After 2 years period, the energy management system is less accurate and work with less precision	Find solutions that evaluate the energy management system performance – either so that the system is always accurate or so that system evaluation reveals inaccuracies so that system could be re-configured.
Interoperability with existing hardware	Develop drivers/solutions that address interoperability issue
Detailness of energy consumption metering	System should allow device level monitoring and performance analysis
Difficulties to include new units to the system	Automated detection of new nodes
Current systems are unable to prioritise energy sources	Different available energy sources (grid, local, renewable) should be prioritised
Current systems show only aggregated energy balance	Capability for segregation of energy consumption by type and sub system e.g. ventilation, walls, windows etc.
Feasibility of building system control and active configuration	Benefits should be clear – how much energy is saved due to the system, how much energy the system consumes Automated feasibility calculation Automation and energy prices affect less than active end-user behaviour
End-users lack knowledge about behavioural consequences	Basic energy reducing principles explained – e.g. 1 degree reduction of indoor temperature results in 5% saving; esco principles etc.
Freely programmable automation control and methods	
Reports currently static and provide low value	Reports (and KPIs) should be based on the customer(or service provider, end-user) needs
Static system control logic	System should allow active configuration and reconfiguration according to system boundaries, historical performance
Total energy consumption does not reveal where energy is actually consumed	Total energy consumption should be mapped with subsystems energy consumption
Many apartment buildings have central heating system control – individual apartment are unable to control indoor conditions	Apartment level heating system control
Problem is identification of consumers and consumption amount – difficult to evaluate where	Continuous monitoring of energy consumption and performance

and how much energy has been consumed	System should enable the creation meaningful performance metrics
The problem is installing and controlling devices from various hardware manufacturers	Interoperable standards, drivers and protocols
Currently the building environment has to be mapped and described by hand	Autonomous drones equipped with sensors that create the buildings map
Energy baseline is currently formed by hand – for audits and other purposes	Automated energy baseline forming derived from consumption metering
The problem is to verify the impact of energy efficiency activities	Automatically generated energy efficiency impact reports + continuous feedback of system (energy system + management system)
The problem is to find the optimal renewable energy technology solutions	The system could enable suggestion for renewable energy installations taking into account system parameters and performance
The problem is to find the optimal balance between energy efficiency and end-user comfort	Comfort should never be compromised for energy efficiency Rather end-users should be educated how to save energy – what are the suitable actions in which situations and how behaviour could be adjusted System could suggest how to improve behaviour to save more energy
Current tools only display a portion of the information required by an energy manager to allow proper energy management – and they are far from providing clear and understandable information to the end-user	Develop tools that provide clear and concrete information easy for consumers to understand without requiring services of a third party consultant
Lacking of tools towards finding affordable energy solutions for installations	Further develop system that brings together ICT producers, suppliers and customers to promote energy efficient technologies and renewable energies
The main problem is the cost of such systems and the lack of knowledge about the benefits possible to achieve with such systems	Clear benefits of the system should be explained – raise awareness
The problem is reliability of metering devices (e.g. reliability of collected data from pulse meters)	Contemporary technology provides better reliability of metered data. System should propose clear requirements on suitable metering devices
Generally very little of consumption is metered – not enough available consumption data	There are two directions a) Companies such as power and water companies already have information on consumption – they should enable better access to this data b) Installation of additional meters
Metered data that is available has low resolution (e.g. only monthly resolution) so energy saving potential is difficult to evaluate	Consumption should be metered at least with hourly resolution One potentially effective method for energy saving potential evaluation is the use of daily duration curve method. If there is high consumption over a long period of time during the day one could conclude that there might be potential to save energy (e.g. by adjusting time schedules etc.)

One main concern about ICTs is related to the price (installation, maintenance etc.) and the user friendliness of the system. However ICT plays essential role for good municipal energy planning and management and it is crucial to understand key performance indicators.	Future developments should offer the necessary information for the end-users to allow self-management options. The final objective should be enabling to make good decision regarding energy consumption and production. It is important that users have access to information such as energy demand, energy prices and the origin of the energy. Such system should allow: • Monitoring the energy consumption over the internet • Train local personnel about energy efficiency actions • Help to implement energy saving actions
Integration with existing systems	Open interfaces, standardised protocols
Real-time data logging and system-wide communication	ICT solutions operating with hardware to capture and communicate the real-time data among systems
Software management – keeping software up to date	Modular architectures that can evolve over time and be up to date (safety, security, reliability etc.)
Device management – servicing and maintenance activities follow static and outdated service model	M2M platform for device/service lifecycle management – evaluation of device status over the lifecycle
Energy management systems are unable to report the reasons behind the changes in energy consumption	The system should be able to inform the users about the potential reasons behind changes in energy consumption
Usability of energy management system is poor – generally designed for knowledge heavy engineering processes. The users expect that solutions would be as usable as tablet or smartphones. Energy monitoring solutions are currently far behind	The usability of the system should be made simple and understandable even for non-professional users
It is difficult to influence occupant behaviour without real-time data	Real-time consumption data should be available
It is difficult to assess performance data at the asset level	Standard ontology within management system is required It should be easier to access and map consumption data at the asset level
Integration is a problem between different building automation and energy management systems	Standardised interfaces and compliant data exchange protocols
Differences in data model used by proprietary systems – interoperability interfaces difficult to create	Tools for adapting data model, mapping and transformation tools among different data models
The middleware for gateway needs to be programmed for each communication case	Tools for mapping of communication between different data models
Lack of algorithms for energy forecast	Development of standard data model for forecasting
Building managers need to be convinced to be open to new installations of building management systems. Benefits of such systems need to be clearly presented, most importantly energy savings achieved with the system	Clear benefits of adopting new system operating besides or substituting existing system Assurance that new system can operate along with existing Access to Real-time performance data is most important
Explaining technical environment and energy saving possibilities to non-technical persons with	Utilising graphical 3D BIM models could help – make is visual

the use of technical drawings. Generally non-technical persons do not understand schematics for building systems or wiring etc.	
Schematics often are not up to date – real situation is different	Easily updating BIM models when operating environment changes
Locating and access to relevant metering points and cables	Flexible metering devices accompanied with BIM model that would reveal the relevant metering points
Compatibility issues between different existing proprietary systems	Standardised protocols, interfaces and data models able to communicate with different systems
Existing energy management systems cannot generally interoperate with building automation.	Generally building automation system not designed to incorporate data externally from different hardware or software vendor
It is not clear how non-technical end-users (occupants and tenants) users can contribute to energy savings	Basic energy saving principles should be explained through the system
Lack of resources put into building operation optimisation	Solution should inarguably demonstrate value of energy management services and improve fault detection and continuous commissioning
Product development, you have to do everything yourself	Open standards that enable collective contributions and provide framework for development
Hard to sell devices and solutions, end users have little experiences of such devices and they seem to be afraid or lack of knowledge.	Part of promoting and disseminating the solution, benefits should clearly be explained – who benefit, how much, what is needed from them
It is not feasible for manufacturers to program for customers.	Platforms should be generic and easy to understand enough to program the platform themselves
Closed applications and proprietary devices – customers are generally tied to use the hardware related software	Open frameworks that are able to operate with multiple hardware solutions Suitable interfaces for interoperability
Current systems are not able to easily detect system changes	System should automatically be able to detect if new nodes are added to the environment
System operation is static – stays the way it was programmed	It would be good if system could be able to constantly fine-tune its operations based on past performance
People are not motivated to save energy because of little economic benefits.	End users will have more interest for reducing energy consumption and do load shifting when the spot tariff markets become available (or more common). There is no need to do load shifting if you have fixed tariff
Selling energy back to grid is difficult and often legislatively restricted or legislation does not promote small producers. Small producers are not able to compete on the same grounds with large producers.	Also selling energy to grid would interest more if Feed-in tariff was implemented In addition, suitable legislation is needed which would allow households and small producers to better compete with large producers, or be more protected and retaining their interest to install renewable energy production.
Decision support	Prediction and forecasts on energy consumption, weather data, energy prices and other relevant energy performance indicators would support decision making
Cost related information is generally not included with systems	Providing cost information

Visualisation of consumption data	Easy to understand consumption data visualisation to support decision making in energy saving activities
Generally automation systems are not able to provide feedback about operational parameters	Performance parameters provided by the system
Technically complex building systems need the help of ICT solution for monitoring and control	Automation of the data collection could save costs Software that provides holistic overview of processes within the neighbourhood – if manual work is required for monitoring energy management is not feasible
Currently only technical service providers are able to analyse consumption data, mostly because the collection and data processing needs specific knowledge	If data collection and initial data processing (standard processing) would be done by the software, there is a lot that single person could also analyse – precondition is that performance data in a suitable form needs to be available
People in centrally heated apartment buildings generally do not care about heating costs since heating energy is not separately measured and costs are evenly divided	The use of heating cost allocator could help to share heating costs in relation to actual consumption
Money should motivate tenants to save energy, but energy costs form only a part of the total living costs	
How to motivate elderly people who don't use computers?	
It is difficult to justify to all of the cooperative members the need for installing such system.	Explanation for regular people about the necessity and benefits of the system
Automation systems do not work properly – difficult to design the operations to work as needed considering dynamic operation and changing environments	Automation system should be able to adapt with dynamic operating environment
It is too resource intensive to actively monitor energy consumption with human resources	Data should be processed into useful form as well as historical data should be easily accessible
Current solution enable monitoring single buildings, but not the whole building stock	An integrated solution for monitoring and processing data of multiple buildings
Current building automation systems have no reasonable prioritisation of alarm	Better prioritisation of alarms
Sensors cannot understand (system does not understand) if it is faulty	Create self-controlling method for sensor fault discovery (and recalibration)
Currently consumption metering data is not meaningfully assembled, to enable comparison between buildings or systems	The information should be assembled from different sources consistently so that comparison would be possible and would not require additional calculation
Monitoring of real-time information, Resources of Property Manager versus Maintenance Manager -> in some cases the resources (time) of Property Manager are insufficient for Manager to follow the real-time data on hourly basis to react	Training of the responsible personnel to use the IT-programs and following through the organization's internal policies consistently.
The value of implementation of IT-programs is unclear as well as how much manual work it reduces	Clear demonstration of added value and benefits of IT-programs – not only monetary but also work load reduction etc.
When proposing new ICT solution besides to an existing one many features are duplicated but none becomes fully obsolete	Overlapping of IT-programs should be eliminated
Interoperability of different systems, but not only among different automation system but also	Building system and environmental characteristics should be able to be transferred from one module to another in an

various ERP and other ICT solutions	easy way (manual work should be reduced) for example consumption data from metering system could send inputs to accounting to enable simply validate the charged amount
Too complicated technologies, too expensive	Must be much cheaper, self-learning systems and degree of automation must be higher (reduce manual labor)
Accessing and manipulating building systems – lot of manual work needed	Digitalized operating environment of buildings and systems
Building plans are often not updated to the real situation or installed systems not adequately characterised	System should enable easy updating of built environment as well as building system characterisation
Too difficult and technical monitoring and management software	User-friendly software, as if it were a videogame, that allows to model, plan and manipulate system operations
It is difficult to collect relevant data for preliminary system characterisation	Modelling tools to easily incorporate existing system characteristics into new installations
The challenge is to impress upon civil society the importance and necessity of being efficient	Reasons for necessities of being efficient needs explaining for civil society
The real challenge is to promote and boost various energy efficient technologies that they achieve a significant contribution within renewable energies and energy efficient technologies – transformation from existing legacies into energy efficient era	
Planning and execution of building retrofitting	Development of an optimised methodology for planning and executing works on site
Failures and inefficiencies in building system performance	Automated detection of system failures and determination of the subsequent actions – prioritization of fault alarms
Indoor climate quality	Remote management system to control parameters inside building
Managing of retrofitting works and procedures on site	Video visualisation during the execution of retrofit projects
Real time data availability	Standardised interfaces between automation system and management system irrelevant form vendor
Establishing energy baseline requires a lot of manual work	Prepared process for inputting relevant variables to establish the baseline
Generally solutions are either too primitive (little of use) or too expensive (proprietary solution)	Open framework for businesses and service providers to build their solution upon
Technology enables wide range of solutions, but issues depend on the neighbourhood so the communicating of information is important – the residents should understand why such solutions are important for them	Ensuring the resident about the benefits (e.g. feel safe, costs reduced)
It is difficult to connect solar energy production with grid since distributed systems may pose a threat to grid stability and system safety	Easy connection to grid for renewable energy when all safety and grid stability requirements are met
The adaption of new ideas	Educating end-users, most powerful method is a supporting community (take a look at opensource and maker communities)
Investment decisions are difficult to make since benefits are often not clear and tools for validation are not included	System could provide simple investment and feasibility suggestions or calculations RE could be presented as providing security in the times of

	crises
Delayed data from system operators	Real-time consumption and production data would enable more precise forecasts
	Two directional data feed – ability to limit load would be an asset
Generally transformers are owned by system operators, therefore current legislative environment does not promote grouping of neighbourhood residents together	For energy trading within a neighbourhood would be possible, the electricity grid should be designed accordingly, but this requires system operator for the neighbourhood microgrid
small system operators not allowed according to legislation – potential danger to grid stability	In order to create neighbourhood grid, legislation should allow local distribution system operators, or legislative bodies which are allowed to represent the residents
Single consumers separately do not fulfil traders' expectations	Residents should commonly decide the dedicated trader and commit themselves to the contract • market priced contracts - allows better margin; • stable price contracts - margin does not play role, contract length essential
	Financial benefits does not arise from price gains due to grouping of consumers rather than knowledgeable consumption;
Energy traders have limits for capacity – minimum and maximum	Energy provider should be dedicated for the neighbourhood – it would not be feasible that many traders act within one such system

7.2.2 Recommendations not addressable in the scope of this project

In the table below, are issues that are important but not addressed – no possibilities to influence in the scope of this project

Problem	Comments and recommendations
Legislative environment does not promote solutions that enable local energy production, selling as well as energy efficiency	Legislation should enable better conditions for selling of locally produced energy Large corporations are unwilling to feasibly enable solutions that promote energy efficiency (e.g. installation of monitoring devices, grid connection etc.)
Old specialists have outdated knowledge	Educating specialists, licencing specialists
Legislative rules prefer lowest bids even though lowest bid may not be the best	Legislation should be updated to consider other than costs e.g. overall impact, energy savings, life cycle costs etc.
The main problem is the cost of such systems and the lack of knowledge about the benefits possible to achieve with such systems	Activities to raise awareness of the importance of energy efficiency could be improved. Bureaucracy involves great efforts, every process requires many work visits, paperwork, reports, Authorities' commitment to promote renewable energies and energy efficiency is a major challenge.
Technologies for energy saving exist but not widely used	Regulations promoting and stimulating the adaption of Energy Efficiency technologies
It is difficult to evaluate the actual energy savings with specific technologies	Publicly available data about pilot projects implementing various technologies that would enable the evaluation
Sufficient data not available regarding energy saved with given technology	Data from pilot projects could be made available with Open Data platforms
Reliability of data collected with sensors	Use of reliable sensors
Benefits of demand side management are unclear	The benefits that Energy producers, DSOs are willing to offer for consumers should be investigated
Comfort vs. energy saving	Most current projects state that comfort should never be compromised. More studies are needed to investigate: *How people would react if comfort is being limited *What are the benefits if comfort is temporarily being limited
The impact on overall result of shifting consumer loads	Open questions need studying - Impact on neighbourhood level might be higher than on building level - Different device types may contribute differently: - Fridge: low consumption, only short time periods, low temperature range - Control of white goods in general - Freezer: bigger temperature range than fridge, higher consumption

	- Heating devices, e.g., heat pumps, air condition: reasonable, however in Belgium these types of devices are not yet common compared with Scandinavian or southern countries.
The impact of demand side response could be relatively small 25% of energy is consumed by homes – 75% by industry	- feeling: even if you combine all of households, impact on the grid will be not that significant - from DSO or TSO perspective: much easier / convenient with one big company on standby than thousands of people however: home level should not be neglected and energy management in households will become be more and more popular - if you combine power events with (automated) demand response- over time it can become significant help to the grid
When decision maker in an organisation has to decide whether or not to adapt new solution the benefits are not clearly presented – who benefits, who should use the system, who is the actual end-user and why is it important for the benefitter that such system would be in use – organisations very often do not have a person responsible for energy management	Shared understanding of responsibilities and benefits regarding energy saving Educating and training of landlord, owner and tenant – non-technical persons
It is not clear why non-technical end-users (occupants and tenants) should save energy – what are their benefits. Often economic benefits are small or even not directly connected to the users behaviour (shared costs etc.)	Other than economic benefits should also be explained
The problem is to persuade people to install such systems	Thorough database with case studies ex post facto data where savings due to use of different energy management systems are presented would help to persuade people
Building plans are often not updated to the real situation or installed systems not adequately characterised	Better technical education in the field on energy efficiency
The real challenge is to promote and boost various energy efficient technologies that is achieves a significant contribution within renewable energies and energy efficient technologies – transformation from existing legacies into energy efficient era	

7.3 Annex III – Expert interview template

Questionnaire for interviews

1 General data	
Interviewee (expert)	
Title	
Expertise areas	
Do you accept that we acknowledge your contribution by publishing your name & company? (yes / no)	
Organization of the expert	
Business activities related to energy management	
Stakeholder group(s)	
Interviewer	
Date of interview	
Time	
Place	

2 Priorities for further development *What is it in your business/daily work that you don't like? What does not work like it should? What part of the process makes you frustrated? Where is the pain?*	
Please name your top ICT related priorities/issues/problems regarding Energy management	**Indicate what kind of future developments are needed to address the listed priorities**
What else comes to mind?	

3 Information requirements
What kind of information would you require from an energy management system?
What kind of information is relevant to your customers or end-users?
What else comes to mind?

After finishing with the interview questions, kindly request the interviewee to complete the Online Survey as well at http://www.webropolsurveys.com/S/4FC952DFBE76A324.par

7.4 Annex IV – Online survey template

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

Thank you for taking part in EEPOS project online survey. We appreciate your contribution!

For more information you are welcome to visit EEPOS project official website -->www.eepos-project.eu

Have you participated in personal interview by EEPOS project members? *

◯ Yes, just finished with interview and now taking the online survey

◯ No

Priorities for further development

We are developing Neighbourhood level Energy Management System with Renewable Energy Trading capability and sophisticated End-user engagement applications.

For this development work we would gladly ask for your opinion.

Imagine an Energy Management related ICT solutions with regards of your and your organisation's daily activities. Imagine activities resulting in efficient energy use and Renewable Energy utilisation.

Please name your top ICT related priorities/issues/problems regarding Energy management

What is it in your business/daily work that you don't like? What does not work like it should? What part of the process makes you frustrated?

____

____

____

Please indicate what kind of future developments are needed to address the listed priorities

And how ICT solutions could help?

____

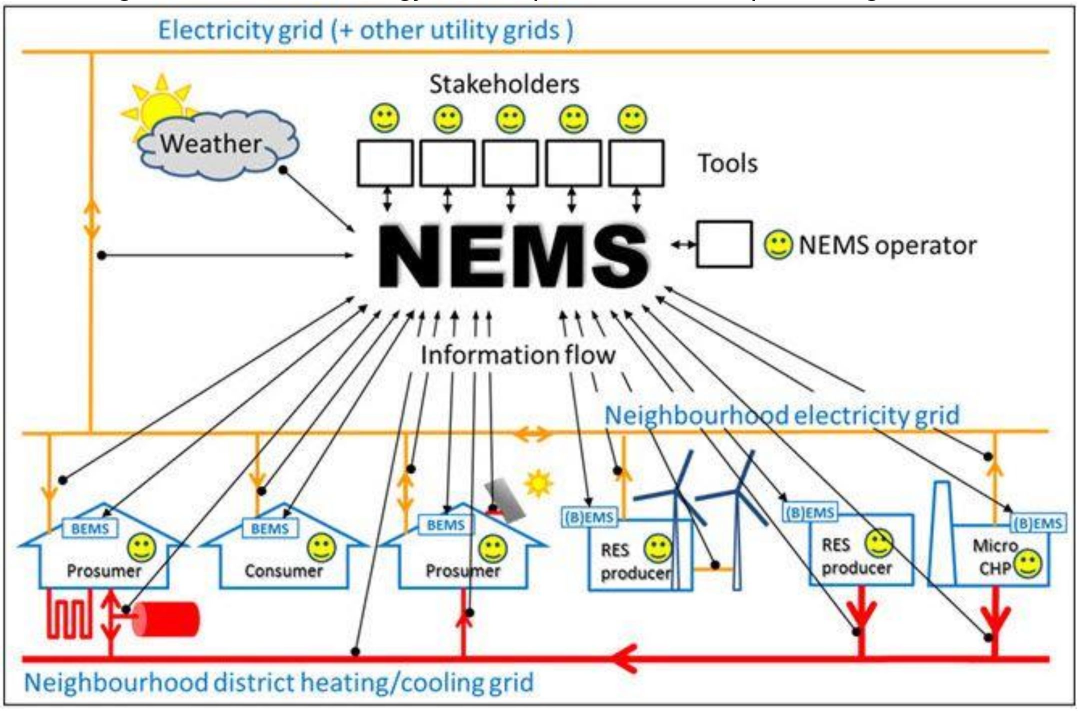
____

____

Information requirements

EEPOS is a research and development project aiming to put into effect the idea of energy positive neighbourhoods. The EEPOS consortium develops tools for energy optimization and end user involvement to improve the management of energy generation and consumption on the neighbourhood level.

The main idea is to develop technologies and business models that will support energy trading in the neighbourhood. The neighbourhood and users will profit from brokering and energy services. Business models will enable a win-win situation between the stakeholders of the electricity and heat trading chains. Information platform with user interfaces for different stakeholders plays a key role in stimulating users to reduce energy consumption without comp romising comfort.



The new EEPOS services will be transparent for both customers as well as providers and allow benefit sharing between them. This will improve customers' information basis to make decisions on energy consumption. The raising of awareness on energy consumption will reduce users' energy costs and reduce energy peaks in the grid.

What kind of information would you require from an energy management system?

What kind of information would help you to save energy and improve energy efficiency? e.g. Electricity consumption, Neighbourhood level electricity price, Sold and purchased energy, Local renewable energy production etc.

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What kind of information is relevant to your customers or end-users?

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Comments and questions:

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Here you can see the principal process for energy management.

Please rate the part of the process on the importance in improving energy efficiency. Which activities do you find most important? You are welcome to add specific comments later.

Process description

Please rate the importance from **1** = "Not important" to **5**= "Very important" or **0**= "No opinion"

(With) A Neighbourhood Energy Management System [NEMS] (You) should be able to...

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	1	2	3	4	5	0
A) ...Conduct Energy Review at defined intervals	○	○	○	○	○	○
B) ...Conduct Energy Review in response to major changes in the system boundaries and environment affecting the system	○	○	○	○	○	○

C) ...Establish Energy Baseline (based on the Energy Review)	○	○	○	○	○	○
D) ...Define boundary criteria acceptable by the users and methods available based on the operating environment for EnMS activities.	○	○	○	○	○	○
E) ...Create an Energy Management Action Plan	○	○	○	○	○	○
F) ...Implement Energy Management Action Plan	○	○	○	○	○	○
G) ...Verify that Energy Management activities are executed as configured	○	○	○	○	○	○
H) ...Make Energy Efficiency improvement suggestions based on the patterns and potential recognised from system operation	○	○	○	○	○	○
I) ...Report on savings achieved and other operational aspects	○	○	○	○	○	○

Comments or questions:

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Functionality of the EEPOS NEMS (based mainly on Use Cases used in ASHRAE 2010)

Please rate the importance from **1** = "Not important" to **5**= "Very important" or **0**= "No opinion"

How important is that the NEMS... *

	1	2	3	4	5	0
A) ...Is interoperable with standards?	○	○	○	○	○	○
B)... Allows to minimize customers energy costs by managing power demand by contracts and tariffs?	○	○	○	○	○	○
C)... Allows to manage neighbourhood level energy production?	○	○	○	○	○	○
D)... Allows to forecast customers energy demand?	○	○	○	○	○	○

E)... Allows to buy and sell energy?

F)... Supports social, environmental, and regulatory related information for customers who wants to control related aspects of their energy consumption?

G)... Supports to buy energy from different energy suppliers?

H)... Allows to balance power purchases between utility and on-site generation?

I)... Allows to measure detail level power (e.g. heating, cooling, outdoor lighting, washing machine, selected plug) to calculate related cost and consumption?

J)... Supports the measuring of energy cost, emissions and consumption for online and historical data (e.g. daily, monthly and yearly) reports?

K)... Supports the measuring of energy cost, emissions and consumption for accounting?

L)... Supports the measuring of energy cost, emissions and consumption for benchmarking (comparing against similar buildings, certificate, etc.)?

M)... Supports the measuring of energy cost, emissions and consumption for validating (e.g. using temporary measurement equipment)?

N)... Supports to communicate generation for grid maintenance and planning (e.g. when the distribution system maintenance should do etc.)?

O)... Supports the receiving instantaneous power quality information to validate power service level agreement?

P)... Supports the direct load control by an external source?

Q)... Supports energy bids?

R)... Supports for defining the customers power demand target (low target -> possible penalties, high target -> no savings)?

S)... Supports the feature where the neighbourhood operator or energy broker is able to see customer's load shifting parameter setup (e.g. which energy price means lower power consumption)?

T)... Supports historical energy information for forecasting future use?

U)... Supports information of onsite generation (electric, thermal) capacity?	○	○	○	○	○	○
V)... Supports information of onsite storage (electric, thermal) capacity?	○	○	○	○	○	○
W)... Supports information of weather forecast?	○	○	○	○	○	○
X)... Supports information of energy price for different demand levels?	○	○	○	○	○	○
Y)... Supports information of customers present energy demand?	○	○	○	○	○	○
How would you rate the IMPORTANCE[1] of automated demand response[2] on distribution grid level[3] for “smart” grid development?	○	○	○	○	○	○
How would you rate the PRIORITY[4] of automated demand response on distribution grid level for “smart” grid development?	○	○	○	○	○	○

Please evaluate the importance of the following support functions[5] of centralised automated demand response systems on distribution grid level related to local grid. *

	1	2	3	4	5	0
Congestion management / peak load shaving	○	○	○	○	○	○
Phase balance[6]	○	○	○	○	○	○
Voltage control[1]	○	○	○	○	○	○

Please evaluate the importance of the following support functions[2] of automated demand response systems on distribution grid level related to local generators. *

	1	2	3	4	5	0
Generation surplus compensation[3]	○	○	○	○	○	○
Other generator support functions	○	○	○	○	○	○

Please evaluate the importance of the following support functions[4] of automated demand response systems on distribution grid level related to electricity market. *

	1	2	3	4	5	0
Secondary frequency control[5]	○	○	○	○	○	○
Other electricity market support functions	○	○	○	○	○	○

Choose THREE technical features[1] of centralised (automated) Energy Management systems on distribution grid level, which you think are the most important.
If you would like to change a selection you have made, click on it again to deselect it. *

- ☐ Fast installation[2]
- ☐ Easy programming[3]
- ☐ Plug & play[4]
- ☐ Continuous operation[5]
- ☒ Data logging[6]
- ☒ Security of data[7]
- ☒ Privacy of data[8]
- ☐ Fault/Error alarms[9]
- ☐ Other features, specify

Other features:

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Choose THREE barriers for Energy Management implementation on distribution grid level, which you consider to be the most serious.
If you would like to change a selection you have made, click on it again to deselect it. *

- ☐ Immature technology[1]
- ☐ Poor policy support[2]
- ☐ Lack of research & development activities
- ☒ Lack of research in active end-user involvement[3]
- ☒ Lack of standards[4]
- ☒ Lack of open standards[5]
- ☐ High implementation costs
- ☐ Low economic benefits[6]
- ☐ Security and privacy of data[7]
- ☐ Lack of skilled workers
- ☐ Poor compatibility between existing protocols, systems and standards (open and proprietary)
- ☐ Other barriers, specify

Other barriers:

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Comments and questions:

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How would you rate the importance/ relevance of the following variables in decision making (or for making behavioural adjustments)?

Which indicators would help you to make better decisions to save energy?

Please rate the importance from **1** = "Not important" to **5**= "Very important" or **0**= "No opinion"

Electricity consumption (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○
Subsystem level (AC, heating, etc.)	○	○	○	○	○	○
Device level	○	○	○	○	○	○

Thermal energy consumption (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Electric power (kW) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Subsystem level (AC, heating, etc.)	◯	◯	◯	◯	◯	◯
Device level	◯	◯	◯	◯	◯	◯

Thermal energy power (kW) *

	1	2	3	4	5	0
Neighbourhood level	◯	◯	◯	◯	◯	◯
Building level	◯	◯	◯	◯	◯	◯
Apartment level	◯	◯	◯	◯	◯	◯

Cost of the use of electricity (€) *

	1	2	3	4	5	0
Neighbourhood level	◯	◯	◯	◯	◯	◯
Building level	◯	◯	◯	◯	◯	◯
Apartment level	◯	◯	◯	◯	◯	◯
Subsystem level (AC, heating, etc.)	◯	◯	◯	◯	◯	◯
Device level	◯	◯	◯	◯	◯	◯

Cost of the use of thermal energy (€) *

	1	2	3	4	5	0
Neighbourhood level	◯	◯	◯	◯	◯	◯
Building level	◯	◯	◯	◯	◯	◯
Apartment level	◯	◯	◯	◯	◯	◯

Forecast of electricity demand (kWh) *

	1	2	3	4	5	0
Neighbourhood level	◯	◯	◯	◯	◯	◯
Building level	◯	◯	◯	◯	◯	◯
Apartment level	◯	◯	◯	◯	◯	◯

Forecast of thermal energy demand (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Sold and purchased electrical energy (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Sold and purchased thermal energy (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Local renewable energy production (kWh) *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Total CO_2 emissions *

	1	2	3	4	5	0
Neighbourhood level	○	○	○	○	○	○
Building level	○	○	○	○	○	○
Apartment level	○	○	○	○	○	○

Total load shifting done (kWh) *

	1	2	3	4	5	0
Neighbourhood level						
Building level						
Apartment level						

Cost savings of load shifting (€) *

	1	2	3	4	5	0
Neighbourhood level						
Building level						
Apartment level						

Fault detection *

	1	2	3	4	5	0
Neighbourhood level						
Building level						
Apartment level						
Subsystem level (AC, heating, etc.)						
Device level						

Neighbourhood level
(based on the trading possibilities within the neighbourhood) *

	1	2	3	4	5	0
Electricity price						
Thermal energy price						
Electricity price forecast						
Thermal energy price forecast						

General variables *

	1	2	3	4	5	0
Weather data	○	○	○	○	○	○
Weather forecast	○	○	○	○	○	○
Indoor air temperature	○	○	○	○	○	○
Indoor air relative humidity	○	○	○	○	○	○
Indoor air CO_2 levels	○	○	○	○	○	○
SPOT power market electricity price	○	○	○	○	○	○
SPOT power market electricity price forecast	○	○	○	○	○	○

Comments or questions:

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Please share information about your professional background.

General data

***** = Mandatory question

Your name

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Job title

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Your expertise areas *

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Organization of the expert

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Organization's business activities *

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Do you accept that we acknowledge your contribution by publishing your name and company? *

○ YES

○ NO

Do you want to get feedback on the project results (via email)? *

○ YES

○ NO

Insert your email for feedback

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Thank you for participating in our survey! Your answers will go to developing better solutions for sustainable living!