WP4 report for REMODECE

Energy piano

End-use load recording in the Residential sector

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1. Introduction

The overall objective of the REMODECE (Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe) project is to contribute to:

- an increased understanding of the energy consumption in the **EU-25+2** households for the different types of equipment, the consumers' behaviour and comfort levels
- identify demand trends
- evaluate the potential electricity savings in the residential sector that can implemented by existing means as very efficient appliances and reduced standby consumption.

The availability of high quality end-use data is an essential condition for the definition of policy recommendations to influence through a combination of increased energy efficiency of household appliances to be sold in the **EU-25+2** in the next decade, as well as to influence the user behaviour in the selection and operation of that equipment. REMODECE collect data by new monitoring and surveying campaigns.

EU countries without earlier end-use load recording campaigns are to include the total consumption and end/uses: cooker, refrigerator, freezer, washing machine, tumble dryer, dishwasher, entertainment as TV, DVD and CD player, computer and peripherals, oil or gas burner including circulation pump, residential air condition and the 10 most used lamps as separate end-uses. Second best is recording on the sum of groups of lighting in case the installation is including that.

EU countries that already have executed end-use load recording campaigns (with data to be included in the EU database) will besides the total consumption concentrate on the appliances with a lot of changes: computer and peripherals, entertainment systems as home movie systems, game/playstation consoles, DVD players/recorders and Large plasma TV, new Standby consumption by set-top box, DVD players/recorders and plasma TV, residential air conditioner and lighting (as many lamps as possible with first priority to CFLs and halogen lighting).

The campaign should include one full month of end-use recording per home. Summer months with little use of lighting and customer absence due to holidays has to be avoided except for the air conditioners has to be recorded in the summer months.

In case of recording on appliances which are sensitive to temperature as air conditioner, the outdoor and indoor temperature has to be recorded.

The purpose of this report is to give:

- Priority of which end/uses to include in the campaign
- ID system to be used to ensure unique identify of all measurements and recordings
- Advice on how to handle the load data retrieval including ID system for all measurements, data retrieval, quality control and repair of data.
- Checklist for preparation and installation.
- Comparison of equipment for end-use recording in the domestic sector
- A "catalogue" produced based on material from manufactures and partners including main features, prices (these may always be negotiated with the manufacturer), list of organisations that have experience with use of the equipment, website of manufactures for additional information and contact

2. Priority of end-uses to include in the campaign.

The amount of recording equipment is limited thus priority of which end uses to include has been discussed at the first two projects meeting. The decided priority is listed below.

Bulgaria, Czech Republic, Hungary and Romania:

1. Total consumption
2. Washing machine
3. Tumble dryer
4. Entertainment as a group of appliances in living room: TV, DVD, CD, …
5. Computer and peripherals as a group for home office
6. Refrigerator (period consumption + spot metering of load at installation by SEM 10)
7. Freezer (period consumption + spot metering of load at installation by SEM 10)
8. 10 most used lamps individually or the sum of lighting by groups in the installation
9. All kind of stand by consumptions recorded at the time of installation by SEM 10 including satellite amplifier, Internet connection, chargers, etc.

If possible add:

- sum of computer and TV set per teenager room
- cooker including oven
- dishwasher
- oil or gas burner including circulation pump
- Water heating

Belgium, Denmark, France, Germany, Greece, Italy, Norway and Portugal

1. Total consumption
2. TV + VHS + DVD + Home Cinema
3. Large TV screen or other specialities might be recorded separately
4. CD + Stereo
5. Computer and peripherals as a group in office room
6. Sum of computer and TV set for every teenager room
7. 10 most used lamps individually or sum of lighting by groups in the installation
8. Air conditioning (only southern countries)
9. All kind of standby consumptions recorded at the time of installation by SEM 10, including satellite amplifier, setop boxes internet connection, chargers, etc.

If possible add:

1. Separate recording on individual appliances within the nine groups above
2. cooker including oven
3. washing machine, tumble dryer, dishwasher

Refrigerator and freezer consumption might be recorded over a short period along with spot metering of the load at time of installation by SEM10 equipment.

3. ID for end-use recordings and other measurements

It is necessary that all measurements and end-use load recordings from the participating countries have unique ID in order to perform data analysis in WP 5 (SINTEF responsible) and for storage in the EU database created in WP2 (Enertech responsible).

The ID is composed by 15 digits including: **cccc pp nnn aaaaaa**

cccc is a country code
pp is the campaign number
nnn is the number of the household included in the program
tt aa nn is a number identifying each recording point/file that can be an appliance, the mains (total consumption per home) or a temperature

1. Country code cccc

The code consist of the 1 followed by the national telephone code of the country, e.g. 45 for Denmark and 351 for Portugal.

1032 for Belgium
1045 for Denmark
1033 for France
1049 for Germany
1030 for Greece
1039 for Italy
1047 for Norway
1351 for Portugal
1359 for Bulgaria
1420 for Czech Republic
1036 for Hungary
1040 for Romania

2. Campaign number pp
The campaign number is a consecutive numbering of measurement campaigns.
In REMODECE we will use campaign numbers 01.

3. Household number nnn
The household number is the numbers of households participating in the campaign e.g. 1-100 for a campaign including 100 households.

4. Appliance number tt aa nn

- **tt** identify the type of appliance
- **aa** identify the specific appliance
- **nn** is the relative number of the appliance in case there is more than one.

Due to lack of recording equipment, the sum of consumption for several appliances may be recorded summated by use of a multiple switch box (can be used for audiovisual, computer, lighting and small cooking appliances). In this case, **aa** must be a cluster code. Cluster recording should only be used when it makes sense to analyze the recorded data.

On/off recording of cluster lighting must in the data handling be split into data files for each lighting source in the cluster.

01 Cold appliances

01 01 01 Refrigerator 1
01 01 02 Refrigerator 2
01 01 03 Refrigerator 3
01 02 01 Fridge freezer 1
01 02 02 Fridge freezer 2
01 03 01 Chest freezer 1
01 04 01 Vertical freezer 1
01 05 01 American freezer 1
01 06 01 Vine fridge 1

02 Washing machines, dish washers...

02 01 01 Washing machine 1
02 02 01 Dish washer 1
02 03 01 Clothes dryer (without condenser) 1
02 04 01 Clothes dryer (with condenser) 1
02 05 01 Discharge clothes dryer 1
02 06 01 Washing machine with cloth dryer 1
02 07 01 Iron 1
02 08 01 Vacuum cleaner 1
02 09 01 Central hover 1
02 10 01 Steam cleaner 1
02 11 01 Sewing machine 1

03 TV

03 01 01 CRT TV <=55cm 1
03 01 02 CRT TV <=55cm 2
03 02 01 CRT TV >55 and <=72cm 1
03 03 01 CRT TV >72cm 1
03 04 01 LCD TV <=52cm 1
03 05 01 LCD TV >52 and <=81cm 1
03 06 01 LCD TV >81cm 1
03 07 01 Plasma TV <=107 1
03 08 01 Plasma TV >107 and <=120 cm 1
03 09 01 Plasma TV >120 cm 1
03 10 01 Video projector 1
03 11 01 LCD/Plasma TV controller 1
03 91 01 Cluster of TV + VCR 1
03 92 01 Cluster of TV + VCR/DVD 1
03 93 01 Cluster of TV + DVD 1
03 94 01 Cluster of TV + VCR + HI-FI 1
03 95 01 Cluster of TV + VCR/DVD + HI-FI 1
03 96 01 Cluster of TV + DVD + HI-FI 1
03 99 01 Cluster of other combination of TV and/or audiovisual appliances 1

04 Audiovisual appliances

04 01 01 Combined VCR/DVD 1
04 02 01 Combined VCR/TV 1
04 03 01 Combined HD/DVD 1
04 04 01 VCR 1
04 05 01 DVD player 1
04 06 01 DVD player and recorder 1
04 07 01 Home cinema 1
04 08 01 Games console 1

04 09 01 Hard Disc 1
04 10 01 Set top box with hard drive 1
04 11 01 Satellite/cable set top box 1
04 12 01 Digital terrestrial television box 1
04 13 01 Decoder 1
04 14 01 Satellite amplifier 1
04 15 01 Antenna booster 1
04 16 01 Audio/tuner amplifier 1
04 17 01 Subwoofer amplifier 1
04 18 01 Hi-Fi 1
04 19 01 Portable Hi Fi 1
04 20 01 CD player 1
04 21 01 Cassette player 1
04 22 01 Gramophone 1
04 23 01 Speakers 1
04 24 01 Security camera 1
04 25 01 Camera charger
04 26 01 Retro projector 100-150
04 27 01 Retro projector >=150
04 28 01 Active loud speakers 1

04 91 01 Cluster of appliances that accompany TV (amplifier, decoder, DVD) 1
04 92 01 Cluster of HI FI appliances (radio, CD, Gramophone etc.) 1
04 93 01 Cluster of home cinema and DVD 1
04 94 01 Cluster of home cinema, DVD and audio amplifier 1
04 95 01 Cluster of TV and HI FI appliances
04 99 01 Cluster of various TV and audiovisual appliances

05 Computer

05 00 01 Computer site 1
05 01 01 Desktop 1
05 02 01 CRT monitor <17” 1
05 03 01 CRT monitor 17” 1
05 04 01 CRT monitor >17” 1
05 05 01 LCD monitor <17” 1
05 06 01 LCD monitor 17” 1
05 07 01 LCD monitor >17” 1
05 08 01 Desktop + CRT monitor <17” 1
05 09 01 Desktop + CRT monitor 17” 1
05 10 01 Desktop + CRT monitor >17” 1
05 11 01 Desktop + LCD monitor <17” 1
05 12 01 Desktop + LCD monitor 17” 1
05 13 01 Desktop + LCD monitor >17” 1
05 14 01 Desktop + monitor + UPS 1
05 15 01 Laptop 1
05 16 01 Laptop + CRT monitor <17” 1
05 17 01 Laptop + CRT monitor 17” 1
05 18 01 Laptop + CRT monitor >17” 1
05 19 01 Laptop + LCD monitor <17” 1
05 20 01 Laptop + LCD monitor 17” 1
05 21 01 Laptop + LCD monitor >17” 1

05 91 01 Cluster of desktop + CRT monitor + printer 1
05 92 01 Cluster of desktop + CRT monitor + printer-scanner-copier 1
05 93 01 Cluster of desktop + LCD monitor + printer 1
05 94 01 Cluster of desktop + LCD monitor + printer-scanner-copier 1

05 95 01 Cluster of desktop + CRT monitor + printer + TV + HI-FI 1
05 96 01 Cluster of desktop + LCD monitor + printer + TV + HI-FI 1
05 97 01 Cluster of laptop + printer 1
05 98 01 Cluster of laptop + printer + TV + HI-FI 1
05 99 01 Cluster of PC and/or peripheral computer appliances 1

06 Peripheral Computer appliances

06 01 01 Inkjet printer 1
06 02 01 Laser printer 1
06 03 01 Photo printer 1
06 04 01 Printer-scanner-copier 1
06 05 01 Scanner 1
06 06 01 Copier 1
06 07 01 Modem 1
06 08 01 Internet/TV/Phone box 1
06 09 01 Router 1
06 10 01 WIFI module 1
06 11 01 Wireless mouse 1
06 12 01 Wireless headset 1
06 13 01 Computer amplifier 1
06 14 01 External hard disk 1
06 15 01 Electrical CD storage 1
06 16 01 USB hub 1
06 17 01 Fax 1
06 18 01 Paper shredder 1
06 19 01 Picture receiver 1
06 20 01 Picture transmitter 1
06 99 01 Cluster of various peripheral computer appliances

07 Air conditioning + heating

07 01 01 Mono split 1
07 02 01 Multi split 1
07 03 01 Heat pump air/air 1
07 04 01 Heat pump air/water 1
07 05 01 Heat pump water/air 1
07 06 01 Heat pump water/water 1
07 07 01 Circulation pump 1
07 08 01 Humidifier 1
07 09 01 Mobile air conditioner 1
07 10 01 Fan 1
07 11 01 Well pump 1
07 12 01 Gas burner for heating 1
07 13 01 Oil burner for heating 1
07 14 01 Electric water heater 1

08-12 Lighting ID (see below)

tt identify the type of lighting source. In case of cluster recording on more than one lighting source, use code 99.

aa identify the **room** using the following codes:

00 Total lighting consumption
01 Bar
02 Bathroom
03 Bedroom for parents or guests
04 Corridor

05 Dining room
06 Entrance
07 Garage
08 Guest room
09 Hall
10 Kitchen
11 Living room
12 Office
13 Outside
14 Sauna
15 Stairs
16 Store room
17 Studio
18 Washing room
19 Cellar
20 Bedroom for children
21 Security lighting

nn identify the relative number of the single lamp. In case of three bedrooms with a total of 4 incandescent lamps, the numbers will be 01-04

In case there is more than one room of one type, you can use the first digit in **nn** to specify the room number and the last digit to identify the relative number of the single lamp. Example: 08 20 11 (tt aa nn) is the first incandescent lamp in no 1 bedroom for children, while 08 20 21 is the first incandescent lamp in no 2 bedroom for children.

Using this system there can maximum be 10 lamps of the same type in a room but that should normally not be a problem.

08 Lighting Incandescent

Examples 08 02 01 Incandescent no 1 in bathroom
08 02 02 Incandescent no 2 in bathroom
08 03 01 Incandescent no 1 in parents bedroom
08 20 01 Incandescent no 1 in bedroom for children

99 03 01 Cluster no 1 in parents bedroom (e.g. including 2 incandescent + 1 halogen)

09 Lighting Low voltage (12 V) halogen

10 Lighting 230 V halogen

11 Lighting Flourescent tubes

12 Lighting CFL

14 LED

13 Cooking

13 00 01 Cooker 1
13 01 01 Oven 1
13 02 01 Microwave oven 1
13 03 01 Bread maker 1
13 04 01 Espresso coffee machine 1
13 05 01 Coffee machine 1
13 06 01 Ice cube maker 1

13 07 01 Kettle 1
13 08 01 Toaster 1
13 09 01 Food processor 1
13 10 01 Juice blender 1
13 11 01 Cooker hood 1
13 12 01 Egg cooker 1
13 99 01 Cluster of cooking appliances (except cooker) 1

15 Reserve

16 Other appliances

16 00 01 Electrical seat 1
16 01 01 Electrical bed 1
16 02 01 Automatic door 1
16 03 01 Water softener 1
16 04 01 Aquarium 1
16 05 01 Whirlpool spa bath 1
16 06 01 Sauna 1
16 07 01 Hair dryer 1
16 08 01 Electric toothbrush 1
16 09 01 Alarm system 1
16 10 01 Gas sensor 1
16 11 01 Guitar amplifier 1
16 12 01 Turntable table 1
16 13 01 Electric clock 1
16 14 01 Electric clock with radio 1
16 15 01 Electric clock with radio and CD 1
16 16 01 Battery charger 1
16 17 01 Water bed 1
16 18 01 Curling iron 1
16 19 01 Iron for steam dry ironing 1
16 21 01 Phone call identifier 1
16 22 01 Simple answering machine 1
16 23 01 Phone-fax 1
16 24 01 Mobile phone charger 1
16 25 01 Cordless phone 1
16 99 01 Cluster of several small other appliances 1

17 Total consumption (mains)

17 00 01 Total consumption of the site.
17 01 01 Total consumption for installation zone/group 1 (recording on a zone/group in the installation)
17 01 02 Total consumption for installation zone/group 2
17 01 03 Total consumption for installation zone/group 3
17 02 01 Total consumption residual (mains subtracted all end-use recordings)

18 Temperatures

18 01 01 Outside temperature
18 02 01 Air conditioned room 1, mention the type of room
18 02 02 Air conditioned room 2, mention the type of room
18 02 03 Air conditioned room 3, mention the type of room
18 03 01 Electric heated room 1, mention the type of room
18 04 01 Room 1 without air con. or elec. heating, mention the type of room

4. Handling of load recording data

In order to succeed with load recording campaigns systematic data handling is crucial.

All partners need to set up procedures for handling of all recorded load research data including the following functions:

1. Handling the all customers and load appliances by systematic ID (see part 3).
2. Installation with training and documentation for routines.
3. Remote reading of data every night with daily control of data. Remote reading is preferable due to the high control, but alternatively data can be taken by visit of the customer every week or at least every month.
4. Quality control.
5. Data repair/correction of failures.
6. Storage of accepted data in national database.
7. Load Research analysis facilities (own analysis besides the analysis SINTEF Energy performs).

4.1 ID of every recording point

See part 3 concerning the ID system to use. Enertech has provided installation sheets which can be used to keep track on all information at installation including standby consumptions measured.

4.2 Information to collect at the time of installation

At the time of installation of end-use recording we must use the opportunity to collect more information by:

1. Collecting information about every end-use to be recorded - this is especially important when several appliances go in as a sum and one end-use recording.
2. Spot metering on small appliances not included in the end-use recording – standby consumption is very important to measure e.g. by SparoMeter (equipment 1 described in the “catalogue”).
3. Note of consumption information e.g. from appliance label
4. Size of the family, type of home and area

4.3 Remote reading, integration period and type of recording

Remote reading is a benefit since data can be taken home every night and data is thus maximum lost for a day in case the equipment fails – this is especially a benefit for long campaigns while campaigns with recording only a month per customer maximum risk a loss of one month data. In case of no remote reading, it is convenient if the equipment have internal storage for the campaign period.

End-use recording in other EU project are nearly all done with 10 minutes integration period while some countries e.g. the Nordic countries has a tradition of using equipment with 15 minutes integration period. It is recommended to use 10 minutes integration period in Remodece as far as possible.

Also the total load from the electronic meter has to be recorded with 10 minutes integration period which makes it possible to calculate the residual of small appliances as the difference between the total load and all the end-uses recorded.

End-use recording is most easily installed by the plug in type which is also giving less visual discomfort for the people living in the houses and much smaller costs for installation. Clamps or cable junction must be used if the appliances can not be plug in.

4.4 Quality Control of data

Data must go through a standardized quality control including functions for correction/repair of data in the process or later.

No data must pass into the load research database before the user of the system has approved data.

Types of control to perform:

- Control of start of new file fits with stop of last file
- Control for excessive zero intervals
- Data values should be within a set of high/low boarders specified by the user.
- Load factor should be within a set high/low boarders specified by the user.
- Graphic display of data

4.5 Data Repair and Correction:

Small holes in data repaired based on load on same types of days and energy consumption for the period.

There shall be manual editing of data which the option of correcting, adding or deleting data or intervals of data. Manuel editing shall include graphical display of data.

Any repair/correction of metered data shall be traceable by

- List of files with problems
- List of missing data for at given period
- List of data which is not accepted due to bad quality

4.6 National database

Accepted data is to be stores in a load recording database using the systematic ID of each customer and appliance.

There shall be procedures for data backup as well as the possibility to restore the original data.

5. Standby consumptions

WP2 includes actually standby consumption for the appliances shown in the list below. The list can thus be used for check of which instantaneous standby consumptions might be useful to measure.

Please send your standby consumptions to Enertech for inclusion in the WP2 database:

- Please use a text files or an excel file including four columns: household number, appliance ID **tt aa nn** (see the description in section 3), the measured standby power (in W) and extra appliance description/comment.
- Example for household number 9: 9, 030201, 3500, Sony LCD TV 60 cm
  9, 061301, 2200, Motorola ADSL modem
  9, 160103, 1850, Mini oven BcB2
  ...

Type	Appliance	Type	Appliance
Cold	Refrigerator	**TV/Video**	CRT TV
	Refrigerator - freezer		LCD TV
	Chest freezer		Plasma TV
	American freezer		Videoprojector
Cooking	Coffee machine		DVD player
	Cooker (oven + hotplate)		DVD recorder
	Microwave oven		Hard Disc
	Kitchen oven		VCR
HiFi	HiFi system		Combined VCR/DVD
	Speakers		Combined VCR/TV
	CD player		Combined HD/DVD
	Clock-radio		Home cinema
Office	Desktop		Satellite/cable set top box
	CRT monitor		Digital terrestrial television box
	LCD monitor		Games console
	Laptop		Security camera
	Ink-jet printer	**Various**	Air conditioning system
	Laser printer		Alarm systems
	Photo printer		Vacuum cleaner
	Printer-scanner-copier		Security lighting
	Scanner		Toothbrush
	Modem		Gas sensor
	Internet/TV/Phone box		Battery charger
	Computer amplifier		Halogen lamp
	External hard disk		Clothes-washer
	Electrical CD storage		Dishwasher
	WiFi module		Electrical bed
	Wireless mouse		Electrical seat
	Router		Alarm clock
Telephony	Phone call identifier		Hairdryer
	Simple answering machine		Condensation clothes-dryer
	Phone-fax		Discharge clothes-dryer
	Mobile phone charger		Water treatment
	Cordless phone		

6. Check list before installing end-use recording equipment

Enertech has kindly provided check list and hints for preparing and executing installation. This information is reorganized and put together below.

6.1 Preparation

- ☐ Make appointment with the residents for the next month in order to avoid delays
- ☐ Confirm appointments
- ☐ Prepare your recording equipment (programming and configuration)
- ☐ Prepare more equipment than you need to avoid not having enough
- ☐ Site list for households including address, phone numbers and roadmap.

6.2 Installation

- ☐ Equipment for momentary power monitoring e.g. SEM10.
- ☐ All type of recording equipment
- ☐ At least one extension cord with multiple plugs
- ☐ ID appliance code list
- ☐ Installation sheet including appliances and standby consumption measured
- ☐ Questionnaire to be filled on site
- ☐ Check the switch box (size, age, quality and safety) for if it is possible to install.
- ☐ Start by explaining to the residents the way the measurement campaign will be conducted and the type of equipment you will install in their household. If the residents are negative then cancel the participation and find another household which is better than later experience some of the equipment are disconnected.
- ☐ Never give tips on how to reduce the electricity consumption before the end of the monitoring campaign.
- ☐ Never monitor two or more appliances with the same equipment unit before you know from the manufacturer if it is possible (except for the audio and computer equipment).
- ☐ Take photos from the switch box before and after the recording equipment is installed in order to avoid discussions later of the changes carried out.
- ☐ Using the SEM10, take care always to unplug the appliance from the SEM10 before unplugging the SEM10 from the main power.

6.3 Useful things to bring with you at installation

- ☐ multiplug (20)
- ☐ dominos
- ☐ male and female plugs
- ☐ wire ☐ 1,5 mm^2 ☐ 2,5 mm^2 ☐ 4 mm^2 ☐ 6 mm^2
- ☐ cable ☐ 2x1,5 mm^2 ☐ 2x2,5 mm^2 ☐ 3x1,5 mm^2 ☐ 3x2,5 mm^2
- ☐ adapters 20/16 A
- ☐ Colson ring clamps
- ☐ Nails, fixture accessories.
- ☐ Pocket lamp
- ☐ tools: screw drivers (8), nippers, stripper, phase tester, cutter, hammer, dry rag
- ☐ Tape
- ☐ Voltmeter
- ☐ writing support material
- ☐ scrap paper
- ☐ thumbtack
- ☐ Cork
- ☐ A little mirror for reading appliance information at their back

7. Comparison of Equipment

7.1 Momentary standby consumption

The “catalogue” in part 4 includes equipment for measurement of momentary standby consumption or consumption over a short period: Equipment no. 1, 3 plus partly 4 and 5). This equipment can be used to collect extra consumption information at the time of installation (see part 2.2). Equipment no. 1 is the cheapest with a price of 40 €.

7.2 End-use load recording

The end-use recording equipment to record time series includes different types of equipment:

- Power Detective, plug in type, communication in house by power line and remote reading (equipment no 2).
- CE version 3, plug in type, transfer of data to pc (equipment no. 4).
- EMU 10. MEMO, transfer of data to pc (equipment no. 5).
- Enertech data logger with both plug in and amp clamp, lamp meters and temperature logger, transfer of data to pc (equipment no. 6).
- Janus data loggers with transfer of data logging over power line and remote reading (equipment no. 7).
- Multivoies with modules of 6 amp clamps, Palm for control, display of data and transfer to pc and optional remote reading (equipment no. 8).
- ACR SmartReader data logger including 3 channels for load recording and one channel for temperature (equipment no. 9).
- SIC 100 plus data logger including 2 channels for load recording, 1 channel for analogue value and 1 for temperature (equipment no. 10).
- ZE110 that is an electronic meter which might me used for the recording of the total load of the household. The difference between the total load and all the end-uses recorded will be a time series of the load for the residual of all remaining appliances (equipment 11).
- Hobo H08-002-02 is a two-channel logger for temperature and load or another external measure (equipment 12).
- Watteco 230 is a non-intrusive equipment that can record all end-use by one unit installed in the home. 4-5 hours has to be spend at installation in order to learn the equipment the signature of every end-use by turning them on and off one by one. Besides this, Watteco also has a Wattpulse unit for plug in recording on single end-uses (equipment 13).
- Aiut monitoring system including units plug in, inserting into the wire and access to an electronic meter (equipment 14).
- Tell it online Electronic Housekeeper which is a home automation system including all kind of necessary recording, many optional services and a presentation screen (equipment 15).
- Innovus Myhome@ home automation system including all kind of necessary recording, many optional services and presentation by Web software (equipment 16).

Table 1 gives an overview of main characteristics and price for suitable end-use equipment.

In case of no remote reading, the internal storage of the equipment is important and is stated.

The prices mentioned are what are collected directly from the manufacturer or by Remodece partners. In case of buying, the new and maybe better offers might be available by direct contact to the manufactures mentioned in part 4.

Equipment	*Load chan-nels*	*Plug in*	*Clamp*	*Remote reading*	*Price in €*	*Price € per channel*	*Software price in €*
Power detective	1	Yes	-	Yes	116	116	773 (server)
CE version 3	1	Yes	-	No	220	220	150
EMU 10. MEMO	1	Yes	-	No (70 days memory)	526	526	66
Enertech with plug in	1	Yes	-	No 1,2 year memory	120	120	500
Enertech with amp clamp	1	-	Yes		165	165	
Enertech lamp meter logger	1	Optical sensor			35	35	
Janus data logger	1	Pulse input		Yes	135	135	1200
Janus with plug in or clamp	1	Yes	Yes		165	165	
Multivoies+12 clamps+Palm	12	-	Yes	Optional	1420	118	Included
ACR SmartReader	3	-	Yes	Optional	500	167	190
ACR SmartReader+clamps	3	-	Yes		785	262	
SIC 100 plus	2	Pulse input		Yes	510	255	Included
Hobo H08-002-02+clamp	1	-	Yes	No	158	158	90
Watteco 203 (include all)	35	-	Yes	Yes	3,500	100	
Watteco Wattpulse	1	Yes	-	Yes	80	80	
Auit AMAL end-use plug-in	3	Yes	-	Yes	88	29	Concentrator 335 €
Auit AMAB cable junction	1(3)	Yes	-	Yes	88	88	
Tell it online, 15 end-uses + Elecronic housekeeper	1	Yes	-	Yes	62	62	Presentation screen unit including all 333 €
Tell it three phase recording	1	Into wire unit		Yes	76	76	
Tell it online lamp meter	1	Into wire unit		Yes	33	33	
Innovus one-phase plug-in	1	Yes	No	Yes	50	50	8 € per product
Innovus three-phase	1	Into wire unit		Yes	107	107	
Innovus lamp meter	1	Into wire unit		Yes	47	47	

Table 1 Comparison of end-use recoding equipment

Based on table 1 and focusing input methods, remote reading/internal storage and price per channel the most suitable equipment for the end-use measurement campaign seems to be:

1. Power Detective due to a low price and easy installation. Other equipment has to be used along with this equipment for appliances and lamps with no plug in access.
2. Enertech due to a full concept and prices in the lower end. This equipment don't have remote reading and control can thus be performed during a measurement period for a home. The internal memory is large.
3. Watteco 203 non-intrusive one unit recording is so easy to install and the price per channel is low.
4. Watteco Wattpulse plug in unit is also with a low price. Other equipment has to be used for appliances and lamps with no plug in access.
5. Tell it online home automation system includes all types of recording and might be the cheapest system. This equipment is designed for permanent end-use recording including a large number of optional services and a smart presentation unit, but the system could also be used for end-use recording campaigns.
6. Innovus home automation system includes also all types of recording with small prices. This equipment is designed for permanent end-use recording including a large number of optional services and pc interface, but the system could also be used for end-use recording campaigns.

8. “Catalogue” of end-use recording equipment

8.1a SEM 10 – Stand by Energy Monitor

Website: http://www.nzr.de

Features:

Manual reading of:

- Energy consumption in kWh (pr. Day, week or 30 days);
- Energy costs, currency-independent display (costs);
- Minimal power (W);
- Maximal power (W);
- Current power (W);
- Current current-consumption (A);
- Current voltage (V).

Experience with use of the equipment:

- ISR, University of Coimbra, Portugal

Price/unit: 40 €

8.1b SparoMeter NZR 230

Website: http://www.sl-electric.dk/

Features:

Same equipment as SEM 10

Experience with use of the equipment:

- CEU University, Hungary
- Utiltities in Denmark
- The equipment is sold all over the world

Price/unit: Depend on the number of units bought

8.2 Power Detective

Website: http://www.sl-electric.dk/

Features:

- Load recording including 70000 loads each with time stamp
- Integration period 1, 5, 10 , 15, 30 or 60 minutes
- Able to record loads in the interval 0,2 – 3600 W (max 2% failure)
- Configuration by power line or internet (through router) connection
- Display of kWh, costs, minimum and maximum load plus actual load, current and voltage
- Data are transferred to a data collector unit by m-bus protocol
- Remote reading by Internet router by TCP/IP 10/100 base T(TX) protocol
- Optional can be added a relay for demand response (load management)

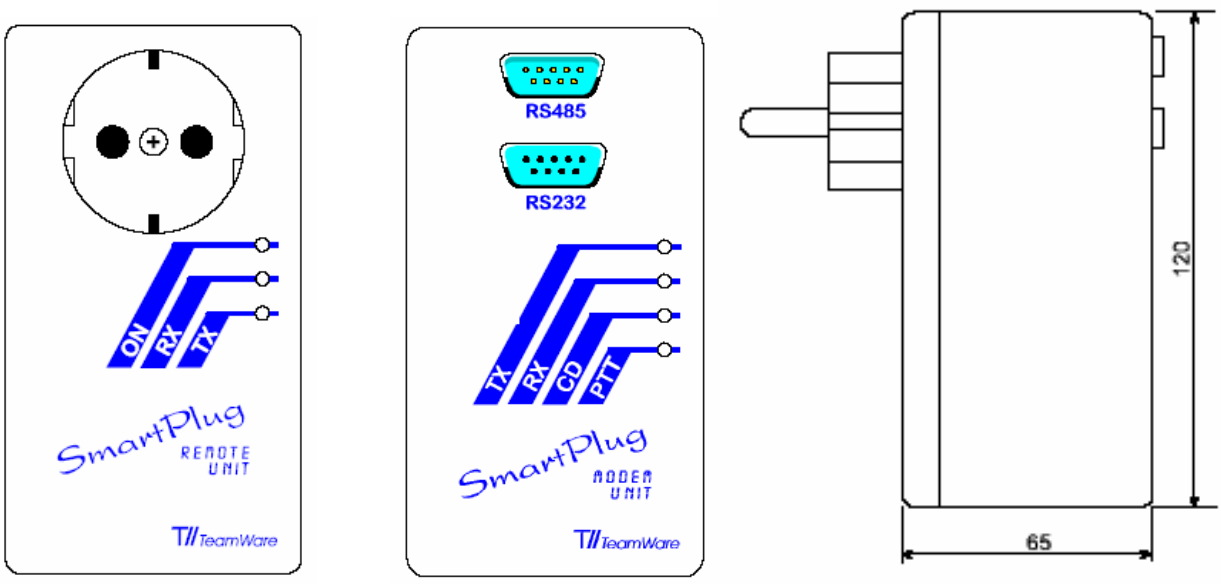
Experience with use of the equipment:

- A new product requested by a Danish utilities and some other countries for load research and demand response

Price/unit:

- 116 € per Power Detective unit (depend on the number you are buying).
- 773 € for Web-server with memory card to collect all the data by power line from all power detective units sued in the house.
- 57 € for powerline modem with USB interface.

8.3 SmartPlug



Website: www.teamware.it

Features:

- Voltage and current
- Active and reactive load, instantaneous and average for programmable period
- 8A or 16A version
- Input serial data, in standard RS232 or RS422, are sent as modulated signal on power network and received by any other side of the network by another transceiver and converted again in serial form. Communication speed 1200/2400 bps.
- Another product is HIPER 32 remote control unit for data acquisition and recording including 16 digital channels and 8 analogue channels.

Experience with use of the equipment:

- Teamware has in week 9 contacted eEGR, Italy and provided the above information

Price/unit:

- SmartPlug Remote Unit 8/16A: price 205,00 EUR /unit (minimum ordinable quantity: 250 units)
- SmartPlug Modem Unit: price 110,00 EUR /unit (minimum ordinable quantity: 50 units)
- Hiper32 control unit with 16 digital I/O: price 1050,00 EUR /unit (minimum ordinable quantity: 50 units)
- Expansion board for Hiper 32 with 8 analog inputs: price150,00 EUR (minimum ordinable quantity: 50 units)

8.4 CE Leistungs-energiemessgerate

Website: http://www.christ-elektronik.de/www/produkte/messgeraete/leistungs-energiemessgeraete/

Features:

- Version 1 display W and kWh
- Version 2 display W, kWh, V, A and kWh/hour (average?) and costs
- Version 3 also has a pulse output to record load time series and can also measure reactive load.
- Christ also sell a meter recording W and kWh and optional pulse output for load recording.

Experience with use of the equipment:

- E-ster bvba, Belgium (has 77 CE version 1 and 3 CE version 3)

Price/unit: 120-150 € for version 1 of the equipment depending for 10-10 pieces

Around 220 € for version 3 and around 150 € for software

8.5 EMU 1, EMU 10. MEMO Electronic Meter

Web-site: http://www.emuag.ch/englisch/produkte/steckdosen/steckzaehler.htm

Features:

The electronic meter **EMU 1** provides instantaneous values.

EMU1.x4K and EMU-CHECK plug-in energy and power analyser with consumption cost accumulation in EURO by setting cost per kWh.

EMU 10. MEMO is used to find the quality and quantity of the electricity 1 consumption as momentary values or load profiles. It is a single-phase electronic electricity meter of class 2 accuracy having a maximum current rating of 16 A. It measures and stores the following values:
– Real Voltage (momentary value) 176 – 264 V
– Real Current (momentary value) 0.010 – 16 A
– Active Energy 0.00 – 999 kWh
– Apparent Energy 0.00 – 999 kVAh
– Reactive Energy 0.00 – 999 kvarh
– Active Power (momentary value) 0.000 – 4.22 kW
– Active Power Demand 0.00 – 4.22 kW every 5, 10, 15, 30 or 60 minute
– Apparente Power (momentary value) 0.000 – 4.22 kVA
– Reactive Power (momentary value) 0.000 – 4.22 kvar
– Power Factor (momentary value) c 0.02 – 1.00
– Network Frequency (momentary value) F 45.0 – 65.0 Hz

The **EMU 10. MEMO** metering system is an open system including:

- Electronic Meter **EMU 10. MEMO** with power plug or clamp-on type current transformer
- Bi-directional infra-red Interface for data transfer and configuration
- Battery-supported real time clock.
- Synchronisation of values in several units by programming the date and hour of the start along with the time interval between the reading of values (between 6 seconds and 99 days)
- NVRAM (non-volatile data storage memory) capacity is 256 kbytes (optional 128 or 512 kB) that can include 7 electrical values with time stamp measured every minute for up to 7 days.
- The display of values might be faded out on the instrument by configuration.
- Configuration and data transfer Software **EMUMEMW**

Experience with use of the equipment:

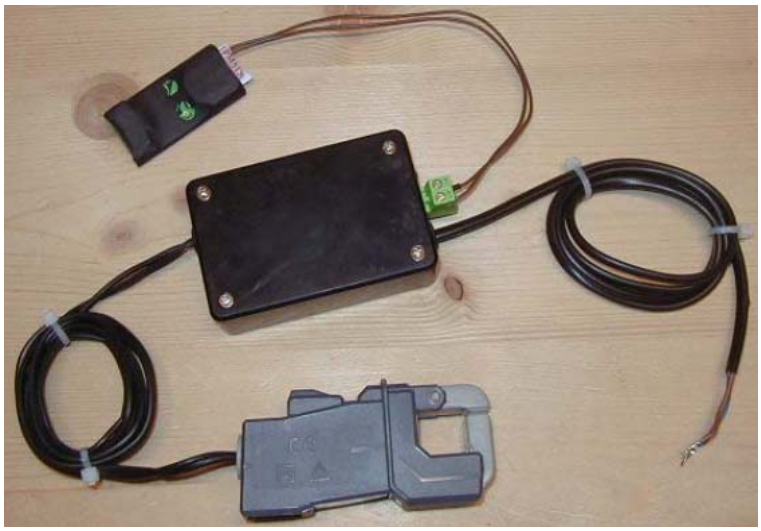
- ISR, University of Coimbra, Portugal
- ADEME, France
- DEFU, Denmark
- A+B International Sustainable Energy Advisors, Switzerland

Price/unit (€):	***1-9 units***	***10-24 units***
EMU 10. MEMO “Starter set” (1 unit, optical interface and EMUMEMW)	592.1	
Additional EMU 10. Memo (in case software is used at the same pc)	526.3	526.3
EMU1.x4K	138.2	134.9
EMU1.x8K or EMU1.x9K	197.4	193.4
EMU-Check ”Cost” or EMU-Check ”Power Level”	71.1	69.1

8.6 Enertech Data Loggers

1. 

2. 

3. 

Website: http://siedler.club.fr

Products and features:

1. Serial watt data logger for maximum 2600 W that works autonomous for 1,2 year with 10 min. integration period. Data are then transferred to pc by Oscar software.
2. Lamp meter logger that require no connection to supply network. Recording up to 32000 events time of the events of turning lighting on and off. Oscar software transfer data to pc.
3. Wattmeter with amp clamp and pulsemeter (the weight of one pulse is 0.5 Wh). It works autonomous for 1.2 year with 10 min. integration period and measurement range 3W – 22kW. Data are then transferred to pc by Oscar software.
4. Thermometer (-50 – 120^{O}C) 1,2 year data with 10 min. integration period. Oscar software.

Experience with use of the equipment:

- French research projects

Price/unit: Product 1: 120 €, 2: 35 €, 3: 165 €, 4: 45 € and Oscar software: 500 €.

8.7 Janus data loggers

Energy dispatcher

Net manager

Website: www.janus-tek.com

Products and features:

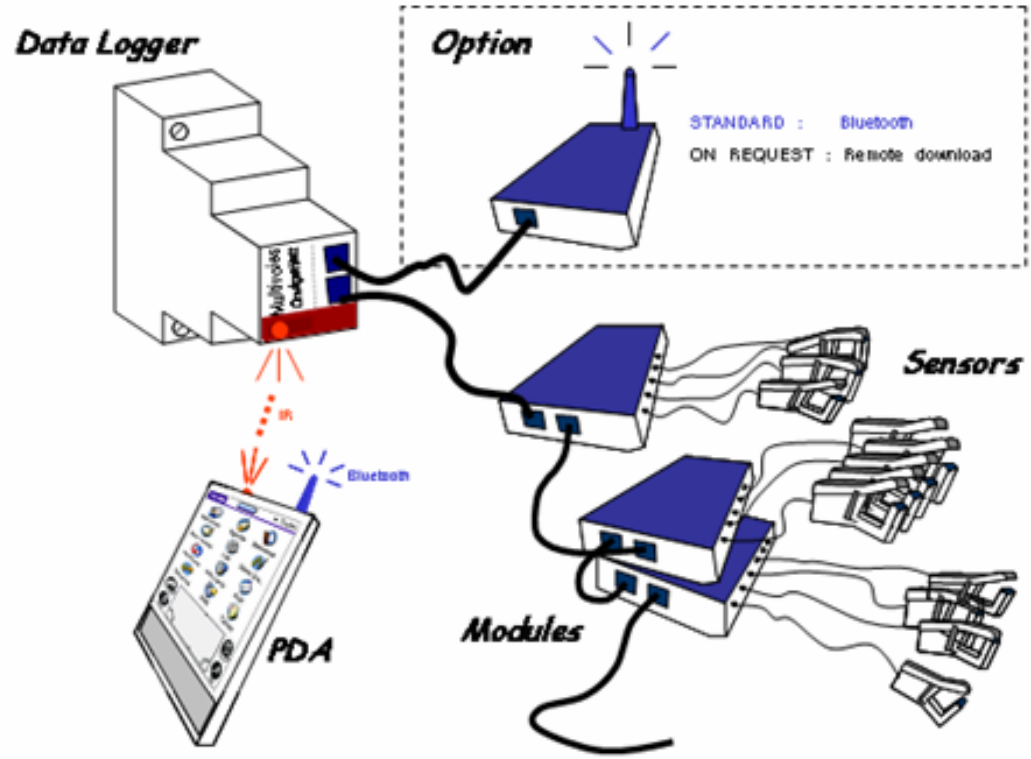
1. Energy dispatcher cover data logging over power line including kWh and load profile with integration period from 1 minute to 1 year. Storage Capacity: 768 readings with time values equal to 5,3 days with 10 minutes values.
2. Supporting many networking facilities.
3. Energy dispatcher with amp clamp
4. Thermometer data logger (-10 – 85^{O}C) 768 readings with time stamps.
5. Netmanager used to connect the monitoring equipment together and daily remote download on the power line network. It can be reached via GSM, GPRS and PSTN.
6. Demand manager use data from the energy dispatcher and thermometer logger to perform programmable load shedding. Temperature override facility.

Experience with use of the equipment:

- French research projects

Price/unit: Product 1: 135 €, 2: 165 €, 3: 170-470 € and 4: Software: 1200 €.

8.8 Multivoies



Website: www.omegawatt.fr

Products and features:

1. Multi channel Central (6 – several hundred channels) data logger especially appropriate for installation in switchboards. Measurement interval: 2 W – 230 kW. Integration period: 1 second – 60 minutes. 5 months memory in case of use of 10 minutes integration period.
2. Each module has 6 amp clamps/current sensors where 3 types are available: miniature current transformer (2.5 W – 10 kW per phase), standard open-able current jaws (5W – 20 kW) and miniature open-able current jaws (5 W – 20 kW).
3. Palm/PDA using Bluetooth or infrared communication to set up the system, for real time display of any consumption (54 channels displayed at a time) and for manual download of data on the PDA which then can be taken to computer through Palm pilot synchronisation with USB cable. This also include a pc software that transform the data from Multivoies format to text format.
4. On request, a remote download device using GSM or PSTN can be delivered.

Experience with use of the equipment:

- Ice rink in Grenoble, SYDEL in Burgendy and actual STEM campaign in Sweden.

Price/unit: Central: 420 €, Module: 200 € and Bluetooth module: 400 €

4.9 ACR SmartReader Data logger

Website: http://www.microdaq.com/acr/smartreader/3.php

Features:

- Data logger including 3 channels for load recording and temperature recording by internal temperature sensor.
- Using logging every 1 hour the storage includes data for 1 year.
- Measurement by current clamps. Load down to 10 W can be recorded if times 10 times loop is established in the measurement.

Experience with use of the equipment:

- SINTEF Energy Research, Norway

Price/unit: 500 € per SmartReader

95 € per clamp.

8.10 SIC 100 plus Data logger

Website: http://www.tritec.ch

Features:

- Two digital channels for load recording
- One analog channel
- Two channels for temperature
- RS232 interface for connection to pc or modem
- Highspeed modem
- SIC-VIEW software for visualisation of load recording at pc
- Load recording can be based on an optical reader for Ferraris meters or an impulse signal for new meters.

Experience with use of the equipment:

- A+B International Sustainable Energy Advisors, Switzerland

Price/unit: 510 € per SIC 100 plus

170 € for optical reader to Ferraris meter

8.11 ZE110 - one-phase meter with 15 min values

Website: http://www.zpa.cz/ZpaE110DU_en.htm

Features:

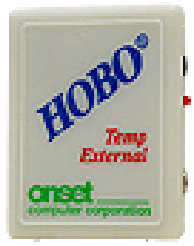
- Energy consumption in kWh
- Energy consumption for every interval of 15 minutes during 3-4 months
- Remote reading or communication by infrared port.

Experience with use of the equipment:

- SEVEn, the Energy Efficiency Center, Czech Republic

Price/unit: 150 €

8.12 Hobo H8 Temp/External Channel Data Logger



Website: http://www.onsetcomp.com/Products/Product_Pages/HOBO_H08/H08_family_data_loggers.html

Features for Hobo H08-002-02:

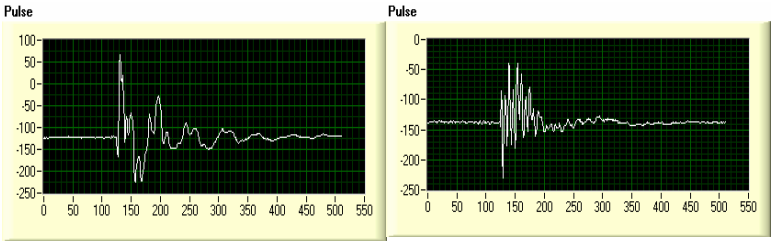
- Two channel with internal temp sensor and one external channel
- Clamp to measure load.
- It is not possible to do remote reading of the H8 while some other Hobo product have that option.

Experience with use of the equipment:

- SINTEF Energy Research, Norway

Price/unit: 61 € for Hobo H08-002-02
97 € for the clamp
90 € for HOBOware software.

8.13 Watteco 203 and Wattpulse



Wattpulse plug-in unit

Website: http://www.watteco.com

Features:

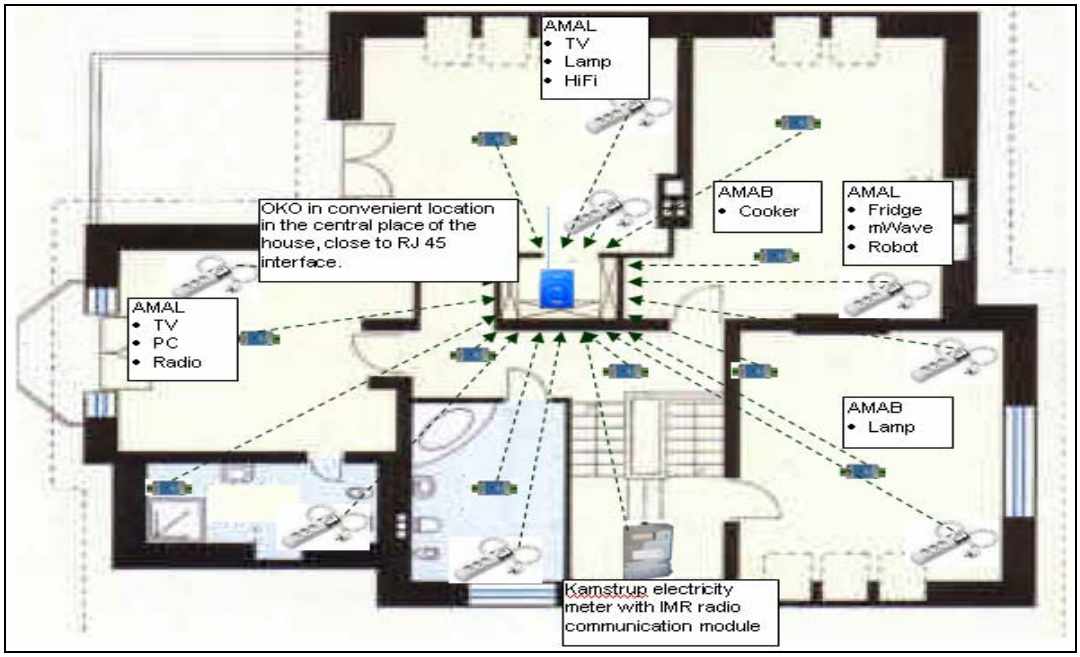
- Watteco 2003 use non-intrusive technique to estimate the load of all significant load in the household by measuring very detailed on the total load.
- Watteco 203 use pulse analysis per second make use of the fact that every load unique transient. Even two identical light bulbs will have unique signatures due to different location on the network.
- Watteco 203 can quickly be connected by clamp-on CTs.
- After installation of Watteco 203 walk around the building and switch every load on and off in order to record the unique signature of each appliance. The learning process may take 4-5 hours.
- Consumption of each load is logged every second and can be sent via Internet to energy management software giving a comprehensive analysis of the consumption by individual load profiles per appliance.
- For load where the learning process can not be performed in good conditions, the Wattpulse plug-in unit (5-3600 W) can be used and communicate and storage data in the Watteco 203 unit by communication every 10 minutes. This might e.g. be used for logging some lighting.

Experience with use of the equipment:

- Ademe, France

Price/unit: Watteco 203 cost 3,500 €
Wattpulse plug-in unit 80 €

8.14 Aiut Energy Monitoring



AMAL with load recording for three appliances by a counter for each 

AMAB cable junction for recording on 3-phase appliances or lighting  (8 x 5 x 3 cm)

OKO concentrator, radio based incl. Kamstrup meter, Internet 

Website: www.aiut.com and www.signalix.com (sales and support in DK)

Features:

- Lamp consumption is measured in Wh by the AMAB
- Max 6% error on loads between 100 and 2,000 W
- Integration period one minute or larger
- Remote reading by data are sent from OKO every 5 minutes

Experience with use of the equipment:

- Remote reading system used in Denmark by BP Gas and Hillerød utility

Price/unit:

AMAL or AMAB	88 €
OKO	335 €
AKAM meter communication	56 €

8.15 Tell it online Electronic housekeeper

Electronic housekeeper

- News: Last TV news, last radio news, weather forecast and a number of online newspapers
- Music: Jukebox, online radio, FM radio, buy music at the Internet and optional DAB radio
- Communicate: chalender, contacs, SMS / MMS and VOIP (e.g. Skype)
- Shopping: Online shop and information link to third parties (e.g. supermarkets)
- Alarms: on/off of alarm
- Energy: Management of electricity, water and heat in the house and consumption statistics
- Set-up: Internet connection, e-mail account etc.
- More: Page 2 including optional free menus

Plug in 

Unit to record start/stop of lighting 

Website: www.tellitonline.com and www.zen-sys.com (Z-wave)

Features:

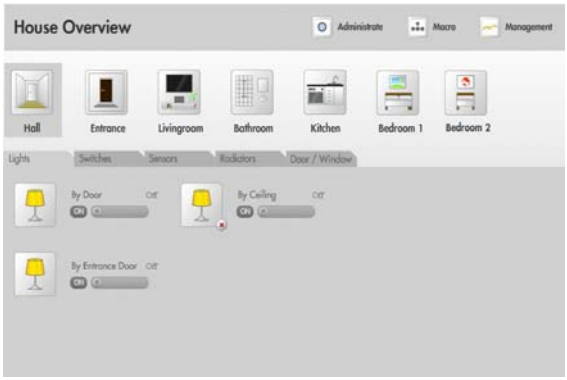
- Electronic housekeeper communication and presentation unit including a web server and SQl database
- Wireless communication by the Z-wave system
- Plug in unit with management by the electronic housekeeper or through Internet, optional including meter to record the consumption with recording period down to 1 minute
- Lighting dimmer unit that can dim or close the lighting and record every event of start and close of lighting
- For three phase appliances can be used a unit combined with an electronic meter

Experience with use of the equipment:

- Danish Electricity Saving Trust and the utility Sydvest Energy

Price/unit:		
	Electronic housekeeper	333 €
	Plug in including meter	40 €
	Lighting unit	33 €
	Three phase unit and meter	76 €

8.16 INNOVUS MyHome@



1-phase plug-in 

3-phase 

1-phase Lighting 

Central gateway 

Remote control 

Wall mount control 

S0 pulse ReaderCom for energymeters 

Website: WWW.INNOVUS.DK

Features:

- Home automation system using wireless communication by the Z-wave system
- Management, controlling and data access by interfaces pc, local touch screen, tv screen plus set top box or Mediacenter, cellular phones or PDA.
- 1-phase plug-in unit for load recording but can also serve as relay based switch (on/off).
- 3-phase cable junction for load recording but can also serve a relay based switch (on/off).
- Lighting unit cable junction for load recording but can dim the lighting by touching the unit or by remote control or software based front end.
- Central gateway coordinates all information flow and storing data for several months i.e. in a MS SQL server, data is available by XML.
- MyHome@ application for user management also include consumption feedback.
- Control by Web-interface, own or B&O remote control unit or wall mount switch.
- S0 pulse ReaderCom for recording on energy meters.

Price/unit (approx. dimensions l/w/h [mm]):

- MyHome@ softwareapplication € 8 product fee + €1 monthly license fee
- 1-phase plugin unit (120 x 65 x 40) 50 €
- 3-phase unit 107 €
- 1-phase lighting unit (diameter 90, height 30) 47 €
- Central gateway (120 x 120 x 40) 162 €
- Remote control unit (180 x 30 x 25) 47 €
- Wall mount controller (65 x 65 x 15) 36 €
- S0 pulse ReaderCom for energymeters 57 €