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IDEAS: Intelligent NeighbourhooD Energy Allocation & Supervision

Deliverable 5.5
Impact report Finnish demo

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Deliverable Administration & Summary					IDEAS
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Editor	POS/COP				
DoW	**Task Description:** *Operate and evaluate the upgraded neighbourhood in the Finnish demo-site* In this task the upgraded neighbourhood in the Finnish demonstration site will be operated over a period of nine months. It is estimated that the implementation will require one month prior to the operation and the evaluation will require one month subsequent to the operation therefore the task will run for eleven months in total. The following are expected to be implemented and maintained at the Finnish Demonstration site: 1. The prototype energy management tool consisting of an internet based infrastructure & decision support system for control management as specified in WP 3 and developed in WP4. 2. Mixed reality user interfaces as specified in WP 3 and developed in WP 4. It is envisaged that these interfaces will be • Hand-held augmented reality based tools for visualisation and interaction with home oriented energy usage. • Public energy use awareness screens installed in the common / public spaces. It was expected that the implementation would be realised by the connection of smart meters installed in each building to the internet based decision support systems. As with the French demo the implemented system would integrate three solutions corresponding to three types of targets for energy savings: 1. Solution for promoting more energy efficient household behaviour 2. Solution Public Energy Awareness Interfaces 3. Solution for energy company operational and service managers **Deliverable description:** A report detailing the impact of the internet based infrastructure and decision support system for control management in the Finnish demonstration case measured against the baseline data supplied by D5.1. [month 34]				
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11.	2015/11/20	Tracey Crosbie , Ethan Lumb and Muneeb Dawood UoT	Restructuring and editing/rewriting of the text prior to submission to the commission.

Table of Contents

ACRONYMS

CHP	Combined Heating and Power
CoP	City of Porvoo (project partner)
DNO	Distribution Network Operator
DREG	Distributed Renewable Energy Generation
DSM	Demand Side Management
DSO	Distribution System Operator
EDF	Électricité de France
ENTSO-E	European Network of Transmission Services Operators for Electricity
EPC	Energy Performance Contracting
EPN	Energy Positive Neighbourhood
EPNSP	Energy Positive Neighbourhood Service Providers
ESC	Energy Supply Contracting
ESCo	Energy Service Company
FIT	Feed-In Tariff
GWh	Gigawatt Hour
HEA	Home Energy Awareness (project pilot app)
HEAA	Home Energy Awareness App (project pilot app)
HDD	Heating Degree Days
HVAC	Heating, Ventilation and Air Conditioning
IBM-F	IBM Montpellier, France (project partner)
IBM-H	IBM Haifa, Israel (project partner)
ICT	Information and Communication Technology
IEC	Integrated Energy Contracting
IoT	Internet of Things
IUT	University Institute of Technology, Bordeaux (project partner)
kWh	Kilo Watt Hour
MWh	Megawatt Hour
OpenHAB	Open Home Automation Bus
PE	Porvoon Energia (project partner)
PLC	Power Line Communication
POS	Posintra (project partner)
PPP	Public Private Partnership
PV	Photovoltaic
PWN	Private Wire Network
ROI	Return on Investment
SSM	Supply Side Management
TNO	Transmission Network Operator
UoT	University of Teesside (coordinating project partner)
VTT	VTT Technical Research Centre of Finland (project partner)

EXECUTIVE SUMMARY

The main objective of the IDEAS project is to illustrate how communities, public authorities and utility companies can be engaged in the development of energy positive neighbourhoods (EPNs). These are neighbourhoods in which the annual energy demand is lower than the annual energy supply from local renewable energy sources.

This report concerns the demonstration and validation phase of the project. It presents the findings from a pilot study undertaken as part of the project. This study involved testing the tools, interfaces and business models developed in the project for the Finnish pilot, in Omenatarha, a residential area in Porvoo (see figure i below). The pilot includes 23 district heated detached residential houses. They are all equipped with a non-delayed electricity monitoring solution implemented as part of the pilot and district heat demand data and electricity demand data were monitored via the billing meters of Porvoon Energia the local energy supply company.

Figure i: Omenatarha pilot area, 23 single family district heated detached houses.

The tools and interfaces tested in the Finnish pilot include:

1. A neighbourhood energy management system (EMS) developed to optimise storage/retrieving and buying/selling energy and supply energy demand predictions for energy trading
2. Innovative user interfaces developed to interact with the occupants of an EPN:
    a. Interfaces required for producers to interact with the services required for Demand Side Management, Supply Side Management and energy trading energy etc.
    b. Home Energy Awareness Application (HEAA) for demand side management, in order to interact with the residents of the pilot households.
    c. Community based interfaces, in the form Public screens that raise energy awareness and 'promote' the concept of an EPN to the occupants of the EPN and the wider public.

The logic underpinning the Finnish pilot study is to identify if the tools and elements of the business model tested at the pilot site could move the neighbourhood towards a financially viable energy positive neighbourhood in the Finnish context as illustrated in the Figure ii.

The research conducted included simulations that were used to test the viability of one of the key revenue streams underpinning business models developed in the IDEAS project: Namely reduced costs for energy production and increased profits from optimising the production, storage/retrieval and buying/selling of energy. The approach taken in the simulations and how they relate to the tools implemented at the site is illustrated in Figure iii. This report also describes how user interfaces were tested through the deployment of the tools and interfaces on site and the assessment of their impact on the occupants and managers of the site through questionnaires and interviews

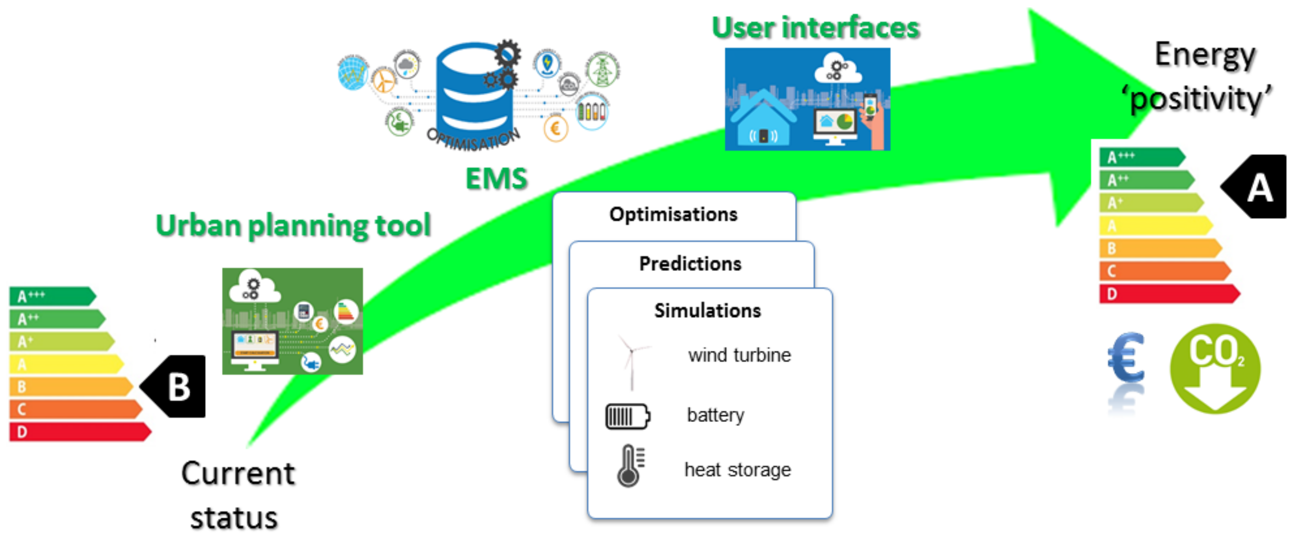


Figure ii. Logic underpinning the demonstration phase within IDEAS

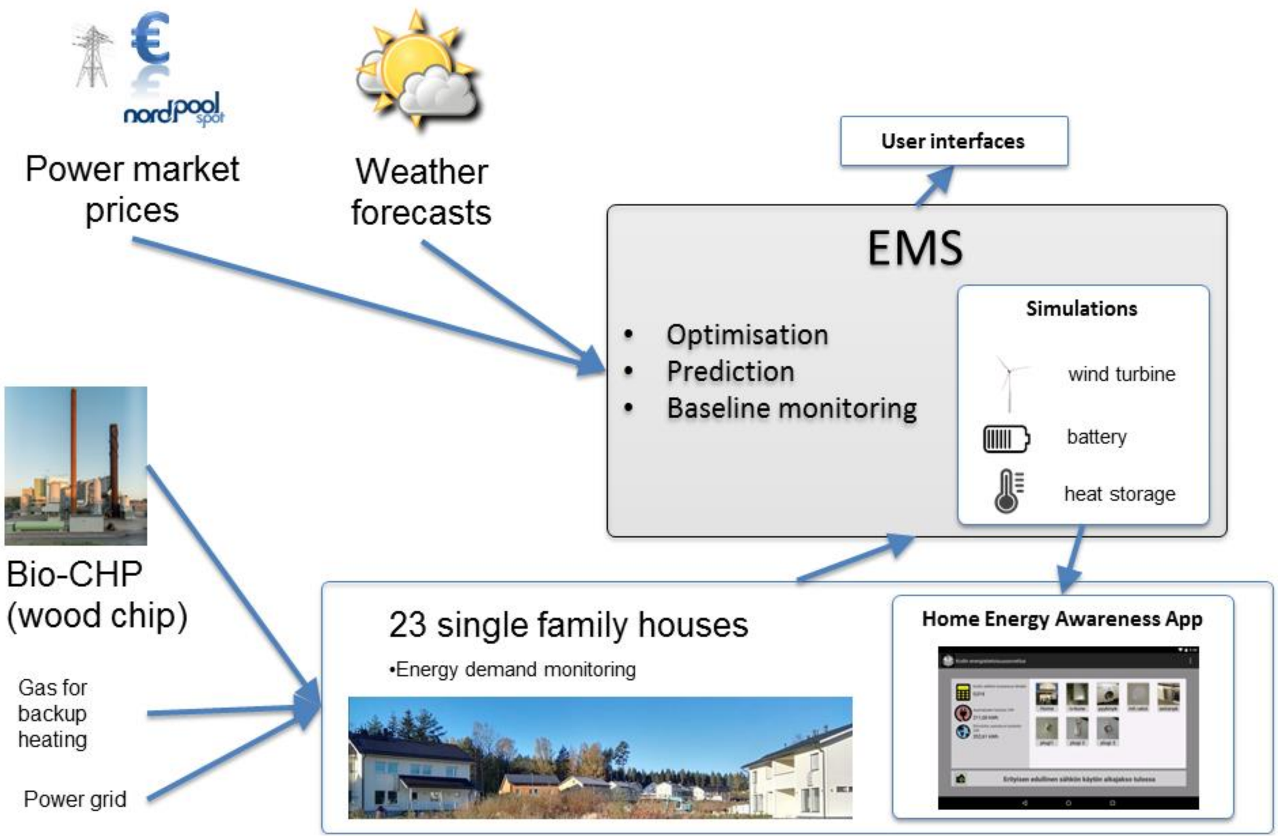


Figure iii: Pilot set up used to test the EMS, the interfaces and the business models.

In the simulations it was assumed that the EPN consists of 1350 single family houses. Detailed energy demand data was available for 23 households. Thus the energy supply and demand and storage elements were scaled down for 23 households for the purpose of simulations. The following parameter values were used in simulations: CHP size was 100kW, ratio of heat to electricity for CHP plant was 75.25 to 24.75, heat storage capacity was 200 kWh, maximum heat storage and retrieval rate was 50kWh/h, electricity storage capacity was 150 kWh, maximum electricity storage and retrieval rate was 30 kWh/h. Following fuel costs were used: CHP fuel cost was 16 Eur/MWh, gas heat fuel cost was 55 Eur/MWh and wind turbine fuel cost was 14 Eur/MWh.

Five scenarios were simulated:

- The first is the business as usual (naive) scenario, in which there is a bio fuelled CHP plant supplying heat and electricity. The CHP operation is based on the outdoor temperature. Any excess heat demand is met by a biogas fuelled plant. Excess electricity demand is met by the grid.
- In the second scenario (naive+WT) a wind turbine is added to the system.
- Three scenarios assumed the existence of heat and electricity storage elements and are based on the application of the optimisation algorithm embedded in the EMS:
  - In optimisation scenario A the goal of optimisation is to maximise profit,
  - In optimisation scenario B the goal is a balance between profit and CO_2 emissions reduction,
  - In optimisation scenario C the goal is to minimise CO_2 emissions.

Supplied energy	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
bioCHP-electricity MWh	105,9	105,9	112,0	110,1	105,5
bioCHP-heat MWh	322,0	322,0	340,5	334,7	320,6
Gas heating MWh	10,4	10,4	61,6	54,3	15
Grid electricity MWh (negative = sold more than bought)	26,2	-137,7	-128,8	-131,7	-128,5
Wind turbine MWh	0	163,9	163,9	163,9	163,9
Total	464,5	464,5	549,2	531,2	476,3

Table 1. Comparison of simulated scenarios versus business as usual (values for the 23 households)

In optimisation scenarios A and B, more CHP electricity was produced compared to naive, naive+WT and optimisation scenario C. This resulted in more electricity being sold to grid resulting in larger profit than other strategies. This also increased the CHP heat energy generation compared to other strategies.

Gas heating was also increased in case of optimisation scenarios A and B. This was due to more active use of storage elements (for energy trading) in these cases. No storage element was present for the naive and naive+WT strategy; hence gas heating was less used. Gas produced heat is lower in the optimisation strategy C because it was assumed in the optimisation that gas heating has a higher CO_2 emissions than CHP generated heat.

In all optimisation scenarios and in the naive+WT scenario, more electricity is sold to the grid than bought from it. This was due to the addition of wind turbine generated electricity.

From the above, it is clear that the best scenario for reducing CO_2 emission is the third optimisation scenario (minimise CO_2 emissions). As shown in the table above, the wind turbine produces a significantly greater amount of energy than the CHP plant, which can be sold to the grid with profit due to the feed in tariff applicable in Finland. In all the scenarios which include wind turbine, the wind turbine electricity production was the same and its operation was independent and was not influenced by the optimisation algorithm.

Move towards energy positivity due to energy optimisation

The total heat demand of the neighbourhood was 332 MWh. In the first two optimisation scenarios, the CHP plant produced heat was 340.5 and 34.7 MWh respectively. Thus, in the first two optimisation scenarios, the heat demand is met to 97 % by the bio fuelled CHP plant, making the neighbourhood almost energy positive in case of heat energy.

The total electricity demand of the neighbourhood is 131.6 MWh. In all the scenarios where the wind turbine was used, this energy demand was met by the wind turbine alone hence making the area energy positive in terms of electricity. This is reflected in the On-site Energy Raito (OER) for each of the optimisation scenarios which is the KPI developed in the IDEAS project to measure energy positivity.

$$\text{OER} = \frac{\text{Cumulative energy supply from local renewable sources (heating \& electricity) MWh/year}}{\text{Cumulative energy demand (heating \& electricity) MWh/year}}$$

	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
OER	92 %	127 %	133 %	131 %	127 %
Energy positivity level indicator	**B**	**A++**	**A++**	**A++**	**A++**

The findings illustrate that the proposed EPN with the EMS optimiser achieves a clear reduction in the CO_2 emissions, but the cost of the supplied energy is slightly higher than the baseline scenarios without energy optimisation. This is due to the feed in tariff in Finland for wind energy (which is time limited). However it would be simple to resolve this issue if FITs were paid to energy producers regardless of whether the energy is sold outside of an EPN or sold directly to customers within the EPN and premium based FITs (PFITs) which pay a premium on top of the variable market price are applied.

The findings from the usability testing of the HEA suggest that it could considerably support demand side management and people would almost always shift their energy use according to advice provided by notifications from the HEAA.

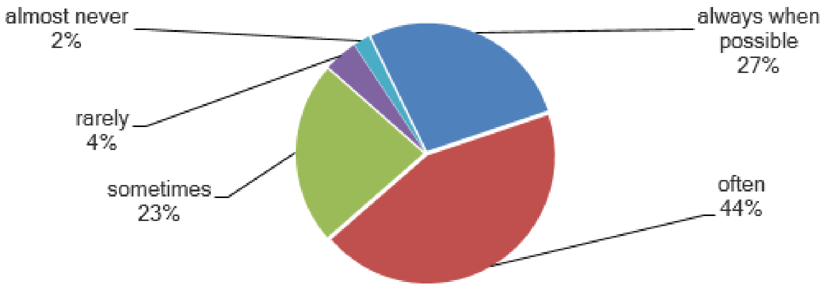


Figure 41. People are ready and willing to shit their demand based on provided notifications.

Another significant finding for the incremental rollout of an EPN, is the people living in the Finnish pilot area prefer the idea of the joint procurements of renewables to the idea of investing in renewable energy technologies at the household level. This suggests that a community funded approach would be plausible at the pilot site.

1 Introduction

1.1 Purpose

This report presents the findings from Task 5.5 "Operate and evaluate the upgraded neighbourhood in the Finnish demo-site." The primary objective of the task is to provide empirical evidence of the benefits of the internet based infrastructure and decision support system for control management in terms of energy 'positiveness', total cost of operation, CO_2 reduction and improved services for users. The impact in the Finnish demonstration case is measured against the baseline data supplied by earlier work in the IDEAS project[1].

The tools and interfaces tested in the Finnish pilot include:

1. A neighbourhood energy management system (EMS) developed to optimise storage/retrieving and buying/selling energy and supply energy demand predictions for energy trading
2. Innovative user interfaces developed to interact with the occupants of an EPN:
    a. Interfaces required for producers to interact with the services required for Demand Side Management, Supply Side Management and energy trading energy etc.
    b. Home Energy Awareness Application (HEAA) for demand side management, in order to interact with the residents of the pilot households.
    c. Community based interfaces, in the form Public screens that raise energy awareness and 'promote' the concept of an EPN to the occupants of the EPN and the wider public.

The logic underpinning the Finnish pilot study is to identify if the tools and elements of the business model tested at the pilot site could move the neighbourhood towards a financially viable energy positive neighbourhood in the Finnish context

1.2 Contribution of partners

POS lead the operation of evaluation of the upgraded neighbourhood in the Finnish demo-site in this task, contributions to work involved were made by the following partners:

- UoT: Optimisations and simulations, significant support in leading the work.
- PE: Organizing the data acquisition via the billing meters, and via third party subcontractors. Mounting of the z-wave equipment in each pilot household that have required electrician.
- POS: Pilot site management including on site installation, configuration and operation of the z-wave solution, Home Energy Awareness Application testing, weather data acquisition, power market price data acquisition, simulations, all the calculations for optimisation and simulation analysis, KPI calculations
- COP: Equipment purchasing, public screen mounting, stakeholder interviews, stakeholder surveys, written contributions to the report
- VTT: Equipment purchasing, conducted on-site usability tests and analysis of them
- IBM-F: EMS operation
- IBM-H: Home Energy Awareness application development and testing
- CSTB: Provided the public screen content
- NOBA: Assisted with structure of report and calculations

POS lead the production of this report. Contributions, comments, recommendations and revisions to this document were made by the following partners: UoT, NOBA, CoP, VTT, and IBM-F. Specifically:

[1] Gras, D. et al. (2014) IDEAS Deliverable 5.1 *Energy monitoring data collection*

- NOBA: Pascale Brassier: An initial Table of Content, the representation of KPI evaluation
- CoP: Maarit Ståhlberg: Awareness increase through public screens and web portal influence
- IBM-F: Denis Gras: EPNSP interface description
- UoT: Tracey Crosbie: A restructure and modification of the chapter conclusions, lessons learned and the executive summary.
- UoT: Muneeb Dawood: 2.3.2 EMS prediction and optimisation algorithms.
- VTT: Mia Ala-Juusela: 5.4 which describes the usability testing of HEAA and chapter 4.4 which describes the corresponding methodology.
- IBM-H: ICT system layout and HEAA description

1.3 Relations to other activities in the project

Figure 1 illustrates the relationship between the work presented in this report and the other activities in the project. As illustrated, the work presented in this report:

- Builds on the earlier work conducted in the IDEAS project as part of WP4 in Task 4.1 *"Prototyping the Neighbourhood Energy Management tool*" and Task 4.2 *"Prototyping the user interfaces."*
- Is closely related to the Task 5.1 "*Energy monitoring data collection"* that constitutes a reference (baseline) to which the data collected during the demonstration phase is compared.
- Task 5.2 "*Pre-production tests: validating and debugging the tool*" provides validated tools and sets up the Finnish pilot environment.
- Contributes to the plans being developed for future commercial exploitation of the assets produced during the lifetime of the IDEAS project in Task 2.4 "*Exploitation Planning*" and is informed by Task 2.3*" Generalised business models."*
- Is framed by the stakeholder engagement undertaken as part of Work Package 6 *"Dissemination and Community Engagement."*

1.4 Issues encountered during the Pilot

The pilot site rollout started with successful implementation of the measurement instrumentation in each of the 23 households in which it was intended to pilot the Home Energy Application (HEA). However the rollout could never be fully completed. Issues encountered with the integration and the stability of the real-time system of data gathering in the IOC element of the EMS were not fully resolved until the later stages of the pilots. This meant that the HEA could only be tested in five households rather than the twenty three that we had hoped for. It can be concluded from this that not enough time was built into the project time line for the debugging of such a tool. In an attempt to address the more limited pilot of the HEA than anticipated:

- A usability test for the HEA was designed which was completed by the 5 households to which the devices were given in the pilot.
- The usability test was extended with an online survey which was sent to 109 people, of which 49 responded and the finding were analysed.

Due to the delays in achieving a stable system a stakeholder workshop was cancelled. Instead a web based survey examining the impact of public screens was conducted. Some KPIs were not calculated because the project was not able to achieve impacts on the pilot household energy demand due to the delayed delivery of the HEAA. See Appendix I which outlines the original methodology planned to test the efficacy of the HEAA and Chapter 6 which presents the lessons learnt from the issues encountered in piloting the IDEAS solutions.

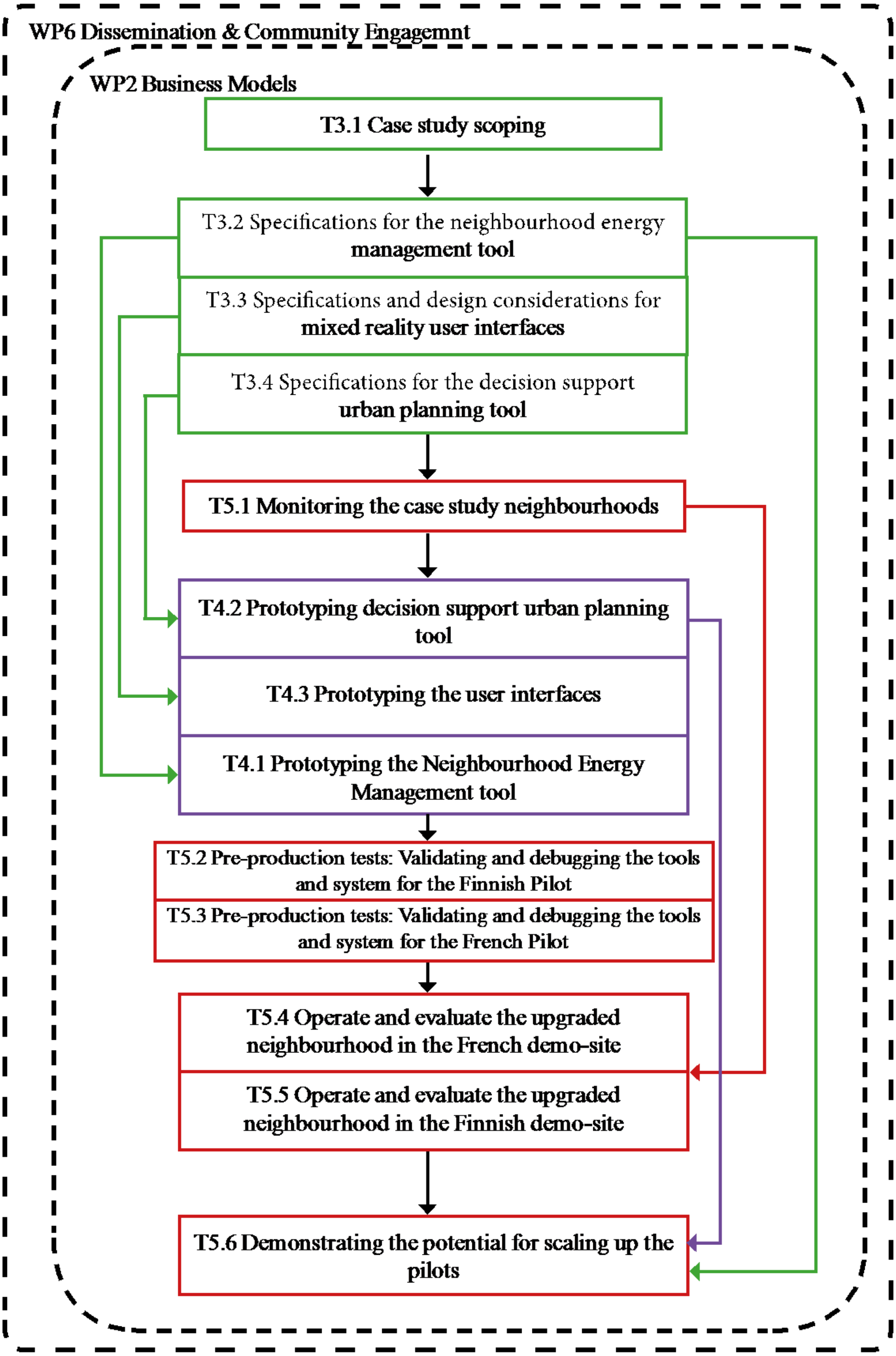


Figure 1. Relations to other tasks in the project

1.5 Structure of the report

Chapter 2 introduces the pilot site, the energy infrastructure that was simulated to test the EMS and the tools implemented at the pilot site, describing the content and the aim of each tool.

Chapter 3 describes the privacy strategy adopted in relation to the data collected on site and post-processed to feed the different tools.

Chapter 4 presents the methodology used for the analysis of the data collected during demonstration phase and the analytical approach used to extract useful information from the data and feedback collected.

Chapter 5 provides the mains results achieved in terms of energy savings and awareness as well as progress towards an energy positivity and summarises the findings of the analysis conducted as part of the pilot.

Chapter 6 provides a strategy to ensure the wider replicability of the piloted solutions and qualitative assessment for the progress and discusses the lessons learnt from the demonstration in the Finnish pilot site.

Chapter 7 presents the main conclusions as to the potential of the piloted solutions in Finland.

2 PILOT SITE: TOOL IMPLEMENTATION AND SIMULATION

2.1 Introduction

This chapter provides a short description of the pilot, the energy infrastructures that are simulated in the testing of the Energy Management System (EMS) and the tools and interfaces implemented at the Finnish demonstration site.

2.2 Description of the pilot

The Finnish pilot site is a residential area, with a nursery school located on the same area. It consists of 23 district heated households that were recruited to participate in the project. The stakeholders at the pilot site are listed in table 1 below.

End-user	Name of the person	Organisation	Role/position in the pilot site	Additional real role during the demonstration phase of the IDEAS project
1	Omenatarha pilot household resident, Asemo users	pilot group	Target group for improving energy awareness	Interacting with HEAA, Asemo and Skaftkärr.fi
2	Omenatarha nursery school visiting parent / staff; Kompassi staff	CoP + outsiders	Target group for improving energy awareness	Interacting with nursery school public screens
3	Citizens of Porvoo		Target group for improving energy awareness	Interacting with Kompassi interactive public screen. Visiting Skaftkärr.fi. Passing by the Kompassi window screen, in the city centre.
4	Jukka Rouhiainen	PE	EPNSP	Receives information from ESCo UI
5	Kristian Bäckström	CoP / POS	Site manager-Coordinates the link between the Finnish pilot site and the IDEAS project	Management of the monitoring systems deployed in the Finnish pilot site

Table 2 List of the end-users involved in the demonstration phase of the IDEAS project

The pilot neighbourhood receives heat and electricity from a bio-CHP (wood chip) power plant located in Tolkkinen, roughly 10km from Omenatarha. The bio-CHP supply power is re-dimensioned in the calculations to match the heat demand of the district heated buildings in Porvoo (only during outdoor temperatures below -5°C it is assisted with gas heat supply). The district heat network serves 1900 buildings of which 1350 are detached houses such as the pilot houses in Omenatarha. The EPN simulations are sized to 1350 detached houses with a wind turbine (3.3MW), battery and heat storage investments. These simulated resources are also scaled down (by 1350/23 → scaling factor 58.7) to match the 23 households in the calculations. For the simulated (84 meter high) wind turbine, it means a maximum power of 56 kW that is received by the pilot area. Wind turbines, energy storage and EMS setups are not as economically feasible for very small neighbourhoods such as the 23 houses.

The EMS is connected to data sources such as weather forecast and day-ahead electricity tariffs, as displayed in **Error! Reference source not found.**2. The ICT architecture employed at the Finnish demo site is illustrated in Figure 3.

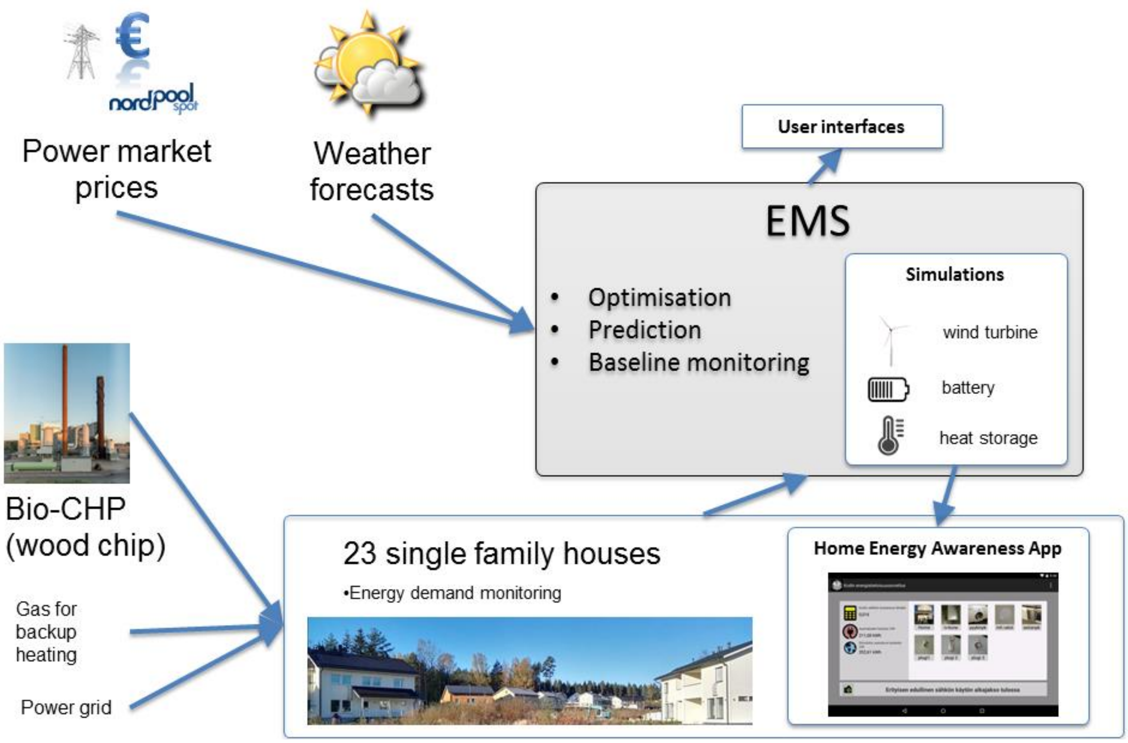


Figure 2: Pilot set up used to test the EMS, the interfaces and the business models.

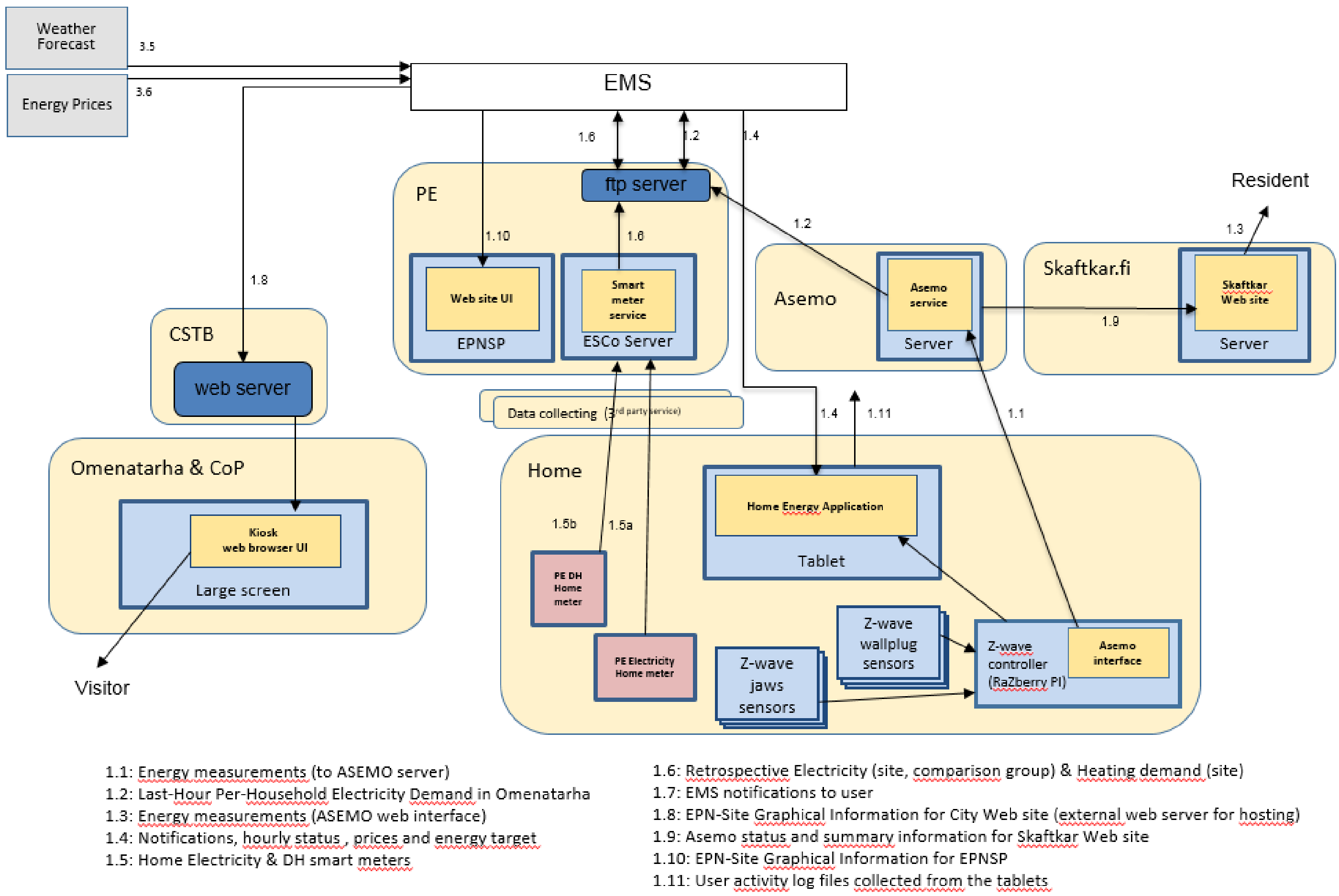


Figure 3: IT Infrastructure at the Finnish Demo site

The main elements of the demo may be viewed as: (i) an EPN control centre located at IBM-F; (ii) customer domain smart meters connected to data concentrators hosted by POS and PE and (iii) a home energy application embedded in each of the residents' homes. The user interfaces engage communities and individuals in the operation of EPN. They cover all the aspects of how users in the demo site can act and what they will experience as a result of those actions. The access to the management system data is provided using web technologies to enable both facilities managers and residents to take advantage of the information presented on the provided interfaces.

2.3 Energy Management System (EMS)

Each pilot household is connected to the Energy Management System (EMS). The EMS (Figure 4) is implemented by using IBM® Intelligent Operations Centre (IOC), a software solution designed to facilitate effective supervision and coordination of operations. The main features of IOC used are: database and data management, geographical information systems, web hosting and internet interfaces, performance metrics/analytical engines and optimisation tools.

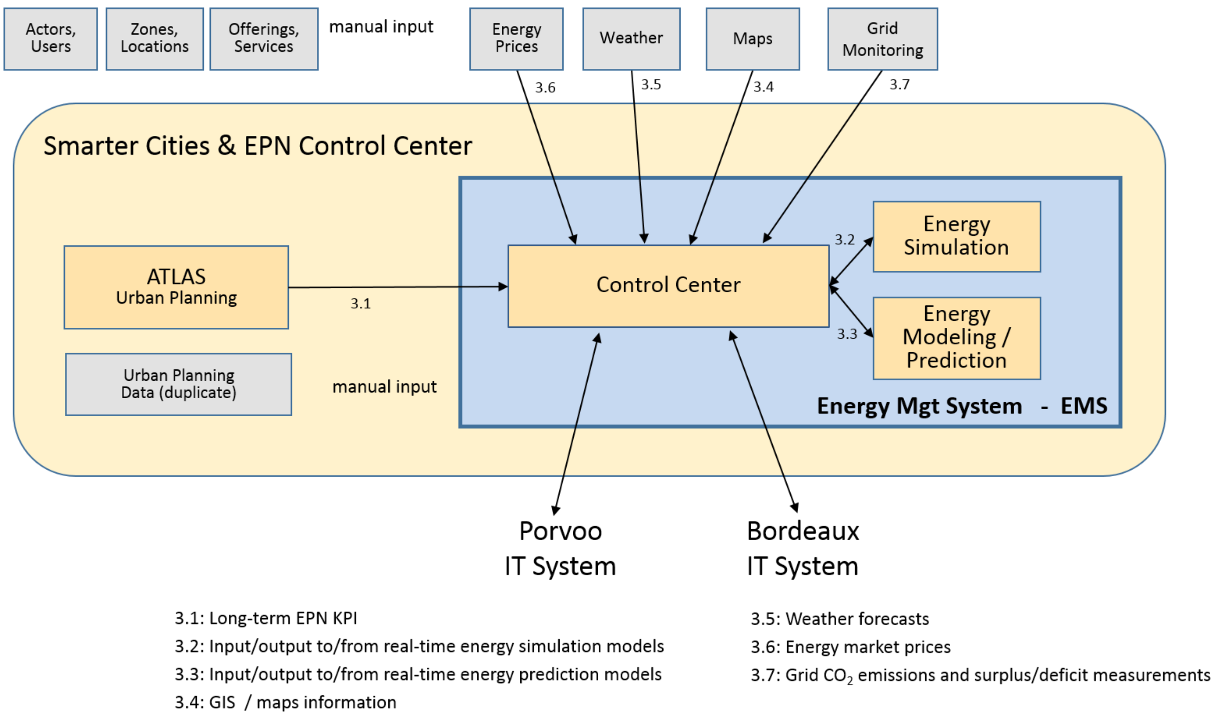


Figure 4. The EMS layout

The EMS is an optimisation and decision support tool for an EPN. All aggregated monitoring data is transmitted to the EMS, which also fetches weather forecasts and hourly electricity tariffs. The tool is used for coordinated and optimised demand side management (DSM) and supply side management (SSM) to reduce and shift peak energy demands and smooth out the inevitable production variability of renewable energy. Although EPN Service Provider is responsible for ultimately making decisions related to aspects of energy management in an EPN, this is supported by the outputs of the EMS.

The EMS includes simulated heat storage with a capacity of 29.3 MWh (for EPN of 1350 houses) and a simulated 8.8 MWh Li-Ion battery for electricity storage. The heat storage has a leak of 5% of the stored heat energy each hour.

The EMS triggers energy related notifications for the residents that are displayed on a Home Energy Awareness App (HEAA). The HEAA has been developed to address the use case related to Home Energy Management. The notifications received and displayed by HEAA are supposed to advise the residents to shift their energy consumptions to either prefer or avoid some particular time of day. The notification trigger mechanism at EMS is based on upcoming energy prices, weather conditions, estimated demand, and estimated battery and heat storage status.

The EMS contains optimisation algorithms for running the system optimally based on costs, CO_2 or a balance of them both.

2.3.1 EMS notifications to residents

One of the main ideas of the Finnish pilot is to provide the residents with energy related advises (one approach for demand side management), by asking the residents to attempt to prioritize/or decrease either heating or electricity consumption for some particular hour(s). The residents would receive a notification to their Home Energy Awareness (HEA) app on the tablet.

2.3.2 EMS prediction and optimisation algorithms

The energy demand prediction algorithm has been described in D 3.2 (Short, M., et al 2013). Energy demand prediction for next 24 hours is based on the past energy demand and temperature data. At any hour, there is a correlation between current energy demand and temperature value, the last hour value, the value at same hour previous day and the value at same hour one week ago. This correlation has been exploited in the prediction algorithm.

The optimisation algorithm has been described in detail in D 4.1 (Short, M., et al 2014). Input to the optimisation algorithm is the predicted values of energy selling price, energy buying price, fuel cost of various energy generation resources, equivalent CO_2 tax for each energy generation resource, renewable energy generation, electricity and heat demand. Output of optimisation is the decision variables for the next 24 hours. These include amount of energy to store or retrieve, power setting of CHP plant and the amount of energy sold or bought to/from grid. Prediction and optimisation algorithm operate in rolling horizon fashion and are recalculated every hour as new information becomes available.

2.4 Data acquisition

The introduced measurement instruments for the Finnish pilot site provide

- Non-delayed electricity demand data for the whole household, for EMS predictions
- Appliance level data to be used by HEAA.

The whole household consumption is measured using Home Energy Meter 3 (HEM3, see Figure 5) instruments manufactured by Aeon Labs. HEM3 and Fibaro Wall Plug (see Figure 6) devices are used for measuring the consumption of home appliances. For that purpose each household received two HEM3 and three wall plugs. The HEM3 devices were installed by an electrician whereas the use of portable wall plug devices was up to the resident. A total of 69 HEM3 devices have been installed in 23 households, and 69 wall plugs have been delivered for the residents to use.

Figure 5. Aeon HEM3

Both types of metering device send power reports via wireless z-wave mesh network to a Raspberry PI unit which is also configured to operate as an Asemo client. This client is configured to transmit the most interesting data to the Asemo-server using http post. From Asemo only whole household consumption is exported to an intermediate ftp server (hosted by PE), from where the EMS which retrieves the values.

Figure 6. Fibaro wall plug

2.5 Awareness interfaces

Efforts have been put to make the energy more visible and provide energy related information to improve the energy awareness of the citizens of the area.

2.5.1 Public screens

The purpose of this tool was to provide citizens of Porvoo a better understanding of how the Finnish pilot site consumes energy and engage them in the concept of an EPN. The energy awareness interface makes the resident of Omenatarha aware of current energy consumption in relation to historical consumption for their neighbourhood. This interface enabled the IDEAS project and the city of Porvoo to promote EPN to the residents.

Public screens were deployed at strategic locations: three wall mounted 21” Android tablets were installed at the Nursery School in Omenatarha (Figure 7) and one in the city centre at the citizen service point of COP, where also Building Development department and Urban Planning department are located.

Figure 7 Public screen for improving energy awareness

The interface on these public screens offers a big picture/overview of the neighbourhood and then zooms slowly to a more detailed level. They show consumption data as well as historical data. Electrical consumption, district heating consumption and CO_2 emissions are displayed with average figures for the last 30 days, and benchmarked to similar data from the comparison group. In order to attract the attention of the inhabitants, tips and a quiz are also proposed to promote sustainable behaviours (Figure 8).

The citizen service point Kompassi has a 37” (non-interactive) info screen at its window where IDEAS project is also promoted.

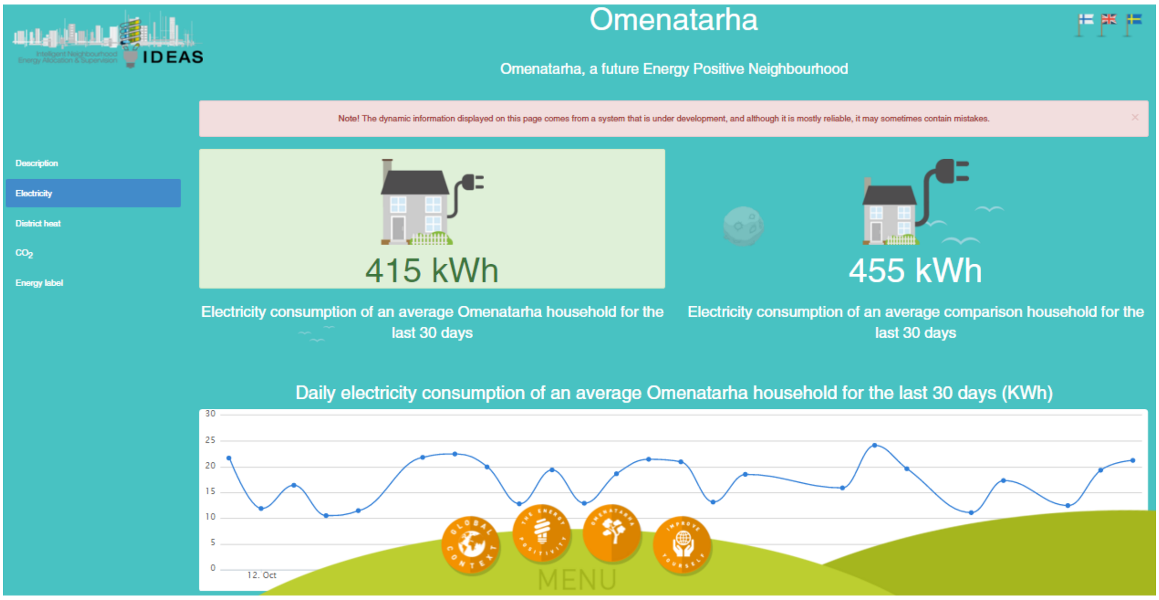


Figure 8. An example page of the public screen interface content

2.5.2 EPNSP interface

The EPN Service Providers User Interfaces are those made available to the Energy Service Provider in Finland i.e. Porvoon Energia see figure 9.

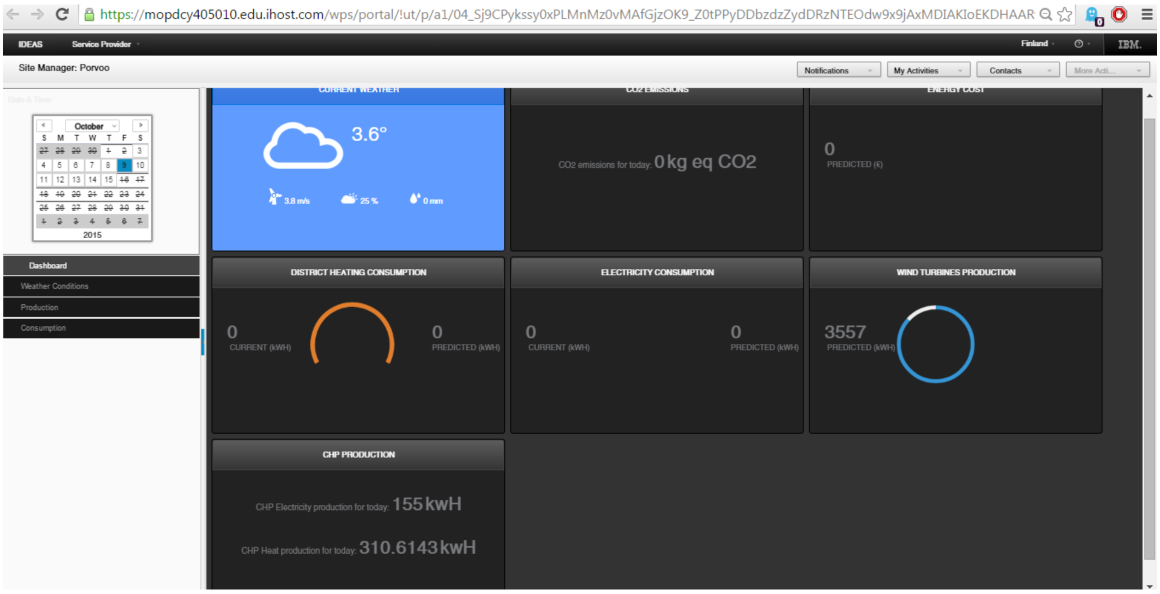


Figure 9. EPNSP dashboard screenshot

Based on standard web technologies (portal), they offer dash boarding, alerting and notifications capabilities to numerous end users who are getting shared or custom views. Operations Managers and Operators don't need the same type of information.

Dashboards can lead to drill-down menus, while operators can get low level detailed data (by meter, by building, etc.).

It should be noticed that offering a unique web portal to these people allows sharing standard views, while custom views are restricted to specific end users.

These EPNSP User Interfaces (Figure 9) could be easily extended to external end users like prosumers (clients of the Service Provider) and even City Officers (linkage with Urban Planning, CO_2 footprint, etc.) though this was not done in this project (not in the definition of work and scope).

That's where the value of such an ICT framework appears clearly, meaning that you can in future projects combine operational, analytics and decision support capabilities - including user and communities interactions - while sharing the same data, either open data or restricted data.

Though this was not the purpose in this project, industrializing mobile interactions with this platform is pretty straightforward.

In IDEAS, we used REST APIs for EPNSP User Interfaces - like for all other data interfaces - and therefore the learning curve was pretty short for all partners involved in the project (though they were not ICT companies except IBM).

In future projects, the scalability and high availability capabilities of what we did in IDEAS could be easily demonstrated, both in terms of data volumes and end users. It should be noticed, that, optionally, data streaming (large volumes, high frequency) and big data capabilities can be reinforced in real large projects.

The EPNSP User Interfaces have been used by POS and PE to effectively validate the data during demonstration. In addition, partners had access to a "query builder" tool (in that case, free access to IBM Data Studio) to scroll the databases and look for data which were not shown on end users screens.

2.5.3 HEA Application for residents

Home Energy Awareness Application (HEAA) is an application that runs on a Nexus 7 2013 tablet computer, delivered to the pilot households. The HEAA is used to inform home residents about fine grained energy consumption and to help them meet the energy supply objectives of the EPN. It provides the residents with detailed information about energy consumption of their home appliances, as well as the entire home, and information about the current overall status of the EPN in which they live.

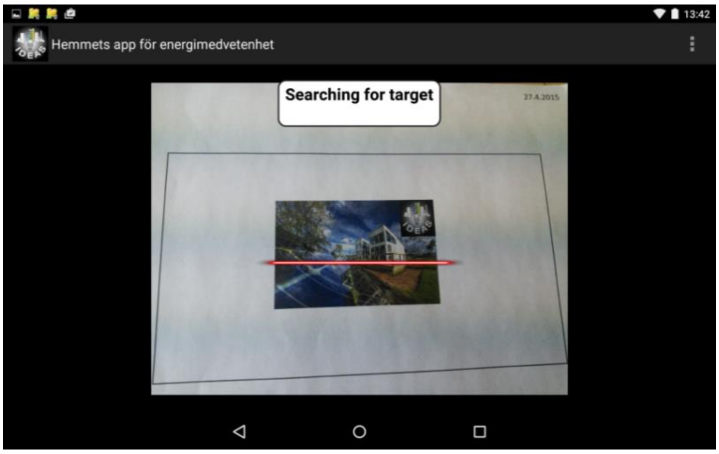


Figure 10: HEAA augmented reality feature for recognizing (tagged) appliances. While searching, the red line scans repeatedly from top towards bottom

This application is connected to the EMS and receives real-time notifications about suggested changes in electricity and heat consumption based on availability. The residents are informed in simple terms that there is an excess or deficit of energy. The HEAA was also designed to record user activities with the app, and to transmit them to EMS where they can be collected for offline analysis. The resident can see the current energy consumption for each configured appliance by using HEAA's augmented reality feature (by visual object recognition using the tablet camera) specially designed for identifying predefined target appliances within people's homes, as shown in Figure10. This technology can be used in future with other user interfaces such as Google Glasses.

Once the appliance is recognized, it displays a gauge meter and the current power consumption, as shown in 11

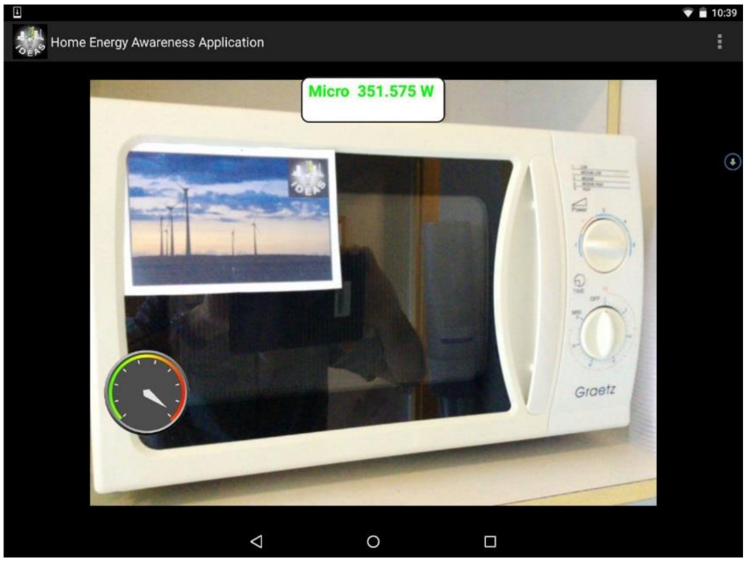


Figure 11. Augmented reality has detected an appliance, and displays a gauge meter.

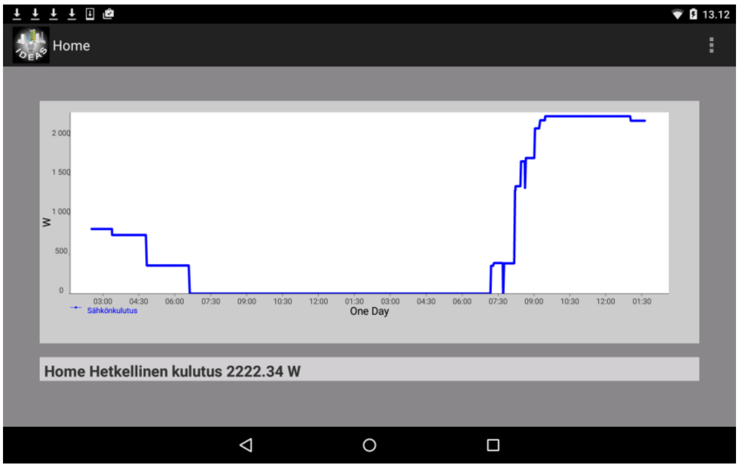
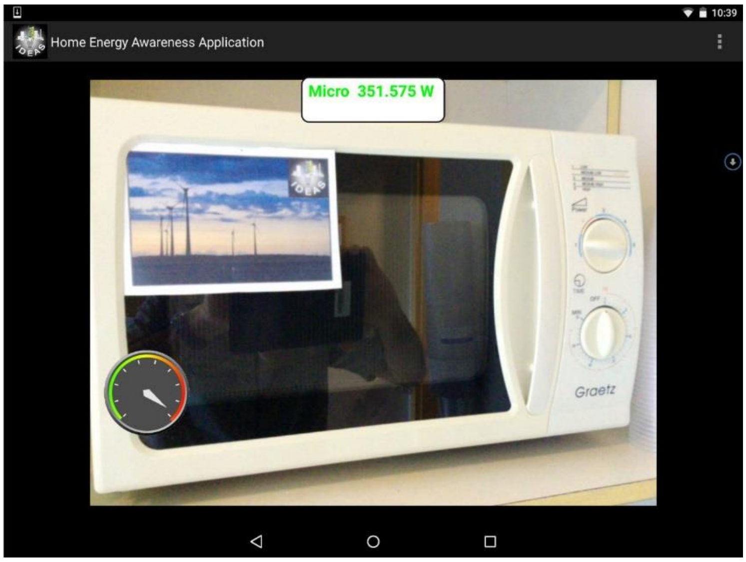


Figure 12. HEAA view of the 24 h consumption history

The resident can view the current and 24 hour historical energy consumption for each configured



appliance (see

12) by clicking the corresponding appliance icon in the HEAA main view, see Figure13.

The original plan was that each of the 23 households would be provided with one. For evaluating the application 5 of them got the tablet in October and the rest of the families later. As they were deployed, the application was configured and special tags were placed on the appliances in order to enable appliance recognition. The resident/user was instructed to put the tablet as a display frame in a central place of the home.

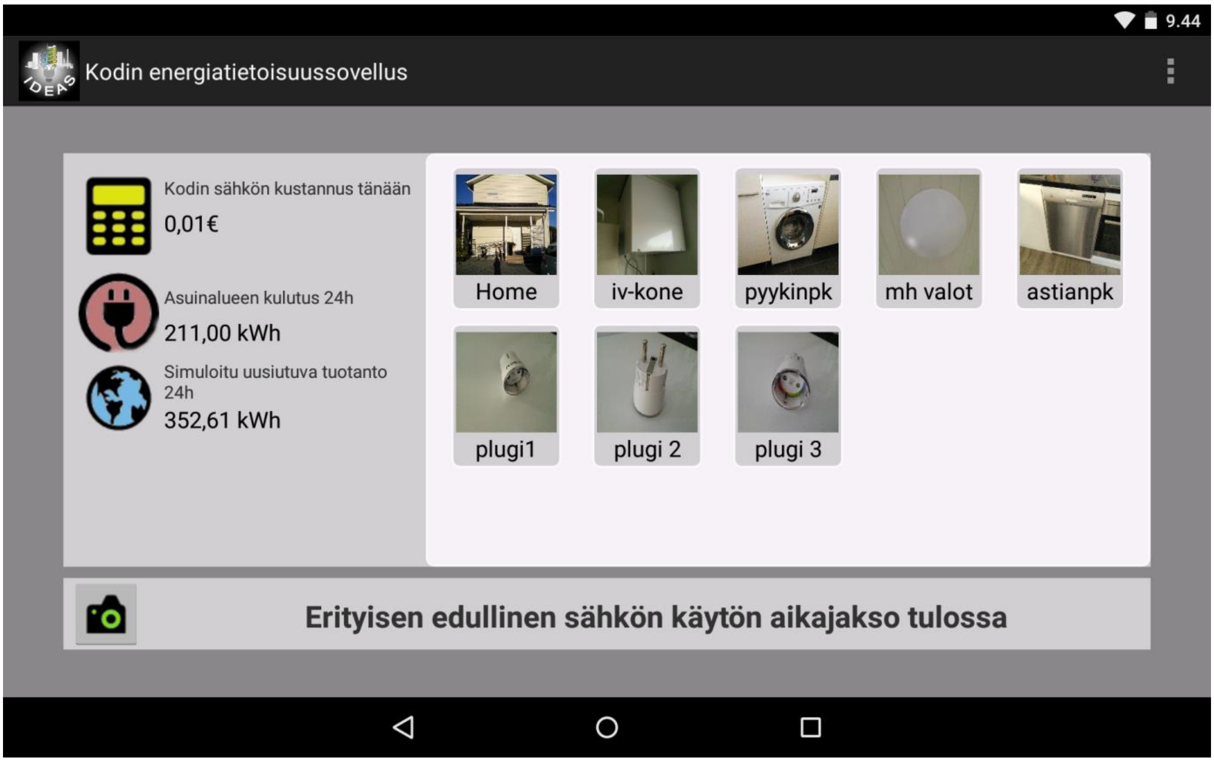


Figure 13. HEAA main view

3 Privacy strategy

3.1 Identification of sensitive data

Household energy consumption/production data can be sensitive data, since it reveals personal living habits. In particular it is easy from this kind of data to identify when people are at home and when people's' properties are empty. However, once the data is aggregated to sum the data of several households it cannot be used to identify living habits associated with particular individuals or households and can be considered statistical data which can be made public.

3.1.1 The data security within households

The measurement data from households are collected using two types of meters: z-wave meters and the Energy Company's billing meter.

3.1.1.1 Billing meters

The data paths for the billing meter data to the Energy Company's billing system (interfaces 1.5a & 1.5b) are part of pre-existing Energy Company's infrastructure and thereby out of scope. Corresponding meters are used in the similar way all over the world.

3.1.1.2 Z-wave network

The z-wave measuring devices are wireless, working on the 868.42 MHz. Their wireless range is fairly short, which means any sniffing or intrusion attempts on the z-wave network would require access very close to the homes. Devices that are located indoors barely have any range outdoors. The nominal range is around 30m in "open air" conditions, but in practice with walls it's much shorter. The z-wave controller is requiring explicit interaction for each new z-wave node to join the network. The access to the z-wave controller is restricted to the IP subnet of the household.

3.1.1.3 Residential home IP subnet

The wireless network of the homes will be used in the pilot site. The z-wave controller (Raspberry PI with RaZberry daughter board) is visible and unprotected on the home subnet. The residents will not be provided any user account on that Raspberry for the pilot period. The resident is expected to be responsible for the security of the subnet.

3.1.1.4 The security of the data transfers

The privacy aspects of the interfaces related to IT infrastructure at the Finnish demo site are presented in Figure 14. The secured connections of the IT infrastructure

- Interface 1.1. The outbound connection from the Z-wave controller for exporting data to Asemo is encrypted using SSL, and can thereby be considered secure. This interface transfers the most sensitive measuring data: almost real time data for all measured devices at maximum resolution provided by the z-wave controller.
- Interface 1.2. The data exporting routine from Asemo server to EMS. An hourly executed export for predefined streams with one hour resolution. The streams to be exported are the total electrical consumption for each pilot site household. The data is anonymized in such sense, that only POS has the required map to translate the stream id back to resident or street address information.
- Interface 1.5a. Out of scope (Energy company billing meter and setup).
- Interface 1.5b. Out of scope (Energy company billing meter and setup).

- Interface 1.6. The ESCO export interface to EMS for DH and electricity data from billing system. This data is much delayed and has poor resolution. The data is aggregated and anonymized.
- Interface 1.8. Aggregated only, can be considered as public data.
- Interface 1.9. Skaftkärr.fi is a user interface for the residents where they may embed their own Asemo charts of their measured data within a web portal. The web portal is using openID authentication. The communication with the Asemo server is encrypted with SSL. All Asemo content that is visible on the web portal is embedded using iframe and the measured data is actually delivered directly from the Asemo server (not transferred to any other intermediate site).

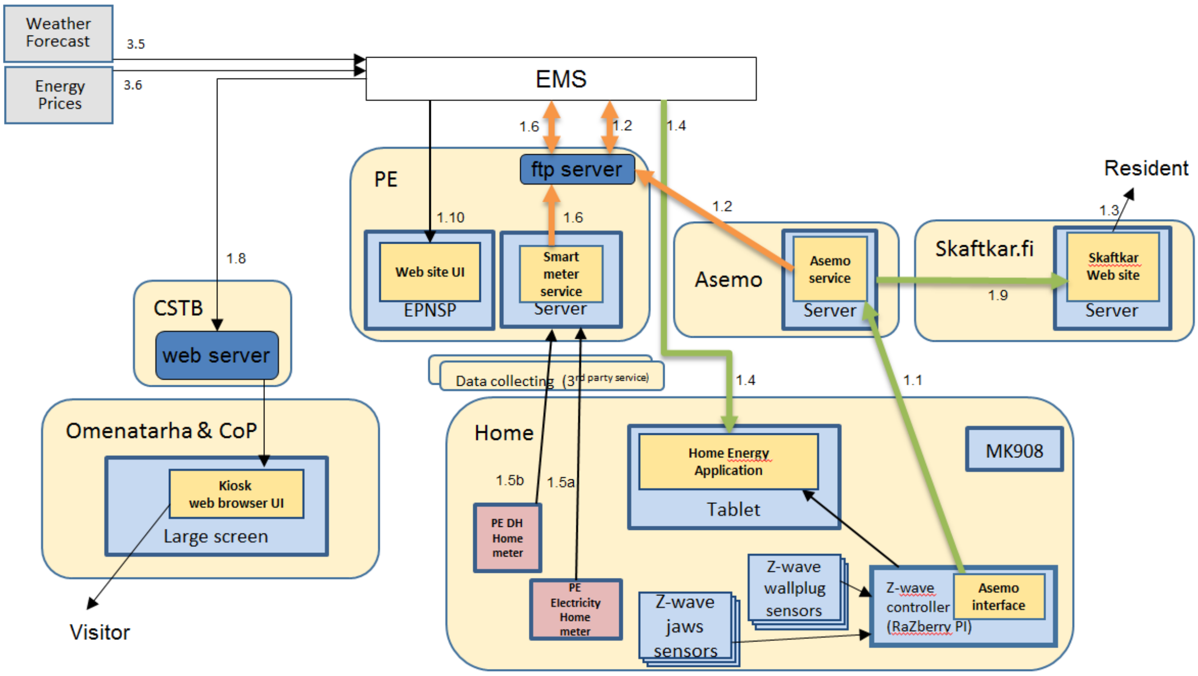


Figure 14. The secured connections of the IT infrastructure

3.2 The security of the data storage

The EMS receives anonymised data used as inputs to simulation and optimisation models. The IOC does not store data related to the Finnish resident's profiles. The post-processing is working on aggregated data (EPN-Energy Positivity Neighbourhood demand / supply…..) and notifications will be the same for each EPN. Regarding security, the two IBM IOC environments are hosted in a secured ICT infrastructure. IBM-F is putting significant efforts into managing these environments and applying the related security policies. For example at the network level we are using a virtual private network to communicate with the IOC. This requires a valid VPN certificate. The information exchanged with the IOC is secure (HTTPS) requiring authentication.

3.2.1 Asemo

Asemo.fi is running as a virtual server on a dedicated server, currently located in City of Porvoo's subcontractor's (Posintra) premises. The hosting and backup is outsourced to a third party. Nobody other than Posintra and the hosting third party has systems accounts on the virtual server and host server. The number of services running on asemo.fi is kept to a minimum, and they are all encrypted. The physical access to the server is restricted to the staff of Posintra and the landlord of the premises (City of Porvoo). Off-site backups are regularly sent over encrypted connection to a foreign third party server.

3.2.1.1 Data privacy agreements with householders

Posintra has signed IDEAS pilot participation agreements with 23 households of Omenatarha. A blank template of these agreements is found in *APPENDIX A. Resident agreement*.

Omenatarha residents taking part in the IDEAS demonstration and validation (WP5) have signed up to the agreement. This agreement gives City of Porvoo and its subcontractor (Posintra) the right to collect, store and use the measured or otherwise collected data. The data is defined in the agreement as well as the time period for collecting it (i.e. the measurements). The data may consist of various energy measurements (detailed consumption, production), living conditions and identification facts, information of the use the IDEAS applications and user interviews. Transfer of the data to a third party is allowed but the transferred data has to be anonymised. According to the agreement only City of Porvoo and its subcontractor (Posintra) have the information for associating households and the corresponding data.

4 METHODOLOGY USED IN THE EVALUATION/DEMONSTRATION

4.1 EMS optimisation evaluation against baseline

4.1.1 The benchmarked scenarios

Three optimisation scenarios have been developed for the Finnish pilot. Optimisation process produces values for storing/retrieving energy (heat and electricity) to/from storage and for selling/buying electricity to/from grid and to sell heat to grid over next 24 hours.

Optimisation scenarios:

1. Optimisation is set to 100% Maximising economic profit.
2. Optimisation is set to 50% Maximising economic profit and 50% minimising CO_2 emissions.
3. Optimisation is set to 100% minimising CO_2 emissions.

In order to determine a favourable value of the γ parameter for the Finnish site, the optimisation is configured to run with following combination of γ parameter and electricity buying and selling price.

In addition to these three optimisations scenarios and the naïve baseline scenario, even a naïve scenario including the simulated wind turbine has been provided, in order to separate the EMS optimisation impact and the wind turbine impact from each other.

4.1.2 Baseline and optimisation data

The baseline data monitoring via the electricity and district heating billing meters has provided the project with a lot of data. Some data gaps in the district heat demand data have however occurred; therefore a continuous heat demand has been created out of a HDD calculation, using the existing measured demand data achieve a good calibration. The weather data has been loaded from www.wunderground.com and the hourly power market tariffs from www.nordpoolspot.com.

The wind turbine simulation and the EMS optimisations for using energy storages, controlling CHP and power market trading were calculated and analysed offline. The baseline scenario was calculated as the naïve business as usual scenario, which means that the CHP is controlled according to heat demand. Any excess electricity from the CHP is sold to the grid, and any deficit electricity is bought from the grid. If the CHP is insufficient to meet the heat demand, then it's assisted with gas for supplying heat.

4.1.3 Simulated trading with the power grid

The local electricity supply and demand is balanced with the grid according to prices on the Nord Pool Spot day-ahead market Elspot. That's where bids for defined volumes of energy supply and energy demand has to be given previous day before 12 o'clock CET. (The spot prices are locked down according to where the bids meet each other, and are announced previous day at around 12:42 CET. Later energy trading is made on the intraday market, named Elbas). The EMS buying and selling decisions are made one hour before, based on forecasted weather and demand data as well as retrieved Elspot prices.

4.1.4 Emission calculations

The CO_2 emissions for the CHP are considered as zero, since it uses a local forest as renewable fuel (wood chip). The CO_2 emissions for the assisting gas heat supply are also considered as zero, as PE nowadays uses only bio-gas. However, when the local renewable demand is larger than the local supply, electricity has to be supplied from the grid. In this case the electricity from the grid it counts for 286.14 gr CO_2 and 1.27 mg used nuclear fuel for each bought kWh.

4.1.5 Data used for the simulated resources

The simulated investments (wind turbine, heat storage, electricity battery, EMS) have been dimensioned for the EPN (1350 houses), but the cost, capacity and performance calculations represent only the pilot site (23 house) portion of the total. Cost and performance features are chosen to match the larger imaginary EPN, and linearly scaled down (using factor 58.7) to get corresponding numbers for the pilot area.

The 3.3 MW wind turbine simulation uses measured wind speed data from ground level (which had an annual average speed of 3.1 m/s), but they were scaled up with a factor of 1.8 to match the conditions for the same location at the altitude of the wind turbine. (50 m altitude at Emäsalo has an annual average wind conditions above 6 m/s). This simulation produced 163.9 MWh of energy. (Finnish Meteorological Institute, 2008).

	EPN: 1350 houses		**23 pilot houses**	
Wind turbine size	3,30	MW	**56.2**	**kW**
Heat storage energy capacity	11,7	MWh	**200**	**kWh**
Heat storage size m^3	585,7	m^3	**10**	**m^3**
Battery capacity	8,8	MWh	**150**	**kWh**
Battery I/O throughput	1,8	MWh / h	**30**	**KWh / h**
CHP size	3,8	MW	**64.9**	**kW**

4.2 The public screen survey

The public screen content quality was evaluated through a public screen survey that was conducted among the staffs of the same building where the Kompassi citizens' service point is. The results are described in chapter 5.3.3 starting at page 34.

4.3 Energy awareness questionnaire for residents

The residents of Omenatarha can join a Living Lab system developed for inhabitants of Skaftkärr area enabling them to monitor their energy consumption in real time. They have also been invited to participate in three briefing sessions organised by the City of Porvoo's Building Supervision Department. These sessions gave basic information on how energy efficiency should be taken into account in the house planning and later on in living. Because of these actions and because the participation in the IDEAS demo was voluntary it could be assumed that the new residents are more aware of the environment and energy issues than an average resident somewhere else.

To find out residents' awareness level and the impact of the IDEAS demo on it, a survey was conducted. An interview of the individuals was executed along with the z-wave measuring equipment installation at the households. It was also an opportunity to engage the households to the issue. At each household only one of the adult residents answered the questionnaire. He or she filled the form independently on a Nexus tablet and in very few cases some help was required.

The questionnaire for carrying out the survey was devised by POS. A valuable contribution and comments were also made by CoP. The tool used was Google Forms. Hence the respondents were able to use a browser for answering and the result was easier to analyse compared to e.g. a questionnaire on paper.

4.4 HEA app usability test, extended with online survey

A qualitative usability testing of the HEAA was conducted by using in-depth interviews of the residents during the tablet delivery and HEAA configuration within the homes. The usability of the HEAA was tested by residential users in the Finnish pilot households. The development of the HEAA was based on the use case described in the beginning of the project. The use case is copied below (as chapter 4.4.1) from D3.3 Specification for the user interfaces, to remind of the original intention and purpose of the HEAA.

The usability test was extended to with a light-weight online survey which was sent out to 109 people at the City of Porvoo, of which 49 responded. Screen captures of the survey form are found in *APPENDIX G. HEAA Usability test extension survey* and the results are presented within the charts in chapter 5.4.

4.4.1 Use Case Description (Use case #1: Home Energy Management)

This use case describes how to inform home residents about fine grain energy consumption in order to help them meet Energy Positive Neighbourhoods (EPN) energy supply objectives.

The main justifications for this use cases are: Residents in EPN want to be aware of their local neighbourhood energy production/consumption situation so that they can contribute their share towards meeting the collective neighbourhood energy positive consumption/production goals. They do not necessarily want to partake in micro energy trading deals, but are willing to shift their demands or patterns of usage in some cases if they are informed in simple terms that there is an excess or deficit of energy. Therefore, residents are going to be notified by the neighbourhood Energy Management System (EMS) about potential actions that should be taken. A small number of appliances or energy consuming devices were ‘tagged’ in the home of each resident. An application that runs on a hand held device showed the resident the saving potential of these home appliances so that one can take action. The application made the resident aware of current and historical energy consumption for each appliance. The provided interface is going to be natural even for novice users.

5 Results

5.1 EMS impact

5.1.1 Impact on the operation

The addition of heat and electricity storage in combination with day-ahead market prices makes it feasible to optimise the trading and control of the production for different purposes. Normally the CHP is controlled according to the heat demand. With the optimised scenarios it's easy to notice in Table 3 below that the CHP has produced excess heat (which is wasted) for the optimised scenarios, but is providing more profit and lower emissions. The CHP production ratio is fixed (24.75 % electricity and 75.25 % heat), which means the small portion of electricity, has justified the production of the excess heat that is wasted. The heat demand was 332 MWh, but the optimised scenarios produced almost up to 70 MWh excess heat (which mostly is consumed by the 5 % hourly heat loss of the heat storage- Figure 15).

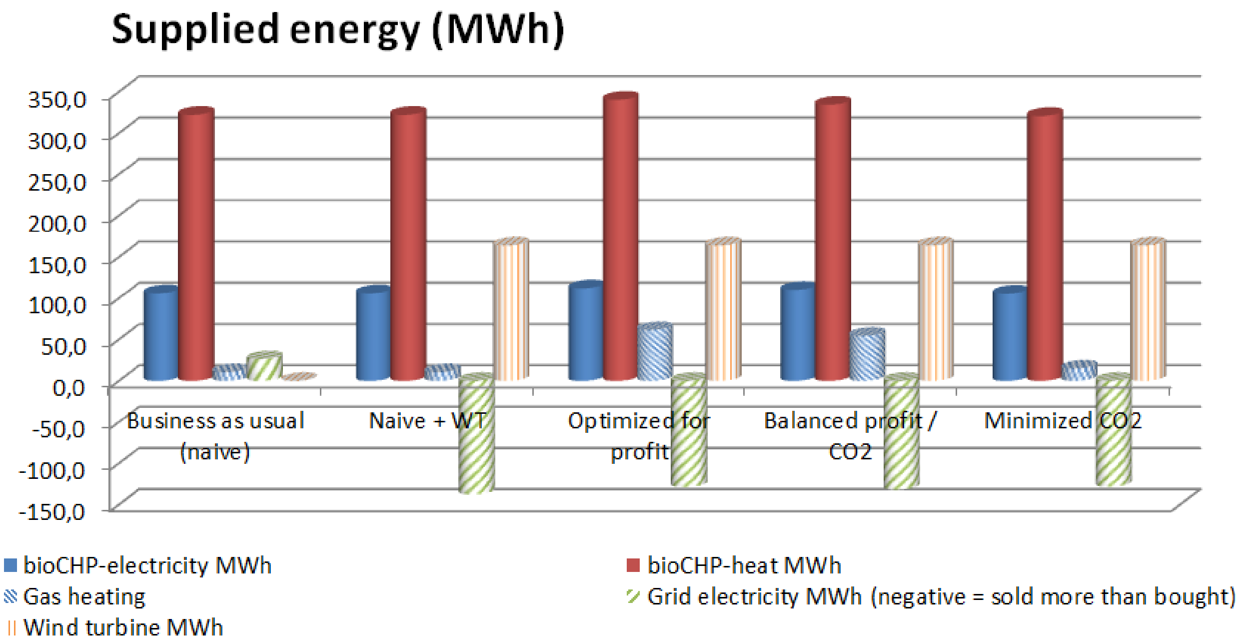


Figure 15. The supplied energy of the different scenarios. The grid energy is negative in all scenarios except baseline, which means more electricity has been sold to than bought from the grid

Supplied energy	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
bioCHP-electricity MWh	105,9	105,9	112,0	110,1	105,5
bioCHP-heat MWh	322,0	322,0	340,5	334,7	320,6
Gas heating MWh	10,4	10,4	61,6	54,3	15
Grid electricity MWh (negative = sold more than bought)	26,2	-137,7	-128,8	-131,7	-128,5
Wind turbine MWh	0	163,9	163,9	163,9	163,9
Total	464,5	464,5	549,2	531,2	476,3

Table 3. Comparison of simulated scenarios versus business as usual (values for the 23 households)

In the optimisation simulation scenarios, it was assumed that the value of relative CO2 emissions of gas generated heat energy was higher compared to the CHP generated heat. Thus in the minimise CO_2 scenario, heat energy demand was met mostly by the CHP generated heat and gas generate heat was much less. The CHP generated heat mostly followed the heat demand. In that case, no excess electricity was produced by the CHP plant, which could be sold to the grid hence less excess heat energy was generated.

The heat storage usage is clearly visible in Figure16, and for battery in Figure 17 - Figure19.

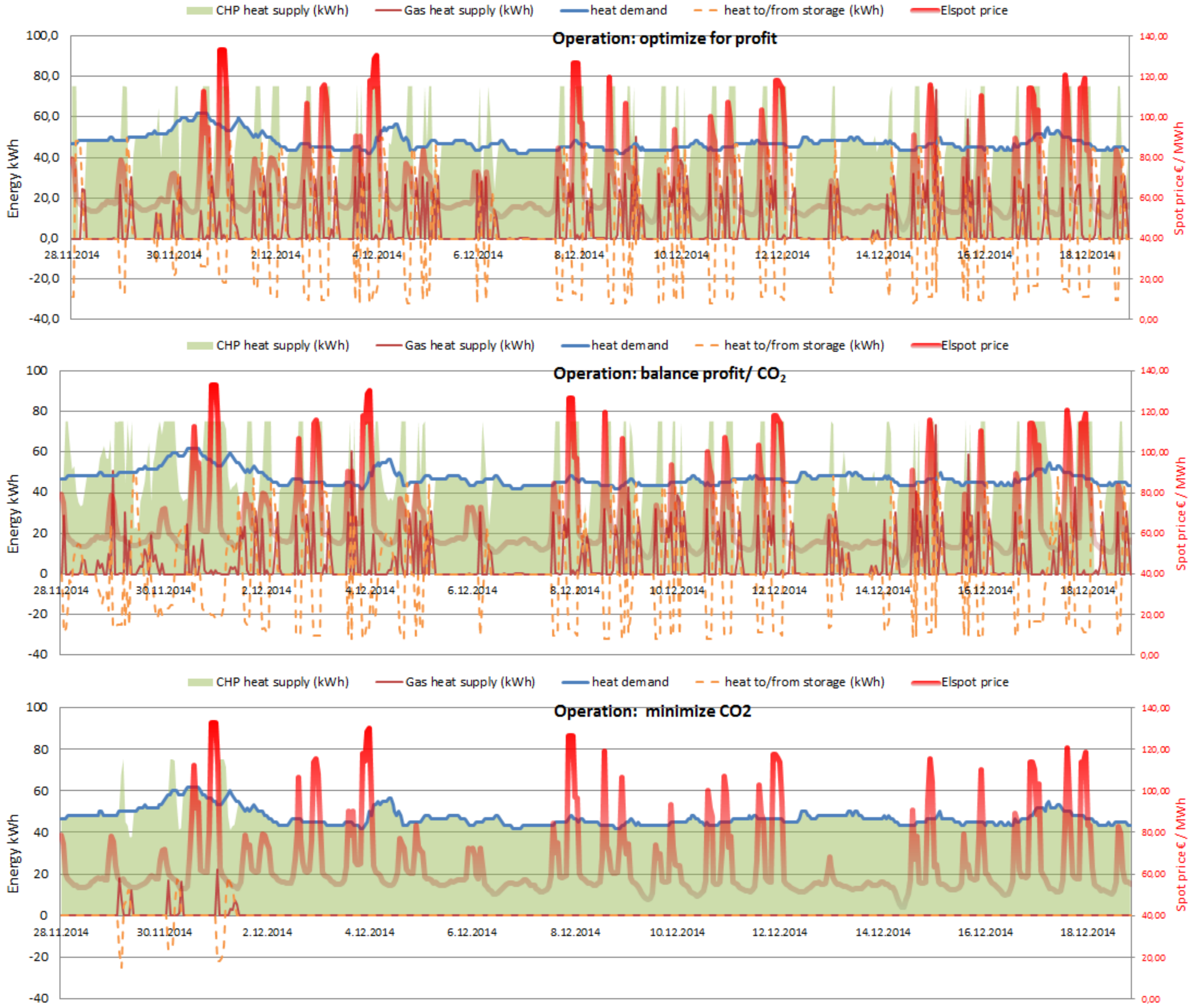


Figure 16. The differences of the operation are visible in this figure (500 hour long period), where heat demand, supply, storage and spot prices are plotted in the same chart. Mostly the CHP (green area) matches the heat demand (blue line)

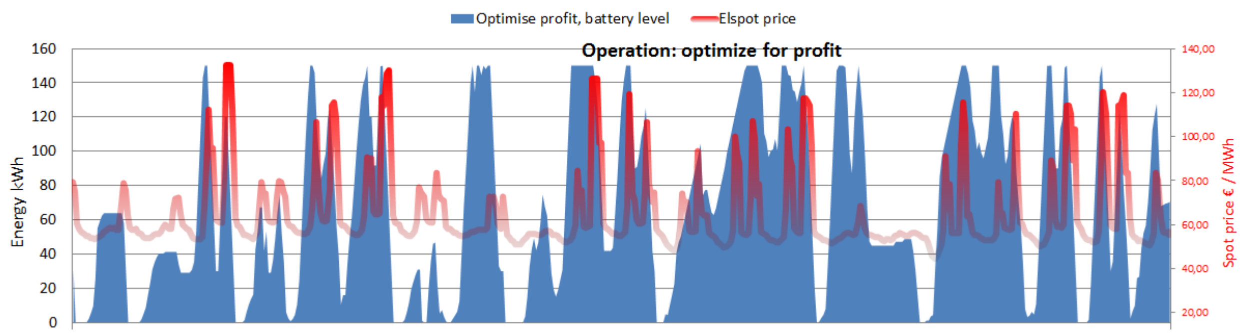


Figure 17. The optimise for profit scenario is most actively using the battery, with 237 battery

cycles a year (depth or discharge: 90%). Here's the same 500 hour period as in Figure16, and it shows that the battery is discharged when spot price is high

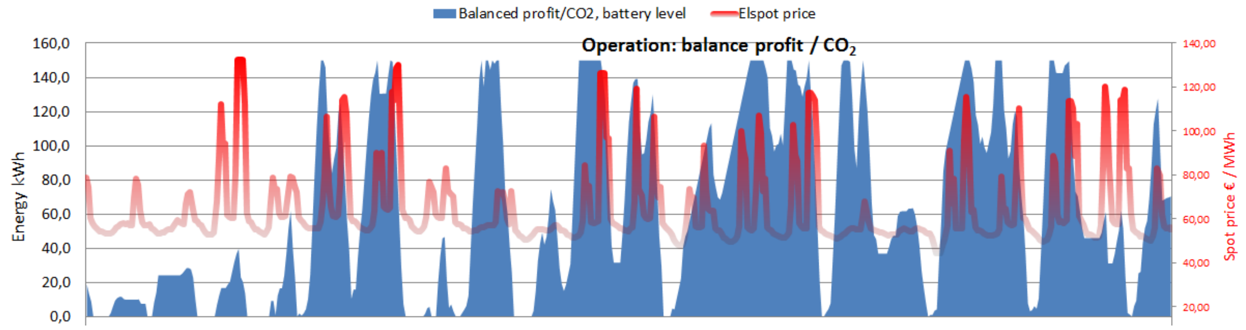


Figure 19. The balanced scenario did 98 battery cycles per year

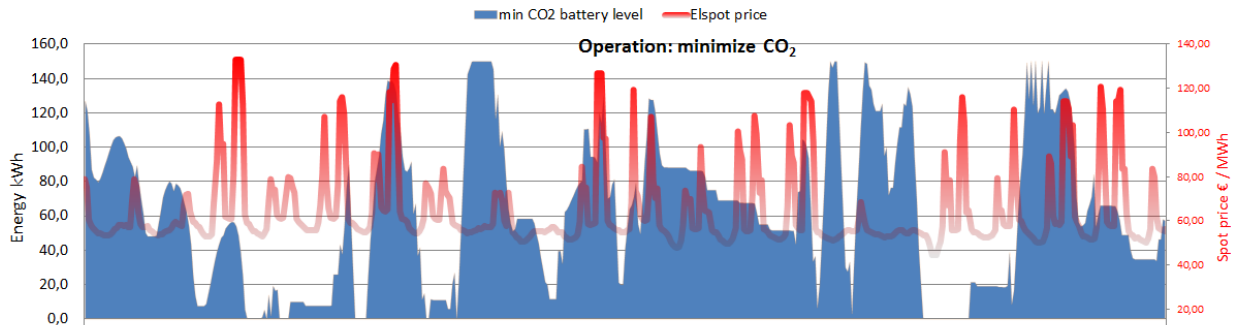


Figure 19. The minimise emission scenario uses battery more gently and calm, with only 73 battery cycles per year

5.1.2 Investment calculation

The calculations illustrate that the return on investment with the prevailing circumstances is not feasible but using some reasonable assumptions they are showing positive results.

5.1.2.1 Battery investment, now vs. the future

Currently the batteries are still expensive but are also rapidly getting cheaper. By assuming the price decrease will continue a few more years, the battery investment can be considered feasible. The calculations are based on a price of 730 k€/MWh, which are assumed to decrease with 60% in the near future and thereby reach 291 k€/MWh (PowerTech Systems, 2015; Ramez Naam, 2015).

5.1.2.2 Elspot price level, now vs. the future

The average of the Elspot prices for the measured period (12 month) was 30.86 €/ MWh, but a few years earlier (2010) the annual average was 84% higher (56.64 €/ MWh). Calculations assuming that the energy prices soon will raise back the previous higher levels, roughly halves the ROI time. This seems a reasonable assumption given that in 2015 *"despite the fact that in August the Nord Pool Spot (NPS, 2015) area water reservoir levels stayed high, electricity costs throughout the whole region were higher than the average cost for last month. Finnish prices rose to their highest since February.......... Finnish prices increased even by 12.9 %, with the average Finnish electricity amounting to EUR 31.12 per MWh."* It must also be noted that increasing price volatility is seen as inevitability in the future for the Nord Pool market and this will further increase the possible profits from energy arbitrage (Eesti Energia, 2015; Fortum, 2015).

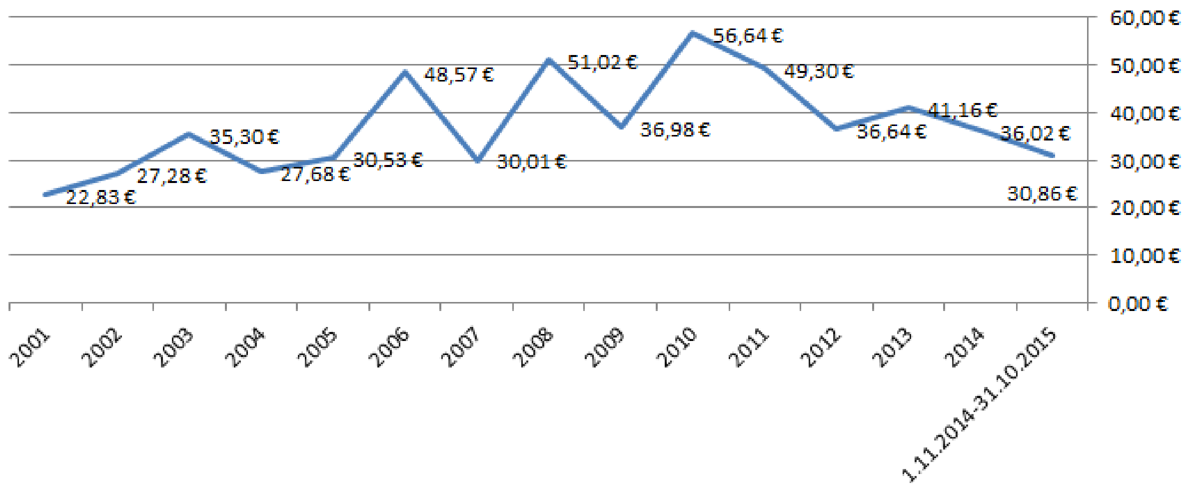


Figure 20. Annual average of the Elspot price €/MWh for the Finnish power market, compared to the measured period (1.11.2014-31.10.2015) [Nord Pool Spot]

5.1.2.3 Profitability

As described in *D2.2 Specific business models for demo cases* the increased profits will be derived by reducing costs in electricity production/procurement distribution and regional and main grid transmissions as a result of optimising the local production, storage/retrieving and buying/selling and distribution of electricity. The calculations focuses on comparing the alternative costs for supplying energy, and examines the annual cost differences compared to business as usual, also in relation to the required investment costs.

A significant part of the transmission and distribution costs can be avoided by bypassing the national grid and for electricity which is both locally produced and local consumed. This is shown in Figure21 below (Crosbie, T. et. al. 2014).

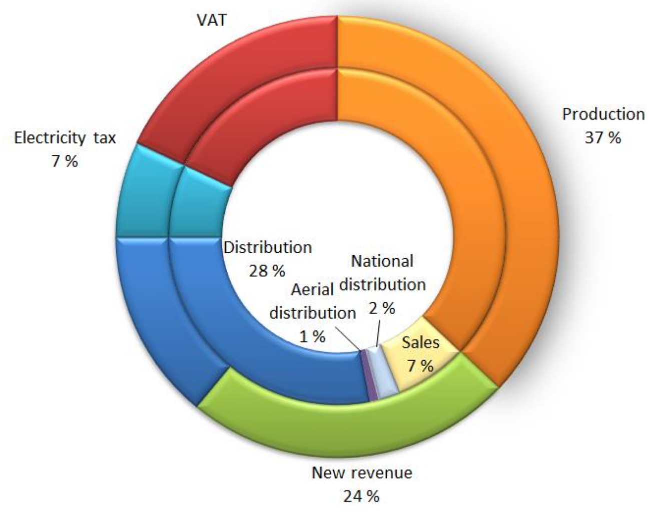


Figure 21. The EPN cost distribution of the end user energy price. The inner donut is the original, the outer is according to the proposed business model.

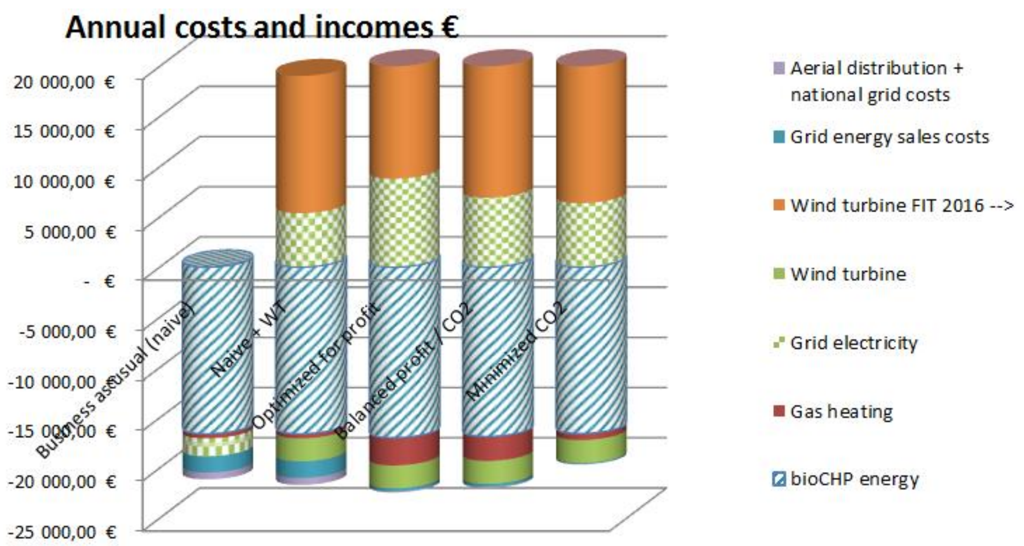


Figure 22. The cost structure. The grid electricity is a cost in baseline scenario, but in the wind turbine scenarios it's an income.

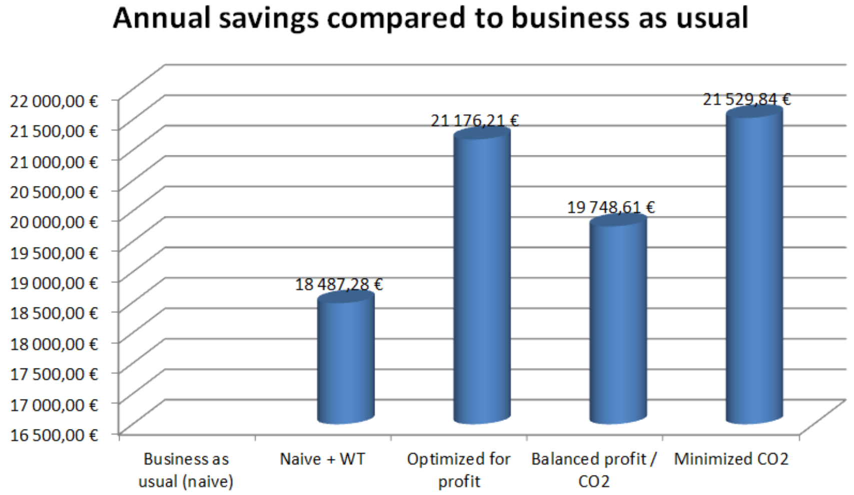


Figure 23. The yearly savings side by side (not inlcluding investments)

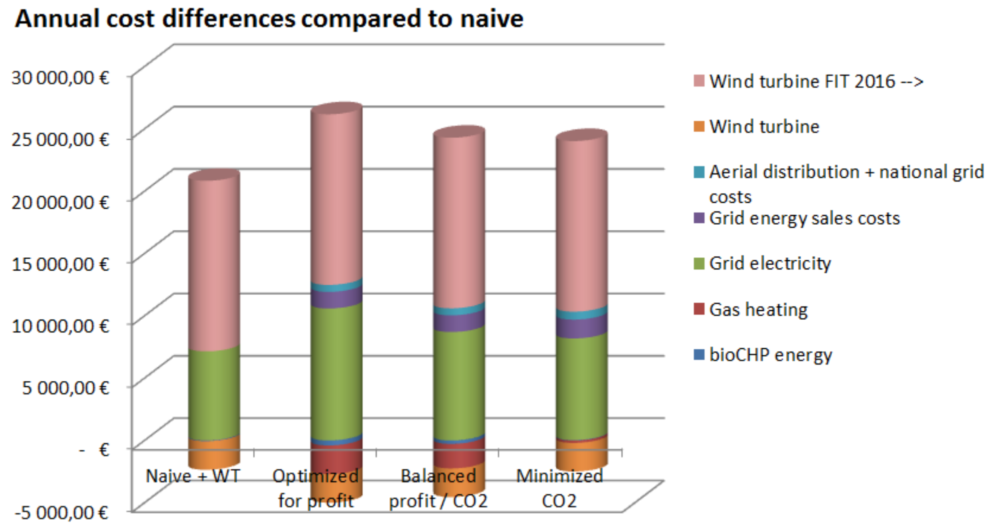


Figure 24. Differences in costs and incomes compared to baseline scenario. The largest difference is the income from the wind turbine feed in tariff, which distorts the market and prevents competition by the proposed business model

5.1.2.4 Cost calculations and annual savings

As the cost breakdown table below (Table 4) reveals, the optimised scenarios has savings in the sales costs and aerial distribution + national grid costs, which reflects the green slice in the donut chart in Figure21. It can be noted that the profit and balanced scenarios are using a lot more gas for heating, than the other scenarios. Unfortunately the wind turbine feed in tariff is not reasonable to expect to receive in the EMS scenarios where the national grid is bypassed for the wind turbine, in order to avoid the related costs (Figure 22 - 24). Therefore they are marked with red in the table, and the return on investment calculations are provided both with and without the FIT.

	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
Investment costs					
Battery: 0,15 MWh			43 634,48 €	43 634,48 €	43 634,48 €
Heat storage: 0,5 MWh			1 995,67 €	1 995,67 €	1 995,67 €
Wind turbine 3.3MW		78 711,11 €	78 711,11 €	78 711,11 €	78 711,11 €
Total		**78 711,11 €**	**124 341,26 €**	**124 341,26 €**	**124 341,26 €**
Annual operation and maintenance costs					
bioCHP energy	- 16 583,31 €	- 16 583,31 €	- 16 976,34 €	- 16 852,24 €	- 16 554,28 €
Gas heating	- 468,35 €	- 468,35 €	- 2 772,46 €	- 2 443,62 €	- 663,43 €
Grid electricity	-1787,49 €	5 360,69 €	8 797,80 €	6 911,08 €	6 364,60 €
Grid energy sales costs	-1 613,21 €	-1 643,70 €	-279,44 €	-275,11 €	-100,41 €
Aerial distribution + national grid costs	-682,70 €	-704,44 €	-119,76 €	-117,91 €	-43,03 €
Wind turbine operation		-2 294,66 €	-2 294,66 €	-2 294,66 €	-2 294,66 €
Wind turbine feed in tariff		13 686,01 €	13 686,01 €	13 686,01 €	13 686,01 €
Total	**-21 135,06 €**	**-2 647,78 €**	**41,15 €**	**-1 386,45 €**	**394,79 €**
Annual savings compared to baseline		**18 487,28 €**	**21 176,21 €**	**19 748,61 €**	**21 529,84 €**
Annual relative costs		87% lower	100% lower	93% lower	102% lower

Table 4 The energy supply cost structure, including incomes from spot market trading and feed in tariffs. The FIT for the optimised scenarios are not very reasonable, as the wind turbine typically is bypassing the national grid and serving the neighbourhood directly.

5.1.2.5 Return on investment scenarios

Battery prices, wind turbine feed in tariffs, and power market prices are all affecting the time return on investments. Therefore it’s justified to compare the simulated scenarios side by side, as in Table 5 below. They are all achieving annual savings, and the EMS optimised scenarios are significantly better at reducing the emissions. Based on the bolded values in the table, it can be concluded that the EMS is competitive on a market without distorting feed in tariffs, when the average power market prices are higher (as there is more to gain with tricky trading), but it requires also that the battery prices are lower. It’s probably just a matter of time when those conditions will be fulfilled.

The feed in tariff is not feasible to include for a wind turbine which mostly is disconnected from the grid and serves the EPN directly bypassing the transmission network cost overhead.

		Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
Spot 55,00 €	ROI with FIT (reduced battery price)	4,3 years	5,9 years	6,3 years	5,8 years
	ROI without FIT (reduced battery price)	16,4 years	16,7 years	20,6 years	**15,9 years**
	ROI with FIT (todays battery price)	4,3 years	9 years	9,7 years	8,9 years
	ROI without FIT (todays battery price)	16,4 years	25,4 years	31,4 years	24,2 years
Spot 30.80 €	ROI with FIT (reduced battery price)	5,2 years	8 years	8,3 years	7,4 years
	ROI without FIT (reduced battery price)	46,4 years	61,5 years	87,5 years	37,4 years
	ROI with FIT (todays battery price)	5,2 years	12,1 years	12,6 years	11,2 years
	ROI without FIT (todays battery price)	46,4 years	93,8 years	133,6 years	57 years
Spot 70,00 €	ROI with FIT (reduced battery price)	3,9 years	5,1 years	5,5 years	5,2 years
	ROI without FIT (reduced battery price)	11,8 years	**11,5 years**	14 years	**11,7 years**
	ROI with FIT (todays battery price)	3,9 years	7,8 years	8,4 years	7,9 years
	ROI without FIT (todays battery price)	11,8 years	17,5 years	21,3 years	17,9 years

Table 5. The annual average spot price level, the Li-Ion battery price and the wind turbine feed in tariffs are playing important roles in the return of investment calculations

5.1.3 KPIs evaluation

The key performance indicators that were defined in D3.1 Case study scoping, are also found in APPENDIX C. The KPIs.

5.1.3.1 On-site Energy Ratio and Annual Mismatch Ratio

The On-site Energy Ratio is defined as follows:

$$\text{OER} = \frac{\text{Cumulative energy supply from local renewable sources (heating \& electricity) MWh/year}}{\text{Cumulative energy demand (heating \& electricity) MWh/year}}$$

The Annual Mismatch Ratio is defined as follows:

$$\text{AMRx} = \frac{\text{Hourly local supply (by energy type: heating \& electricity) kWh}}{\text{Hourly demand during that same hour (by energy type: heating \& electricity) kWh}}$$

In the case of Omenatarha, the local bio-CHP and the simulated wind turbine production are considered as local renewable sources. The Figure25 below shows that the EMS optimisation significantly improves the On-site Energy Ratio. However, the annual mismatch ratio for heat is clearly bigger, since the heat production is not directly controlled according to the heat demand anymore.

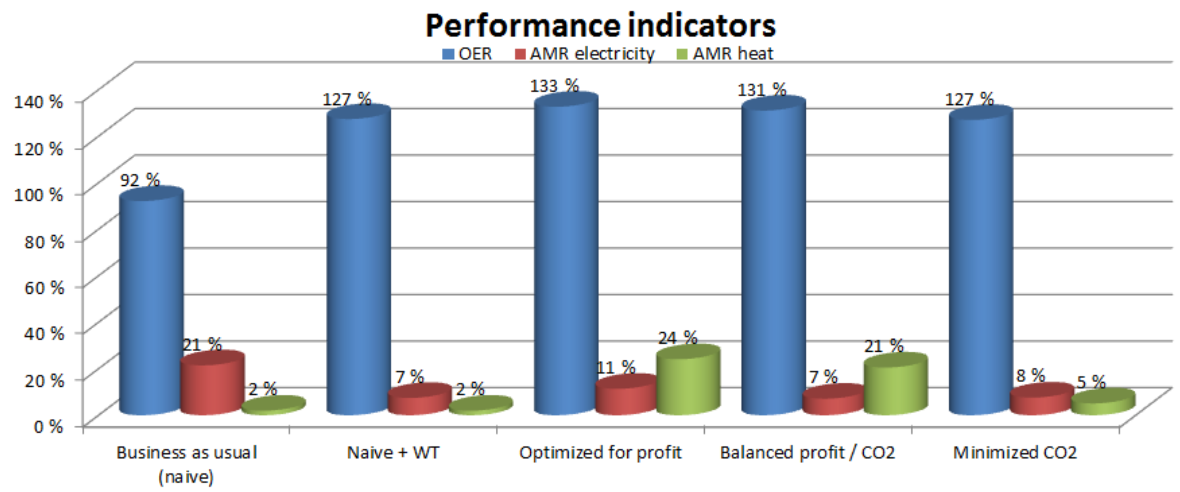


Figure 25. EMS impact on OER and AMR

5.1.3.2 Maximum Hourly Surplus

The Maximum Hourly Surplus is defined for each energy type as follows:

$$\text{MHS} = MAX\left(\frac{\text{Hourly local renewable supply} - \text{Hourly energy demand}}{\text{Hourly energy demand}}\right)$$

	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
MHS electricity	125 %	970 %	960 %	973 %	973 %
MHS heat	0 %	0 %	696 %	696 %	663 %

Table 6. The EMS optimiser has dramatically raised the maximum hourly surplus for both electricity and heat

The MHS electricity indicator has been calculated taking into account as local renewable supply source for electricity the CHP and the Wind Turbine.

The MHS heat indicator counts only the heat supplied by the CHP as local renewable energy.

5.1.3.3 Maximum Hourly Deficit

Maximum Hourly Electricity Deficit,

$$\text{MHD} = -MIN\left(\frac{\text{Hourly local renewable supply} - \text{Hourly energy demand}}{\text{Hourly energy demand}}\right)$$

The MHD electricity indicator has been calculated taking into account as local renewable supply source for electricity the CHP and the Wind Turbine.

The MHD heat indicator counts only the heat supplied by the CHP as local renewable energy.

	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
MHD electricity	92 %	92 %	100 %	0 %	0 %
MHD heat	41 %	41 %	100 %	100 %	100 %

For instance, the MHD heat for the baseline scenario has occurred during the highest peak in the

Figure26 below.

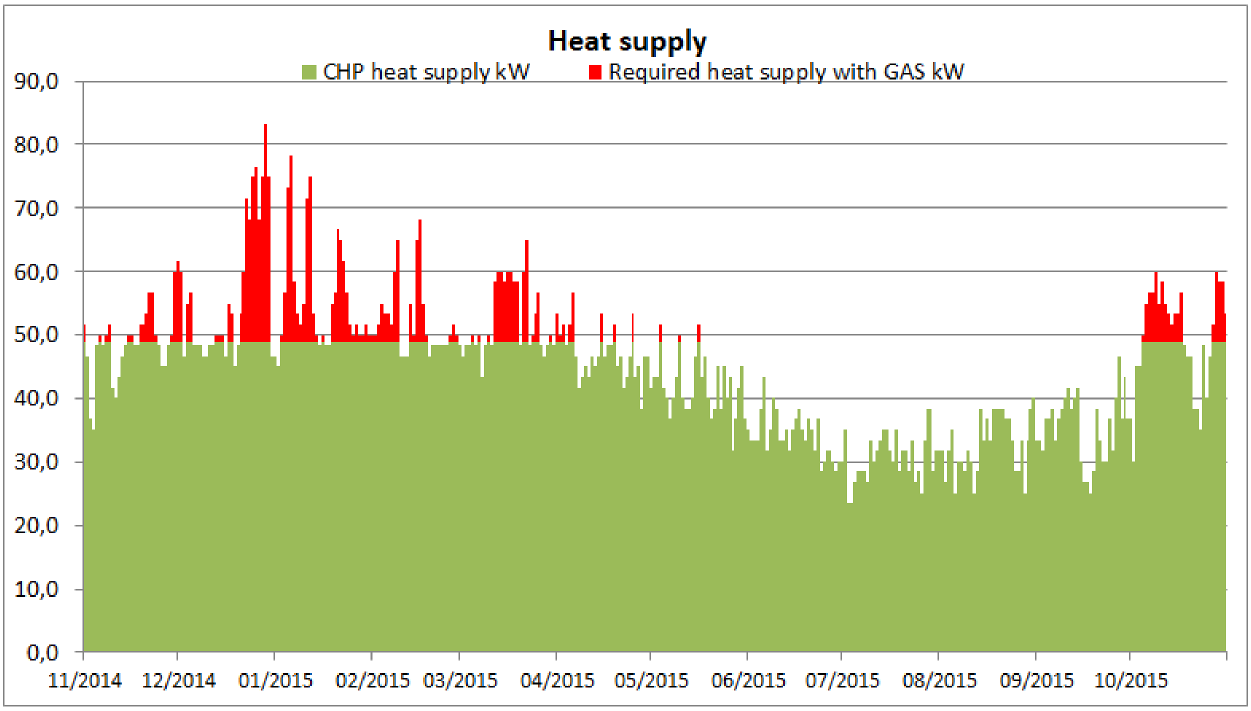


Figure 26. Heat supplied by local renewables (CHP, green) and assisted with bio-gas (red) during the largest demand peaks. This is the baseline scenario.

5.1.3.4 Monthly Ratio of Peak hourly demand to Lowest hourly demand (RPL)

RPL = Monthly Ratio of Peak hourly demand to Lowest hourly demand.

In addition to considering the overall annual energy balance it is important that the balance between supply and demand for different types of energy (i.e. heating, cooling and electricity) are taken into account along with the matching of the timing of the supply and demand of these different types of energy. The latter is necessary to avoid the challenges caused by peak demand hours particularly in relation to electricity. The measured values of extremum hourly demand (high and low) for electricity and heating are presented in Figure 27.

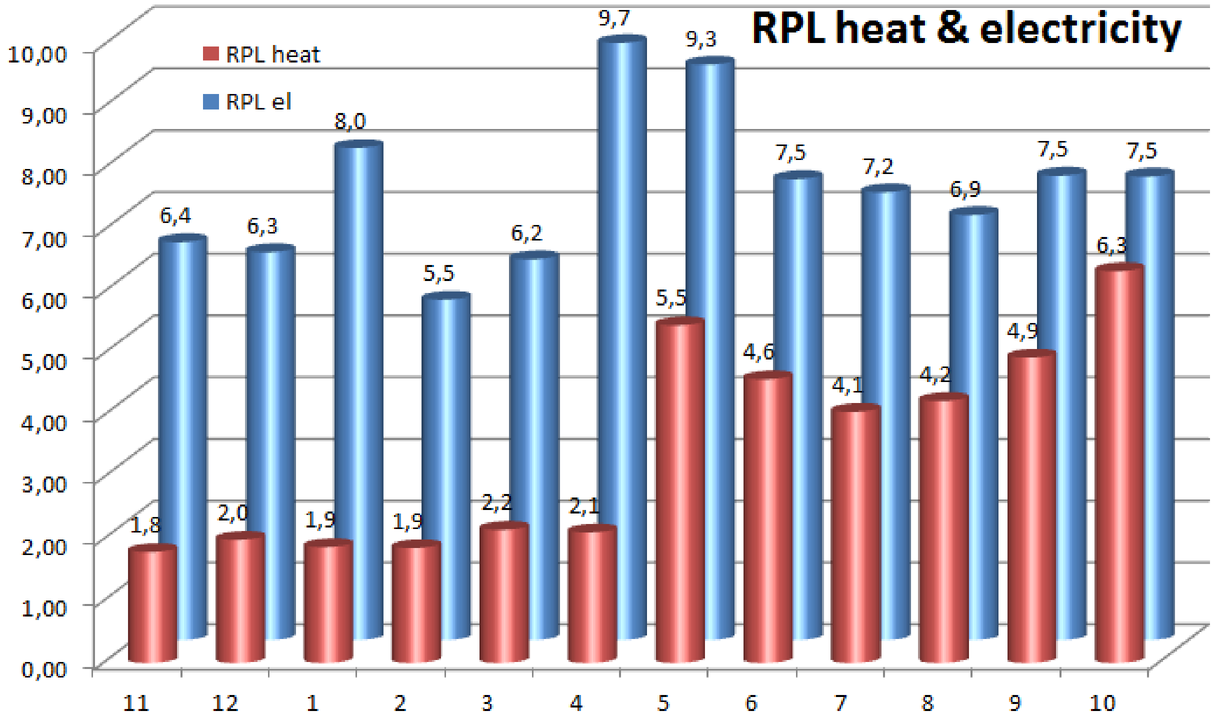


Figure 27. Monthly Ratio of Peak hourly demand to Lowest hourly demand evaluated for both district heat and electricity (Nov 2014-Nov 2015)

5.1.3.5 Low energy demand (compared to similar areas): heat

The annual heat demand of the Finnish pilot site is 60-65% lower than the national average for detached houses. Based on official statistics, Finland has 1165000 detached houses, with an average size of 109.9 m^2. According to Statistics Finland, the total annual heat demand of these houses is 31493 GWh, which equals to about an average annual heat demand of 27 MWh per house, or annually 245 kWh/ m^2 (Figure 28).

The Omenatarha pilot average house size is 160.9 m^2. The annual heat demand per average pilot house is 14 MWh, which means annually 86 kWh/ m^2 or in other words >60% less than an average Finnish detached household per area (Figure 29 & 30).

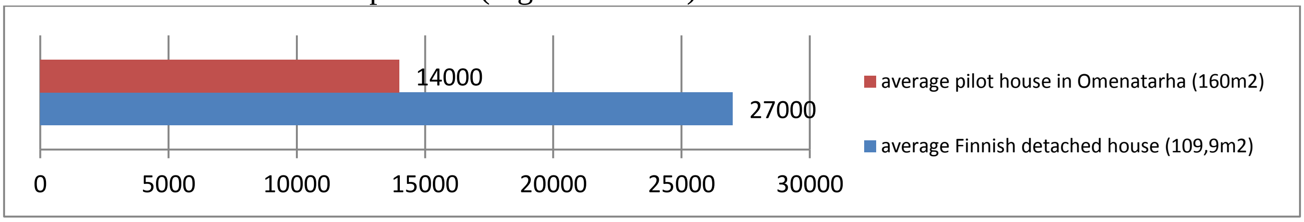


Figure 28. Annual heat demand of detached houses (kWh)

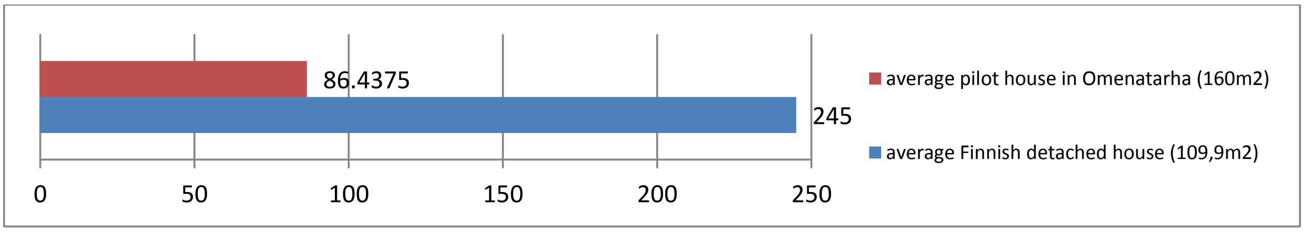


Figure 29. Annual heat demand per m2 (kWh)

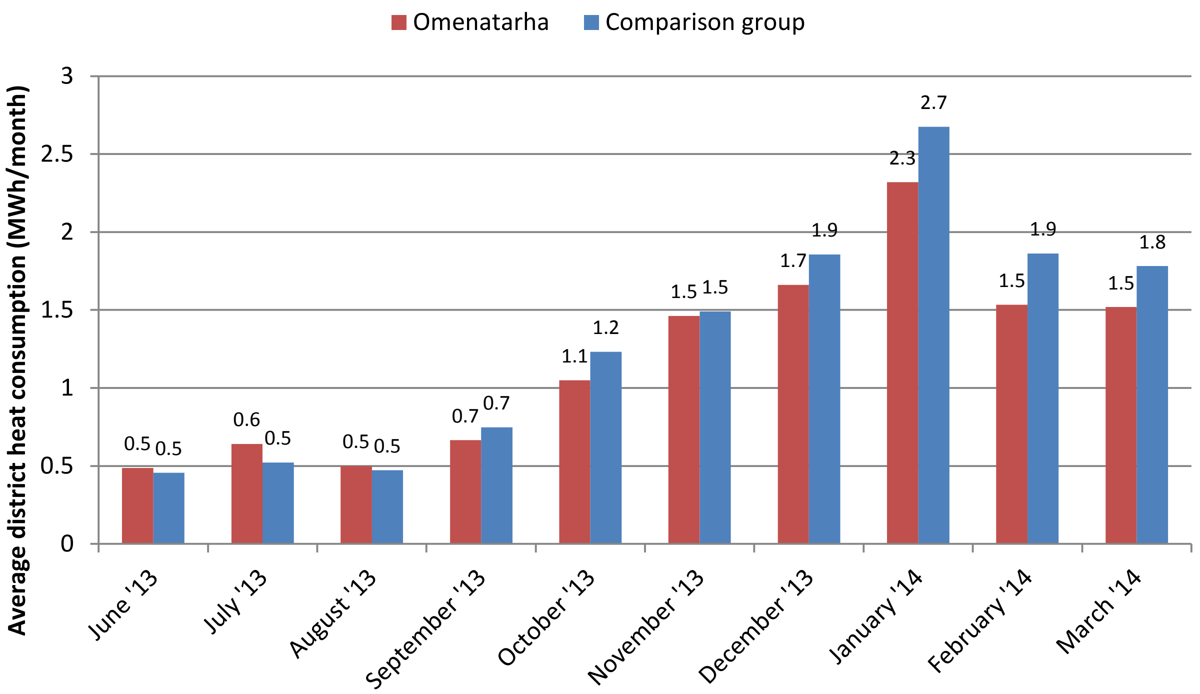


Figure 30. The heat demand of the pilot area is also slightly lower than the comparison households

5.1.3.6 Low energy demand (compared to similar areas): electricity

The annual electricity demand for the pilot site is 140 MWh, and with 61 residents it means annually 2.3 MWh/capita. For 23 households it means an average of 6.1 MWh / household (Figure 31 & 32).

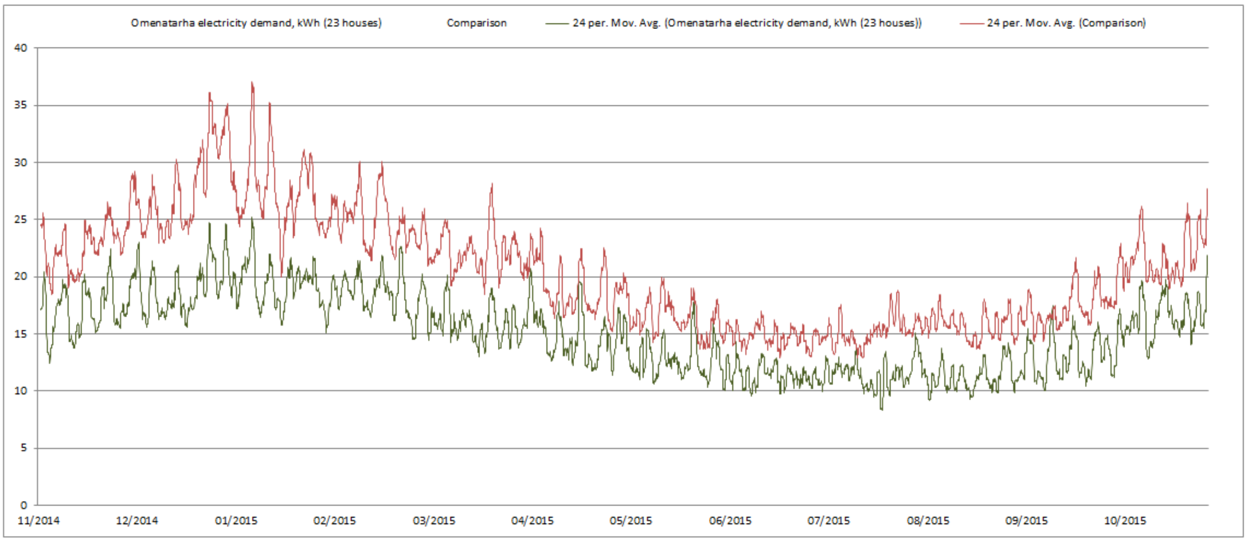


Figure 31. Pilot site household electricity demand versus a comparison group household (kW). An Omenatarha household has in average 25.9% less electricity demand than a comparison household.

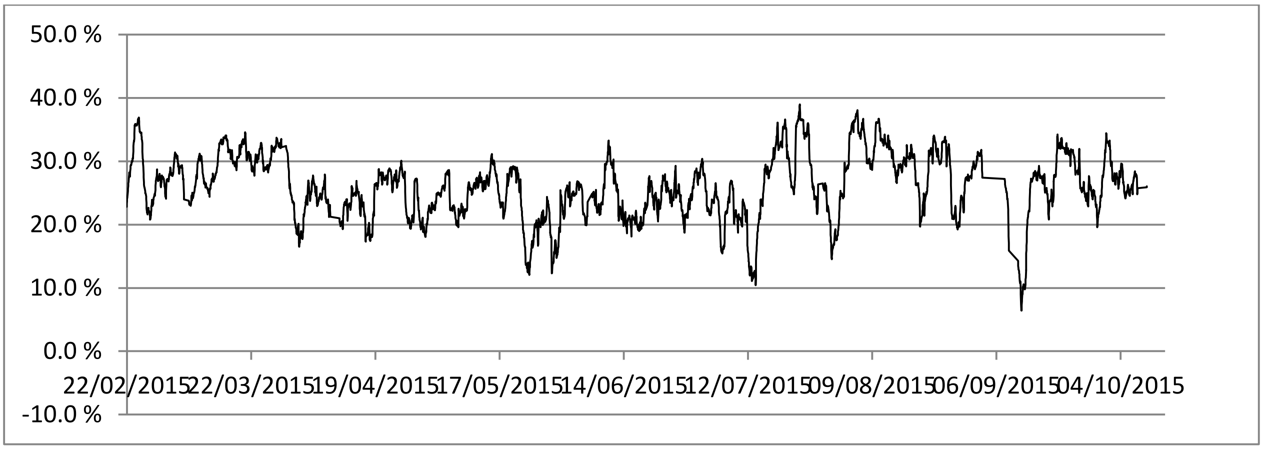


Figure 32. This chart describes how much less an average household of the pilot site consumes electricity, compared to an average comparison group household. The difference is neither significantly growing nor decreasing.

5.1.3.7 Transport of biomass

The transport distance of the biomass used for the CHP plant which serves the pilot, comes from within a radius of approximately 40-50 km from the plant, according to the suppliers.

5.1.3.8 Little environmental impact

The CO_2 emissions are 75% lower than the baseline scenario, and as much as 42% lower using the optimiser compared to the wind turbine without any optimiser or storage (Figure 33).

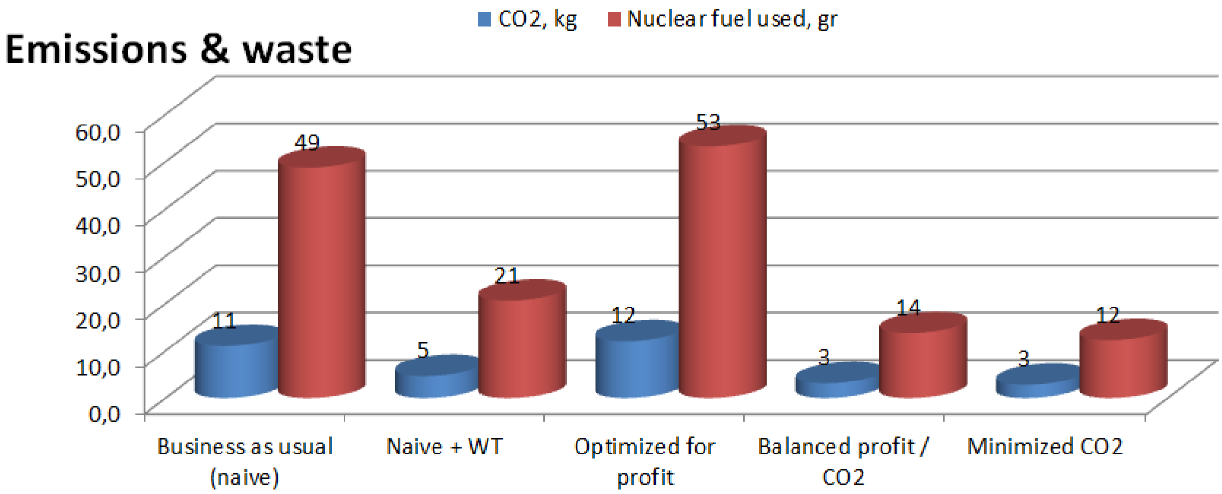


Figure 33. Emissions of the different scenarios. None of the bio-CHP, the gas, nor the wind turbine causes CO_2 emissions, only the purchased electricity from the grid are counted for emissions.

5.1.3.9 Energy positivity level indicator

Letter A+++-G.
The Omenatarha area has been evaluated to classify with an Energy positivity label “B”. The Energy positivity level is a classification of the OER value; where for the pilot group has an OER value of 98%. The classes are defined in figure 34.

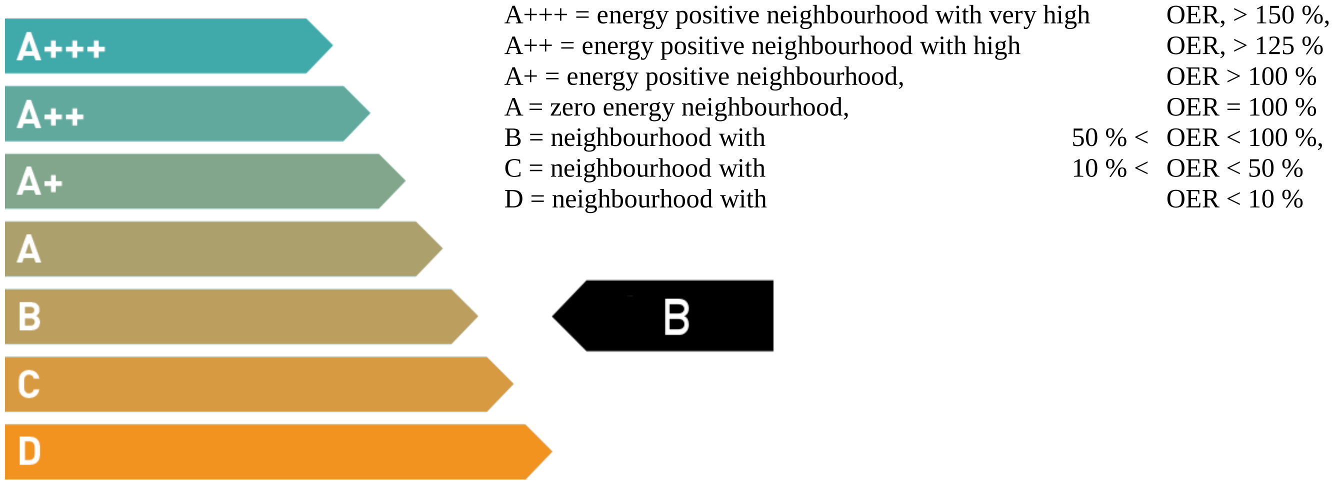


Figure 34. The Finnish pilot Energy Positivity level

To reach better energy positivity level, it would be necessary to produce more renewable energy on the area or to reduce the consumption.
Currently, already 92 % of the pilot site energy demand is produced from renewable sources on the area. To reach energy neutrality (A level), it would be necessary to produce 26 MWh of more renewable energy annually. This means e.g. about 215 m^2 solar panels for the pilot site.
To reach the best energy positivity level (A+++), it would require a 50 % overproduction.

	Business as usual (naïve)	Naïve + WT	Optimised for profit	Balanced profit / CO_2	Minimised CO_2
OER	92 %	127 %	133 %	131 %	127 %
Energy positivity level indicator	**B**	**A++**	**A++**	**A++**	**A++**

5.2 The Skaftkärr web portal

The existing web portal (Figure 35) was updated during the project to host IDEAS related information. The portal is in Finnish and its target group is the residents of Skaftkärr area, other local stakeholders and even all individuals interested in the energy efficiency. The purpose of the update was to generate a broad awareness of the IDEAS project and to facilitate a communication channel towards Omenatarha residents. For that purpose also a Facebook user Skaftkärr was created, as shown in Figure 36.

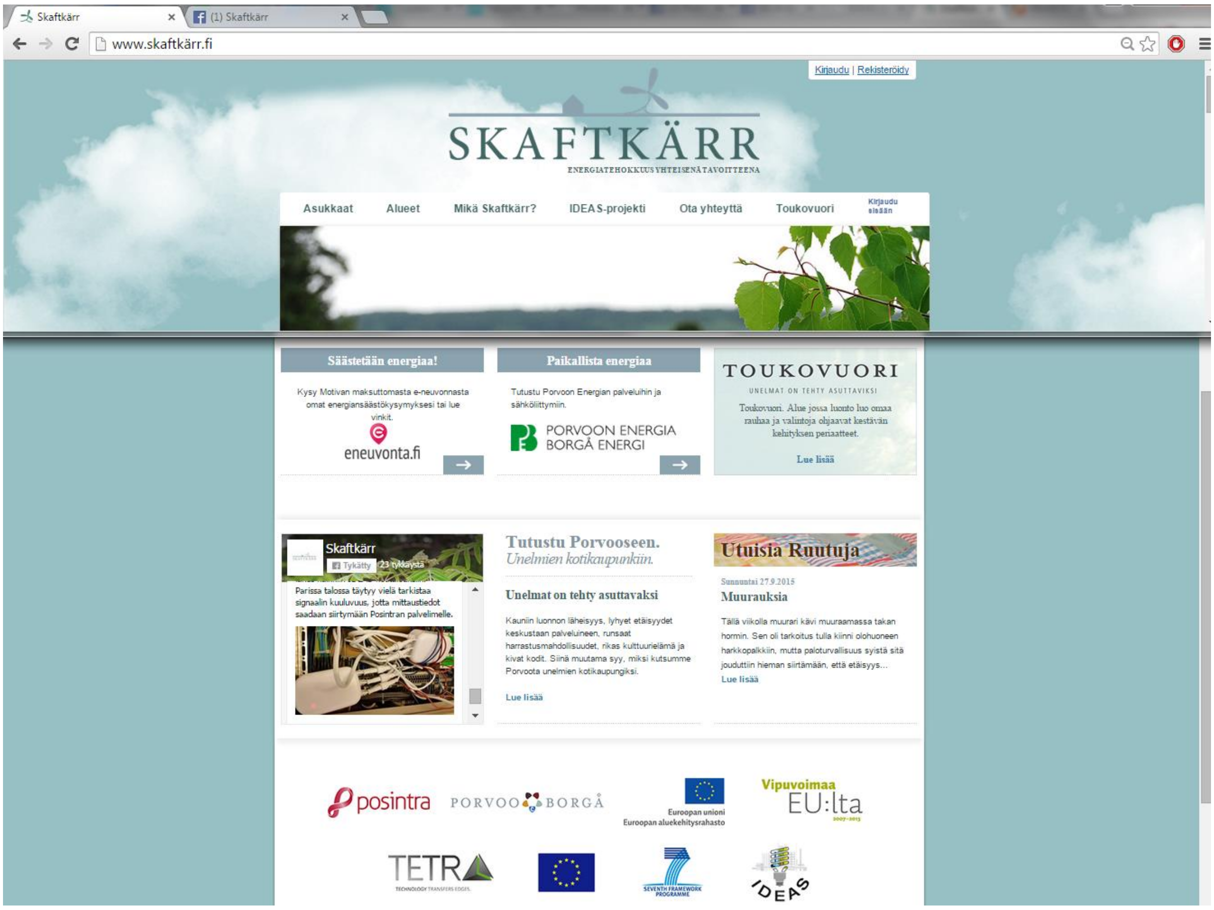


Figure 35 Skaftkärr web portal

During the project the information and other material related to energy efficiency was published mainly at the Facebook.

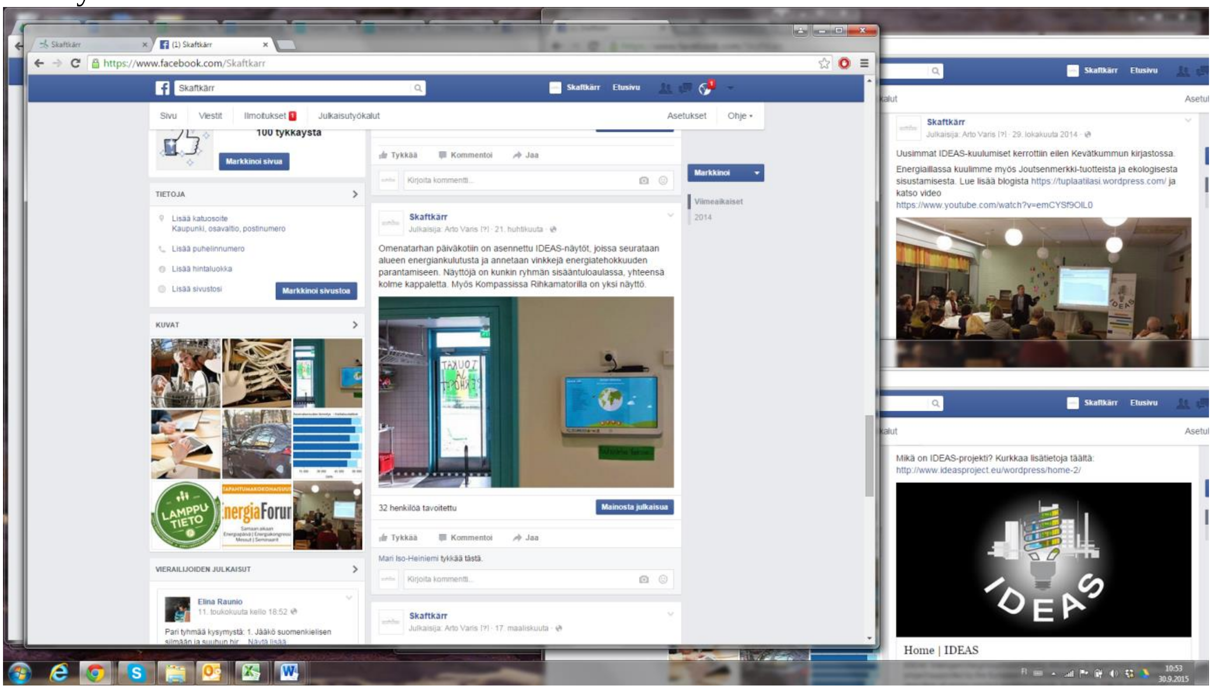


Figure 36 Skaftkärr at Facebook

The intention to boost the information flow during the test phase was not applicable and while the deployment was reported, the project delays in the application development were not greatly advertised.

5.3 The public screens, energy awareness interfaces

5.3.1 Omenatarha nursery school public screen

An appointment was arranged at 26th of May 2015 with CoP, POS and the Omenatarha nursery school staffs on nursery school site and the content of the three previously mounted public screens were introduced in-depth. In addition to the nursery school director, two other staff members attended the appointment.

The staff were guided how to use the screen, and how to find information about different levels (global, Finland, Porvoo, Omenatarha). They were asked to guide and encourage parents of the nursery school children to look for energy efficiency information via these screens. The staff had a very positive attitude to the experiment, since the Omenatarha nursery school has a focus on sustainable living and recycling.

5.3.2 Kompassi public screens

Another appointment was arranged with the Kompassi staff at 19th of May 2015. Three people from Kompassi staff attended (all who were available). The agenda was mostly the similar as for the nursery school staff, but with a particular emphasize on how the IDEAS-project supports the City of Porvoo goals for energy efficiency improvement and minimising of carbon footprint. The staff were advised to encourage the contact point visitors to explore the content of the public screens.

5.3.3 Public screen content survey

The perception of the public screen content was studied using a survey for the staff of City of Porvoo working in the Kuntatalo building, where the Kompassi citizens' service point is. 24 people responded to the survey, which was sent to all 92 people working in the building. The provided information can be considered very relevant, as 92% are interested in saving energy, and 88% are interested in using renewables energy, as seen in **Error! Reference source not found.**37.

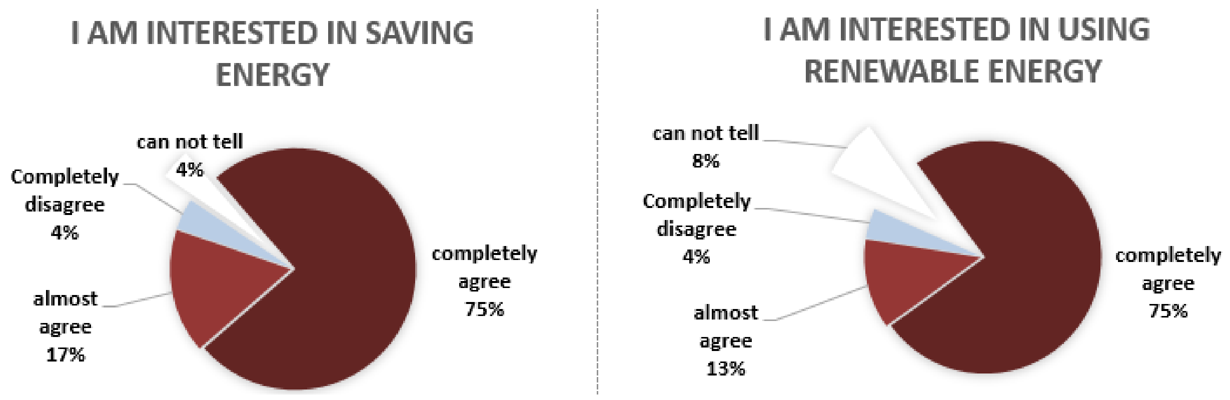


Figure 37. The attention of the audience

The content included new information for most of the people, and they found it interesting and inspiring, which can be seen in **Error! Reference source not found.**38. Only a fourth of the respondents did not find any new in information and only 4 % did not think it was interesting. A majority got inspired to get more information. The layout and navigation received fairly good feedback, which can be seen in Figure39.

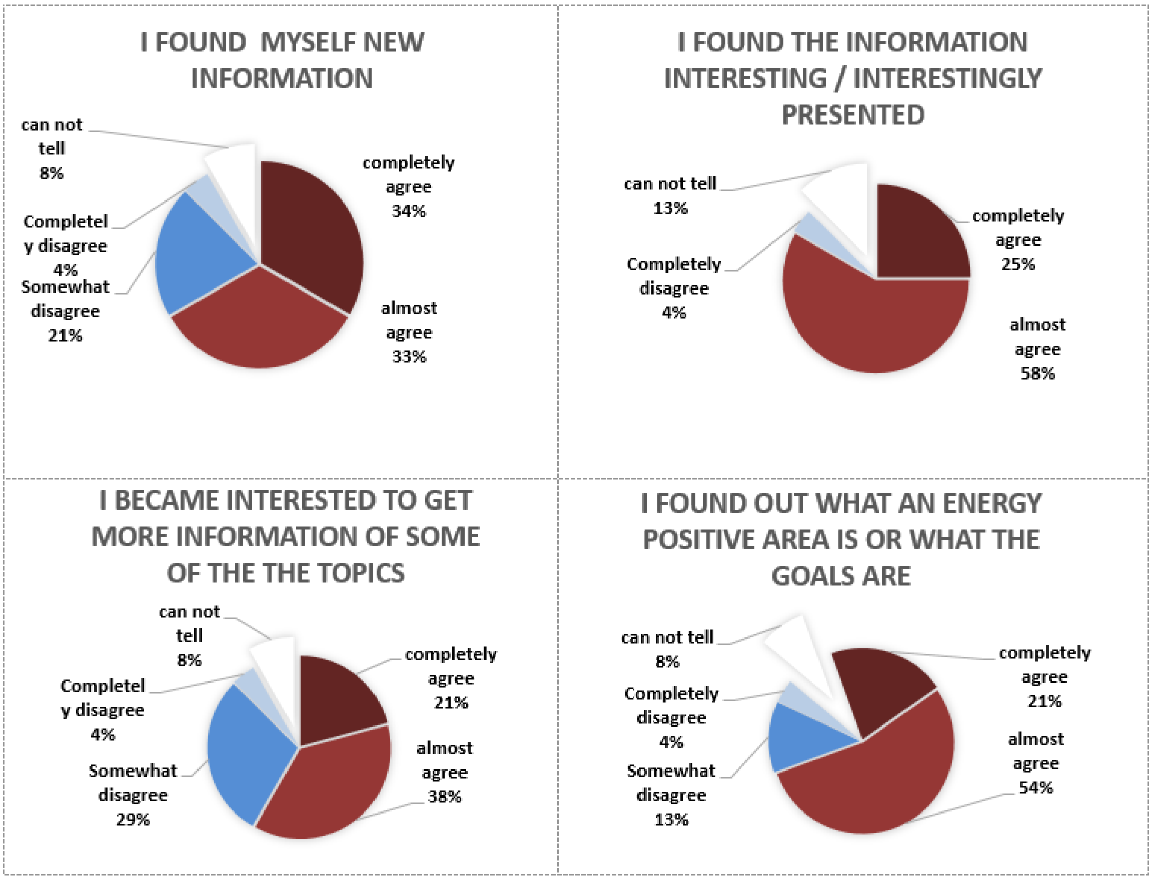


Figure 38. The usefulness of the content

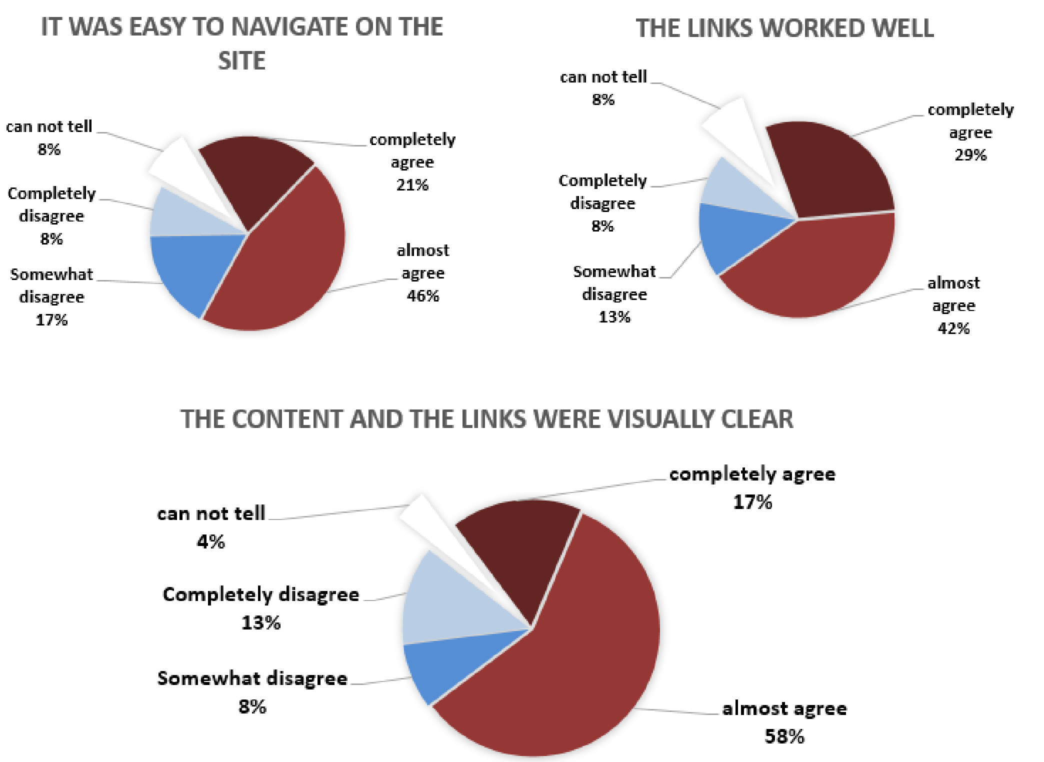


Figure 39. Layout and navigation

5.4 The HEA application for households

Five usability tests with the end-users, the residents in Omenatarha area, were conducted on 7th (two tests) and 9th (three tests) Oct, 2015. The purpose of the usability test was to evaluate the interactions of the end-users with the HEAA. The performance of the HEAA has been checked in terms of responsiveness and stability when the user performs different tasks. In concrete terms, the usability test evaluates the HEAA against the indicators of navigation, predictability, and the intelligibility of the interfaces.

Two facilitators from Posintra were present during the tests, except only one of them during test in Home 2. In addition, an observer from VTT was present during all tests to keep record on the events and the comments of the users, and gather feedback of the estimated effects of the application. From the residents, there was present either the master of the house (in Homes 2 and 3), the lady of the house (in Homes 4 and 5) or both (in Home 1).

Before performing the tests, a facilitator introduced the HEAA to the users by explaining the structure of the HEAA, the functionalities and the interaction with the interfaces by means of an example. The facilitator has also been present during the execution of the tests to measure the time spent in the realization of the tasks.

After each usability test an evaluation form has been completed, which includes the information regarding:

- Time spent: an amount of minutes.
- Task completion: yes or no answer.
- Scores for each usability indicator: between 4 (worst) and 10 (best).

The usability indicator scores can be affected by issues such as slow loading, erratic behaviour of windows, incorrectly calculated values and unexpected log-offs. They are relevant in terms of visualisation and understanding any displayed information. Essentially, the HEAA should enable a non-technical user to take advantage of the system.

The usability of the HEAA is evaluated in terms of:

- Navigation: browsing and selecting information to be displayed.
- Predictability: providing the expected views.
- Layout and graphics: organisation and structure of the interface, legibility of visual elements.

All the usability tests followed the same procedure, and the test results were very similar in most cases. Therefore the results of the tests are combined in the Table 6 below, presenting the findings and comments connected to individual tests.

Before running the usability tests, the facilitator installed the applications and connected the images with the relevant measurements, and explained the use of the application to the users. There was a problem with the connection to the EMS server on the second day when the usability tests were performed, so part of the information was not coming to the application, but instead the way the information would be displayed was shown to the users by screen shots from earlier visits. Because the tests had to be run in the connection of installation of the system, very few data was available in the HEAA graphs, but the users were able to understand how it would look if more data was available. This was supported by showing screen shots from test appliance, where data had been received for longer period. The tablets began immediately after setup to collect own history, and they were left for the users to use.

STEPS	FINDINGS AND COMMENTS
STEP 1: The resident opens the application.	Home 1 & Home 2: The application did not start at first try. Home 3 & Home 5: The application started easily and quickly. Home 4: There was no connection to the Wi-Fi when the user first tried, although it had been working just a minute ago, when the facilitator demonstrated the use of the application. After a while the connection was re-established, and the HEAA could be easily found and opened.
STEP 2: The user finds out if there are notifications.	The notification could be easily located on the screen, but during the tests in Homes 3, 4, and 5, the connection to EMS was down, so there were no notifications. The users were shown an example of the notification as screen shot from earlier tests.
STEP 3: Finding the notification, opening it, and finding out when the action is pending.	The notification was in general easy to find and open. In Home 1, there was a user with less experience on using touch screen applications, and it was not at first intuitive that the notification banner needs to be clicked to see the advice. During the tests in Homes 3, 4, and 5, the connection to EMS was missing, so there were no notifications available. The user was shown an example of the notification as screen shot from earlier tests. According to the users, if there was a notification, they could have found it easily, and also would have been able to find the advice. Their first reaction in fact was to click on the banner, causing an empty notification field to appear on the screen.
STEP 4: Show the demand history of the appliance. Home 1: The demand history of the dish washer was looked at. Home 2: The demand history of the dish washer and the oven was looked at. Home 3: The demand history of dishwasher, oven, sauna, plug 2 and plug 3 was looked at. Home 4: The demand history of the oven was looked at. Home 5: The demand history of the oven was looked at.	This information was easy to find in all cases, but due to the short time from installation, there was no consumption to be seen in most cases. Home 2: The user noted that it would be very interesting to see the consumption history of the car heating (which was currently not displayed for this house). In Home 3 the application showed consumption even if the oven was turned off. The resident instantly had a plan on how to find out if this was correct information or not. This raised also discussion of the potential benefits of the HEAA: one could see if there is some unexplainable constant consumption that could be addressed. This is facilitated especially with the three movable plugs. With the help of the HEAA, e.g. the stand-by power of TV and computers could be easily visualised to the family members, and underline the need to completely turn off the devices during night-time and absence. This was also discussed during other visits.
STEP 5: Finding out the current consumption of an appliance with the help of the AR feature. Home 1: The current demand of the dish washer and the house was looked at. Home 2: The current demand of the dish washer and the oven was looked at. Home 3: The current demand of dishwasher, oven, sauna and the whole house was looked at.	Home 1 and 2: The application crashed at first attempt, but on the second attempt it opened quite quickly, taking a bit more time in Home 2. Home 3: The feature was easy to find and opened relatively quickly. Easy to use. Home 4: It was not very intuitive that the image of the camera needs to be clicked to use this feature. But once it was found, the application opened quite quickly and was relatively easy to use. Home 5: The image of the camera was not found at first glance. When it was found, it opened relatively quickly, and also the image recognition did not take extensive time. The need to keep the camera pointed towards the tag was not intuitively clear, but the user soon

Home 4: The current demand of the oven, plug 1, plug 2 and plug 3 was looked at. Home 5: The current demand of the oven was looked at.	understood that this needs to be done to see the consumption meter. This step required a lot of imagination from the users, as real image recognition was not available, but instead some tags had to be used, and for the test they were not even attached to the real appliances. It was however relatively easy for the residents to use their imagination and understand how it could work, and how e.g. Google glasses could be used to find the current demand of different appliances. There was also a lot of discussion of the usefulness of this feature. It was quite evident for the users that if the appliance is in use, there is consumption, and no need for seeing it on the hand-held device (or Google glasses). But quite quickly the users did find some use for this application too: they thought that it could be very useful in finding unexpected consumption, or faults in the appliance on one hand, and basic consumption on the other hand, e.g. the level of stand-by consumption of different appliances. But using this for fault detection would entail information about normal behaviour of the appliance. It was not very evident for the users why it would be interesting to compare the current consumption to the consumption history of the appliance.
STEP 6: Looking if the area has been energy positive during previous 24 hours (in the imaginary case that it is fed by the simulated wind turbine).	All of the users could conclude that the area had been energy positive during the previous 24 h (energy consumption of 23 households 211 kWh, simulated renewable production 352.16 kWh). This information was easy to find, by comparing the 24 h consumption of the area (23 households) to the 24 h production of the simulated wind turbine. In some cases (Home 2 and 4) the users tried to click on the icons to find more information. During the tests in Homes 3, 4, and 5, the information from EMS was not available, so the users were again shown the screen shots from previous tests, to simulate this step.
STEP 7: Looking at the 24 h energy cost of the house.	This information was easy to find for all the users. Most of them were interested to see longer time history. This is available through the Asemo service, the use of which was afterwards checked with them. Home 3: Because the coffee machine and air conditioning was on during the test, there was even some consumption to be seen in the graph. The resident noted that the average consumption of the individual household would also be an interesting figure, for instance for one and two weeks, and one month.

Table 7. Work flow and findings from the user tests

5.4.1 Usability test results

The following table presents the results of the usability test.

Values	**Time spent (minutes)**	**Tasks completed? (N/7)**	**Navigation (4-10)**	**Predictability (4-10)**	**Layout & graphics (4-10)**	
Usability test						
Home 1	5	7/7	9	8	7	
Home 2	7	7/7	8	10	10	
Home 3	10	5/7	10	6	-	
Home 4	10	5/7	9	10	10	
Home 5	4	5/7	9	10	10	
Average	7.2	-	9	8.8	9.25	
Positive comments after completing the tasks:	Home 1: In general quite easy to use. The images with own appliances and home makes the application feel very personalised and familiar, makes it feel that this is really about our own house and own consumption. Home 2: Easy to use, nice to have images of own devices, makes it very intuitive to find the right consumption history. Home 3: The look is simple, functional and does the trick. (Instead of number, the user wanted to give this as statement of the layout and graphics, because he was a professional in the field of designing graphics for digital devices, and felt uncomfortable to give numbers to people in same position.) Home 4: The historical demand for the appliances is very easy to find due to the images of real appliances. Home 5: Very easy to use, even for non-technical person.					
Negative comments after completing the tasks:	Home 1: For a non-technical person it was not evident that the banner needs to be clicked to see the advice related to the notifications. The application seems not to be completely finished yet, it does not function very reliably. Home 2: There could be more devices connected to the application. Home 3: It is not very practical to have this information in separate device. Instead, this should be developed towards an application that is available for many devices that are in daily use, e.g. the phone or PC. It would be better to have calibrated, “normal” limits for the consumption, instead of momentary consumption compared to					

	history. With this function, you could also check if the appliance in working like it should. There could be even more information available, e.g. more information on historical development. Home 4: The camera is maybe not the most intuitive image for the AR feature, and maybe also not placed in most evident part of the screen.

Table 8. Table of test results from the usability tests

5.4.2 Potential effects of using the HEAA

The results in this subchapter are merged from both the on-site interview of five residents and the extended online survey for usability (with 49 respondents) which took place on SurveyMonkey. The presentation is structured with a qualitative description of the visited residents first, followed by a corresponding pie chart representing all the online survey answers for the same question.

A selection of the questions related to the potential effects of HEAA:
If you had such application in use, do you think that you would have read the notices given by the HEAA, in scale 1-5 (1=always when possible; 2= often; 3=sometimes; 4=rarely; 5= almost never). Out of the 49 respondents, 2 skipped this question and 7 comments were recorded (translated into English):

I live in a rented house so I cannot use such an application; reminder date must be when people on average are at home; I believe that the initial enthusiasm still feeling like I must pay frequent attention, but in the long term it would be gradually less; at least initially; because of our own economic use of solar panels and wind power plant, we use electric mains electrical devices, if necessary, so during the period 18-22 utilization of grid electricity likely anyway; because this is a separate device, I say 4. If I would receive notifications to email or some other social media device. Therefore 4, rarely; especially if the advice is related to energy price.

After analysis the average response was 2.2, therefore the notices are viewed as useful on the application.

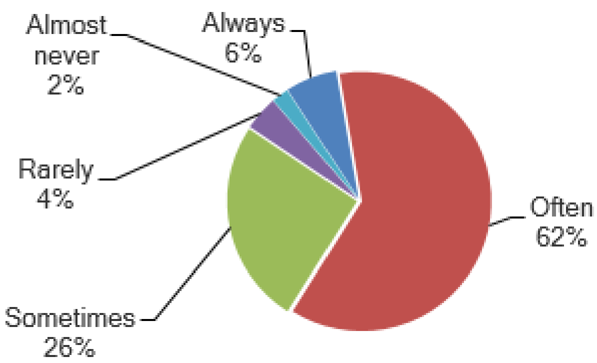


Figure 40. Most of the respondents do think they would have read the notifications provided by HEAA. The chart includes data combined from the extension survey results (n=49)

Do you think you would have shifted your energy use according to the advice given by the HEAA, in scale 1 to 5? (1=always when possible; 2=often; 3=sometimes; 4=rarely; 5=almost never).

In response to this question, only one respondent skipped the question, and 4 comments were recorded (translated into English):
I would be ready to transfer energy at a better time, but it is not possible when you live in a rented house, and I cannot wash the laundry for example at night when you have neighbours; Consumption should be able to compare the costs and tell us what is cheap electricity price compared to “normal”; I believe that the application would change use of some, for example, use of washing machines. However, I believe that, for example, began to use the sauna to plan on the basis of these; If I don’t have to take immediate action, I would follow the notifications. I could e.g. program the dish washer or washing machine, if there are cost benefits. I could even sometimes follow the timing recommendations for sauna. All this assuming that the notifications would come to suitable device. There is no price limit which would trigger action; the thought is more on the long term cost benefits available.

After analysis the average response was 1.8, therefore, the respondents would almost always shift their energy use according to advice provided by notifications from the HEAA.

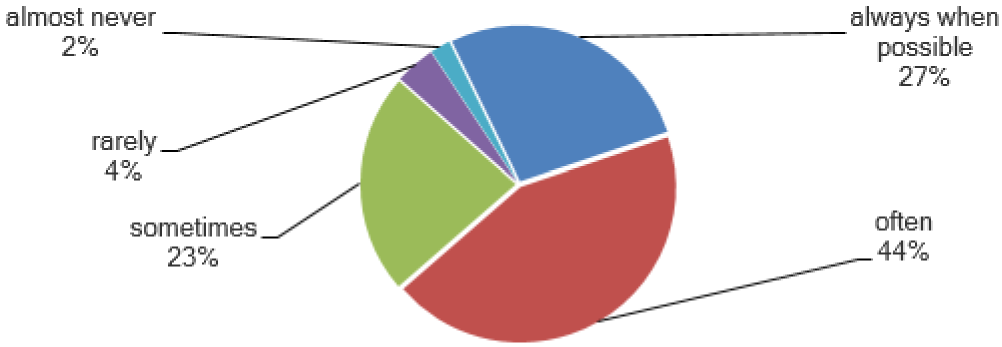


Figure 41. People are ready and willing to shit their demand based on provided notifications. (Chart includes data from extension survey n=49)

A third question related to HEAA was: Do you think that information about your energy use would have an effect on your energy usage habits? (1=reduced remarkably; 2=reduced slightly; 3=no effect; 4=increased slightly; 5=increased remarkably).
In response to this question on 1 respondent skipped the question and four comments were recorded (translated into English):
The reference point for consumption must be visible on the same screen; I will try now to minimise my use of energy, so that the information would not have an impact on energy at my disposal; yes, I would think, if I could see immediately how, for example, a computer on at night, I ensure to go and check to turn it off; I think it would be beneficial if it is shown in concrete terms (=money) how much can be saved.
Following analysis an average response was 1.6; therefore, the respondents’ behaviour would be greatly affected by the HEAA.

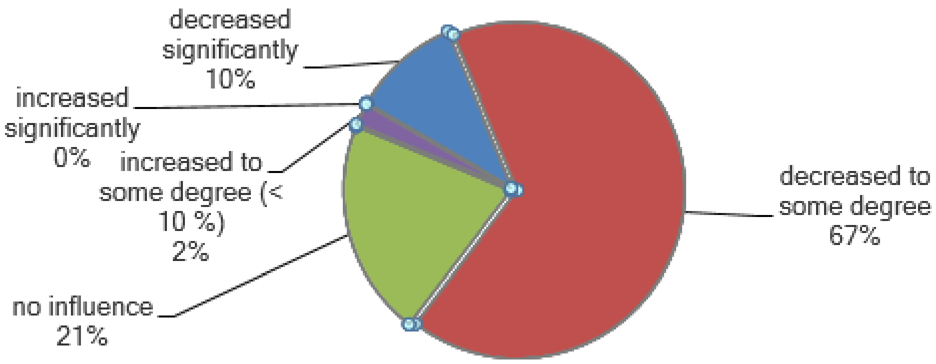


Figure 42. Three out of four think that their energy usage would decrease slightly or significantly by improved awareness of own consumption. (n=49)

A final question that related to HEAA that was asked: how useful would such a mobile application be which displays the current electricity consumption of different household appliances by aiming at them with the camera of your phone? (1=very useful; 2=somewhat useful; 3=not very useful; 4=not useful; 5=not useful at all).

In response to this question, 4 respondents skipped the question and 6 comments were recorded (translated into English):

Should know what is the average, responsible for machine consumption and/or what is the best class of the machine consumption; if any of the device must be used, then use it as energy consumption; I do not think that in the long run such endure to do. Momentarily pretty nice information, however, would be more convenient if all information can be viewed at one time would have a very basic screen, the weather this kind of a black art; after all, it is of course nice to know, but the device consumes electricity which it consumes, and it can do nothing if (e.g. the microwave probe) wants to eat the food warm; I prefer to buy efficient energy devices and use them as normal. (If the device must be used so as instantaneous fuel consumption is not terribly relevant); used mainly in the case if you need to identify deeply rooted in our economy of energy to run e.g. in some way defective and therefore less efficient household appliances.

Following analysis, the average response was 2.8, indicating that the respondents believed a mobile application device would be increasingly useful.

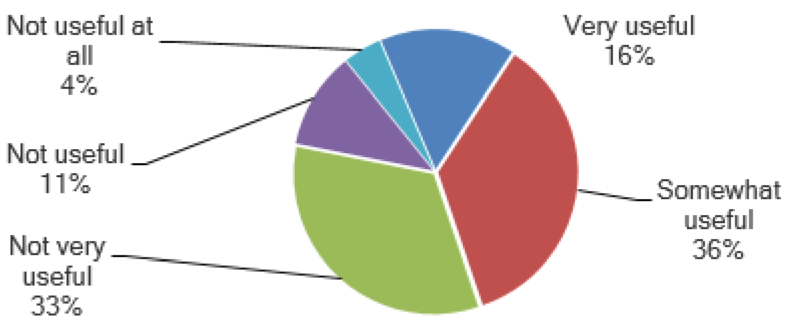


Figure 43. A slight majority of the respondents think that the approach with augmented reality used on a mobile device is useful. (n=49)

A final question related to the business model:

In Finland very few people invest in PV panels and other renewable energy technologies for their homes. Another approach to enabling people to invest in renewable energy production is community energy projects, joint procurements. In community energy projects, a co-operative approach is taken, the investors live in the area where the investment takes place; they not only have a financial return, but also benefit in-kind, e.g. they have access to renewable energy for free or at a lower tariff than the open energy market. Do you think such business model would increase the interest of Finnish people to invest in local renewables, when no installations are required at home? (1=significantly more interesting; 2=slightly more interesting; 3=no influence on interest; 4=slightly less interesting; 5=significantly less interesting).

In response to this question, 4 respondents skipped the question and 6 comments were recorded (translated into English):
We need to discuss more, and presents research results to the public. The current argument based on nuclear power and energy policy in Finland to bet undermines debate and the development of activities; if energy will become viable and the market should be able to the job. I do not think the need for joint activities; everything is ultimately attached to the bottom line. Maintenance of the common system could be costly though kWh would be cheaper. Is there a reasonable payback period (e.g. the equipment is paid for itself in before you have to replace one); through joint purchases for the price it is what could make the case interesting. Such a concept of marketing requires some more work than, for example, be fitted to your roof panels the order; interesting for my own account at least, can't speak in general for Finnish people; might have a positive effect.

Following analysis, the average response was 1.8, indicating that the respondents believed the business model could increase the interest of Finnish people to invest in local renewables.

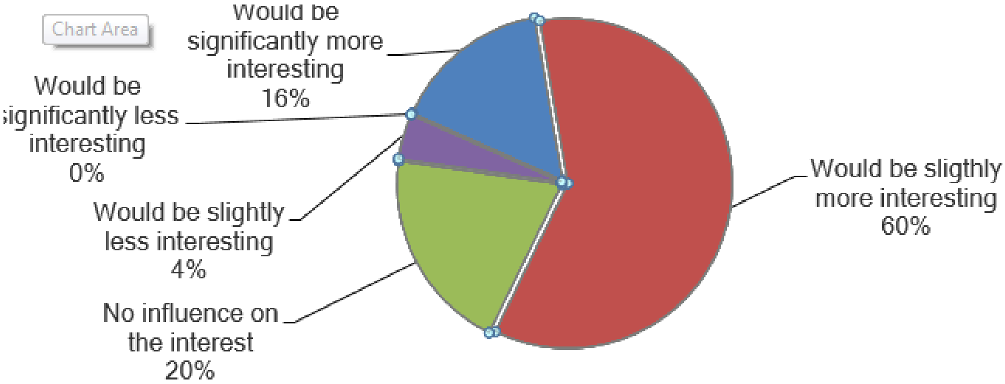


Figure 44. This result underpins the proposed business model of EMS + DREG. People would prefer joint procurement of local renewables, instead of for instance PV installations on own rooftops. (n=49)

5.4.3 Conclusions of the HEAA usability

The overall attitude of the end-users was very positive. They were mostly convinced that this kind of application would have been used and useful for them for timing their energy use, mostly related to costs. They also thought that the longer use for the application would influence their energy usage, and reduce it further. Many of the respondents noted, however, that the effect would be limited, because they already have reduced their energy use to minimum. As a conclusion, it can be said that the biggest effect of the HEAA for EPN would come through the notifications and the following peak load reduction, and timing of the residents' energy use according to availability of renewable energy, provided that this is guided by the energy pricing.

In general the HEAA seems to be relatively easy to use, and intuitive even for non-technical users. The users seemed to appreciate especially the feature that the images in the buttons presented their own appliances rather than just and representative. It made the HEAA personalised, and reminded that it is question of their own house and appliances. The usefulness of the AR feature was not evident at first glance, but the residents could imagine some ways they could use it to further reduce their energy usage.

One of the users noted that it is not very practical to have this information in separate device. Instead, this should be developed towards an application that is available for many devices that are in daily use, e.g. the phone or PC.

5.5 Current levels of energy awareness

An administered survey was used to identify pilot participants' awareness of energy issues was conducted in 19 households during equipment installation visits. It can be concluded that the residents do overestimate their electricity costs and energy required to perform everyday tasks in the households such as running the washing machine. This means an improvement in the energy awareness may even cause more ignorance to the electricity consumption, which thereby may increase. This chapter describes the interview results in more detail.

5.5.1 The households

The typical pilot household is a family with young kids. 15 of the 19 respondents were men and the average age was 38 years (n=12). The average household size was 2.7 residents (compare to the national average household size 2.04), and the size distribution is shown in Figure45.

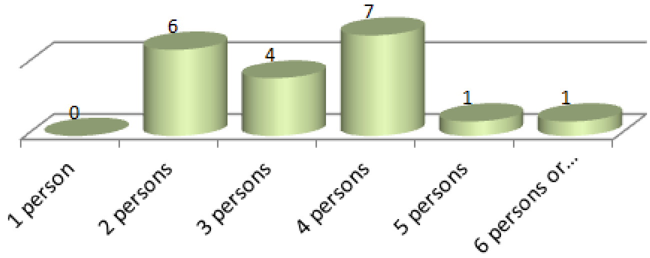


Figure 45. The household sizes of the pilot area

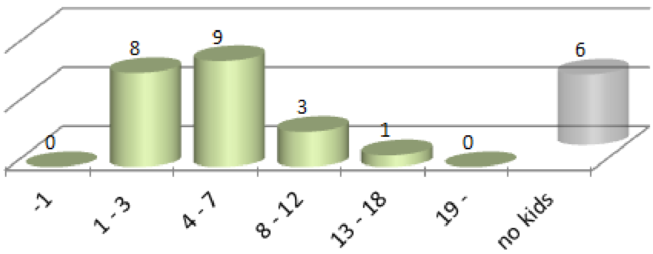


Figure 46. The age distribution (years) of the children in Omenatarha.

The pilot site has 63 residents (n=19). The average detached house size in Finland is 109.9 m^2, and the corresponding average size of pilot site houses in Omenatarha is 160m^2 (46% larger). All of the pilot houses have their own sauna.

5.5.2 Habits of following bills

The habits of monitoring bills are exposed through the questions in Figure 1 below.

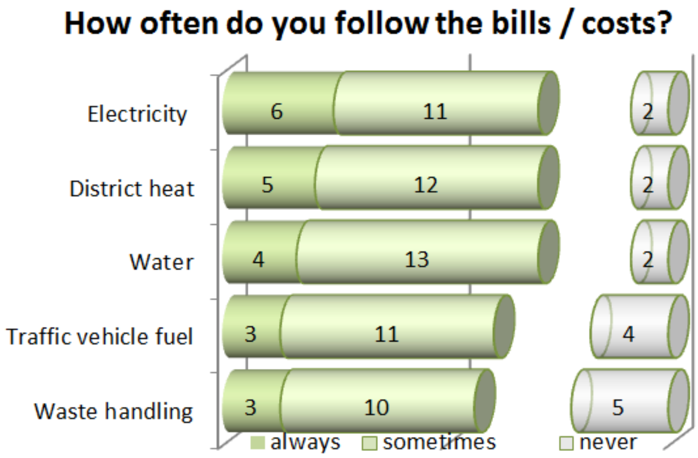


Figure 1. The habits of following bills

5.5.3 Omenatarha district heat demand awareness

The respondents were asked to estimate how much less heating energy per residential square meter the Omenatarha households consumes, compared to average Finnish detached houses. The correct answer, 60%, was described in chapter 5.1.3.5 on page 29. The answer would obviously surprise the residents, which Figure 2 reveals.

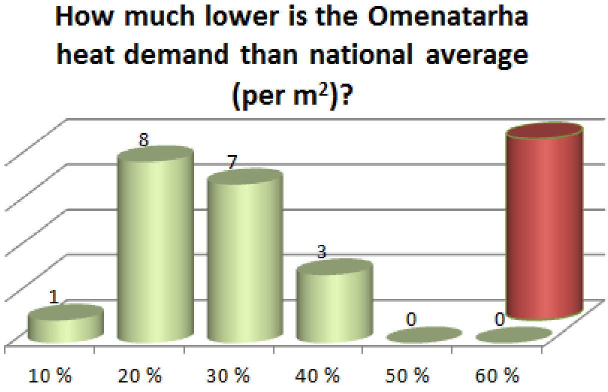


Figure 2. How much less residents believe an average Omenatarha house consumes heat energy, versus an average Finnish detached house (annually per square meter).

The residents had also to estimate their own average annual district heating costs for Omenatarha. The annual heat energy cost is roughly 800€ for an average pilot household (but there's an additional fixed 358€ power fee for the subscription, which explains why many have answered the following higher alternative).

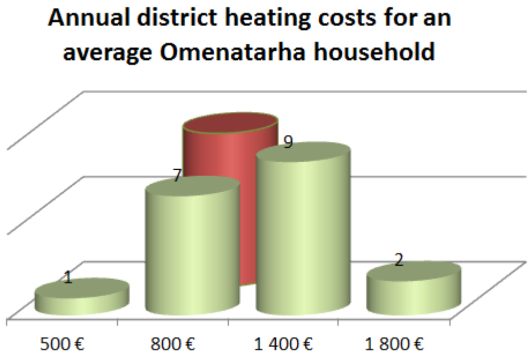


Figure 3. The resident awareness of an average Omenatarha house annual district heating costs

5.5.4 Omenatarha electricity demand awareness

The respondents had to estimate how much their annual cost for electricity is (Figure 50), and most of them did overestimate the costs. An average Omenatarha household consumes annually around 6100 kWh electricity.

This number can be used in a typical energy agreement, the PBE Original (provided by PE), to get a cost sample. The fixed subscription fee (for 3x25A) is 11.72 € / month and for each kWh consumers need to pay additionally 0.0971€/kWh (it consists of 0.066 €/kWh for the energy + 0.0311€/kWh transmission). These prices include VAT 24%. This will give 6100 kWh * 0.0971€/kWh = 592€ for the energy, and additionally 12 months *11.72€/month = 140.64 € for the subscription. The respondents did overestimate their annual electricity costs which in average is 732€, but a majority expected it to be over 900€.

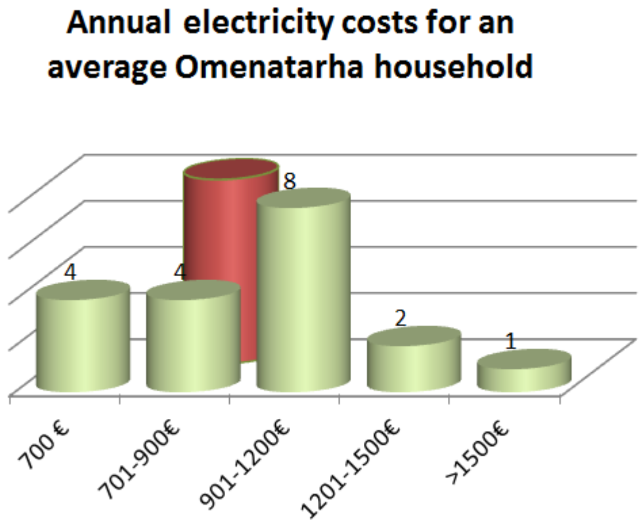


Figure 4. The resident awareness of a typical Omenatarha house annual electricity costs.

A clear majority of the residents do overestimate the cost of using a home appliance such as washing machine, which can be seen in Figure 5. The typical answers were around 5 times bigger than the true cost. A normal washing machine consumes about 850 kWh energy to run a 60 °C coloureds program with 4 kg laundry. The current total cost for consumers for electricity is roughly 0.10 €/kWh, which would mean 0,085€.

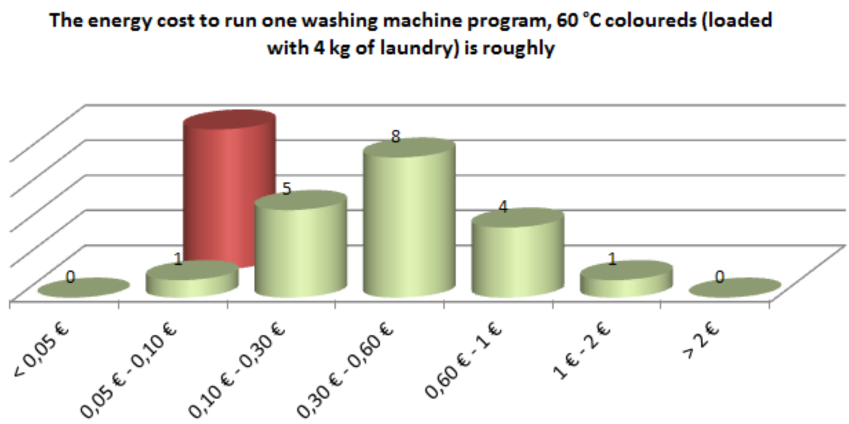


Figure 5. The resident awareness of washing machine costs

5.5.5 Acceptance to shift electricity demand

Producing and consuming energy

14 of 19 respondents were willing to choose district heating, if they built their own house again. 13

of the households would consider air heat pump or geothermal heating. Less attractive energy production methods were small-scale windmills, pellet or natural gas burners. Photo voltage panels would be considered by 5 households.

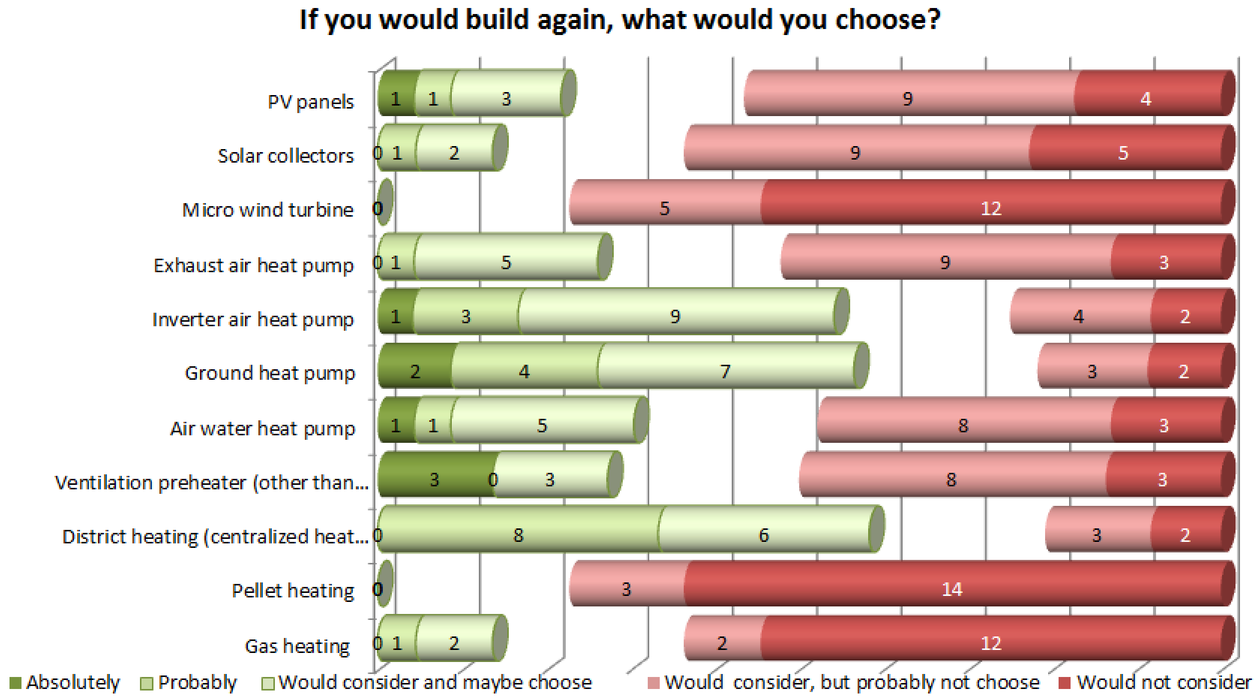


Figure 6. The residents current attitude to household heating solutions and own energy production

General environmental awareness

Only 6 of 19 respondents claimed that they pay attention to the carbon footprint of their mobility. The survey shows that 16 of the residents travel to work by their own car and only 5 ride a bicycle. All respondents recycle paper or paperboard always or usually and a clear majority recycle metal, empty batteries and glass always or usually.

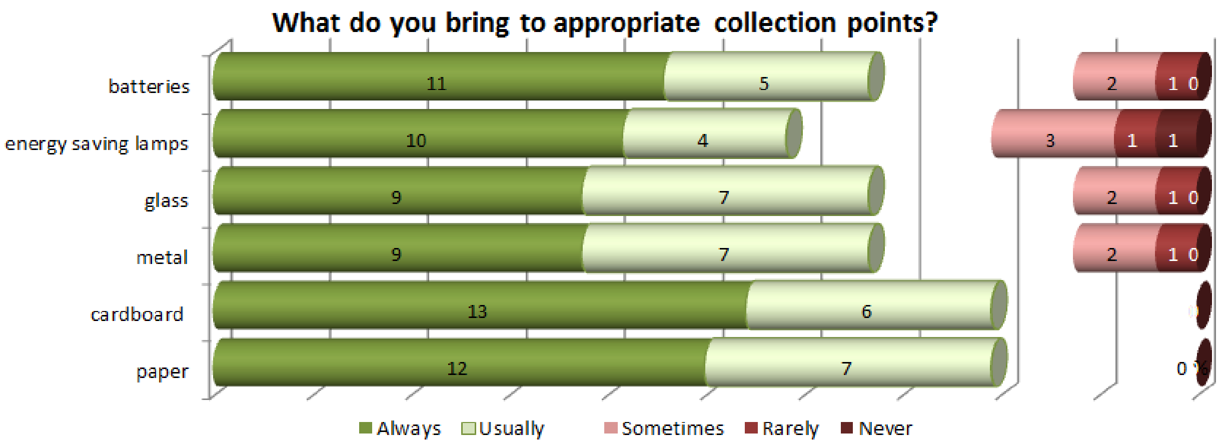


Figure 7. Recycling and waste sorting habits

6 STRATEGY FOR WIDER REPLICABILITY AND ASSESSMENT

6.1 Introduction

This chapter outlines a strategy for the wider replicability of the piloted solutions and their qualitative assessment and presents some of the lessons learnt when piloting the IDEAS solutions.

6.2 Centralized monolithic EMS versus decentralized solution

The IDEAS project approach with a single central system, the EMS, involves certain risks. Centralized systems can in worst cases end up in undesirable situations where someone may regret putting all eggs in the same basket.

The EMS functionality can probably be spread among several similar competitors on an open market. It has not been investigated or planned within the IDEAS project, but could be a good challenge for an Internet of Things call.

6.3 Pilot demo equipment versus production equipment

The metering and communication solution used in the Finnish pilot site can be considered as a retrofitted demonstration solution for an EPN-household.

For creating a large scale production solution, all measuring has to be integrated into robust meters, preferably as standardised features. Retrofitting and additional equipment tend to raise costs. The communication infrastructure should be standardised and wired when feasible, in order to prevent data loss and interference.

6.3.1 Metering solution

Wired measuring solutions are available (for instance KNX relay units with integrated measurement), but not commonly adopted since they are fairly expensive. The z-wave solution used in the demonstration is more intended for retrofitting measurement on existing buildings. The wireless communication of z-wave products might interfere with other radio equipment, and even with appliances like microwave ovens. Our experiences show that the z-wave wireless operation length is also quite limited, even in indoor environments. Therefore, wired solutions should be preferred when planning new robust solutions.

6.3.2 The household energy server

The “household energy server” functionality of Raspberry PI in the pilots could be embedded on some existing systems in the household, for instance on the ESCo electricity smart meter which is located outdoors. The consumption data communication from the appliance measurements to that server could in that case be made over power line communication (PLC), to avoid additional cabling and wireless interference or wireless range problems. The communication uplink to the ESCo is already arranged (independently of any household Internet connection, which is good) from the current household smart meters.

6.3.3 In-house communication infrastructure

A well standardized solution for reporting consumption data using PLC could allow an incremental rollout, even by embedding power measurement features in the appliances themselves. Monitors, televisions and Wi-Fi routers could listen to the in-house PLC-traffic (via their own wall plugs), and would be able to interpret and visualize the consumption data (requires standardized format), almost like HEA.

The incremental rollout of these measurements could also stepwise be implemented by introducing new regulations that starts with requiring embedded measurement on the most power hungry appliances sold on market. One advantage of embedding the measurement into the appliances is the ability to provide an identifier string or icon and category for visualization and statistical purpose. Perhaps an image model required for augmented reality recognition?

6.3.4 Demand side management

Certain home appliances should be partly controllable (within provided limits) by the EPNSP through automation, in order to improve the utilization of the stochastic renewables. This requires a secure two way communication. A typical example of such use would be to allow the ESCo to temporarily increase the hot water boiler temperature from 60˚C to 95˚C, which would reduce the demand for heating water for the following hours. Another example would be to allow the ESCo to affect the indoor temperature temporarily (+-0.5 ˚C).

6.3.5 The communication with household energy server

It would make sense to add some Internet of Things features to the household servers in order to enable more flexible future Smart Grid, Smart City and other M2M communication and interoperability. Most importantly each household server should be able to describe itself (using open standards) in such a way, that other systems automatically can consume the information and cooperate with the capabilities. This can be achieved by implementing the Open Group approved standards; O-DF (Open Data Format) and O-MI (Open Messaging Interface). These would enable other IoT systems to subscribe to interesting events (exceptions for instance) and data patterns.

6.3.6 Communications between EPNSP, Smart City and households

The household energy server could provide data to other interested systems as needed, instead of continuously (which would cause big amounts of unnecessary traffic and data storing). The residents could be able to choose between several competing service providers.

6.4 Lessons learnt

Task 5.5 did not progress as expected (see Appendix I). The specification and implementation with a complex tool such as the IOC in the provided time was technically possible, but with the provided resources too ambitious. IOC was chosen mainly for the desire to exploit the project results and scale it. It was supposed to base the solution on a platform that is able to serve several neighbourhoods of different kind of services (such as local houses services and institutes services). The requirements of the IOC led to delays in the specification phase creating a chain reaction of significant delays in the implementation and rollout of the tools and interfaces at the Finnish Demonstration site. The key reasons behind this have been analysed to suggest how these issues can be avoided in future projects

6.4.1 Complex tools

Problem Identified:

- In retrospect, the IOC was too complex and cumbersome for agile prototyping in a small scale a research project. It added an extra layer of complexity (and red-tape) that hindered progress.
- The implementation phase started too late for a tool like IOC, it led to "specification development to death" in the sense that the functionality could not be delivered on time.
- The notification feature caused significant delays in both specification phase, implementation phase, as well as in testing phase. Such a simple feature could have been rapidly achieved with the help of OpenHAB rule engine, and with a prototyping approach it could have been fine-tuned as specifications were refined. To put it succinctly in a small scale prototype demo, the drawbacks of using a data centre hosted in another country seem to have significantly outweighed the benefits.

Solution for future projects:

- The functionality that it was intended that the IOC would provide could be implemented using other tools, such as OpenHAB, in a much more agile approach, and repeatedly readjusted during the time that was spent on specification.
- In future similar projects for the demonstration it would be more advantageous to have a prototype that managed the data locally using simple protocols agreed between the relevant actors.

The strengths of the IOC would be valuable when scaling up the pilot tools to large scale contexts, where prototyping tools or small scale rule engines cannot meet the performance requirements.

6.4.2 Partners required

Problem Identified:
The project focused disproportionally on the energy data acquisition. The reading of the smart meters at the Finnish demo site is outsourced by PE (the local energy supplier and a partner in the project) to a third party (Empower Oy that is not a partner in the project). This requires that all remote access to the meters is made via Empower services, to which the meters are connected. The service is developed for billing purposes, and is currently not using the full (15 min) resolution of the smart meters. The service delivers the metering data to their customers (energy companies such as PE) with a one day delay which is more than adequate for billing purposes but not adequate for the needs of the EMS developed in IDEAS. Had Empower OY been a partner in the project it would have been much easier to obtain real-time or near real-time metered energy data

Solution for future projects:

Ensure that all partners relevant to energy distribution, energy generation, energy supply and meter reading etc. are included in the consortium at the outset: or at the very least a letter of intent is given from all the relevant organisations related to the required data before the project starts.

6.4.3 Immature equipment

Problem Identified:
In relation to wireless monitoring equipment there were significant issues related to the maturity of the products available on the market. One issue was that they exhibited poor (sometimes insufficient) wireless range from measuring unit to the device (EnviR) that collects the data and transmits the data further. In addition the first technology we selected for the pilots was from a company called CurrentCost Ltd, but they were not able to deliver the requested equipment on time for the pilot due to their ongoing product line upgrade. Several alternatives were screened, and z-wave was chosen as it was supported by many manufacturers. Several alternative z-wave metering devices were tested, of different brands. The z-wave controller was chosen according to what was feasible for the equipment budget, given the requirement that it supports some interface for own code. The controller software (zway) was very unstable, but a major software release (1.7 → 2.0) improved things significantly. Nevertheless, this change of equipment caused a significant delay due to the need to develop new software interfaces. During testing we have discovered stability issue with z-wave. It can be concluded that the z-wave technology does not provide a mature solution for the project.

To put it succinctly the HEM3 devices that were used contained undocumented surprising features and were not always behaving as expected or as advertised. The conclusion is that they are not really mature products.

Solution for future projects:
Wireless communication should be avoided if possible, since the wireless range is too often insufficient. Therefore demonstration sites in future project should already have suitable wiring in place. This should be considered a prerequisite if reliable appliance level measurements are required

for the demonstration. An example of a robust mature choice of technology is KNX. Several manufacturers offers KNX relay units with embedded measuring for each relay. It's very easy to add an OpenHAB for interacting with KNX. All data flow would in that case be based on existing stable solutions. The required equipment budget would be bigger, but the solution would be production stable and would have reduced the risks and the costs for achieving the data flows.

7 CONCLUSIONS

7.1 Summary of tools tested

Some conclusions can be drawn from the tools and interfaces tested in the Finnish pilot which as discussed in this report included:

1. A neighbourhood energy management system (EMS) developed to optimise storage/retrieving and buying/selling energy and supply energy demand predictions for energy trading
2. Innovative user interfaces developed to interact with the occupants of an EPN:
   a. Interfaces required for producers to interact with the services required for Demand Side Management, Supply Side Management and energy trading energy etc.
   b. Home Energy Awareness Application (HEAA) for demand side management, in order to interact with the residents of the pilot households.
   c. Community based interfaces, in the form Public screens that raise energy awareness and ‘promote’ the concept of an EPN to the occupants of the EPN and the wider public.

7.2 The potential of the EMS

The simulations clearly show that CO_2 emissions can be significantly reduced using the EMS. However, the tools require investments that are not the most economical of the compared scenarios this is partly due to the currently low power market prices and high battery prices. It’s likely that power market prices will go up and the battery prices will reduce going down, which will make the proposed approach feasible. However the key issue is the currently high FIT in Finland.

7.2.1 Current Feed-in-Tariff distorts the Energy market

As long as the wind turbine Feed-in-Tariff is favouring grid connected turbines with huge subsidies (price guarantee 83.50€/MWh when power market average price is 30.80€), the market is distorted and does not give room for innovative business models like neighbourhood level turbines that bypasses the national grid when the local demand is high enough. However it would be simple to resolve this issue if FITs were paid to energy producers regardless of whether the energy is sold outside of an EPN or sold directly to customers within the EPN and premium based FITs (PFITs) which pay a premium on top of the variable market price are applied.

7.2.2 Low CO_2 emissions the main advantage

Since the proposed optimised solution is able to reduce CO_2 emissions with 42% compared to a baseline including similar wind turbine, this benefit might well outweigh the often small economical differences between the scenarios. The society has to pay more for reducing emissions, and the monetary aspect is not the only issue that affects decisions.

7.3 Potential of the community interfaces

7.3.1 People were informed and inspired

83% of people found the content of the community interfaces included information that was new to them and found this new information interesting and inspiring. Over 59% were inspired to get more information. The layout and navigation was well received.

7.4 Potential of the HEA

7.4.1 Role in demand side management

The findings from the usability testing of the HEA suggest that it could considerably support demand side management and people would almost always shift their energy use according to advice provided by notifications from the HEAA.

7.4.2 Improvement of energy awareness may backfire

The energy awareness study indicated that many residents are overestimating their electricity costs, the cost for using appliances, and their current heat demand compared to national average. This means that an improvement in the energy awareness (if made in a wrong way), may backfire and cause a more apathetic attitude to the energy use. It’s important for energy awareness interfaces to emphasize the other negative consequences of increased energy consumption, not only the monetary aspects.

7.5 Joint procurements are welcome

People think joint procurement of local renewables is more interesting than installations in each home (such as for instance PV panels on own rooftop). This result underpins the proposed business model with neighbourhood level joint production and an EPNSP, operating distributed renewable energy generation, perhaps in different form.

8 References

Crosbie, T. et.al. (2015) IDEAS Deliverable D2.2 *"Specific business models for demo cases". Available at:* http://www.ideasproject.eu

Eesti Energia (2015) *Energy Market Overview, August 2015.* Available at: https://www.energia.ee/en/uudised/-/news/elektriturg/2015/09/10/energiaturu-ulevaade-august-2015

Finnish Meteorological Institute, et al (2008) *Finnish Wind Atlas – A Joint Venture of Experts* Available at: http://www.tuuliatlas.fi/creators/index.html; Access method: http://tuuliatlas.fmi.fi/en/

Fortum (2015) *Fortum Energy Review, March 2015.* Available at: http://apps.fortum.fi/gallery/Fortum_Energy_review_EN_FINAL.pdf

Gras, D. et al. (2014) IDEAS Deliverable 5.1 *"Energy monitoring data collection".* Available at: http://www.ideasproject.eu

Nord Pool Spot (2015) "*Elspot prices"*. Available at: http://www.nordpoolspot.com/Market-data1/Elspot/Area-Prices/FI/Hourly/

Official Statistics of Finland (2014). "*Dwellings and housing conditions"* [e-publication], Appendix table 1. Household-dwelling units by number of person 1960-2014. Helsinki: Statistics Finland [referred: 19.10.2015]. Available at: http://www.stat.fi/til/asas/2014/asas_2014_2015-05-26_tau_001_en.html

PowerTech Systems (2015) "*Lithium-ion vs Lead-Acid cost analysis"* Available at: http://www.powertechsystems.eu/home/tech-corner/lithium-ion-vs-lead-acid-cost-analysis/

Ramez Naam (2015) "*Why Energy Storage is About to Get Big – and Cheap"*. Available at: http://rameznaam.com/2015/04/14/energy-storage-about-to-get-big-and-cheap/

Short, M., et al (2013) IDEAS Deliverable D3.2 *"Specifications for the neighbourhood energy management tool".* Available at http://www.ideasproject.eu

Short, M., et al (2014) IDEAS Deliverable D4.1 "*A prototype neighbourhood energy management tool".* Available at http://www.ideasproject.eu

Statistics: Energy consumption in households [e-publication] (2013). Appendix table 1. *Energy consumption in households 2008-2013*, GWh . Helsinki: Statistics Finland [referred: 13.10.2015]. Available at: http://www.stat.fi/til/asen/2013/asen_2013_2014-11-14_tau_001_en.html

9 GLOSSARY

Distribution network operators

Distribution Network Operators (DNOs) are responsible for the transport of electricity at a regional level as such they transport electricity at gradually reducing voltages from national grid supply points to final customers, both commercial and domestic. Throughout the EU distribution is a regulated monopoly business.

Dynamic electricity tariffs

Dynamic electricity tariffs reflect the current supply-demand situation on the electricity network depending on the time of delivery

Distributed renewable electricity generation

Distributed renewable electricity generation (DREG) or local, decentralized renewable energy production most commonly involves solar photovoltaic (PV), but can also include small hydroelectric, small-scale biomass facilities, and micro-wind.

Electricity Supply

Electricity supply is the process of buying electricity in bulk and selling it on to the final customer. Suppliers pay for their electricity to be transmitted across the national grid via the local distribution network to their customers. Electricity supply in the UK and XXXX counties is a competitive market

Peak load or Peak demand

These two terms are used interchangeably to denote the maximum power requirement of a system at a given time, or the amount of power required to supply customers at times when their energy demand is greatest

Utilities industry

Utilities industries refers to the companies traditionally involved in the generation transmission and distribution of gas and electricity.

10 APPENDICES

10.1 APPENDIX A. Resident agreement

SOPIMUS ENERGIANKULUTUSTIETOJEN KERUUSTA OSANA SKAFTKÄRR ENERGIA LIVING LAB JA IDEAS-PROJEKTIA

1. SOPIMUKSEN OSAPUOLET

Posintra Oy (myöhemmin sopimuksessa Posintra)
STOK - Sähköisen talotekniikan osaamis- ja kehittämiskeskus
Rihkamakatu 4A
06100 Porvoo
Y-tunnus 1481499-6

Yksityishenkilö (myöhemmin sopimuksessa Asukas)

Nimi:

Osoite:

Puhelin:
Sähköposti:

Kiinteistötunnus:

2. SOPIMUKSEN TARKOITUS JA KOHDE

Osana Skaftkärr Energia Living Lab -toimintaa kotitalouksien energiankulutus halutaan tuoda asukkaille näkyväksi havainnollistamalla hetkellinen kulutus reaaliajassa Web-sivulla. IDEAS-projektissa Asukas saa myös käyttöönsä laitteita ja sovelluksia tätä varten. Energiankulutus- ja tuotantotietoja kerätään energia-neuvontaa, tiedotusta ja tutkimuskäyttöä varten. Näihin tarkoituksiin kerättyjä tietoja luovutetaan vain sillä tavoin anonymisoituina, että tietoja luovuttaneen Asukkaan henkilökohtaiset tiedot pysyvät luottamuksellisina.

Tämän sopimuksen tarkoituksena on sopia kiinteistötunnuksen osoittaman Asukkaan asunnon energiankulutus ja -tuotantotietojen keruusta ja toimittamisesta Posintran käyttöön.

Tämä sopimus korvaa kiinteistötunnuksen osoittaman Asukkaan asunnon osalta tehdyn Posintran ja Asukkaan välisen aiemman sopimuksen, jos sellainen on tehty.

3. ASUKKAAN VELVOITTEET

Asukas huolehtii

- tietoliikenneyhteyden toimivuudesta laitteista Internetiin
- mahdollisista paristovaihdoista
- siitä, että laitteet pidetään päällä
- siitä, että projektin sovellukset ovat käynnissä
- mahdollisen wifi-salasanan syöttämisestä Android-laitteisiin
- sisäänpääsystä asennuskäynnin ja mahdollisten huoltokäyntien yhteydessä.

Asukas toiminnallaan myötävaikuttaa projektin onnistumiseen mm. vastaamalla mahdollisiin kyselyihin käyttökokemuksista.

Internet-yhteyden hankkiminen, kustannukset ja ylläpito ovat Asukkaan vastuulla.

Mikäli Asukas mittausjakson aikana myy, vuokraa tai lainaa seurattavaa kohdetta (talonsa/asuntonsa) eteenpäin, Asukkaan pitää ilmoittaa tilanteesta uudelle käyttöönottajalle ja Posintralle. Asukkaan vastuulla on, että seurattavassa kohteessa seurantakauden aikana asuu vain henkilöitä, jotka ovat tietoisia tämän sopimuksen sisällöstä (erityisesti kohdista 3 ja 4).

3.1. LAITTEISTO

Asukas on velvollinen noudattamaan huolellisuutta Posintran laitteistoa asentaessaan ja käyttäessään sekä ilmoittamaan viipymättä havaitsemistaan vioista. Posintra ja Porvoon Energia voivat avustaa laitteiston asennuksessa.

Asukas ei mittausjakson (kohta 6) aikana saa muuttaa tai poistaa laitteistojen ohjelmistosovelluksia ja Asukkaan on pyrittävä pitämään ne käynnissä ja Internet-yhteydessä.

Seurantalaitteet siirtyvät mittausjakson jälkeen Asukkaan omaisuudeksi, jos Asukas on huolehtinut velvoitteistaan mittausjakson aikana.

Laitteisto on kuvattu liitteessä 1. Posintra pidättää oikeudet muutoksiin.

3.2. TIETOLIIKENNEYHTEYS

Tietoliikenneyhteydeksi tarvitaan Internet-yhteys, johon tiedonkeruulaite kytketään. Asukas voi käyttää yhteyttä myös muuhun tarkoitukseen, edellyttäen että käyttö ei estä energiamittaustietojen keruuta.

IDEAS-laitteet käyttävät ensisijaisesti asunnon langatonta Internet-yhteyttä, joten Asukkaan tulee valmistautua siihen, että hänen on syötettävä verkon salasana Android laitteille.

Asukas huolehtii tietoliikenneyhteyden toimivuudesta mittausjakson ajan.

3.3. TIETOJEN LUOVUTUS

Asukas antaa Posintralle suostumuksen kohdassa 5 määriteltyjen tietojen keruuseen mittausjakson (kohta 6) ajalta. Posintra saa kerätä nämä tiedot myös sähköverkko-yhtiön järjestelmästä. Posintralla on oikeus luovuttaa vain anonymisoituja tietoja eteenpäin kolmannelle osapuolelle. Vain Posintralla on tarvittavat tiedot kulutusdatan ja kotitalouden tunnistetietojen yhdistämiseen, eikä tätä yhdistetietoa luovuteta kolmannelle osapuolelle.

4. POSINTRAN VELVOITTEET

Posintra toimittaa kohdassa 3.1 määritellyn laitteiston.

Posintra kerää mittaustiedot (kohta 5.1) palvelimelleen ja tarjoaa Asukkaalle Web-käyttöliittymän, josta Asukas voi tarkastella oman rakennuksensa energiankulutus-tietoja. Posintra tarjoaa Asukkaalle myöhemmin määriteltäviä palveluja kulutuksen vertailuun ja yhteisölliseen energiansäästöön.

Posintra tarjoaa Asukkaan käyttöön IDEAS-sovelluksen ja laitteiston, jonka avulla Asukas voi seurata mittauksen kohteena olevien kodin sähkölaitteiden tai laite-ryhmien kulutusta. IDEAS-palvelin voi lähettää asukkaalle IDEAS-käyttöliittymään asuinalueen kulutustietoihin perustuvia ehdotuksia energian käytön säästämiseksi tai ajoittamiseksi.

IDEAS-sovelluksen käyttöönotto edellyttää valittujen sähkölaitteiden valokuvausta, joka tehdään yhteistyössä Asukkaan kanssa.

IDEAS-projekti pyrkii tarjoamaan tässä sopimuksessa kuvatun toiminnan koko mittausjakson ajan, mutta häiriötöntä toimintaa ei voida täysin taata johtuen projektin kokeellisesta luonteesta.

Tiedonkeruu ei estä Asukasta käyttämästä laajakaistayhteyttä omiin tarkoituksiinsa.

Posintra kerää mittaustietoja vähintään 31.12.2015 asti.

Posintra tallentaa palvelimelleen mittaustietojen lisäksi tarvittavat tunnistetiedot ja olosuhdetietoja. Jos Posintra luovuttaa tietoja kolmannelle osapuolelle (kohta 3.3), Posintran tulee toimittaa tiedot anonymisoituina siten, ettei henkilötietolain (523/1999) mukaisia Asukkaan henkilötietoja luovuteta.

Energiankulutustietojen keruuseen liittyvä henkilötietolain mukainen rekisteriseloste (liite 2) sekä mm. tietoturvaa kuvaava tekninen dokumentti ovat nähtävissä Posintran internet-sivuilla: http://www.posintra.fi/aineistot/stok-energy-living-lab-rekisteriseloste/

Ajantasainen kuvaus IDEAS-projektin tavoitteista ja etenemisestä löytyy osoitteesta www.skaftkärr.fi/ideas. Mahdolliset aiheeseen liittyviä kysymyksiä voidaan esittää sivuston keskustelufoorumissa.

5. KERÄTTÄVÄT TIEDOT

5.1. MITTAUSTIEDOT

Seuraavat tiedot mitataan:

- sähkön kokonaiskulutus
- laite- ja/tai ryhmäkohtaiset sähkön kulutukset. Laitekohtaiset mittaukset määritellään liitteessä 3.

Lisäksi seuraavat mittaukset tehdään, jos niitä on saatavilla ja niistä osapuolten kesken erikseen sovitaan: kaukolämmönkulutus, vedenkulutus, muut energiankulutus- tai energiantuotantotiedot, sisä-/ulko-olosuhdetiedot, sekä taloteknisten laitteiden asetus- ja anturiarvot.

5.2. TUNNISTETIEDOT

Asukkaan nimi, osoite, sähköpostiosoite, puhelinnumero
Asukkaan IP-osoite, asukkaan tiedonkeruulaitteen MAC-osoite
Verkkoyhtiön käyttöpaikkatunnus

5.3. OLOSUHDETIEDOT

Asukkaan postinumero
Talotyyppi, asuvien henkilöiden lukumäärä, asunnon huoneistoala ja -tilavuus, energiatodistuksen mukainen energiankulutus (kWh/m2)
Rakennusvuosi, lämmitysmuoto, eristys, lämmön talteenotto, lämpöpumput, jne

5.4. SOVELLUKSEN TIEDOT

Tilastotietoa IDEAS-sovellusten käytöstä

6. MITTAUSJAKSO

Mittausjakso alkaa siitä, kun Asukkaalta on ensimmäisen kerran vastaanotettu mittaustietoa Posintran palvelimelle. Mittausjakso on vähintään kahden vuoden mittainen, päättyen aikaisintaan 31.8.2015 niiden osalta, jotka ovat mittaustietoa jo aiemman sopimuksen mukaisesti antaneet.

Jos IDEAS-projektin testijakso (1.9.2014 – 31.8.2015) alkaa suunniteltua myöhemmin, myös edellä mainittu mittausjakson päättymispäivä siirtyy vastaavasti.

7. YHTEYSHENKILÖ

Posintran yhteyshenkilöinä toimivat
Arto Varis (arto.varis@posintra.fi, 050 526 2898)
Kristian Bäckström (kristian.backstrom@posintra.fi, 040 516 6116)

8. SOPIMUKSEN VOIMASSAOLO, IRTISANOMINEN JA ERIMIELISYYKSIEN RATKAISEMINEN

Sopimus tulee voimaan osapuolten allekirjoitettua sopimuksen ja se on voimassa mittausjakson loppuun. Jos kulutustietojen keruu osoittautuu molempien osapuolten kannalta hyödylliseksi, sopimusta voidaan mittausjakson päätyttyä tarvittaessa jatkaa yhteisellä sopimuksella.

Asukkaalla on oikeus irtisanoa sopimus sen voimassaoloaikana. Porvoon kaupungilla on tällöin oikeus periä takaisin tonttia luovutettaessa myönnetty etu (esimerkiksi alennus tontin hinnasta tai vuokrasta). Posintralle jää käyttöoikeus kerättyyn tietoon.

Posintralla on oikeus irtisanoa sopimus, mikäli Asukas rikkoo olennaisesti tämän sopimuksen määräyksiä. Porvoon kaupungilla on tällöin oikeus periä takaisin tonttia luovutettaessa myönnetty etu täysimääräisenä Asukkaalta. Posintralle jää tässä sopimuksessa määritetty käyttöoikeus kerättyyn tietoon.

Sopimukseen liittyvät erimielisyydet pyritään ratkaisemaan osapuolten keskinäisin neuvotteluin. Jos neuvottelut eivät johda tulokseen, ratkaistaan erimielisyys Porvoon käräjäoikeudessa.

Tätä sopimusta on allekirjoitettu viisi (5) kappaletta, yksi (1) asukkaalle, kaksi (2) tontin kauppakirjan / vuokrasopimuksen liitteeksi, yksi verkkoyhtiölle ja yksi (1) Posintralle.

Porvoossa ____._____.2014

Posintra Oy Asukas

____________________ ____________________ ____________________

Ulla Poppius Nimen selvennys: Nimen selvennys:
Toimitusjohtaja

LIITE 1. Tämän hetken laitevaihtoehdot
LIITE 2. Henkilötietolain mukainen rekisteriseloste
LIITE 3. Asukkaan talossa seurattavat laitteet

LIITE 1.
Laitteet22.11.2015

Sähkönseurantalaite, CurrentCost

(Ensisijaisesti käytetään asukkaan jo olemassa olevia CurrentCost-laitteita, jos sellaisia on aikaisemmin toimitettu)

Sähkömittarikaappiin asennettava seurantalaite, joka kytketään optisella silmällä olemassa olevan sähkömittarin vilkkuvaan lediin sekä kodin sähkölaitteisiin laitekohtaiset mittalaitteet.

1. Optinen silmä, silmän radiolähetin, näyttölaite ja virtamuuntaja

Paristokäyttöinen langaton kommunikointi tapahtuu mittausyksikön ja näyttölaitteen välillä. Ensimmäinen paristosarja sisältyy toimitukseen, mutta asiakas on vastuussa paristojen mahdollisesti tarvittavista vaihdoista seurantajakson aikana. Radioyhteysetäisyys mittauslähettimen ja näyttölaitteen välillä saa olla korkeintaan 10–15 m, ja välillä olevat seinät voivat lyhentää sitä oleellisesti. Tiedonkeruulaite tarvitsee sähköpistorasian, internet-yhteyden ja radiokuuluvuuden mittausyksikköön.

2. Laitekohtaiset mittalaitteet kodin sähkölaitteisiin

Sovitaan erikseen asukkaan kanssa asennusvaiheessa. Mahdollisia laitteita ovat esimerkiksi:

- sähkökiuas
- pyykinpesukone
- astianpesukone
- sähköliesi ja -uuni
- auton lämmityspistoke

Android-tikku ja Android-tablet

Android-tikku toimii tiedonkeruulaitteena, joka toimittaa sähkönseurantalaitteen keräämät mittaustiedot Posintran palvelimelle. Tikulla on myös IDEAS-sovellusohjelmisto, jonka avulla Asukas voi seurata mittauksen kohteena olevien kodin sähkölaitteiden tai laiteryhmien kulutusta.

Android-tabletilla Asukas voi seurata sähkölaitekohtaisia energiankulutustietojaan osoittamalla niitä tabletin kameraa käyttäen. IDEAS-palvelin voi lähettää asukkaalle IDEAS-käyttöliittymään (Android-tablettiin tai -tikkuun) asuinalueen kulutustietoihin perustuvia ehdotuksia energian käytön säästämiseksi tai ajoittamiseksi.

Internet-yhteys

Posintra kerää mittaustiedot palvelimelleen Internet-yhteyden kautta. Internet-yhteyden hankkiminen, kustannukset ja ylläpito ovat Asukkaan vastuulla.

IDEAS-laitteet käyttävät keskinäiseen kommunikointiin ensisijaisesti asunnon langatonta wifi-verkkoa. Ellei asunnossa ole langatonta wifi-verkkoa, tai mikäli se ei jostain syystä ole yhteensopiva, asennetaan erillinen ethernet-adapteri. Adapterilla IDEAS-laitteet saadaan kytkettyä langalliseen sisäverkkoon, josta on Internet-yhteys. Asukkaan on pyrittävä pitämään wifi-verkko käynnissä sekä laitteet siihen kytkettynä.

LIITE 2.

Henkilötietolain (523/99) 10 § mukainen rekisteriseloste

1. Rekisterinpitäjä
Posintra Oy/Sähköisen talotekniikan osaamis- ja kehittämiskeskus STOK
Rihkamakatu 4A
06100 Porvoo
Puhelinvaihde 010 8367 700
Email: info@posintra.fi

2. Yhteyshenkilö rekisteriä koskevissa asioissa
Arto Varis
Posintra Oy/STOK
Rihkamakatu 4A
06100 Porvoo
Puh. 050 526 2898
Email: arto.varis@posintra.fi

3. Rekisterin nimi
STOK Energy Living Lab

4. Henkilötietojen käsittelyn tarkoitus
Henkilötietojen käsittelyn tarkoitus on energianeuvonta ja asiakassuhteen hoitaminen. Henkilötietojen käsittely perustuu henkilötietolain (523/1999) 8 §:ään.

5. Rekisterin tietosisältö
Rekisteröidystä voidaan tallettaa seuraavia tietoja:
-nimi, osoite, sähköpostiosoite, puhelinnumero
-asiakkaan IP-osoite, asiakkaan tiedonkeruu- ja raportointilaitteen MAC-osoite ja Posintran asiakkaalle antama asiakastunniste
-verkkoyhtiön käyttöpaikkatunnus
-energiankulutus- ja –tuotantotietoja
-vedenkulutustietoja
-muiden taloteknisten laitteiden antamat tiedot (esim IV-kone tai lämmönohjauslaite)
-olosuhdetietoja (kuten postinumero, talotyyppi ja asunnon henkilöiden lukumäärä, eritelty tarkemmin kohdassa 7)

6. Rekisterin säännönmukaiset tietolähteet
Rekisteriin talletettavat tiedot saadaan asiakkaalta eli rekisteröidyltä tai Posintra Oy:ltä.

7. Tietojen säännönmukaiset luovutukset
Tietoja luovutetaan mahdollisesti tutkimuslaitoksille, oppilaitoksille, energiayhtiöille ja julkishallinnolle. Tietojen luovutus perustuu asiakkaan suostumukseen, ja tiedot ovat luovutettaessa täysin anonymisoituja.
Luovutettavia tietoja ovat seuraavat:
-asiakkaan eli rekisteröidyn postinumero
-asiakkaan talotyyppi, asuvien henkilöiden lukumäärä, asunnon/talon huoneistoala (m2) ja huoneistotilavuus (m^3), energiatodistuksen mukainen energiankulutus (kWh/m2)
-talon/asunnon rakennus- ja peruskorjausvuosi, tärkeät energia-asioihin liittyvät asiat; lämmitysmuoto, eristys, lämmön talteenotto, lämpöpumput, tehdyt muutokset jne.

8. Tietojen siirto EU:n tai ETA:n ulkopuolelle
Tietoja voi siirtyä EU:n tai ETA:n ulkopuolelle, koska energiankulutus- ja – tuotantotiedot sekä olosuhdetiedot tulevat nähtäviin STOKin www-sivuille.

9. Rekisterin suojauksen periaatteet
A Manuaalinen aineisto
Posintra Oy toimii tiloissa, joissa on kulunvalvonta. Rekisteröityjen henkilöiden kirjalliset suostumukset (sopimukset) säilytetään Posintra Oy:n lukituissa tiloissa.
B ATK:lla käsiteltävät tiedot
ATK:lla käsiteltävät tiedot sijaitsevat palvelimilla, jotka on suojattu palomuurilla, käyttäjätunnuksella ja salasanalla. Posintra Oy:n sisällä vain STOKin henkilökunnalla on käyttöoikeus käsiteltäviin tietoihin. Kullakin STOKin henkilöllä on oma käyttäjätunnus ja salasana. Käsiteltävistä tiedoista henkilön yksilötiedot on säädetty salassa pidettäviksi.

LIITE 3.

Toimitusvaiheessa sovitut asiat

- Toimituspäivämäärä ______/ ________ / 201___
- Toimitettu/toimitettava laite __________________________
- Asukkaan talossa seurattavat laitteet ja seurattavat tiedot:

____

____

____

____

____
Asukas:

____
Posintran edustaja:

10.2 APPENDIX B. HEAA User manual

Intelligent Neighbourhood Energy Allocation & Supervision IDEAS

Arvoisa Omenatarhan asukas,

IDEAS -projekti on viivästynyt erinäisistä syistä, mutta nyt voimme viimein toimittaa Android-tabletin ja ohjelmistosovelluksen, jolla voit seurata kotitalouden energiankulutustietoja. Keväällä asentamamme tiedonkeruulaitteet ovat lähettäneet mittaustietoa Posintran palvelimelle koko kesän ajan.

Tabletin toimituksen yhteydessä määrittelemme yhdessä tabletilla seurattavat kodinkoneet. Samalla tehdään ohjelmistosovelluksen käytettävyystesti, joka korvaa aiemmin suunnitellun pidemmän testijakson.

Sähkönkulutusta voitte seurata myös Posintran Asemo-palvelimelta: www.asemo.fi

Käyttäjätunnus:

Salasana:

Ystävällisin terveisin

Kristian Bäckström (kristian.backstrom@posintra.fi, 040 516 6116)
Arto Varis (arto.varis@posintra.fi, 050 526 2898)

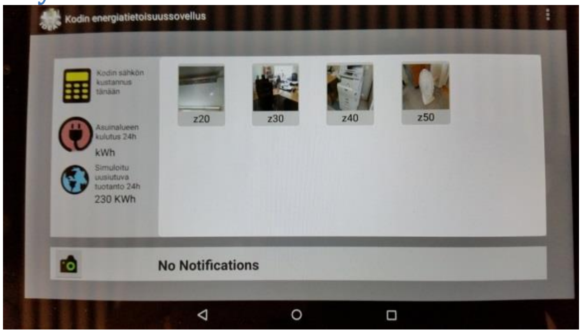
Testin tarkoitus

IDEAS-projektissa eräänä tavoitteena on kokeilla voidaanko myös kuluttajien (yliopistokampuksen tai asuinalueen asukkaiden) toimenpitein edistää energiapositiivisuutta. Omenatarhassa energiankulutus tuodaan kotitalouksille näkyväksi havainnollistamalla se reaaliajassa. Energianhallintajärjestelmän lähettämillä ehdotuksilla kulutusta pyritään siirtämään ajankohtaan, jossa uusiutuvaa energiaa on parhaiten tarjolla.

Testissä seurataan sähkön kokonaiskulutusta ja esimerkinomaisesti kotitalouden joidenkin kodinkoneiden käyttöä. Järjestely on laitteiston ja ohjelmiston osalta karkea demonstraatio, mutta ennakoi ehkä tulevaa. Esineiden internetin yleistyessä voidaan nimittäin olettaa, että kodinkoneet keräävät itse tulevaisuudessa kulutustietonsa ja välittävät ne, asukkaan niin salliessa, kullekin tietoon oikeutetulle osapuolelle; laitevalmistajalle, huolto- tai energiayhtiölle, jne. Asukas voi myös itse hyödyntää tarkempaa mittaustietoa esimerkiksi ostaessaan vaihtuvanhintaista sähköä.

Kodin laitteisto:

Näyttölaite

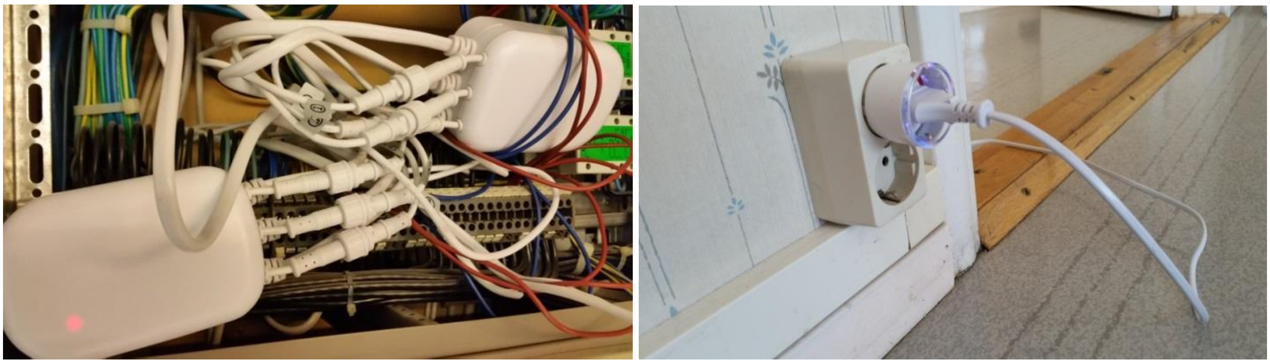


Android-käyttöjärjestelmää käyttävä Nexus-tabletti, johon on asennettu IDEAS-sovellusohjelmisto. Tabletin tulee olla asukkaan lähiverkossa, jotta sovellusohjelmisto saa tarvittavat mittaustiedot tiedonkeruulaitteelta ja energiankäyttöohjeet energianhallintajärjestelmästä.

Tiedonkeruulaite

Linux-käyttöjärjestelmällä varustettu Razberry-laite, joka kerää mittauslähettimien tiedot langattomasti ja lähettää ne Posintran palvelimelle. Tiedonkeruussa käytetään valmistajariippumatonta Z-Wave-verkkoa. Posintralle lähetystä varten laite tarvitsee Internet-yhteyden, joka voi olla langallinen (johdolla kiinni asukkaan reitittimessä) tai langaton (asukkaan WiFi-verkko)

Mittauslähettimet



Sähkökaappiin tai ryhmäkeskukseen asennetut HEM-mittauslähettimet, jotka lähettävät mittaustiedot langattomasti tiedonkeruulaitteelle. Tiedonsiirrossa käytetään Z-Wave-verkkoa.

Pistorasiaan liitetty Fibaro-mittauslähetin käyttää myös Z-Wave-verkkoa tiedonsiirtoon. Jos mittaustieto ei siirry, etäisyys tiedonkeruulaitteeseen voi olla liian pitkä.

10.3 APPENDIX C. The KPIs

Here is the list of KPIs from *D3.1 Case study scoping* for convenience.

No. KPI	Measurements/ Calculations	Unit of measurement
1. On-site Energy Ratio, OER = Annual local renewable supply/annual local demand [%]	cumulative energy demand (all types together: heating & electricity)	MWh/year
	cumulative energy supply from local renewable sources (all types together: heating & electricity)	MWh/year
2. Annual Mismatch Ratio, AMRx = average of the mismatch percentages of each hour of the day for each energy type (see details in separate attachment)	hourly local supply (by energy type: heating & electricity)	kWh
	hourly demand during that same hour (by energy type: heating & electricity)	kWh
3. Maximum Hourly Surplus, MHS = The biggest value during the year for hourly supply per the value of hourly demand on that hour (see details in separate attachment)	hourly local supply (by energy type: heating & electricity)	kWh
	hourly demand on that same hour (by energy type: heating & electricity)	kWh
4. Maximum Hourly Deficit, MHD = The lowest value during the year for hourly supply per the value of hourly demand on that hour (see details in separate attachment)	hourly local supply (by energy type: heating & electricity)	kWh
	hourly demand on that same hour (by energy type: heating & electricity)	kWh
5. Monthly Ratio of Peak hourly demand to Lowest hourly demand, RPL (see details in separate attachment)	The biggest value for hourly demand over the month, for each month of the demo period	kWh
	The lowest value of hourly demand over the month, for each month of the demo period	kWh
6. Low energy demand (compared to similar areas)	energy demand of the area	MWh/year MWh/m^2 year MWh/ inhabitant, year
	energy demand of similar area (similar area is defined for Finnish case, but possibly not for the French case)	MWh/year MWh/m^2 year MWh/ inhabitant, year
7. Little environmental impact (CO_2–ekv emissions mainly, compared to similar areas, radioactive waste could be also included)	CO_2 ekv emissions for the buildings - electricity (for Finnish case, two or three cases: PE electricity mix & average Finnish mix & total renewable mix, for French case EDF average, and possibly total renewable for comparison) - heat (from PE in Finland, from Gaz de Bordeaux for France)	gCO_2-ekv/m^2 year
	CO_2-ekv emissions on the area - electricity - heat	kg CO_2-ekv/year kg CO_2-ekv/inhabitant,

		year g CO_2-ekv/m^2, year
	CO_2-ekv emissions on similar area	kg CO_2-ekv/year kg CO_2-ekv/inhabitant, year g CO_2-ekv/m^2, year
	Amount of radioactive waste related to external energy supply on the area	g/year g/inhabitant, year mg/m^2,year
	Amount of radioactive waste related to external energy supply on similar area	g/year mg/m^2, year g/inhabitant, year
8. Energy positivity level indicator	f(OER, AMR, MHS, MHD, RPL)	letter A+++-G
9. Energy efficiency	E-value of the buildings or energy demand of the buildings (by energy type)	kWh/m^2
10. Peak power demand (compared to similar area)	average hourly power demand of the area	kW
	average hourly power demand of similar area	kW
11. Energy storage	energy storage capacity by energy type depending on storage type, e.g. the storage capacity, volume, mass, temperature, long or short term storage	depending on the storage type, e.g. mass (kg or t), volume (m^3), storage capacity (kWh or Ah or MW)
12. Energy demand of buildings (by energy type)	energy demand of buildings (by energy type)	kWh/m^2 year MWh/year MWh/month MWh/week kWh/day kWh/hour
13. Energy demand by other urban infrastructures (e.g. street lighting)	energy demand by other urban infrastructures (e.g. street lighting)	MWh/year MWh/month MWh/week kWh/day kWh/hour
14. Building integrated renewable energy supply (for each building separately, and whole area)	power and area of building integrated solar PV	kWp, m^2
	power and area of building integrated solar collectors (by type)	kW, m^2
	power and number of building integrated wind turbines	kW, -
	power and number of individual hydro power plants	kW, -
	power and number of the building level micro-CHP plant (for heat and electricity)	kW heat and kW electricity, -

	mass/volume of wood used in fireplaces	kg or m^3
	type, power, COP and number of building level heat pumps	ground/rock/water, kW, -, -
15. District level renewable energy supply	power and area of solar PV on public/common area	MWp, m^2
	power and area of solar collectors (by type) on public/common area	MW, m^2
	power and number of wind turbines placed on public/common areas	MW, -
	power and number of district level hydro power plants	MW, -
	power (possibly number, if several) of CHP plant serving the whole area (for heat and electricity)	MW heat and MW electricity
	type, power and COP (and possibly number, if several) of heat pumps serving the whole area	ground/rock/water, kW, -
16. Points that make the placement of the supply facilities most efficient and sustainable	text describing the surrounding circumstances, e.g. “There is an industrial area next to the neighborhood, with space for bio-CHP plant, so instead of placing the CHP inside the geographical limits of the area, the renewable energy is supplied from the neighboring area.”	-
17. Transport distance of the biomass	weighted average transport distance from the plant	km
18. Total cost of operation	energy costs maintenance costs other costs for operation	€/MWh
19. The improvement of energy awareness level	text describing the energy awareness level of the users	
20. The way and frequency of the energy information provided to the users	text and possibly pictures to describe how the information is presented	
	the frequency of the information	times/year

10.4 APPENDIX E. Public screen evaluation questionnaire

PORVOO BORGÅ

Energiatehokkuuteen tähtäävä IDEAS-projekti

Kysely projektiin liittyvän julkisen näytön sisällöstä ja käytettävyydestä.

1. Löysin näytöltä itselleni uutta tietoa? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

2. Tieto oli mielestäni kiinnostavaa/kiinnostavasti esitetty? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

3. Minulle heräsi kiinnostus tutustua johonkin aihealueeseen enemmän? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

4. Minulle selvisi mikä on energiapositiivinen alue tai mitä sillä tavoitellaan? *

- täysin samaa mieltä
- lähes samaa mieltä

- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

5. Sivuilla oli helppo navigoida? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

6. Linkit toimivat hyvin? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

7. Tietosisältö ja linkit oli visuaalisesti selkeästi esitetty? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

8. Olen kiinnostunut energian säästämisestä? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

9. Olen kiinnostunut uusiutuvien energiamuotojen hyödyntämisestä? *

- täysin samaa mieltä
- lähes samaa mieltä
- jokseenkin eri mieltä
- täysin eri mieltä
- en osaa sanoa

10.5 APPENDIX F. Equipment costs

Breakdown of equipment purchased by VTT for T5.5	
Item	**Roughly cost (€)**
Four large screens (three for the nursery school, to each of the three entrances, and one to the central info point of CoP) = HP Slate21" large Android tablets (241,13 € each)	969
Wall mounts for the large screens (9,60 € each)	38
D-Link 4G LTE Wifi router incl sim card socket, for providing wifi to nursery school public screens (no wifi available in the nursery school for the project)	161
Sim card with 12 month data subscription (for providing nursery school with Internet access)	240
Asus Nexus 7, 2013, 16GB wifi (tablets to show the residents the energy related information and notifications), 26 pieces	5320
Shipping costs	22
TOTAL	6750

Breakdown of equipment purchased by COP for T5.5		
Quantity	**Item**	**Roughly cost (€)**
27	MK908ii Android stick for HEA & EAA*	1 215
26	Wireless gyro air mouse/kb (Measy RC11) kb for accessing the Android stick in tv	495
23	set of AAA batteries	115
12	MK908ii usb ethernet adapter when wifi is not functioning	60
71	aeon zwave home energy meter (3 devices per household, each with 3 jaws, one per phase)	6 012
71	fibaro zwave socket outlets incl measure + control (3 per household)	3 235
25	Raspberry + RaZberry + microsd + power supply + wifi (to support the integration)	2 741
	Shipping costs, custom fees, import taxes, cords, installation accessories, etc.	1247
	TOTAL	15 120

10.6 APPENDIX G. HEAA Usability test extension survey

IDEAS kysely kodin energiatietoisuussovelluksen käyttöliittymästä

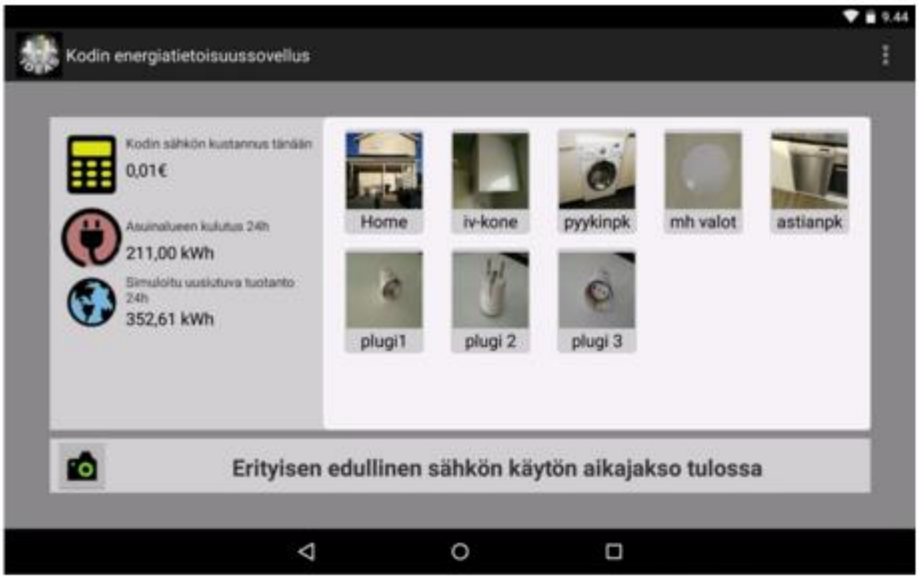
1. Jos teillä olisi ollut käytössä kyseinen sovellus, luuletteko että olisitte pitäneet silmällä sen antamia muistutuksia, asteikolla 1-5?

- ○ 1, aina
- ○ 2, usein
- ○ 3, joskus
- ○ 4, harvoin
- ○ 5,= en juuri koskaan

Muu (täsmennettävä)

IDEAS

IDEAS kysely kodin energiatietoisuussovelluksen käyttöliittymästä



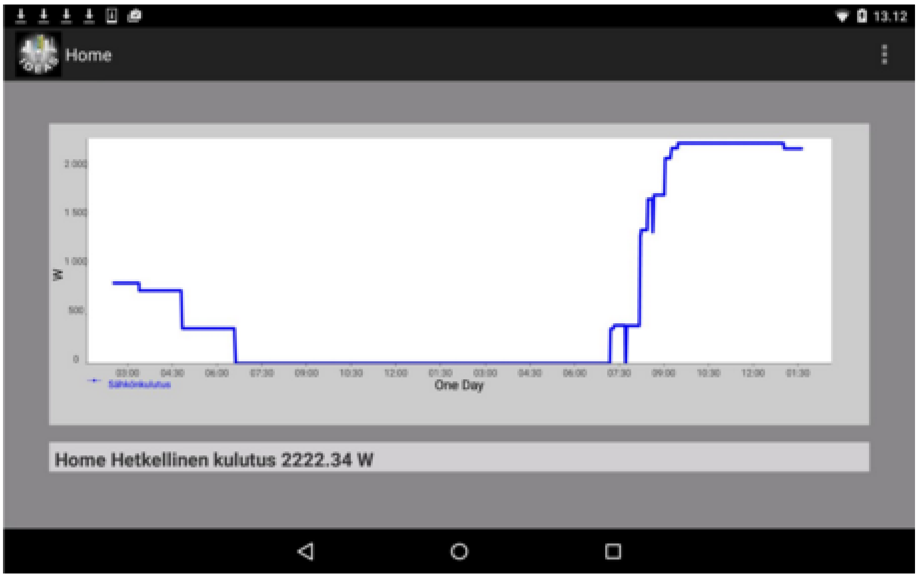
2. Yksi projektin tavoitteista on selvittää, olisivatko ihmiset valmiita siirtämään energiankulutustaan sellaisiin aikoihin, jolloin saatavilla on joko edullisempaa tai uusiutuvilla lähteillä tuotettua energiaa, jos he saavat tietoa ajoituksesta. Luuletteko että olisitte seuranneet sovelluksen antamia neuvoja energiankäytön ajoittamisesta, asteikolla 1-5?

- ◯ 1, aina kun mahdollista
- ◯ 2, usein
- ◯ 3, joskus
- ◯ 4, harvoin
- ◯ 5, en juuri koskaan

Muu (täsmennettävä)

IDEAS

IDEAS kysely kodin energiatietoisuussovelluksen käyttöliittymästä



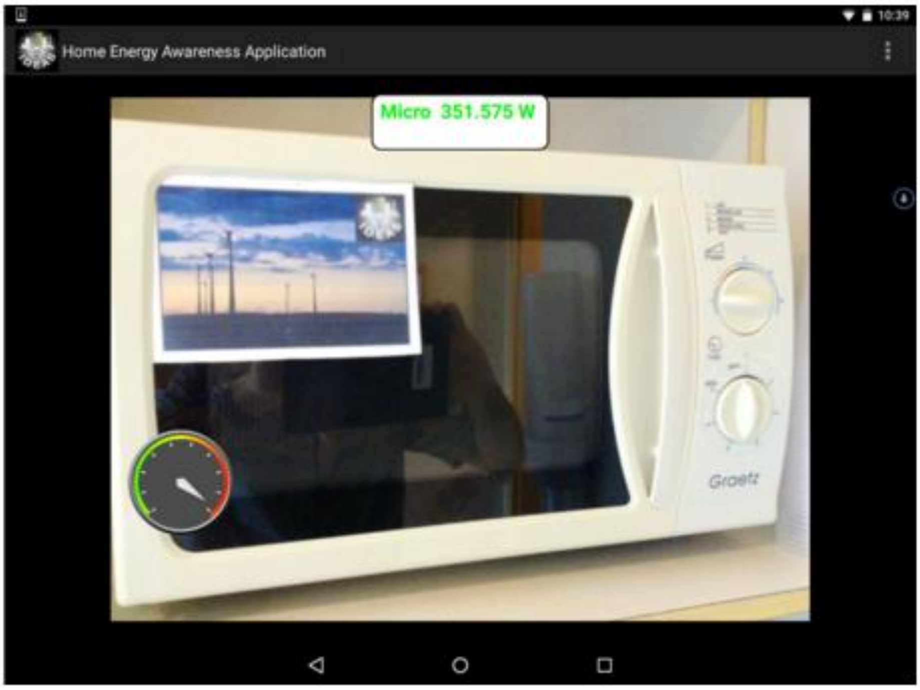
3. Sovellus antaa tietoa myös energiankulutuksesta ja mahdollisuuden verrata sitä alueen keskimääräiseen kulutukseen. Luuletteko että tieto energiankulutuksesta olisi vaikuttanut omaan energiankulutukseenne, asteikolla 1-5?

(Kuvan käppyrä on esimerkkimittaus toimistolta, eikä oikeasta kodista)

- 1, vähentänyt merkittävästi
- 2, vähentänyt jonkin verran
- 3, ei vaikutusta
- 4, lisännyt jonkin verran (< 10 %)
- 5, lisännyt merkittävästi

Muu (täsmennettävä)

IDEAS kysely kodin energiatietoisuussovelluksen käyttöliittymästä



4. Kuinka hyödyllinen olisi oheisen kuvan mukainen mobiilisovellus, joka näyttää eri kodinkoneiden hetkellisen sähkönkulutuksen niitä puhelimella osoittamalla?

- ◯ 1, erittäin hyödyllinen
- ◯ 2, jossain määrin hyödyllinen
- ◯ 3, ei kovin hyödyllinen
- ◯ 4, ei hyödyllinen
- ◯ 5, ei lainkaan hyödyllinen

Muu (täsmennettävä)

IDEAS

Intelligent Neighbourhood Energy Allocation & Supervision

IDEAS kysely kodin energiatietoisuussovelluksen käyttöliittymästä

5. Hankkeessa kehitettiin myös liiketoimintamalleja, jotka lisäsivät alueiden energiapositiivisuutta ja uusiutuvin energioiden osuutta. Eräs tällainen malli on yhteishankinta, jossa ihmiset yhdessä investoivat uusiutuvan energian tuotantoon, ja saavat omistamastaan laitoksesta energiaa markkinahintaa edullisemmin. Suomessa melko harvat investoivat aurinkosähköpaneeleihin tai muuhun uusiutuvaan energiantuotantoon omassa talossaan. Uskotteko että yhteishankintamallit voisivat lisätä suomalaisten kiinnostusta investoida uusiutuvaan energiaan, esim. aurinkosähköön, kun laitteita ei asennettaisikaan omaan taloon, asteikolla 1-5?

- ◯ 1, lisäisi kiinnostusta paljon
- ◯ 2, lisäisi kiinnostusta jonkin verran
- ◯ 3, ei eroa kiinnostuksessa
- ◯ 4, jonkin verran vähemmän kiinnostusta
- ◯ 5, paljon vähemmän kiinnostusta

Muu (täsmennettävä)

Edellinen | Tehty

10.7 APPENDIX H. National remnant distribution for year 2014

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Liite 1

KANSALLINEN JÄÄNNÖSJAKAUMA VUODELLE 2014

Liitteessä on esitetty jäännösjakauman laskemiseen käytetyt lähtötiedot sekä laskukaavat.

Lähtötiedot

Käytetyt lyhenteet:

FOS = Fossiilisilla energialähteillä tuotettu sähkö

RES = Uusiutuvilla energialähteillä tuotettu sähkö

NUC = Ydinvoimalla tuotettu sähkö

Sähkön nettotuotanto Suomessa:

FOS	17,37 TWh
RES	25,40 TWh
NUC	22,65 TWh
Yht.	65,42 TWh

Sähkön kulutus Suomessa: 83,35 TWh

Sähkön nettotuonti:

FOS	2,27 TWh
RES	0,54 TWh
NUC	0,56 TWh
Yht.	3,36 TWh

Alkuperätakuut

Vuodelle 2014 kohdistuneet alkuperätakuiden peruutukset: 20,86 TWh

Alkuperätakuiden tuonti 1.4.2014-31.3.2015: 16,69 TWh

Alkuperätakuiden vienti 1.4.2014-31.3.2015: 15,95 TWh

Energiavirasto
Energimyndigheten | Lintulahdenkuja 4
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Internet www.energiavirasto.fi

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Liite 1

Eurooppalainen jäännösjakauma

FOS	57,46 %
RES	0,67 %
NUC	41,86 %

Hiilidioksidipäästöt: 544,40 g/kWh

Käytetyn ydinpolttoaineen määrä: 1,19 mg/kWh

Hiilidioksidipäästöt

Polttoaine	Sähköntuotannon polttoaine-energia [TJ]	Päästökerroin (sis. hapettumiskertoimen) [t/TJ]	Päästöjen määrä [tCO2]
hiili	55 048	102,00	5 614 896
öljy	1 464	78,00	114 192
maakaasu	22 375	55,00	1 230 625
turve	19 103	105,00	2 005 815
muu kotimainen, ei-bio	6 145	31,00	190 495
Yhteensä			9 156 023

Hiilidioksidipäästöt Suomessa fossiilisilla energialähteillä tuotetun sähkön osalta: Päästöt sähkön tuotannosta Suomessa 9 156 023 t / sähkön nettotuotanto Suomessa FOS 17,37 TWh = 527,03 g/kWh.

Puu- ja muut bioperäiset polttoaineet oletetaan laskennassa päästöttömiksi.

Käytetyn ydinpolttoaineen määrä

Käytetyn ydinpolttoaineen määrä Suomessa: 61,19 t

Käytetyn ydinpolttoaineen määrä Suomessa ydinvoimalla tuotetun sähkön osalta: Käytetyn ydinpolttoaineen määrä Suomessa 61,19 t / sähkön nettotuotanto Suomessa NUC 22,65 TWh = 2,70 mg/kWh

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Liite 1

Laskukaavat

Alkuperältään varmentamattoman tuotannon määrittäminen energialähteittäin

FOS: Suomessa tuotettu FOS (nettotuotanto) 17,37 TWh + Venäjältä tuotu FOS 2,27 TWh = 19,64 TWh

RES: Suomessa tuotettu RES (nettotuotanto) 25,40 TWh + Venäjältä tuotu RES 0,54 TWh + alkuperätakuiden tuonti 16,69 TWh – alkuperätakuiden vienti 15,95 TWh – peruutetut alkuperätakuut 20,86 TWh = 5,81 TWh

NUC: Suomessa tuotettu NUC (nettotuotanto) 22,65 TWh + Venäjältä tuotu NUC 0,56 TWh = 23,21 TWh

Alkuperältään varmentamaton tuotanto yhteensä: FOS 19,64 TWh + RES 5,81 TWh + NUC 23,21 TWh = 48,66 TWh

Alkuperältään varmentamattoman kulutuksen määrittäminen

Varmentamaton kulutus = Sähkön kokonaiskulutus 83,35 TWh – peruutetut alkuperätakuut 20,86 TWh = 62,48 TWh

Ali-/ylijäämän määrittäminen

Ali-/ylijäämä = Alkuperältään varmentamaton tuotanto 48,66 TWh – alkuperältään varmentamaton kulutus 62,48 TWh = -13,83 TWh

Mikäli varmentamaton kulutus on varmentamatonta tuotantoa suurempi, täytetään alijäämä eurooppalaisella jäännösjakaumalla. Mikäli varmentamaton tuotanto on varmentamatonta kulutusta suurempi, siirretään ylijäämä eurooppalaiseen jäännösjakaumaan.

Alijäämä: 13,83 TWh

Alijäämän korjaaminen

Eurooppalaisesta jäännösjakaumasta siirrettävä FOS = alijäämä 13,83 TWh * FOS osuus eurooppalaisessa jäännösjakaumassa 57,46 % = 7,95 TWh

Eurooppalaisesta jäännösjakaumasta siirrettävä RES = alijäämä 13,83 TWh * RES osuus eurooppalaisessa jäännösjakaumassa 0,67 % = 0,09 TWh

Eurooppalaisesta jäännösjakaumasta siirrettävä NUC = alijäämä 13,83 TWh * NUC osuus eurooppalaisessa jäännösjakaumassa 41,86 % = 5,79 TWh

Kansallisen jäännösjakauman määrittäminen

FOS: Suomessa tuotettu ja Venäjältä tuotu FOS 19,64 TWh + eurooppalaisesta jäännösjakaumasta siirrettävä FOS 7,95 TWh = 27,59 TWh

RES: Alkuperältään varmentamaton RES 5,81 TWh + eurooppalaisesta jäännösjakaumasta siirrettävä RES 0,09 TWh = 5,90 TWh

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Liite 1

NUC: Suomessa tuotettu ja Venäjältä tuotu NUC 23,21 TWh + eurooppalaisesta jäännösjakaumasta siirrettävä NUC 5,79 TWh = 29,00 TWh

Prosenttiosuudet:

FOS: 27,59 TWh / 62,48 TWh = 44,15 %

RES: 5,90 TWh / 62,48 TWh = 9,44 %

NUC: 29,00 TWh / 62,48 TWh = 46,41 %

Jäännösjakauman mukaisen sähkön tuotannon hiilidioksidipäästöt

(Hiilidioksidipäästöjen määrä Suomessa tuotetun ja Venäjältä tuodun sähkön osalta 19,64 TWh * 527,03 g/kWh + eurooppalaisesta jäännösjakaumasta siirrettävät hiilidioksidipäästöt 13,83 TWh * 544,40 g/kWh = 10 350 610 t + 7 528 246 t = 17 878 855 t) / varmentamattoman tuotannon määrä jäännösjakaumassa (FOS+RES+NUC) 62,48 TWh = 286,14 g/kWh

Jäännösjakauman mukaisen sähkön tuotannon käytetyn ydinpolttoaineen määrä

(Käytetyn ydinpolttoaineen määrä Suomessa tuotetun ja Venäjältä tuodun sähkön osalta 23,21 TWh * 2,70 mg/kWh + eurooppalaisesta jäännösjakaumasta siirrettävä käytetyn ydinpolttoaineen määrä 13,83 TWh * 1,19 mg/kWh = 62,69 t + 16,46 t = 79,15 t) / varmentamattoman tuotannon määrä jäännösjakaumassa (FOS+RES+NUC) 62,48 TWh = 1,27 mg/kWh

10.8 APPENDIX I. The original plan for methodology of evaluation

10.8.1 Schedule delays

The task T5.5 has not been able to follow the schedule as planned and the progress as expected, therefore it's justifiable to describe the progress that actually has been made.

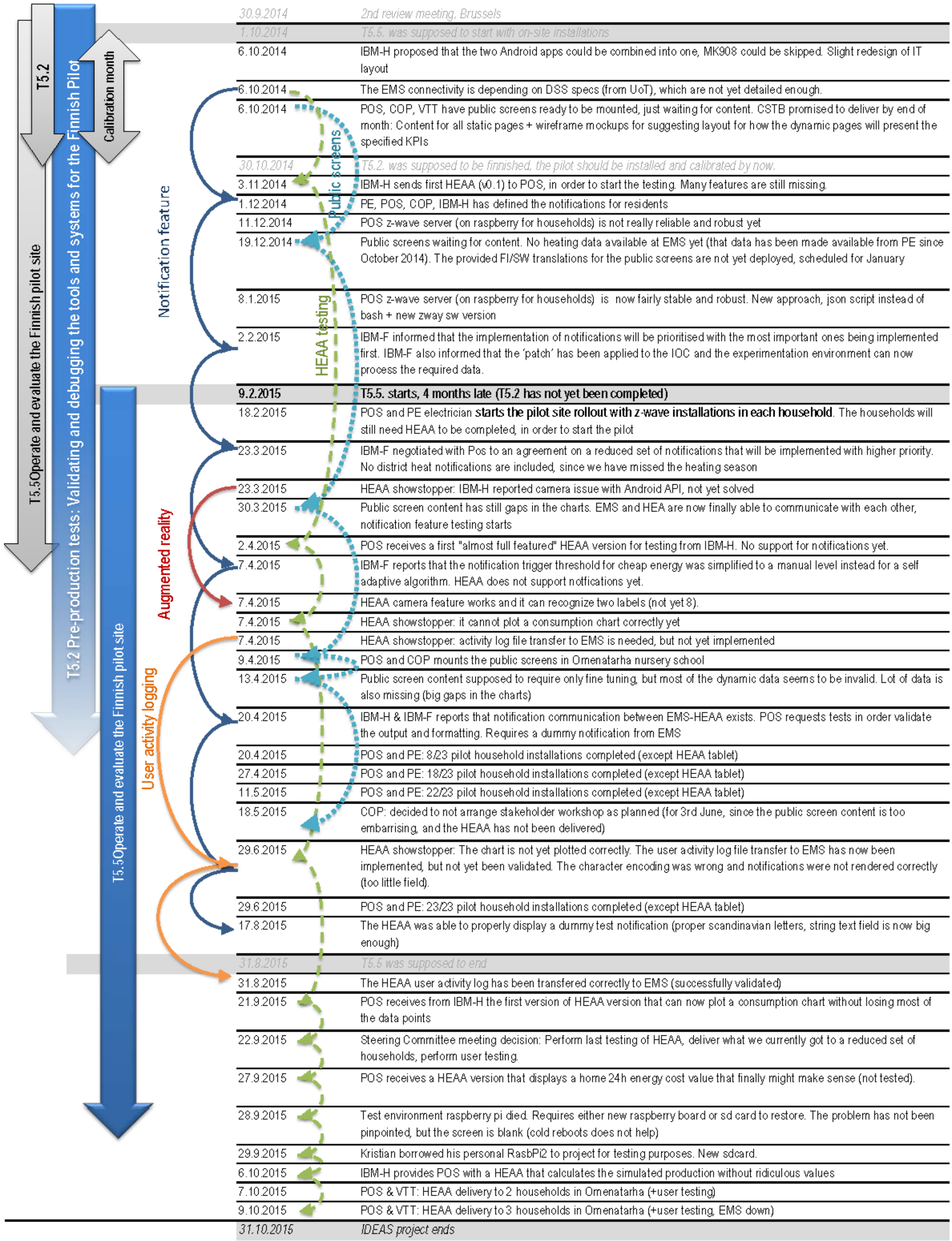

Figure 8. A log of the showstoppers on the critical path for rolling out the Finnish pilot

10.8.2 Comparison between baseline and reporting period

The baseline data against which the tool implementations and the simulations undertaken in this task were collected via the billing meters for district heat and electricity.

10.8.3 Impact detection of DSM using resident notifications

The HEAA can display energy related notifications (received from EMS DSM feature) to users. These notifications advises the residents to act and shift some consumption to or from some particular hour(s) mentioned in the message, as shown in Figure 9 below.

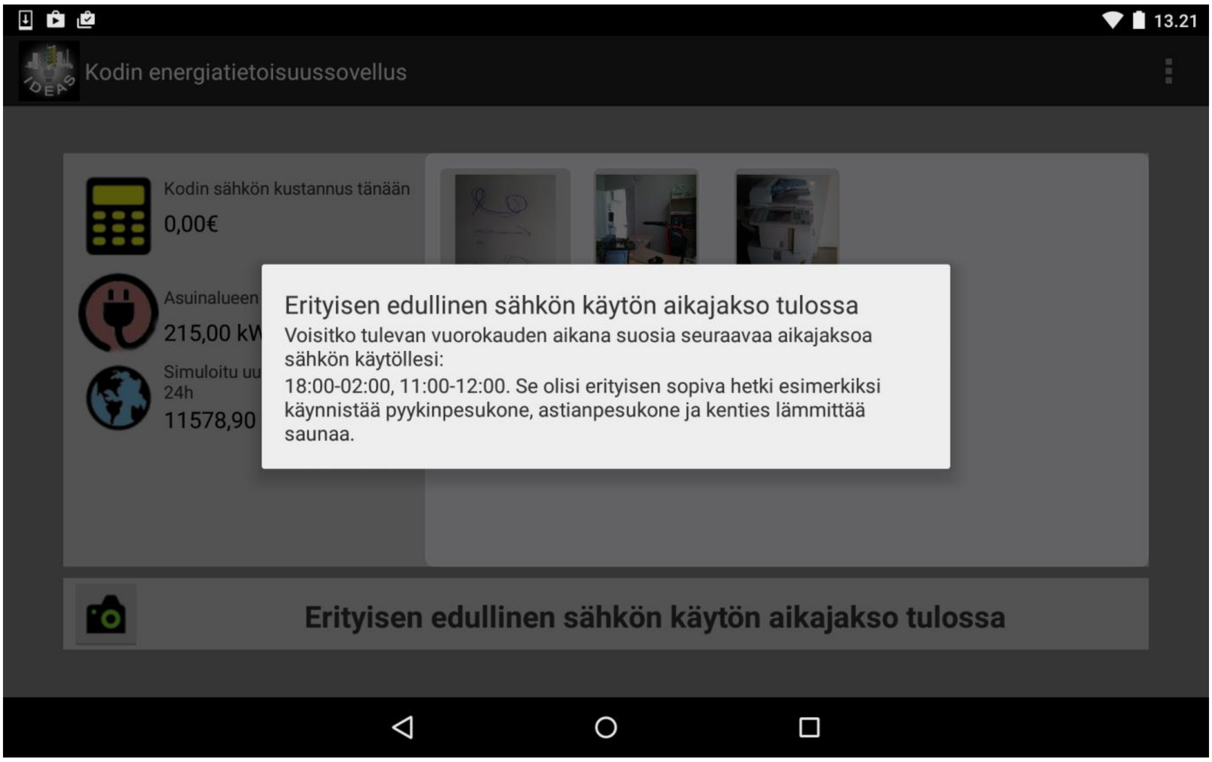

Figure 9 Energy related notification from EMS to residents

The HEAA application at the tablets is regularly polling the EMS with 15 minute interval for new notifications. When a notification has been made available at EMS, all online running HEAA applications at the resident tablets will receive it within the polling interval. All the received notifications regarding upcoming hours are visible in a rolling banner at the bottom of main screen in the app (see Figure on page 13). Each notification will disappear when the hour(s) it describes has occurred.

The HEAA activity logs from each online HEAA app (see Figure 13 on page 88 for a sample) were developed to detect whether the notification really has been delivered to the HEAA, noticed and opened by the user.

For each notification, the set of electricity demand streams for households which has opened the notification will be compared against the rest of the household streams, only for the particular hours mentioned in the notification. Due to the enormous noise of individual household electricity demand, comparison of any individual notification hours against baseline cannot lead to any conclusions with such a small pilot (n=23). The notifications have to be repeated many times in order to reduce the noise, and the difference between baseline and the measured demand of the notified households need to be averaged for all occurred notifications hours.

The chart in Figure 10 below describes one week of 23 individual household electricity demands, where the noise of each separate thin line is obvious.

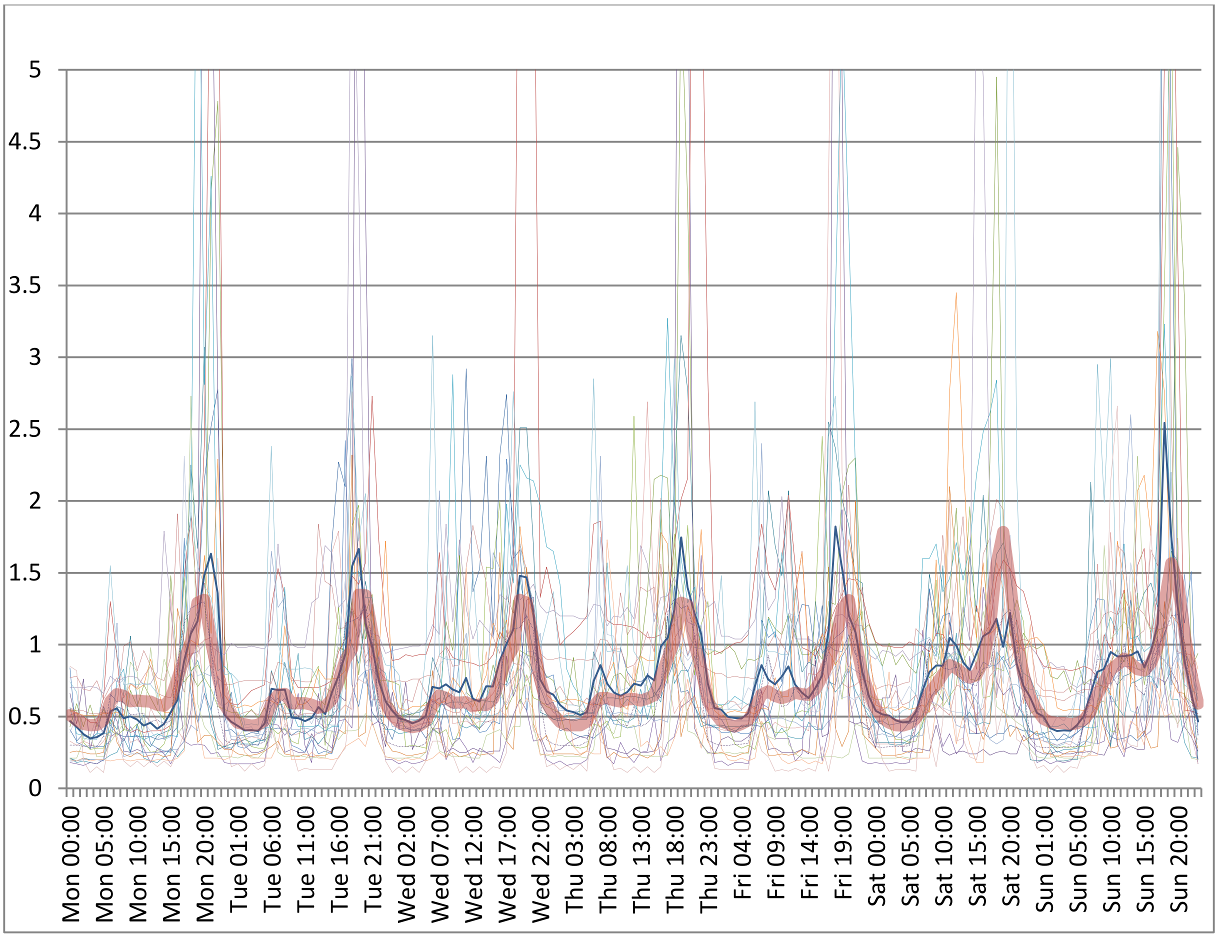

Figure 10. Example of one week individual electricity demand in kW (23 separate households). The thick red semitransparent line is the average of all households, and forms a very clear pattern from one week to another.

Once the signals are averaged over a longer period, the noise disappears and the weekly demand profile is stabilized and clear. The Figure 11 below shows a demand profile for a single household compared to the demand profile of the whole pilot group.

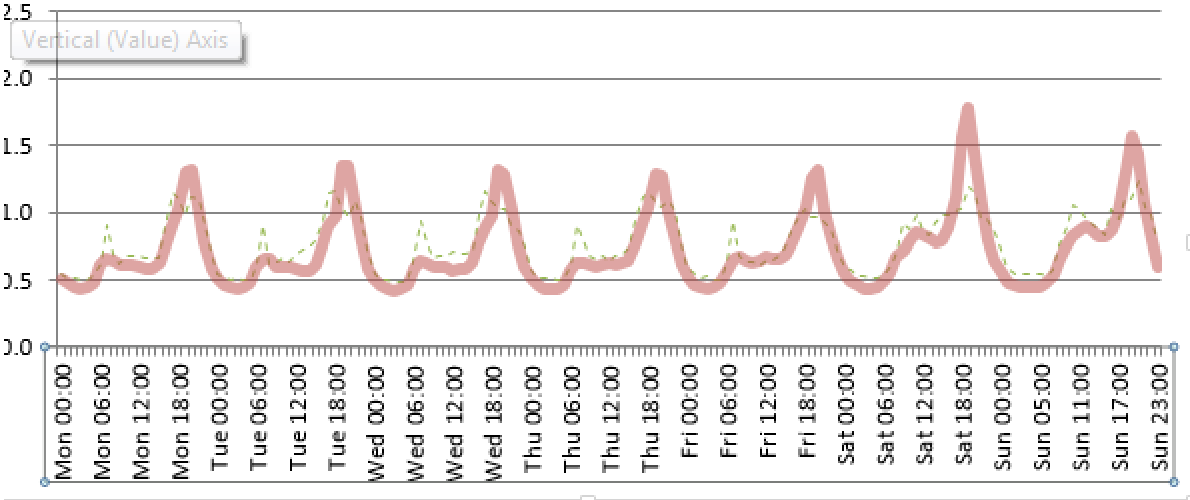

Figure 11. A single household demand (kW electricity) correlates in average well with the pilot group week demand profile. The green dottect line is based on a single household consumption (Oct14-Aug15), while the red is the pilot group average for the same period.

During the heating season, the HDD has a slight impact even on the electricity demand for some households, due to some electrically heated garages or other outdoor storages and buildings.

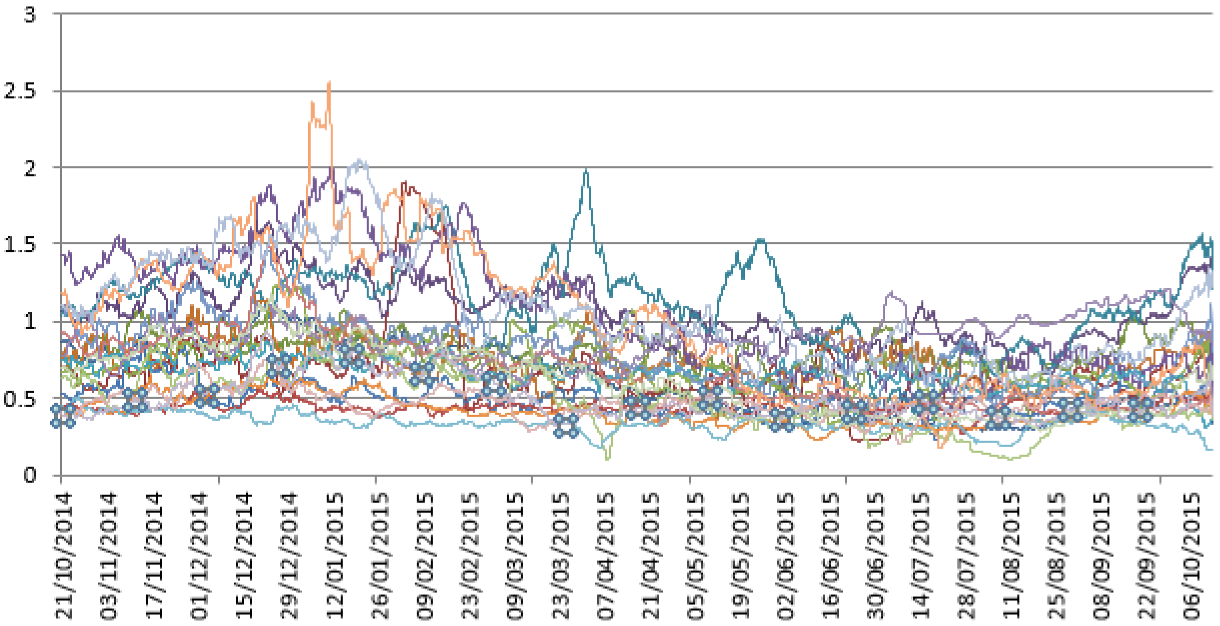

Figure 12. Individual pilot household electricity demands (kW electricity, rolling one week average). Some households are partially heating with electricity, which causes the seasonal wave shape which is higher during winter.

10.8.4 Energy awareness questionnaire for residents

To find out residents' awareness level and the impact of the IDEAS demo on it, a repeat of the first survey was planned. An interview of the individuals was to be executed twice with identical questions, once before the demonstration period and second time just after the period.

The survey was executed for the first time during spring 2015, at the same time with the delivery of measurement instruments.

The second interview of the same respondents was due after the demo period. It was not executed because the demo period was not conducted in its original scale and the rollout of tablets for all households was postponed.

10.8.5 User activity logging in the HEA app

The HEAA is logging the user activity in the background in order to serve two purposes: to group the residents that has noticed a notification (to distinguish them from the rest of the households in impact analysis), and for collecting statistical information about how much the application did interest, which were the frequently used features, stats about app usage frequency and average app usage duration. The produced log files looks like sample in Figure 13 below.

```
2015-08-31T07:35:05+03:00,MainActivity,action_view
2015-08-31T07:35:03+03:00,Appliance,action_view
2015-08-31T07:35:01+03:00,MainActivity,action_view
2015-08-31T06:52:51+03:00,Appliance,action_view
2015-08-31T06:51:03+03:00,Appliance,action_view
2015-08-31T06:51:01+03:00,MainActivity,action_view
2015-08-31T06:51:00+03:00,Appliance,action_view
2015-08-31T06:50:58+03:00,MainActivity,action_view
2015-08-31T06:50:56+03:00,Appliance,action_view
2015-08-31T05:28:07+03:00,Appliance,action_view
2015-08-31T05:28:05+03:00,MainActivity,action_view
2015-08-31T05:27:47+03:00,Appliance,action_view
2015-08-31T05:27:45+03:00,MainActivity,action_view
2015-08-31T05:27:40+03:00,Appliance,action_view
2015-08-31T05:27:39+03:00,MainActivity,action_view
2015-08-31T05:27:37+03:00,Appliance,action_view
2015-08-31T05:27:36+03:00,MainActivity,action_view
2015-08-31T05:27:35+03:00,Appliance,action_view
2015-08-31T05:27:32+03:00,MainActivity,action_view
2015-08-31T05:25:46+03:00,Appliance,action_view
2015-08-31T05:25:44+03:00,MainActivity,action_view
2015-08-31T05:25:37+03:00,Appliance,action_view
2015-08-31T05:25:32+03:00,MainActivity,action_view
2015-08-31T05:16:19+03:00,MainActivity,action_view
```

Figure 13. A sample activity log file named 15_c316819e4828ec4c_150831103507+0300.csv

- A new log file is created on every application launch
- The log file is sent to the EMS server every hour.
- MainActivity is written every time the main screen is entered, during the transition to main screen. Either when the application is started, or when you return to main screen from some sub screen such as recognition screen or appliance screen.
- Every activity operates according to this transition logic (not just MainActivity)
- There is no Exit tag will never be written in this case because if the app has exited the log file will never be sent.

Explanation of the file naming:
File name = HouseHoldID+"_"+ DeviceID +"_"+ CurrentTime +".csv" where

- HouseHoldID: Is the configured id, defined in the password protected setting of the HEA app. In the Example it's 15. This is needed for separating the households that has noticed a notification from the rest of the households, when measuring impact in electricity demand.
- DeviceID: A unique identifier of the device. It’s supposed to be the imei, but if not it fallbacks to android-id (and if even that fails it will generate a random id). More

details on how to imei/android-id of device is read: http://www.android.pk/blog/faqs/how-to-find-your-android-device-id/

- CurrentTime: the time that the log file was sent to EMS. In the example it's 150831103507+0300 (yyMMddhhmmss+offset from UTC), or in clear text 2015-08-31 13:35:07 Eastern European Time.

10.8.6 The public screen evaluation

A feedback workshop for the awareness interfaces was planned and supposed to be held on June 3rd 2015, in order to collect user experiences. However, on May 18th the decision was made to not send out the invitations as scheduled. It was supposed to involve both Kompassi staff and nursery school staff. At that time there was a lot of struggle with the public screen content (too embarrassing values), and the problems were still unsolved at a very late phase of the project, so the time ran out. The feedback workshop was replaced by a public screen feedback survey that was conducted among the staffs of the same building where the Kompassi citizens' service point is. The results are described in chapter 5.3.3 starting at page 34.