Contract number ENER/FP7/260039/BEEMUP

BEEM-UP

Building Energy Efficiency for Massive market UPtake

Integrated Project

EeB-ENERGY-2010.8.1-2
Demonstration of Energy Efficiency through Retrofitting of Buildings

Deliverable D.4.6: Protocol for optimal installation of smart meter solutions for the three sites

Reference: D4.6

Due date of deliverable: 09/2011
Actual submission date: 08/2012

Start of the project: 2011/01/01 **Duration:** 48 months

Organisation name and lead contractor: ISA

Revision: final

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable description

The goal of this document is to analyse specific monitoring requirements of each site and to detail which smart metering solutions could be used to fulfil those requirements.
After identify building characteristics and building owners requirements, a metering solution is proposed, taking into account installation and replication aspects.
Starting point was D3.1 where a general monitoring program was defined for the three sites: Alingsäs, Paris and Delft.
Even if the three sites have completely different characteristics, and although the main focus is on the technologies of BEEM-UP partners, we try to define a protocol that could be used in several retrofitting examples at a wider scale across Europe.

After a brief introduction about the need of tools to help saving energy in residential buildings, we start at section 2 by describing some Smart Monitoring Technologies. After explaining the general concept, we present the state of the art by referring some solutions available in the market. This chapter ends with a presentation of the solutions of ENECO and ISA. In Chapter 3 we identify the main requirements of the monitoring plan. Finally in Chapter 4 we apply the solutions described earlier to the three pilot sites.

Table of content

Chapter 1 Introduction

Social and cooperative housing represents 12% of the housing stock, if 5% of stock is refurbished annually, backed up with a sustained change in residents' behaviour, this can deliver 30% energy reduction by 2020. With a stock of 25 million dwellings providing homes for approximately 70 million people, Social Housing actors can direct and boost energy efficiency and renewable energy market development which will trigger the retrofitting boom and market transformation across the entire residential sector. [1]

This important conclusion of an Advisory Group of the European Commission reflects the importance of mechanisms to create awareness in tenants for the energy saving based almost in behavioural changes.
ICT and more specific Smart Meter solutions can have a determining factor to create this awareness while contributing to enhance the quality of the services provided by utilities.
When all the estimations foresee an increment in energy consumption for buildings (being a large portion for residential buildings) is urgent to implement a massive deployment of tools for automatic monitoring of consumption data in order to inform the user how much is he really spending and how can he adopt some changes to save energy.
Since the reduction of energy consumption through the use of ICT as key enabler technology is expected to be about 15% in the next years, the basic purpose of this document is to develop a method for determining a solution that best fits the requirements of Smart Monitoring solution for retrofitted buildings.

Some basic principles should be followed:

- **Cost effective solutions**
  Monitoring solutions can be affordable to the target population. In fact this aspect affects the "possibilities of replication" criterion, because a solution which is not economically efficient appears less attractive to decision-makers, and thus will less likely be replicated to other places or buildings.

- **User-friendly interfaces**
  In order to create awareness in tenants, interface solutions shall be easy to understand, easy to operate, easy to use and easy to maintain.

- **Replicable and scalable solutions**
  Although each monitoring site has its particular details and some customization might be needed for particular cases, the solutions should be easily replicable and scaled.

- **Interoperability**
  Monitoring solutions should be easily integrated with existing products and their respective networks and protocols.

Chapter 2 Smart Monitoring Technologies

Information and Communication Technologies (ICT) have an important role to play in reducing the energy intensity and therefore increasing the energy efficiency of the economy, in other words, in reducing emissions and contributing to sustainable growth. [1]

There is a common saying stating that we cannot control what we cannot measure. In fact, the first rule to save energy is to discriminate the consumption in order to establish a plan to reduce or reschedule some activities, without losing comfort.

User awareness is a crucial element for changing behaviour.

However, most end-user (tenants) and even building owners or energy mangers, do not have the suitable tools to provide the adequate information in a comfortable way. More and more consumers see their utility bills as a fixed tax they have little to no control over.
Most of the times, the only way to have an accurate measure of the consumption is to frequently make manual readings of the meters. Alternatively, consumers can wait for billing information but usually bills are an estimation of the real usage with an
Of course that we all have the intuitive idea that we should turn off lights when we live a room, turn off the air conditioning when we leave the office, exchange incandescent light bulbs with more efficient CFL, and so on. But how can we quantify, in euros and cents, how much each of those actions will save us at the end of the month? How many people can tell the marginal cost of heating the home to 21° rather than 20º? Who can tell the savings of buying a new efficient appliance and disposing of the old one?
Because the electricity consumer lacks the same kind of information feedback, the typical user has a hard time making rational decisions regarding the strategies that should be followed to lower the electric bill. Perhaps one user will spend an enormous amount of money replacing a particular piece of equipment that was not especially wasteful, and the same user misses another easy action that could be taken with a much larger impact on the electricity bill. Lowering utility bills without detailed accurate information is a frustrating game of trial and error, where well-intentioned efforts can either have spectacular results or no impact at all. That kind of uncertainty is not well conducive to sustained meaningful change that has a lasting impact.

ICT will allow information on energy consumption of every energy-consuming appliance in a home or a building to be provided in real-time, in a user friendly way, thereby empowering citizens to take decisions that lead to energy savings. All stakeholders should have the ICT enabled solutions installed and perfectly operating, and users should be made aware of these systems and being able to “work/live with them”, which will probably lead to drastic change in their behaviour.

2.1 Sensors and Smart Metering

Smart meters and related technology are experiencing a big improvement with the help of sensors. Driven by increasing complexity of remote metering solutions and services, a modern smart meter is now a sophisticated microprocessor based electronic system with wireless technologies. And sensors are a key element for these systems to meet their requirements. In fact, we are facing nowadays an expansion of smart meter technology, becoming more powerful, more reliable and more cost-effective, and as this market grows, consumer and utilities demand is growing.
A multitude of sensor technologies exist. Depending on the technology used, their characteristics like the response time, accuracy, sensitivity, uncertainty, reproducibility, and deviation vary.
All kinds of sensors are developed for both consumer and industrial applications.
Consumer sensors are generally black boxes that provide a value and are poorly documented. Sensors for industrial applications have accurate descriptions concerning measurement

method, precision, deviation, and so on. It allows analysing the measurement protocol and to understand and account for measurement error and deviation, almost impossible with consumer products.

		Units	Information and actions
Energy	Electricity	kW / kWh	By understanding their exact consumption, users can detect some overspending actions and modify behaviour in order to reduce energy usage.
	Gas	m^3	
	Water	m^3	
Comfort	Temperature	° C	This comfort indicator allows adjusting the power of the heating system.
	Relative Humidity	%	It gives data on comfort and indoor air quality, allowing optimizing ventilation system of the house.
	CO_2	Ppm	Control of ventilation depending on indoor air quality.

Table 1

2.2 State of the art

In the following pages we will present a list of solutions available in the market that could be used to develop a monitoring program.
Rather than an exhaustive and complete list it is only an example of equipment from different suppliers.

2.2.1 Energy Smart – British Gas

EnergySmart is a free online service from Bristish Gas that comes with a free electricity monitor and that helps users to determine where they use energy at home.
It is composed by an electricity monitor so users can see how much energy their appliances are using in real time. It can be connected to the user profile and related to their fixed or variable tariffs by using an online tools for monitoring and tracking energy usage.

2.2.2 In Home Displays – GEO-Green Energy Options

GEO produces an extensive range of In-Home Displays for energy consumption and management, supported by online services and mobile applications, to address a number of requirements:

- **Pre-Smart**: connecting to the electricity meter using CT clamps or a LED reader.
- **Solar PV**: connecting directly to the generation meter to give a highly accurate reading.
- **Smart**: connecting to smart electricity, gas and water meters from a wide range of manufacturers using industry-standard communication protocols & standards.

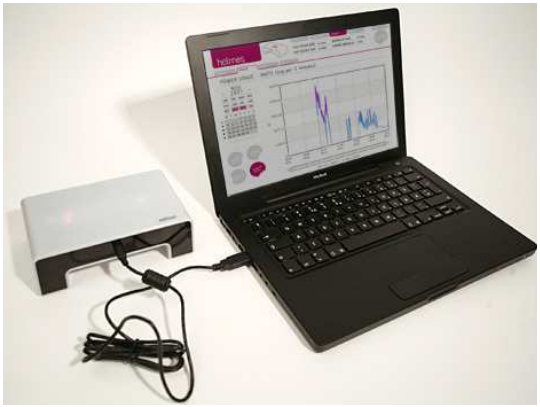
GEO's range of displays comes in 3 main categories:

Base level units primarily display meter information. This can be electricity, micro generation (Solar PV), gas or water. The Solo range works with a single meter of any type and the Duet range works with two meters.

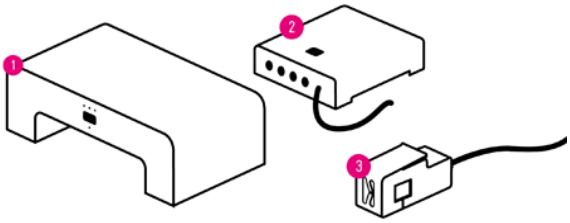
Intermediate displays, like the Ensemble, combine metering with 'smart home' functionality, primarily monitoring and control of individual devices, and web connectivity.

Advanced displays provide complete 'smart home' and metering functionality along with web connectivity and are fully programmable, to enable the energy-efficient home. The Chorus has a colour touch screen display while the "Hub" works with "soft" displays around the home, such as Tablets and PCs.

2.2.3 Wattson & Holmes – DIY KYOTO



Wireless portable energy monitor showing electricity used in the home.
The product is composed by a wattson display (1), a transmitter (2) and a sensor clip. The sensor clip plugs into the transmitter which needs to be positioned securely on a shelf or other, unmoving flat surface. The transmitter sends information to the display inside the home.
By connecting the display to a computer, we can transfer and store all the gathered data and analyse consumptions with dedicated software.



2.2.4 Eco-eye

Eco-eye is a simple but very effective tool which encourages the whole family to use electricity more wisely. By placing the display unit in a prominent place such as the kitchen or mantelpiece, users can find out how power hungry their appliances really are.

Eco-Eye Elite
With a large, clear screen Eco-eye Elite is suitable for wall mounting as well as desk or table top use. Supplied with one sensor for normal domestic use or can accept up to two additional sensors in order to monitor additional supply cables or three phase supply - usually industrial and business premises only.

Eco-Eye Mini
With exactly the same functionality as Eco-eye Elite, the Mini version is compact enough to take with you from room to room and is ideal if you are short on space. It is supplied with one sensor for normal domestic use or can accept up to two additional sensors in order to monitor additional supply cables or three phase supply - usually industrial and business premises only.

Eco-Eye Smart
Smart is a monitor equipped with the same basic features as the Elite and Mini but also loaded with some new ones, and is able to store historical data for 128 days. Battery life i.e. average 3 years dependent on battery choice, function and data output selections.

Smart allows user to set its own daily usage target – attention is immediately grabbed by the on-board instantaneous traffic light load indicator which alerts to excessive usage and the Daily Usage Target Graph which makes it easy to see if user is under or over its target. It can be connected to a computer with the optional Memory Card and USB cable.

2.2.5 Energy Saving Monitor – E-ON

Energy Saving Monitor is used to show how much electricity is used in real time. Users can see the instant effect of switching on and off appliances on their bill.
E.ON also has Plug to be used with E.ON SmartPlus Monitor & Control, allowing remote control and monitoring of appliances.

Smart Energy - Alert Me

This product consists of a simple clamp and SmartMeter reader to be attached to the home electricity meter. This will wirelessly and securely connect to the SmartHub, allowing seeing energy usage throughout the day. SmartEnergy offers three ways to see energy use:

- SmartDisplay shows real-time energy use and costs;
- Free iPhone app to check usage costs while on the go;
- Online dashboard with interactive widgets for complete control.

2.2.7 Energy Hub

The Home Area Network (HAN) solution connects over AMI, AMR or customer broadband, and utilizes advanced web tools for messaging and control during demand response events.
The easy-to-use design of the Home Base gives consumers the information and control their need to achieve real energy efficiency gains in their home. Plus, the modular nature of the system, including Sockets, Strips, Wireless Thermostats, Heavy Duty Controllers, and Wireless CT Sensors, enables utilities to control of a variety of loads in the house.

2.2.8 Smart Energy Kit – ONZO

Onzo's in-home displays deliver information to aid real time decision-making and an understanding of energy usage. On-board intelligence within the display is able to learn an individual consumer's energy use patterns, and through the use of four EnergyTools on the screen is able to provide context and insight for customers on their usage.

The display is an integral part of the Onzo Smart Energy Kit, which also includes a sensor and web portal.

The ZigBee version of the In-Home Display features other screens, including Time of Use (TOU) tariffs, Critical Peak Pricing (CPP) and Pre-pay, and communicates directly with ZigBee enabled smart meters. The display is a certified ZigBee product.

2.2.9 In Home Display – AzTech

This in home display provides precise real time feedback of the house's electric consumption. It is able to communicate directly with smart meters displaying electrical consumption in kW/kWh or currency.
Computer connectivity via USB.
Completely wireless connection to smart electrical meters.
ZigBee Certified, EnergyAxis 900 Certified, ERT compatible.

2.3 BEEM-UP Partners solution

After listing some monitoring solutions available on the market, in the next section we will describe ICT solutions from technologic partners of BEEM-UP project. Although the desired protocol for smart meter installation should not be restricted to these solutions, they will be used within the BEEM-UP monitoring program because of their cost effective characteristics and because of the technical domain over this solutions offered by ICT partners.

2.3.1 ISA – Intelligent Sensing Anywhere, S.A.

ISA provides a flexible set of solutions for energy monitoring in the home (Cloogy), and for professional energy monitoring of public buildings and factories (iMeter). Cloogy is meant to be an easy plug-and-play solution that any homeowner can quickly install. It provides information on the aggregate electricity consumption of the home, and that information can be easily accessed from the Web, from a tablet or smartphone, or from a convenient home display. Optionally, Cloogy can also monitor/control individual power sockets, and it can aggregate gas and water metering.
iMeter is a powerful advanced solution that requires some customization, and a professional installation. Other than being able to monitor electricity, gas, and water, it can monitor environmental variables (temperature, humidity, CO_2 concentration), and it can feed the data to a company's database, for analysis.
Both Cloogy and iMeter are also complemented by ISA's powerful energy cloud service: iEnergy. iEnergy provides users with a Web-Service data infrastructure, upon which more advanced solutions can be built (tablet and smartphone applications, Web portals, and energy analysis services).

2.3.1.1 Cloogy Solution

Cloogy it's a household energy management solution that allows monitoring house consumption and control electrical appliances. Cloogy shows which parts of the house are inefficient and where energy can be saved. It also helps to optimize the use of electrical appliances, in an easy way, eliminating waste and unnecessary costs.

Figure 1 – Cloogy devices

A small easily installable clamp in the electricity meter will convey all consumption information. The data will be gathered in the Hub and shown in real time on a computer, Cloogy Display, tablet and smartphone. Appliances can be monitored and remotely controlled using Power Plugs.

Figure 2 – Cloogy tablet

Because home users can't easily rewire their homes for a new appliance, Cloogy is mostly a wireless solution, built around the ZigBee protocol. Communication is easy to set up, and the system can be up and running in a matter of minutes. The installation is simple and straight forward.

The aggregate consumption of the home is measured in a non-intrusive manner, through an induction clamp that measures the total electric current coming from the utility's meter into the home. The value thus acquired is sent wirelessly to the energy hub, where information is processed, and made available to the home area network, and forwarded to the cloud via the home's Internet router.

This basic architecture is the barebones solution that allows the total consumption to be fully monitored 24/7, so the user can check the consumption history, the trends, and the deviations from a Web browser, from a tablet, of from a smartphone.

Figure 4 – Cloogy Plug

Cloogy then has a range of optional add-ons that truly make the solution a very powerful home energy platform. For the measurement and control of individual appliances, the Cloogy plug can be inserted into an electric socket, and the appliance's plug can be inserted into the other end. The plug can then measure the energy parameters of that particular appliance (current, active power, reactive power, frequency, voltage) for a total characterization of the electric load. Furthermore, the power can be remotely cut off by any authenticated user from a Web portal, a smartphone or a tablet. It is possible to have up to 11 Power Plugs working simultaneously with Cloogy.

For the user who wants to have instant feedback on the amount of energy being consumed, the Cloogy line includes the Cloogy Display, an elegant device that can be placed anywhere in the home,

Figure 3 – Cloogy display

and which provides instant graphical information on the energy consumption at any given time.
The tablet offers the user the full interactive experience of a tablet that is further able to provide precise data on the consumption of the home, as well as the possibility to control appliances.
Finally, Cloogy offers a web interface.

Figure 5 – Cloogy web interface

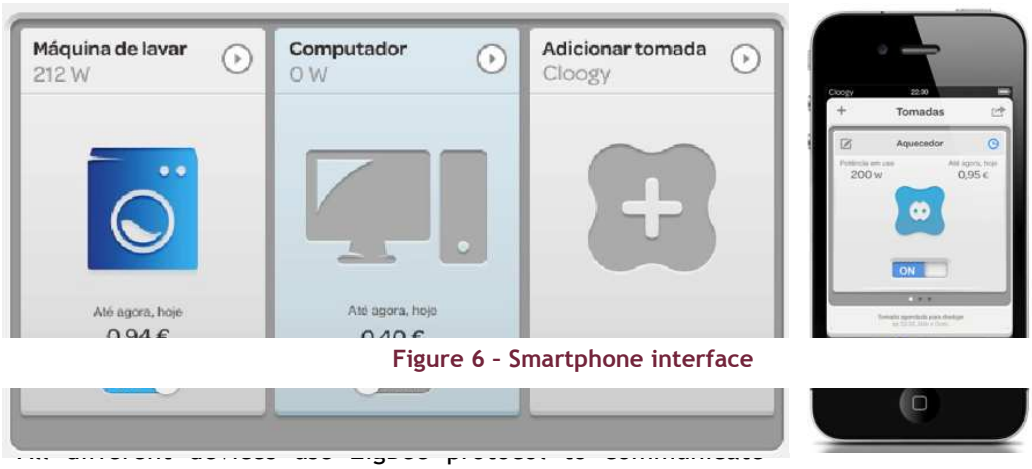


Figure 6 – Smartphone interface

with the central Cloogy hub, which, in turn, uses a standard TCP/IP protocol to connect to the Internet through the home's Internet router. This means that the system can also be easily expanded with devices from other vendors, supporting ZigBee appliances that implement the ZigBee Energy Protocol.

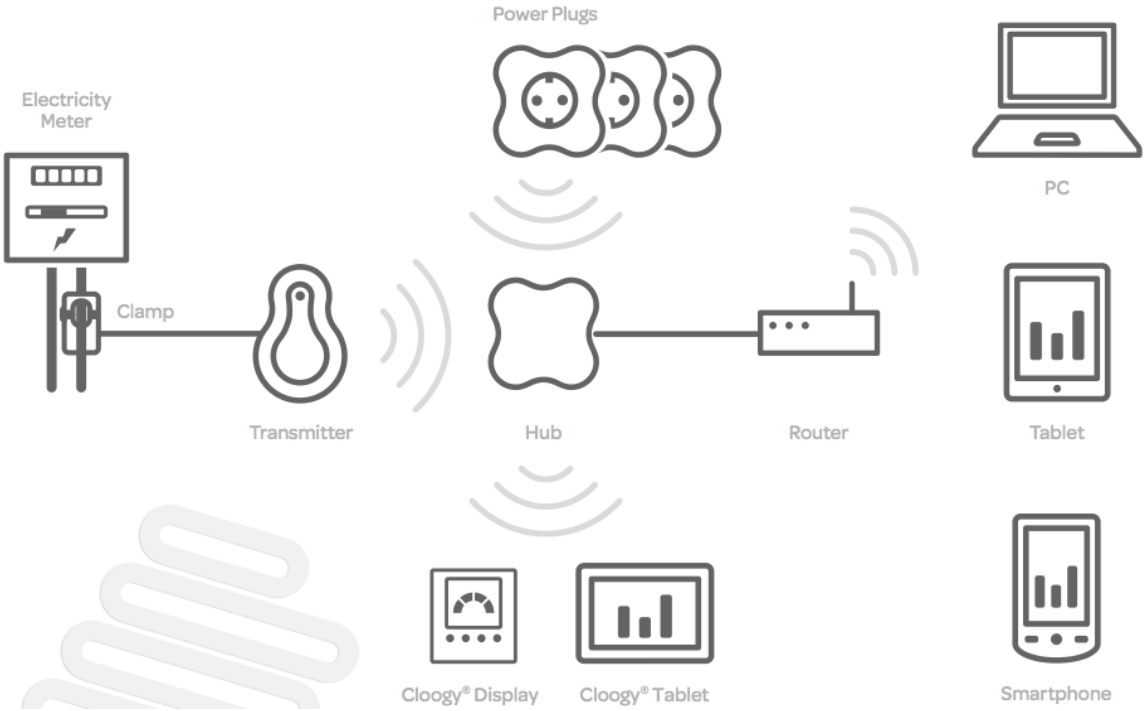


Figure 7 – Cloogy global architecture

2.3.1.2iMeter Solution

iMeter is a system solution for individual real time metering of electricity, gas and water. Data acquisitions can be made via wireless and remote communication technologies. This solution consists in the following components:

iMeterRail

Electricity meter for electric switch boards.

This sensor is able to measure several power parameters, such as:

- Power

- Voltage RMS
- Current RMS
- Frequency
- Power factor

Current: 2 ma – 80 A

Voltage: (3x) 55 – 500 Vac

iHub

This device gathers and conveys data to the communication and management platform.

Receives data from RF 868 MHz and RS485 devices and send over a TCP/IP connection.

Able to communicate with:

- NetMeters (RF device and pulse meter with 2 channels).
- MODBUS devices (Electrical consumption from industrial devices).

Allows the access of the data of each device (consumption, weather values, and other analogical values connected to the devices) through a web portal.

Enables user-customization of the data acquisition parameters directly by the webpage (Ex. Acquisition Period, MODBUS Register(s) and Function Code, Read Retry Count and Interval, Response Timeout).

NetMeter

The NetMeter is a device dedicated to water and gas meter monitoring for meters that have pulse output capability.

The communication from the meter is made by means of a reed-switch reacting to magnetic pulses from the meter. The pulse acquisition through the sensor allows it to increment a digital internal counter and in doing so, to monitor consumption.

Each NetMeter can monitor one or two meters. The device has the ability to communicate wirelessly, setting up a mesh network when other units are inside its radio range.

Web portal

iEnergy is a tool for analyse the data acquired by the sensors.

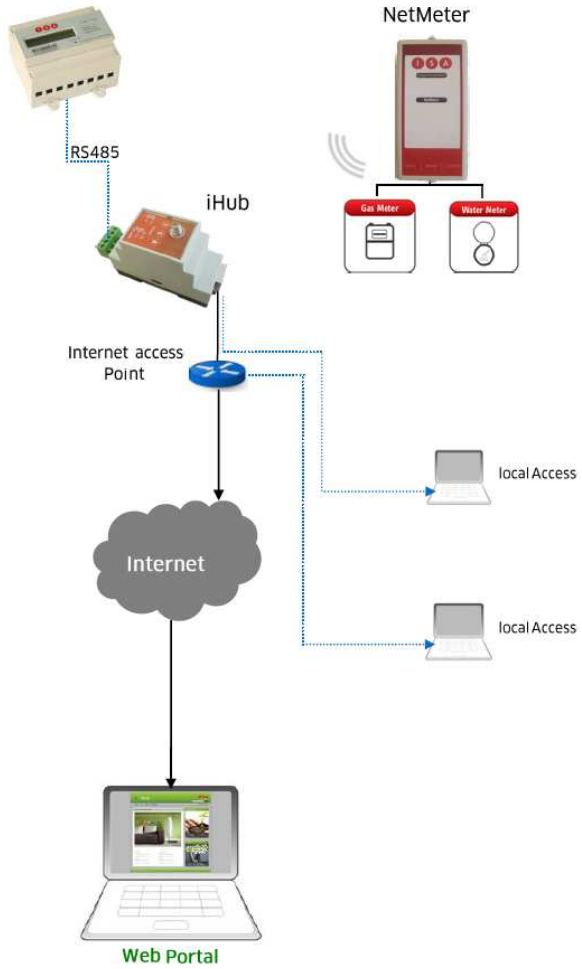


Figure 8 – iMeter global architecture

With this flexible architecture, this solution can be deployed in a range of different scenarios, with the data being easily channelled from the individual sensors to any scalable user back office, running millions of users.

The different display and sensors form a mesh network that connects every device in the home to the central console, which in turn is connected to the Internet, either through a broadband connection or a UMTS connection.
A program running on the console is able to collect data from all the different sensors, store It locally, supply it to a computer program running on the local network, or sending it to a central database on the Internet, a Web-interface is available for consumers to follow their consumption online, and compare with the average consumption in the building.
The overall energy consumption of the dwelling will be monitored by the iMeter which will provide the information obtained either through the interface installed in the dwelling or the internet. The iMeter monitors temperature inside and outside the residence, so that these parameters can be included in the evaluation and correlation of energy consumptions. After identifying less rational utilizations, the resident may opt whether to configure small automations, such as the automatic heating/lighting control and standby consumptions elimination, or to modify behaviours.
The information of consumptions is made available to the consumer, as well as comparative benchmarks of identical households and residences, with the aim of identifying and divulging beneficial proceedings An energy advisory system can be built by collecting the consumption data from different homes, analysing it looking for trends, and benchmarks, and then providing individual advice to each consumer, based on that persons' individual profile.

2.3.2 ENECO

Toon is connected with an Eneco based server through internet via the home wifi router. Energy consumption data from the regular energy meters is transferred wireless (Z-wave) to Toon within the homes.
Toon" analog reading of individual counters will be technical available at September 2012.

Figure 9

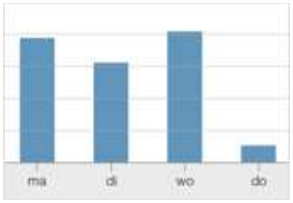
2.3.2.1 Technical specifications

- **Dimensions**
  190 x 120 x 30 mm.
- **Mounting**
  directly on the wall in a draft-free place at 1.5 meters or to the standard built-in junction.
- **Dimensions of mounting plate**
  100 x 55 x 5 mm.
- **Weight**
  about 400 grams.
- **Housing Material**
  PC / ABS
- **Control boiler**
  OpenTherm ® and on / off.
- **Supply voltage**
  24V via heating wires
- **Electricity**
  Around 50 kWh per year in normal use.
- **Screen**
  7 "resistive touch screen, 800x480 resolution.
- **External ports**
  1x USB, 1x Ethernet.
- **Associated peripherals**
  Boiler Module, Adapter, Adapter and Meter Gauge Sensors.

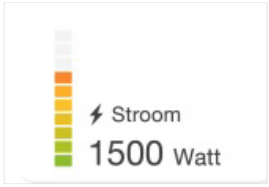
- **Approvals**
  CE Mark
  Open Therm ® certified
  Z-Wave certified

Figure 10

2.3.2.2Main Features



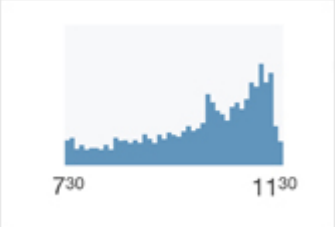
Compare energy
Toon allows users to compare at a glance gas and electricity with consumption in recent days, weeks or months.



Insight into current consumption
With Toon is possible to instantly see how much energy appliances consume. This helps users to be more aware of energy consumption.

Avoid extra charge
Toon notifies users when actual consumption is higher than the estimated consumption by Eneco.

Understanding costs
What users actually pay of energy for a day? Toon offers detailed information about actual energy costs through continuous updates of current rates.



Understanding peak consumption
With Toon is possible to see in real time what the cause of the peak power consumption during the past 4 hours is.

Actual versus estimated consumption
Toon gives instant insight into your actual consumption compared to the estimated consumption by Eneco.

Weather and traffic info
Will it rain or not? Where are the files? Toon gives direct answers.

Posts
Users can receive relevant messages about service disruptions in their boiler, software updates and updates of your delivery rates.

2.3.11.1 Global Architecture

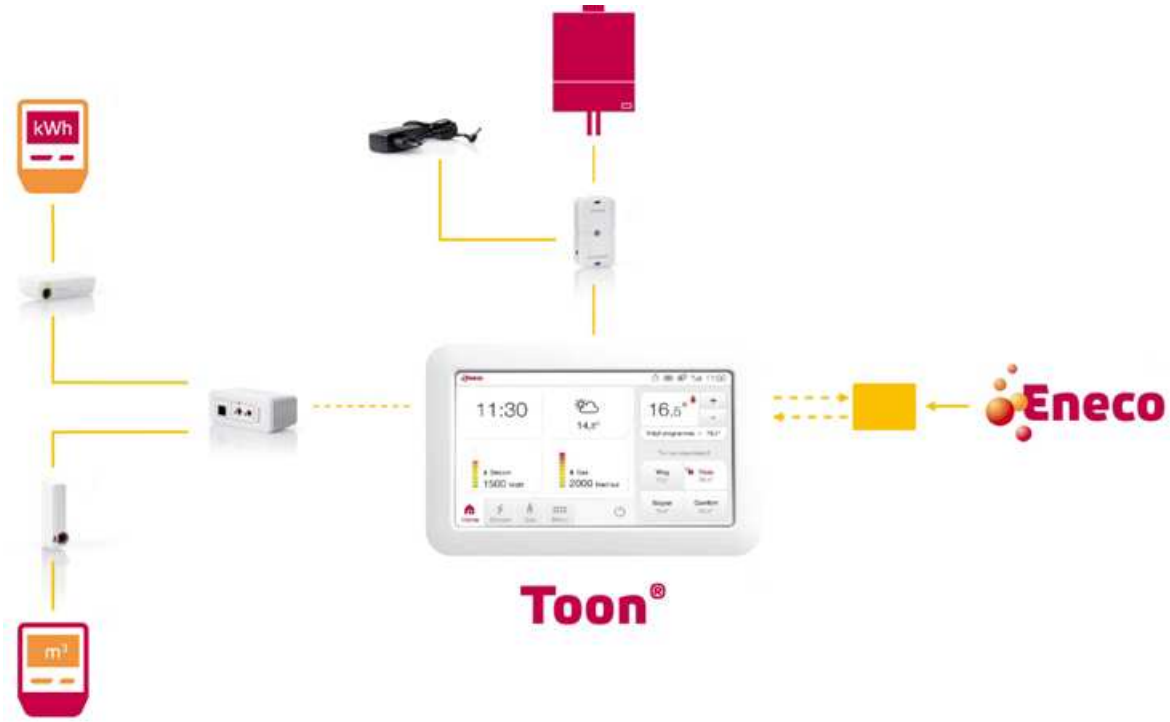


Figure 11

Chapter 3 Monitoring requirements

In this section we will identify the monitoring requirements for each site, trying to define a common approach between them.

We will start by looking at building characteristics, detailing energy sources, main consumption devices and existing communication infrastructure. Next step will be to identify user needs and how smart meter technologies can help them to adopt saving behaviours.

3.1 Building Characteristics

Pilot sites have been described in previous deliverables (D3.2) so we will make only a brief resume of the main characteristics.

Although they are very different with respect to heating systems, energy sources, dimension and even building structure, our goal is to develop a common methodology for the installation of Smart Metering solutions for the 3 sites.

We will have 3 main concerns while defining the optimal solution:

i) Characterization of the building topology, number of dwellings to be monitored, access to fuse boards and meters, and installed equipment.

ii) Communication infrastructure: is there a permanent internet connection? Has the building the right conditions to host a server with the database?

iii) Identification of stakeholders: who will read and analyse the acquired data? Who will benefit with smart monitoring? What kind of information should be delivered?

iv) Building geometry, in order to determine the distance between the sensors and communication gateways.

v) Apartment Type, flat level and flat area, in order to determine the number of radio sensors needed inside the building

3.2 Challenges

In this monitoring program we will have a specific set of challenges to overcome. Let's look at the most important ones:

1 – To specify a Smart Metering solution to collect and present in a detailed way the consumption of each dwelling. Special attention should be taken to measures that allow assessing the energetic gain resulting from retrofitting.
Individual metering saves energy by motivating the tenants to be responsible for their own energy consumption. If used for individual billing, this is an efficient approach to motivate energy saving behaviour. Heat cost metering is a legal requirement in some EU countries and is likely to become a standard across Europe due to the requirement to reduce CO_2 emissions

2 – Empowering the consumer with information which would result in energetic efficiency by behavioural changes. If we want to reduce the building consumption is also necessary to involve the users. If consumers are truly to harness the power of the smart meter, it will need to move out of its traditional location under the stairs or in the garage and take centre stage in the home for all to see and use. And, as the smart meter becomes an essential element of the 'networked home' the user interface will be the single most important component that influences user perception. This, coupled with the need to display more and more information, will dictate display size, type and functionality. Thus the following ICT contains a user layer, which will provide the user with the necessary information about energy consumptions and behaviours. This information must be more that a monthly bill and down to the device/outlet level. This goal can be reached primarily by the elimination of unnecessary consumption such as lighting or air conditioning in empty rooms or standby consumptions, the

centralized control of temperature and lighting, the automatic scheduling of washing machines to lower cost periods during the day, for instance. Furthermore, the continuous monitoring of those variables may enable the detection of abnormal situations like the detection of leaks, which would immediately trigger an alarm and alert the energy manager, or system responsible to the abnormal consumption value. All of this potential savings should be taken without reducing tenants comfort levels.

3 – Supply a tool for building owners that allows them to assess the energetic savings after retrofitting and, this way giving a justification to a probable increase of income.
The monitoring will be continuously and in real-time in order to obtain reliable information about the performance of the buildings.
The European Commission has recognised the potential role ICTs can play in improving the energy performance of buildings in several high-level policy documents. The 2010 Communication "A Digital Agenda for Europe" emphasises that the ICT sector can deliver simulation, modelling, analysis, monitoring and visualisation tools to improve both the design and operation of buildings.

Chapter 4 Monitoring Solutions for Each Site

Our purpose for this section is to describe some possible monitoring solutions for each one of the three sites.
Although there are several solutions in the market that could fit our goals (as we could see in 2.2), we will give special attention to BEEM-UP partners solutions (ENECO and ISA). Nevertheless one of our goals is to define a common approach and methodology to develop ICT solutions and to validate their results.
For each site we have followed a bottom-up approach by first collecting the relevant parameters to be measured (like stated in D3.2) and then identifying the necessary sensors and communication technologies to fulfil our plans. This way we can assure that the selection made is adequately fitted for each pilot site and useful to satisfy the building owners and user's needs.
In the following sections the three different solutions will be described.

4.1 Alingsäs

There are several houses retrofitted in Alingsäs. However it has been decided to make measurements in only one of the buildings (House H).
All the dwellings are only one level and the total area makes it suitable the use of ZigBee solutions for the entire apartment.
After the renovation the buildings will be equipped with mechanical supply and exhaust air with heat exchange. Each house has a central air handling unit (AHU) placed on the top floor of the house.
After renovation all the dwellings have been transformed in passive houses that the major part of the heating demand will be covered with the heat from the extracted from the exhaust air. If necessary more heat can be added with district heating. There is one central heater placed just after the AHU. In each apartment there is one decentralized heater placed in in the supply air channel that the tenants can control themselves.
District heating is used to produce heat and domestic hot water.

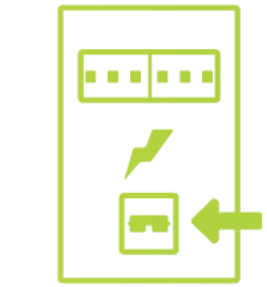
Table 2

Purpose	Target	Scale	Means
Energy consumption	Electrical consumption	Dwellings	Measures of general electricity consumption
Indoor environment parameters	Thermal comfort	Dwellings	Temperature and humidity

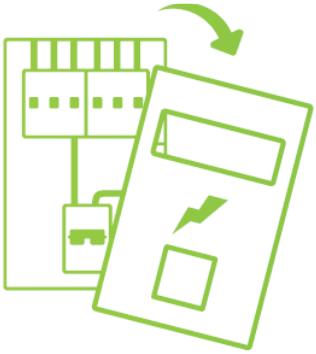
The monitoring scheme can be made by measuring the entire consumption of each house plus two more dedicated meters (plugs) in devices with high consumption profile.
These two meters can be moved whenever the tenants wish, in order to make a more comprehensive energy profile of the house.

This is an example of how to install Cloogy solution in a straightforward manner.

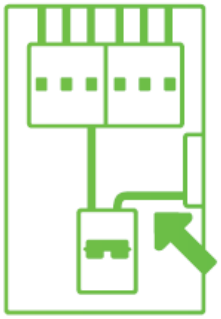
Put the AA batteries in the transmitter – the orange LED should light up, indicating that the equipment is receiving electric charge.



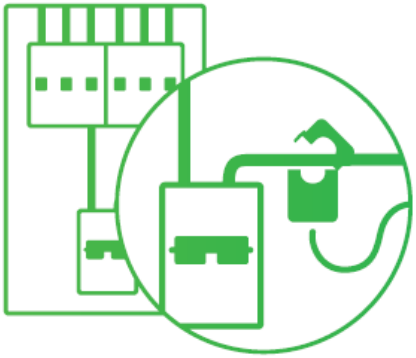
Locate the electric switchboard cabinet and turn off the general circuit breaker.



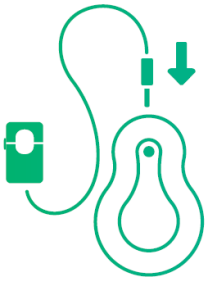
Remove the protective panel.



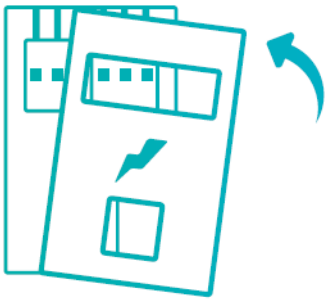
Identify the neutral wire of the electric switchboard (normally it's the blue wire) that comes out of the residual-current device (RCD), as seen in the image.



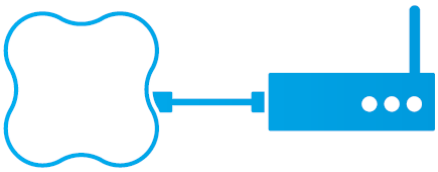
Open the sensor clamp and put it around the neutral wire. Close the Clamp.



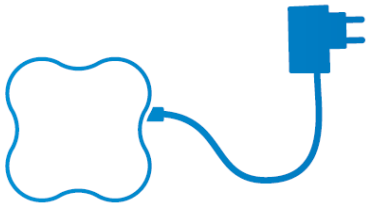
Connect the Clamp to the Transmitter.



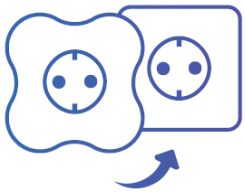
Place the Transmitter inside the electric switchboard cabinet and put back the protective panel. Turn on the general circuit breaker.



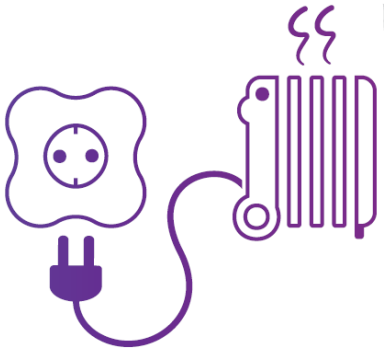
Connect the Hub to an internet router using an ethernet cable.



Connect the Hub to the AC Adapter so that it can receive electric charge.



Connect the Power Plug to the appliance to be monitored. To do so:
a) Connect your Power Plug in your socket (make sure that your Power Plug light up to a blue color, indicating that they are within range of the Hub);



b) Plug in an appliance and control the consummation directly into the Power Plug. The Power Plug's light should turn green once the appliance is consuming energy

Check if everything is working correctly by confirming that the Hub's two LED's have turned green. It may take a few moments until Cloogy starts communicating through the Internet with the web portal www.cloogy.com

After completing the kit's installation process, enter Cloogy's Internet portal through the site www.cloogy.com.

4.2 Delft

As stated in the monitoring plan, 30 dwellings have been selected for the monitoring in Delft. The parameters to be evaluated are defined in Table 3.

Table 3

Purpose	Target	Scale	Means
Energy Consumption	Heating and DWH	Dwellings	Gas consumption measures
	Electrical consumption	Dwellings	Measures of general electricity consumption
Indoor environment parameters	Thermal comfort	Dwellings	Temperature measures

During installation, there is one meter adapter installed and connected to the gas and electricity meter. This meter adapter registers the consumption data and sends it wirelessly to "Toon" where they are shown in graphs. Because "Toon" is connected to internet via wifi, Eneco is able to read consumption rates for gas and electricity as well as temperature settings and indoor temperature. "Toon" can also show whether there are deviations of the estimated consumption by Eneco.

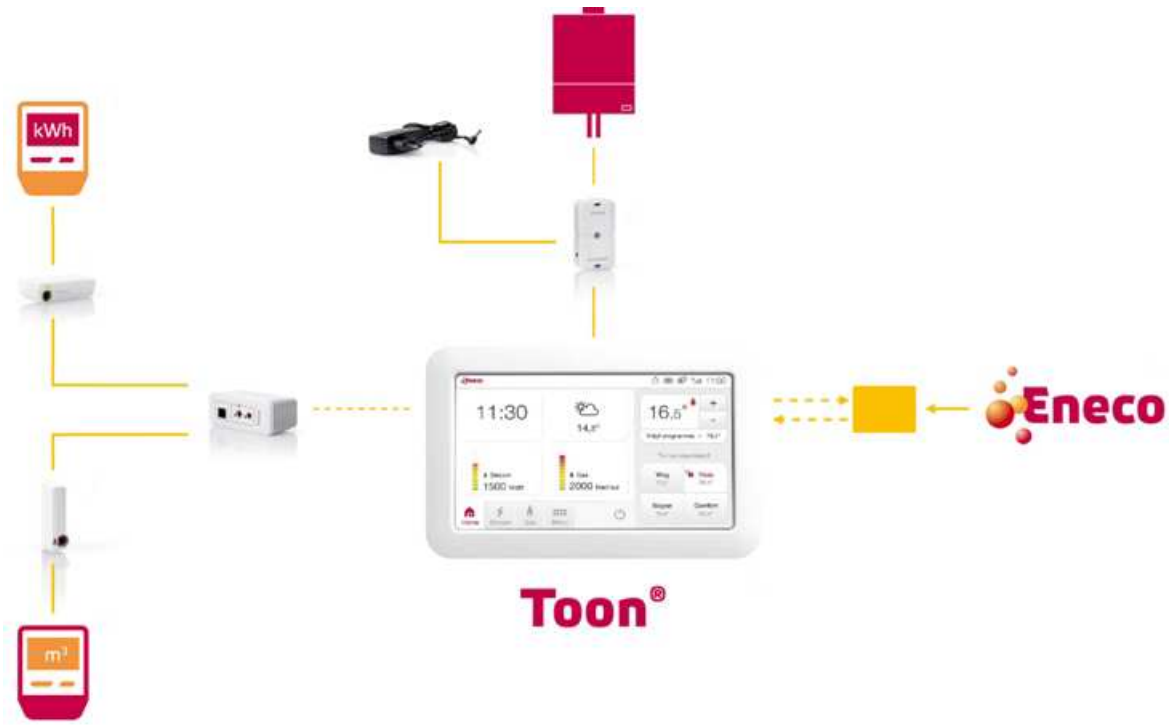


Figure 12

4.3 Paris

Accordingly to D3.2, 17 dwellings have been selected for the monitoring because they are representative of the whole building characteristics. The parameters to be evaluated are defined in Table 4.

Table 4

Purpose	Target	Scale	Means
Energy Consumption	DWH	Dwellings	Electric consumption measures
	Electrical consumption	Dwellings	General electricity consumption
	Lighting	Dwellings	
Indoor environment parameters	Thermal comfort	Dwellings	Temperature and RH measures

Given the differences in the topology and the desired measures, Cloogy or Toon solutions are not the desired technologies to implement in the Paris site.
Although we can measure separated circuits with different clamps connected to one cloogy transmitter, for gas measures we need to use iMeter solution.
Since cloogy solution has a better interface with end user and has devices to monitor specific appliances, we can use am integrated solution like the one represented in Figure 13.

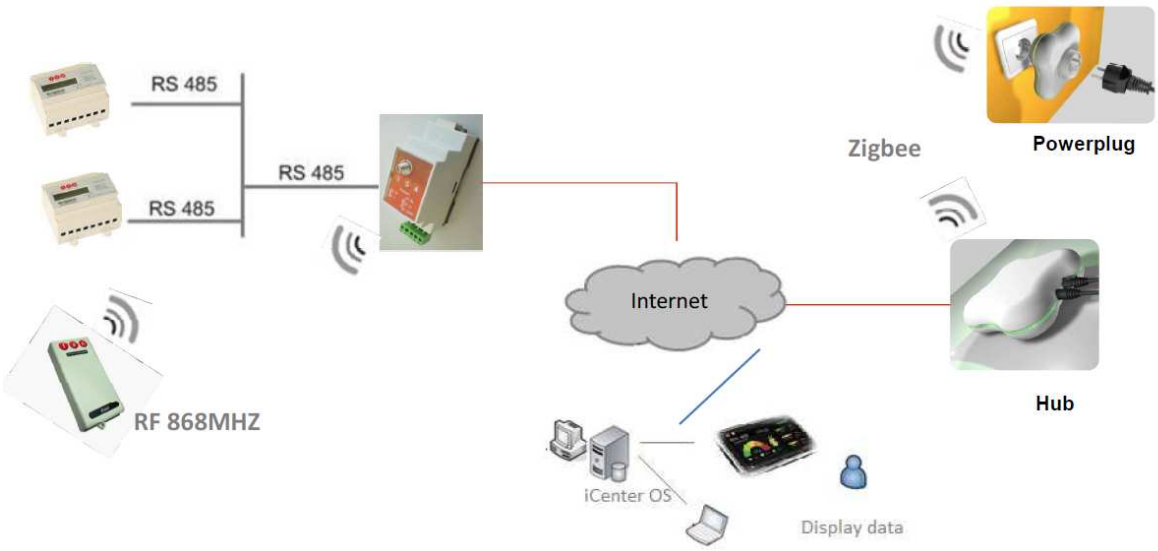


Figure 13

The installation and configuration procedure for the iMeter solution must be accomplished by a skilled technician, since it involves several tasks in the house switchboard.
Some essential requirements must be safeguarded while the retrofitting is taking place:

i) There must be empty space in the switchboard to install de meter (DIN-RAIL);
ii) An internet connection must be present near the meter, to connect the gateway;
iii) The gas meters must have a pulse output in order to connect to the radio device;
iv) Gas meters must be within communication range (typically 50 meters with obstacles).

Chapter 5 Conclusions

It is clear that buildings are responsible for a large amount of energy consumption in Europe, so Energy Efficiency of buildings is a key factor to achieving the EU Climate and Energy objectives.
Since in residential buildings, personal choices influence energy consumption, smart and sub metering technologies are becoming widely available because they provide the ability to determine where (sub metering) and when (smart metering) energy is being used, enabling individual users to see their consumption pattern and adopt appropriate measures for energy saving.
Most studies indicate that feedback about consumption can stimulate resource conservation.
Real-time, smart metering allows for optimization of energy consumption, through occupant behaviour.

Intuitive feedback to users on real time energy consumption in order to change behaviour on energy-intensive systems usage could reduce 5-15% of energy consumption.

In BEEM-UP project, the installation of Smart Meter solutions can have 3 main advantages:

i) Tenants have feedback about energy consumption, allowing a behavioural change by the users;
ii) By analysing consumption data, we can calculate the real gain in energy savings after retrofitting;
iii) Can be an excellent tool to justify an increasing in the rent, without being an extra cost to the tenant (because of energy savings).

The way results are presented to the users is a critical aspect and can dictated the success or failure of the solution. Smartphones and touchscreens are becoming more popular as user interfaces. Besides a web portal dedicated to energy consumption with strong connections to social networking website models, it is important that modern solutions can offer to end-users a tablet and an app for smartphone to interface the solution.

References

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