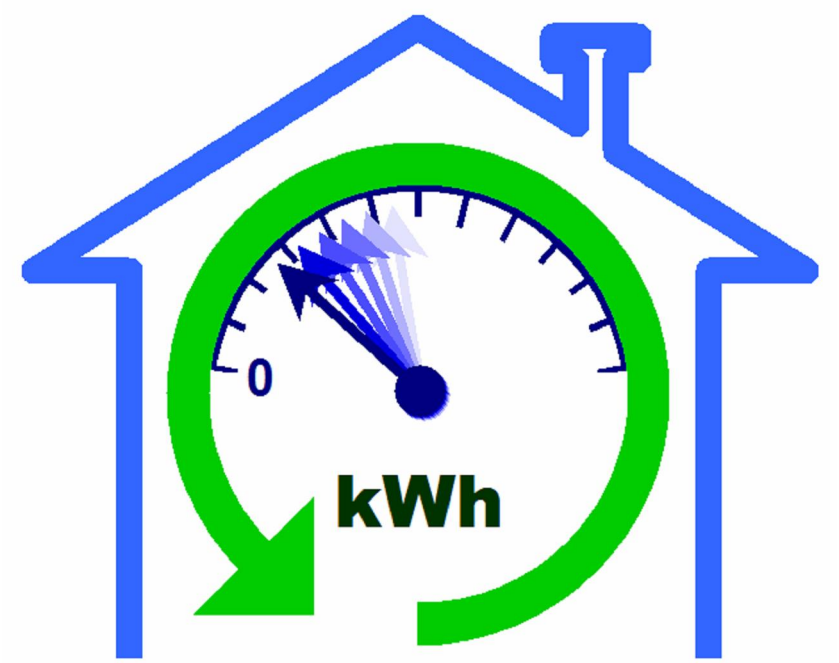
Intelligent Energy Europe



REMODECE

Full title of the proposed action:	**Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe**
Action acronym:	**REMODECE**
Co-ordinator:	**ISR-University of Coimbra** **Dep. of Electrical Engineering** **Pólo II** **3030 290 Coimbra** **Portugal**

Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe

Aníbal de Almeida, Paula Fonseca, Rui Bandeirinha, Tiago Fernandes, Rui Araújo, Urbano Nunes

Muriel Dupret, Jean Paul Zimmermann — **ENERTECH**

Barbara Schlomann, Edelgard Gruber

Casper Kofod

Nicolai Feildberg, Bjorn Grinden

Kammen Simeonov

Tomas Vorizek,

Giorgos Markogianis, Argyro Giakoymi

Iuliana Lazar, Caragea Ticuta

Pedro Lima

Robert Angioletti, Pascal Larsonneur, Sarah Dukhan

Wim de Groote, Jordi de Smet

Diana Vorsatz, Benigna Kiss, Loftus Ann-Claire

Lorenzo Pagliano, Andrea Roscetti

Daniel Valery

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EXECUTIVE SUMMARY

Although significant improvements in energy efficiency have been achieved in home appliances and lighting, the electricity consumption in the average EU-25 household has been increasing by about 2% per year during the past 10 years. Some of the reasons for such increase in the residential sector electricity consumption are associated with a higher degree of basic comfort and level of amenities (particularly in the new EU member countries), the widespread utilization of relatively new types of loads whose penetration and use has experienced a very significant growth in recent years, increased penetration of traditional appliances which still did not achieve the saturation level, increased use of the equipments, increased number of lamps per home, increased size of some appliances and also more single family houses and apartments.

The aim of the REMODECE project was to contribute to an increased understanding of current and impending electricity use by European households resulting from different types of equipment, consumers' lifestyles, and comfort levels. The project evaluated how much electricity could be saved by the use of the most energy efficient appliances, by adopting a suitable behaviour and by the reduction of standby consumption.

The research focused mainly new electronic loads such as: entertainment, information and communication technologies, stand-by consumption, lighting, as well as air conditioning in some Southern Europe countries. In Central and Eastern Europe, because of the lack of reliable data, white appliances have also been investigated. The following countries of European Union were involved in this study:

-Belgium, Bulgarian, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Portugal, and Romania.

Additionally Norway, an associated member of the EE also participated. The 12 countries involved in the project provided a balanced geographical participation of the different areas of Europe, in terms of climate and socio-economic conditions. In this report the 12 countries above mentioned will be designated EU-12. The Swiss Energy Agency SAFE although not a formal partner of the project, participated actively in most of its activities.

A large-scale monitoring campaign and a consumer survey have been carried out in the 12 countries involved in the project: 100 households have been audited per country and 500 detailed questionnaires have been collected in each country. The measurement campaign was performed in about 1.300 households and the survey involved the collection of 6.000 questionnaires. About 11.500 single appliances were analyzed. The appliances were grouped

into 24 appliance groups or “end-uses”. The time interval for the measurements was 10 minutes, collected over a period of about two weeks. The collected data, both from monitoring and from the survey, is accessible from the developed European Residential Electricity Consumption Database, which is online from the project web-site.

The average electricity consumption per household per year was estimated to be 2.700 kWh, excluding electric space and water heating. From the measurements carried out it can be concluded that electronic loads (office equipment and entertainment), are a key contributor to the electricity consumption representing 22% of the total electricity consumption. In basically all types of loads monitored there is a wide range of performance levels in the models available in the households. Figure ES1 shows the disaggregation of the electricity consumption in the residential sector in the countries of the study. It is important to note that the presented disaggregation excludes electric space heating and electric water heating. Standby consumption, which represents about 11% of the total consumption, is embedded in basically all end-uses, but is mostly concentrated in office equipment (includes Internet plus communications) and entertainment appliances.

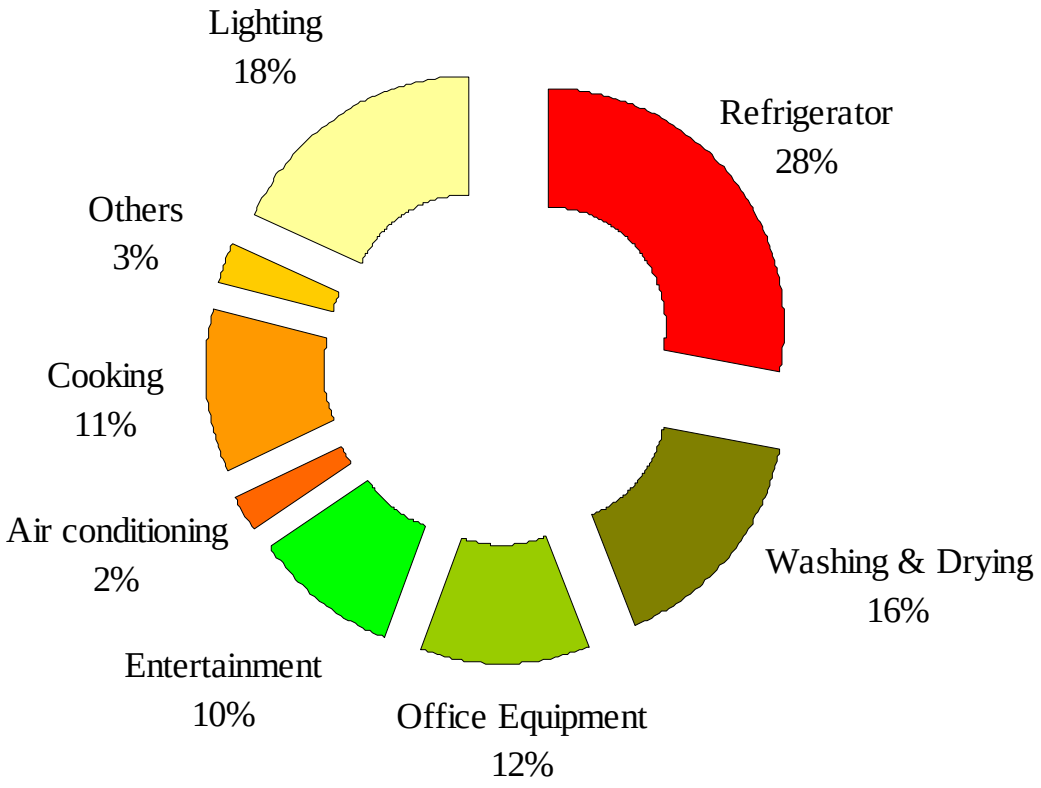


Figure ES1: Electricity consumption breakdown in the residential sector in the EU-12, excluding electric space heating and electric water heating [REMODECE campaign].

Based on the monitoring campaign carried out, next picture shows the load curves for a typical European household for a typical week day of the year.

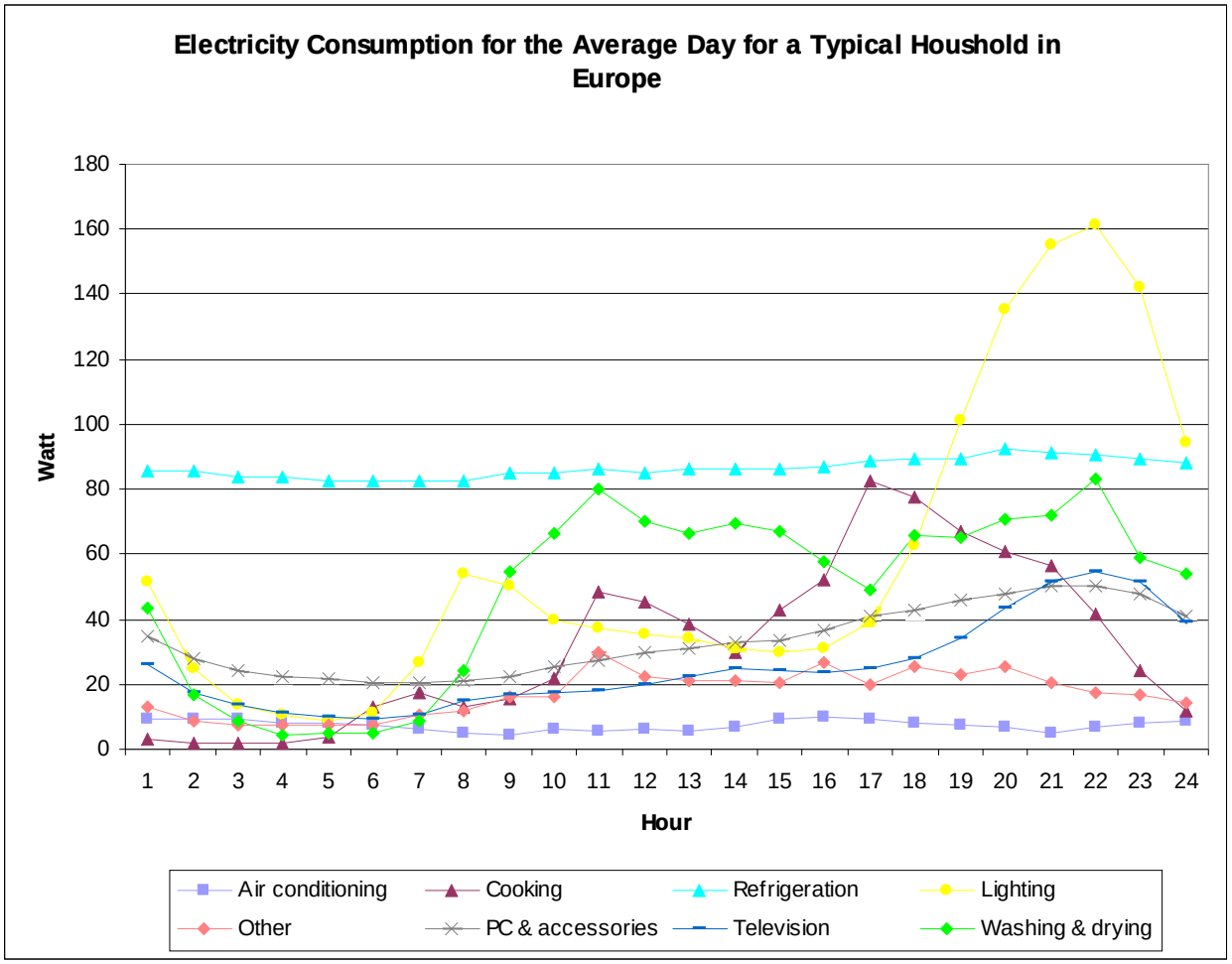


Figure ES2: Electricity consumption in group of appliances for a typical household on a typical day of the week [REMODECE campaign].

The standby electricity consumption for the appliances measured under the REMODECE project is presented in Table ES1. These are values for the typical household. Some of the new electronic appliances have a relatively high share of standby consumption. In such appliances standby may be the electricity required[1] to keep information (as storing TV stations, etc.) in the appliance memory.

On average the standby electricity consumption per household and per year is about 305kWh, which is about 11% of the total annual electricity consumption per household. Standby power is roughly estimated to be 39,8 W per household. It should be noted that standby represents about half of the electronic loads consumption.

[1] Can be avoided by using ”non-volatile” electronic components storing information even if the power supply is disconnected

Table ES1: Standby energy consumption – results from the measurement campaign.

Appliance	**Spot measurements**	**Average standby power considering ownership**	**Considering Ownership At EU-12**
Unit	**W**	**W**	**kWh/year/household**
Microwave oven	2,2	1,5	11,2
Desktop PC including monitor	6,4	5,0	38,7
Laptop PC	2,1	0,9	6,7
Router for internet, Modem, Wireless access point	8,0	3,8	29,4
Scanner	6,3	2,3	17,8
All in one printer	4,4	1,9	14,9
Printer	4,8	3,2	24,6
Fax machine	4,0	0,7	5,3
Phone	2,8	2,5	19,4
TV CRT	3,1	2,9	22,0
TV LCD	1,8	0,4	3,2
TV Plasma	1,6	0,1	1,1
TV Projector	37,5	0,4	3,2
Home cinema	2,7	0,5	3,7
VHS recorder/player	4,9	3,2	24,3
DVD recorder/player	3,8	2,5	19,4
Hi-Fi	4,7	3,4	25,8
Satellite/cable/air set top box	6,4	2,6	20,2
Hard disk (TV recorder)	2,1	0,5	3,5
Video game	1,5	0,4	2,9
Compact Hi-Fi	2,8	1,0	7,7
Total	113,9	39,8	305 kWh/Year

By changing to the Best Available Technology and Best Practice behaviour, the households can reduce their electricity consumption by about 1300kWh, representing a reduction of about 48% of their total consumption. The aggregated savings for the participating countries are roughly estimated to be about 165 TWh. The estimated reduction of electricity consumption can be translated into about 72 million ton of avoided CO_2 emissions per year. At European level (EU-27) the savings potential would amount to around 268TWh.

The annual electricity savings in a typical European household, by switching to the BAT per type of appliance is presented in the Figure ES2.

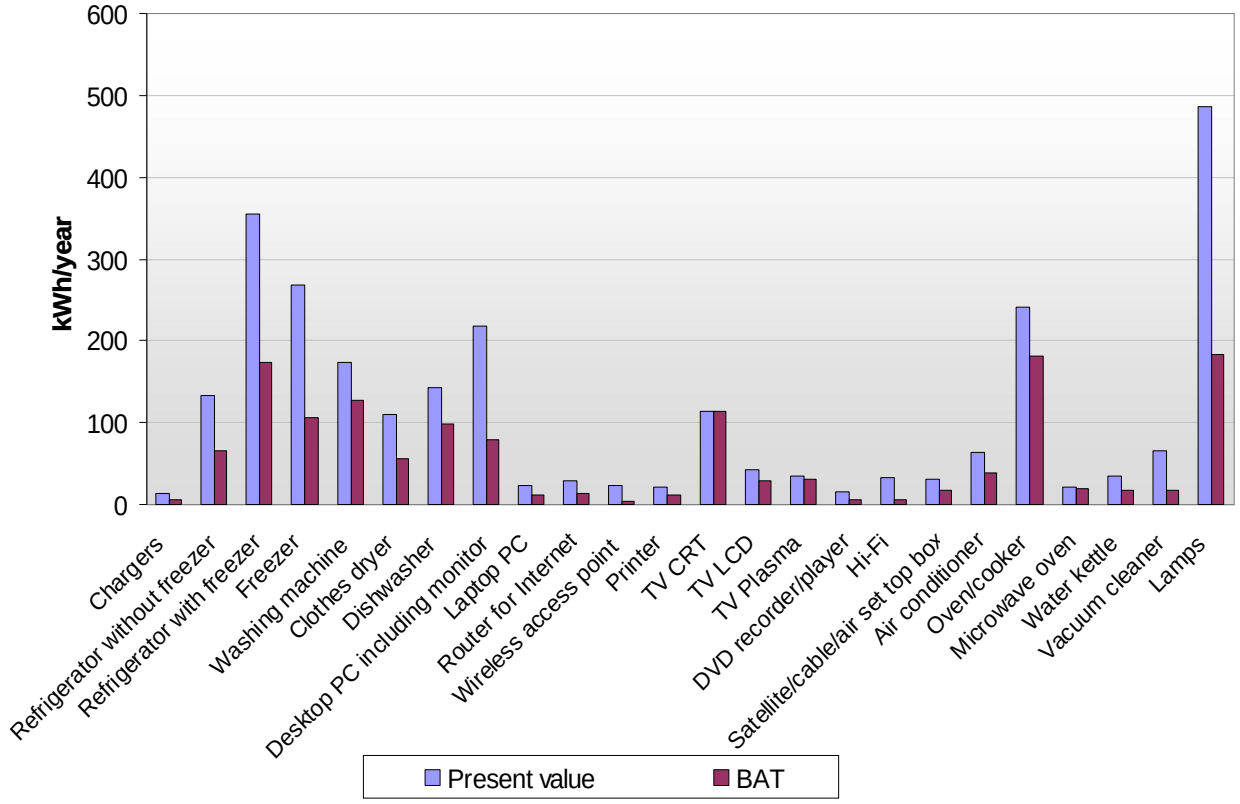


Figure ES2: Electricity savings potential per household and appliance, by switching to the BAT.

The REMODECE project suggests a detailed series of steps and tips to save electricity, through the proper selection and operation of equipment such as:

- adoption of compact fluorescent light bulbs and LEDs. LEDs are rarely used in the residential sector, but can now displace the growing share of inefficient halogen incandescent spot lamps. At a later stage during the next decade, LEDs have the potential to become the dominant lighting technology, because of the superior overall performance (efficiency, lifetime, environmental impact).

- selection of the most efficient appliances namely the change to A+ and A++ appliances.

- behaviour changes also play a key role in decrease electricity use. For each type of equipment desirable behaviour is identified. For example in the case of washing machine possible improvements can be achieved namely through the use of washing cycles at full load, washing with the coldest water as possible, as well as drying clothes by natural means whenever possible,

- selection of efficient entertainment equipment (e.g. LCD TVs instead of plasma or CRT TVs) as well as energy-star labelled office equipment with reduced standby power requirements. Because standby represents about half of the consumption of electronic

appliances, behaviour changes like switching-off electronic appliances when not in use are critical to cut wasteful consumption.

-since air conditioning is growing fast in Southern Europe, the selection of the most efficient equipment, needs to be ensured through minimum efficiency standards. Again behaviour changes can strongly mitigate not only the consumption, but in some conditions even the need of air conditioning. A good example is the use of night ventilation for free-cooling in the summer.

To take advantage of the identified energy-saving opportunities, minimum efficiency standards need to be introduced (e.g. air conditioners) and others have to be tightened (e.g. cold appliances), coupled with suitable policy incentives. Labelling of electricity consumption, including low power modes, appears to be essential to raise consumer awareness.

Current regulations and fuel subsidies, for example, often favour consumption over efficiency. But many possible actions are not taken, because energy users lack information or do not value energy efficiency enough to change their buying habits. Regulation changes, information campaigns, with clear and simple messages targeting households, together with financial incentives can stimulate energy efficiency in the residential sector.

The project results are being disseminated through a combination of channels, includig the following:

- Project **Web-Site (www.isr.uc.pt/~remodece)** online since April 2006
- **Electric Appliance Energy Guide** in the national languages of each partner and in English, downloadable from the website
- press releases, publications in key international energy efficiency conferences, in trade and technical magazines. Other important tools are the
- **HOME ENERGY SAVER** user-friendly software tool, available from the project web-site that enables users to analyze the potential savings in their homes
- Online **European Residential Electricity Consumption Database**.

KEYWORDS

Residential energy, residential electricity, energy monitoring, standby consumption, home appliances, residential lighting, electronic loads, air conditioning, savings potential, energy efficiency policies, market transformation, climate change.

1. INTRODUCTION

Although significant improvements in energy efficiency have been achieved in home appliances and lighting, the electricity consumption in the average EU-25 household has been increasing by about 2% per year during the past 10 years, despite the numerous energy efficiency policies and programmes at EU and national level. In the period 1999-2004, the total electricity consumption in the residential sector in the EU-25 has grown by 10,8%, at almost the same rate as the economy (GDP) [Bertoldi and Atanasiu, 2006].

Some of the reasons for such increase in the residential sector electricity consumption are associated with a higher degree of basic comfort and level of amenities (particularly in the new EU member countries) and also with the widespread utilization of relatively new types of loads whose penetration and use has experienced a very significant growth in recent years. These loads include personal computers, laptops, printers/fax/multipurpose machines, game consoles/ play stations, large-screen home theatres/DVDs, HVAC auxiliary equipment, air conditioners, chargers (phones, power tools), home security systems, garage door openers, etc. A wide variety of small appliances (bread makers, coffee makers) with electronic controls is also entering the market in an increasing scale. Households are becoming more and more dependent on electronic/electric devices and gadgets, with ubiquitous microcontrollers/digital controls being embedded into most apparatus, to improve the performance and the quality of the provided services. Unfortunately in many cases little or no attention is given to the energy consumption, particularly in the standby modes. According to IEA projections [IEA, 2003], 15% of the total appliance electricity consumption in Europe, by 2030, could be due to standby functionality. This represents an important potential saving as it is currently unregulated and efforts to introduce measures to reduce this wasteful consumption are only just beginning (last decade). According to the EuP Lot 6 [EuP, Lot 6], the business as usual standby consumption by 2020 will be around 100 TWh, and the recommended implementation leads to at least a 55% improvement against the business as usual by that time horizon.

In summary, electricity consumption has been increasing because of many different factors, including:

- An increased degree of basic comfort and level of amenities due to an increase of the living standards (particularly in the new EU member countries).
- Increased penetration of traditional appliances (e.g. dishwashers, tumble driers, air conditioners, and personal computers) which still did not achieve the saturation level.

- Increased use of the equipments: more hours of TV watching (or as background company), more hours of use of personal computers (widespread use of internet, tele-working), more washing and use of hot water.
- Introduction and widespread utilization of relatively new types of loads whose penetration and use has experienced a very significant growth in recent years, mainly consumer electronics and information and communication technologies (ICT) equipment (Set top boxes, DVD players and recorders, broadband equipment, cordless telephones, game consoles, home security systems, etc.), many with stand by losses.
- Increased number of double or triple appliances, mainly TVs and refrigerators-freezers, as well as computers (both desktop and laptop types).
- Increased size of some appliances like refrigerators and TV screens.
- Increase of the lighting level, and of the number of light points with a variety of technologies. Although compact fluorescent lamps sales has been increasing fast, the use of decorative lighting with halogen incandescent has also been increasing
- More single family houses and larger houses and apartments. This results in more lighting, more heating and cooling. Population is getting older, spend more time at home, and therefore demand higher indoor temperatures and all day heating in winter and cooling, in summer.

Despite the large increase in the use of electricity in the residential sector and the consequent impact in CO2 emissions, there is little reliable knowledge at European level on how the electricity is used. The availability of high quality data is an essential condition for the definition of policy recommendations to influence through a combination of measures the energy efficiency of the equipment to be sold in the EU in the next decade, as well as to influence the user behaviour in the selection and operation of that equipment. This project was targeted at bridging the existing lack of information, through a relatively large concerted effort.

The detailed characterization of residential electricity use and credible estimates of the huge potential energy savings are important results of this two and a half year long project, carried out in 12 different countries: Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Norway, Portugal and Romania, with the objective of contributing to an increased understanding of current and impending electricity use by European households resulting from different types of equipment including, consumers' lifestyles and comfort levels. A large-scale monitoring campaign in 12 countries and a consumer survey have been carried out: 100 households have been audited per country and 500 detailed questionnaires have been collected in each country. The collected data is accessible from the project Database which is online from the project web-site. In all countries, four types of consumption seem to be rising particularly fast, in particular:

domestic computer and peripherals, new domestic entertainment, standby power, and some lighting technologies such as halogen lamps. The increasing number of CFLs was also investigated. Residential air conditioner loads are also increasing significantly in Southern Europe. Therefore, in Western countries (Belgium, Denmark, France, Germany, Greece, Italy, Norway, and Portugal) the research focused mainly new electronic loads, lighting, as well as air conditioning. In Central and Eastern Europe, because of lack of reliable data, white appliances have also been targeted.

The electricity consumption in the residential sector in EU 27 could be reduced by about 268 TWh per year. This energy savings potential can be achieved with the best technology available (BAT) in the market, coupled with responsible user behaviour, and would lead to an impressive reduction carbon emissions (116 Mton CO_2) as well as save money for consumers. The REMODECE project suggests a long list of steps and tips to save electricity, such as the adoption of compact fluorescent light bulbs and LEDs, the change to A+ and A++ appliances, reduced standby power requirements, use of the washings machines at full load and the coldest water as possible, prefer LCD TVs instead of plasma TVs, buy energy-star labelled equipment and check for the ECO label, in summer use night ventilation for free-cooling, the use of solar water heaters, etc.

The project also addressed the identification of policies and strategies for market transformation to promote electricity end-use efficiency in the residential sector. To take advantage of the energy-saving opportunities identified, some product standards need to be introduced and others have to be tightened, and some policy incentives changed. Current regulations and fuel subsidies, for example, often favour consumption over efficiency. But many steps are not taken, because energy users lack information or do not value efficiency enough to change their buying habits. Regulation changes, information campaigns, with clear and simple messages targeting households, together with incentives can stimulate energy efficiency in the residential sector.

2. METHODOLOGY

The European-wide residential energy monitoring which was carried out focused on electronic loads (entertainment, information and communication technologies, plus standby consumption) and lighting, as well as air conditioning in Southern European countries. White appliances have also been monitored in four Eastern European countries, because of lack of reliable data. Data from previous campaigns has also been collected and was considered for the analysis whenever useful. All the collected data is kept on a European Database, available from the project web-site. The idea is to take advantage of existing monitoring and surveys, by structuring all the available data into a data base of the residential electricity measurements and consumptions (per country and per appliance), which has been updated with the project results.

The monitoring approach was the following:

- In most Western European countries the consumption of the main domestic appliances, namely the load curve, and the peak power, is roughly known. Conventional "main domestic appliances" include cold appliances, washing machines, dryers and lighting.
- In Central and Eastern European countries there are no significant measurements on residential electricity consumption. Therefore it is essential for the policy makers to have relevant data on electrical consumption for domestic appliances in these new EU countries.
- In all countries, four types of consumption seem to be rising particularly fast, in particular: domestic computer and peripherals, new domestic entertainment, standby power, and some lighting technologies such as halogen lamps. The increasing number of CFLs was also being investigated. Residential air conditioner loads are also increasing significantly in Southern Europe and their use was also being assessed during the project.

2.1 Description of the methodology

Within the project it was established a harmonised monitoring and survey methodology to combine the use of selective monitoring with a wider scale questionnaire based survey. This harmonised methodology allows cross comparison of the energy efficiency and performance of similar equipment and households in the different countries involved.
The decision about what data to collect is very important for a cost-effective and reliable characterisation. Based on the already existing databases, enough data was collected to update the existing information. To estimate the disaggregation of electricity consumption by each major end use, the following methodology was selected:

- Analysis of already existing studies, surveys, metering campaigns, databases, statistics, manufacturer's information, market information, etc., on energy consumption in the residential sector, focusing end-use equipment and, operating modes.
- Conducting household surveys (500 questionnaires per country of the study). The questionnaires have been accompanied by expert interviews whenever possible, and user behaviour has also been addressed.
- Conducting detailed audits in 100 households per country, focusing on demand load profiles in real situations.
- Conducting spot measurements for a series of appliances/ end-uses, especially to determine consumption in the standby and off modes of operation, because the available data is still relatively poor in this area.

The starting point of this project methodology was to elaborate a detailed list of all the main end-uses to be analysed, in Eastern European Countries and in the old EU Countries, as well as the definition of the main modes of operation to consider for the monitoring of the different appliances.

The list of loads investigated was divided into 4 main groups according to their main function: domestic computers and peripherals, new domestic entertainment, other standby loads and other loads, including lighting and air conditioning.

A number of relevant determinants need to be known for the analysis and cross comparison of energy efficiency and level of comfort. The relevant determinants to achieve cross comparison are:

- Yearly electricity consumption invoiced by the utility.
- Size and structure of the household in terms of number of people by age category.
- Highest education level in the household (no degree or certificate, secondary high school, vocational or trade certificate, university degree).
- Type of dwelling: apartment or house.
- Location: rural vs. urban.

Other specific data is needed for consumption analysis and cross comparisons of air conditioning, such as the outdoor temperature during the monitoring, the indoor temperatures of the conditioned room and of non-conditioned rooms.

Due to budget limitation and the high cost of the monitoring campaign the conditions in which the campaign took place, the timing, the measurement method, the type of dataloggers used, the sampling method and sample representativeness have been different from country to country. This has obviously consequences on how the data can be used for later analysis.

Therefore a common ground has been established to ensure a minimum consistency within the collected data.

Measurements have been carried out on at least 100 households per country. The measurement campaign was completed by a questionnaire based survey, which targeted a minimum of 500 households per country. Monitoring period for the campaign was two weeks whenever possible, which enabled the extrapolation to determine the yearly consumption.
In relation to the number of end-uses monitored, it was planned to dedicate on average 10 meters to major appliances or end-uses per household (cold appliances, washing machines, consumer electronics…). However it was not always possible to fulfil this requisite. In the case of lighting, at least the 10 main light sources have been monitored per household. The measurement time step depended on the equipment used, but it was of the same order of magnitude for all partners. A time step of 10 minutes is commonly used for this type of monitoring to facilitate data analysis. At the time of installation of end-use recording additional information has been collected, such as:

- 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 meter was used.
- information from appliance label.
- size of the family, type of home and area.
- spot metering on small appliances not included in the end-use recording – standby consumption is very important to measure e.g. by SparoMeter or SEM10.

The total standby consumption cannot be directly measured, since even at night some appliances are necessarily on while fulfilling their primary function, such as cold appliances. In households where heating is not electric, the average total standby load is estimated by subtracting the average consumption of cold appliances, the lighting consumption and if relevant that of monitored loads likely to run at night (e.g. washing appliances when night fare is used) at the same period of night. The resulting value may be regarded as "active" standby consumption, which also takes into account all appliances left on at night but not actually used. The average standby consumption for a particular end use is estimated by taking the lowest consumption at night. The night period is taken, by default, as 3 am to 4 am. When meters are being installed, spot measurements are made on appliances, for off mode, standby and active standby mode.

In France air conditioning was monitored over a longer period 3 months. In other Southern Europe Counties, because of the lack of monitoring equipment, a two week period was used. In these households besides the electricity consumption, the temperature were monitored simultaneously in the conditioned room and outdoors The surface area of the conditioned area was also recorded.

2.2 Definition of Standby consumption within this project

There is not a uniform definition for the operating modes for electronic appliances, and several approaches have been developed worldwide (ACPI, Energy Star, GEEA, Ecolabel, etc.). However, taking this situation into consideration, the Standby consumption in the REMODECE was based on the standard IEC62301.

The final draft of the international standard IEC 62301 "House electrical appliances – Measurement of standby power", published in June 2005, and its European on going transcription EN 62301, specifies methods of measurement of electrical power consumption in standby mode. It is applicable to mains powered electrical household appliances and to mains powered parts of appliances that use other fuels such as gas or oil (e.g. boiler electronic controls and pumps). The objective of this standard is to provide a testing method to determine the power consumption of a range of appliances and equipment in standby mode, generally when the product is not performing its main function.

According to this international standard, the definitions for standby mode and standby power are as follows:

- The standby mode is the lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.
- The standby power is the average power in standby mode.

The standby mode is usually a non operational mode when compared to the intended use of the appliance's primary function. The measurement of energy consumption and performance of appliances during other operating modes or intended use are generally specified in the relevant product standards and are not intended to be covered by this standard. Based on the experience from some partners in the project, it was found to be useful to measure two major standby modes for some appliances, like for example, TVs, DVDs, Power Supplies/Chargers , some domestic equipment, etc. Theses modes are: the Off-Mode and the Standby Active Mode. The first, the Off-Mode is when the device is totally switched off (i.e. the power button is off, but the mains plug is connected). The later, the Standby Active Mode, is the mode when the device is able to respond to outside commands, such as when it is possible to use the remote control to switch on the equipment (i.e. typically is when the LED or display is still on).

In addition to power monitoring, the project investigated the number of hours per day of the appliances in each of the modes. This information is required, because it will give an insight about the people behaviour with equipment. In particular, regarding standby

consumption, the two above mentioned modes can be assessed as behavioural standby vs. technological standby.

2.3 Monitoring equipment used

Several data loggers have been used to collect field electricity end-use consumption. For electricity load recording, devices such as the serial Enertech data logger, Enertech wattmeter and the Power Detective have been used. These serial Wattmeters have been installed to record load profiles in each equipment or set of equipment, to record electricity consumption over two week's with 10 minutes integration period. For spot measurements and standby measures, the Standby Energy Monitor - SEM-10 and the SparoMeter NZR230, and for lighting consumption the Enertech lamp meter logger were used. To download the recorded information from the dataloggers appropriate software was used. In the following paragraphs there is a brief description of the main features of the equipment used in the monitoring campaigns to record electricity consumptions.

Figure 2.1: Serial watt data logger for maximum 2600 W that works autonomous for 1,2 years with 10 minutes integration period. Data are then transferred to PC by a special software package.

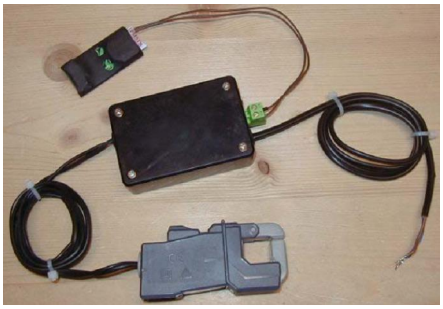


Figure 2.2: Wattmeter with amp clamp and pulsemeter (the weight of one pulse is 0.5 Wh). It works autonomous for 1.2 year with 10 min. integration period and measurement range 3W – 22kW. Data are then transferred to PC by the same software package.

Figure 2.3: Lamp meter logger that requires no connection to supply network. It can record up to 32000 events, time of the events of turning lighting on and off. Data are then transferred to PC by the same software package.

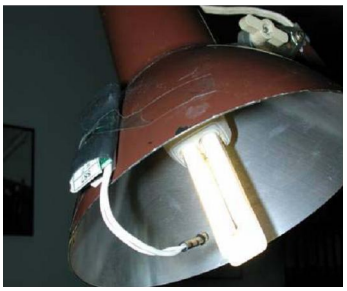


Figure 2.4: Energy and power spot meter with the following capabilities:

- 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).

Figure 2.5:

- 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).

In Denmark a recent developed Home Automation System using wireless communication by the Z-wave system has been tried. However it turned out that this unproved system was not working appropriately and the Danish partner had to change the monitoring equipment to older dataloggers produced by Enertech and which had been used in the EURECO project.

2.4 Data collection

The REMODECE metering has started an important process of filling out a huge gap for household end-use data. There is a need for update campaigns on a larger scale in the future. In the REMODECE monitoring campaign 12 countries have collected a large amount of end-use data time series with integration period 10 minute for a period of 2 weeks in 100 households per country. In addition 500 questionnaires have been collected and the information has been aggregated in one file per country, and storage in the EU database.

To handle data exchange and database storage a detailed identification system (ID) system was used, as well as guidelines for equipment installation, data handling (including quality control, repair, correction of failures, remote reading whenever possible, etc.) and spot metering of standby consumption. All the measurements and end-use load recordings from the participating countries have unique ID in order to perform data analysis and for storage in the EU database created in the scope of this project: http://www.isr.uc.pt/~remodece/database/login.htm
The ID system is composed by 15 digits including: **cccc pp hhh aaaaaa**, meaning:

- **cccc** is the country code.
- **pp** is the campaign number that is a consecutive numbering of measurement campaigns. REMODECE is campaign number 01.
- **hhh** is the number of the household included in the program, e.g. 1-100 for a campaign including 100 households.
- **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:
    - **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, instead of recording individual appliances clusters of appliances have been monitored. A cluster is the set of several appliances with a common purpose, for instance, entertainment appliances, office appliances, small cooking appliances and lighting. In this case, **aa** is a cluster code.

Central and Eastern European countries, without earlier end-use load recording campaigns, have as far as possible included all important end-uses such as cooker, refrigerator, freezer, washing machine, tumble dryer, dishwasher, as well as entertainment as TV, DVD and CD player, computer and peripherals, oil or gas burner including circulation pump, residential air conditioner and the 10 most used lamps as separate end-uses. EU countries that already have executed end-use load recording campaigns (with data to be included in the EU database) have focused at more recent appliances for which there is still no information available: 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 has included 100 homes with end-use recording in 2 weeks or one full month per home. Summer months with little use of lighting and customer absence due to holidays has as far as possible been avoided except for recording on air conditioners where the consumption in the summer months has to be recorded. In case of recording on appliances sensitive to temperature as air conditioner, the outdoor and indoor temperature has also been recorded.

2.5 European data base

The European database was designed to store all collected data as well as data from existing and future monitoring campaigns. The database is hosted at the ISR-UC web server, and can be accessible for free through the project web-site, however requires users to register. Figure 2.6 shows the principle of operation for the database.

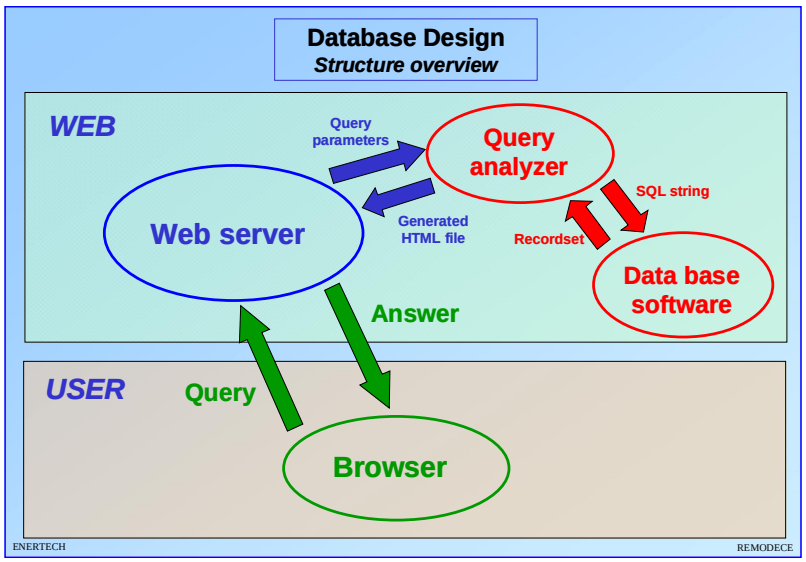


Figure 2.6: Principle of operation of the database.

The Remodece database is contained in one file: Remodece.mdb. This file, for development reasons, was created using Microsoft Access software (V2000 or above). The file contains 14 tables, each one containing a data subset. This multi-table structure permits to limit the size of the global database, to speed up the searches and to simplify the importation of new data. The database is composed of 14 tables, each containing a subset of data that are linked together using specific fields:

- Ø **T_Project** : contains the name of all the monitoring campaigns in the database.
- Ø **T_Country** : contains the list of all the countries involved in the project.
- Ø **T_Household** : contains the list of all the households.
- Ø **T_InhabitantType** : contain the different categories for the Inhabitants.
- Ø **T_Appliance** : contain a description for the different appliances monitored.
- Ø **T_AppList** : contain the list of the different appliances.
- Ø **T_AppFamily** : list the different families (cold, audiovisual,…) present in the database.
- Ø **T_DataList** : list the type of data present in the database.
- Ø **T_AnnCon** : contains the annual consumption.
- Ø **T_MonthCon** : contains the monthly consumption.
- Ø **T_LoadCurve** : contains the daily average load curves.
- Ø **T_MonthLoadCurve**: contains the monthly average load curves.
- Ø **T_StandBy** : contains the standby consumption.
- Ø **T_ Member** : contain the login information's for the user.

Common templates have been developed for the data collection, in order to get a common format of data to be inserted in the common database. Defining the data to be shared needed to take into account different parameters:

- The size of the database depends on the data that will be shared: for one single appliance a full year monitoring at 10 minutes time step represents 52 560 values and an average annual consumption represents only 1 value.
- On one hand the access to the 10 minutes data may interest researchers but on the other hand the majority of the database users are only interested in more general results such as annual consumptions, load curves….
- The data needs to be given with all their specific characteristics in order to place the values in the monitoring context. For example the annual consumption for a fridge depends on the temperature around the appliance and may vary a lot between South and North countries during the summer for example.
- A large amount of appliances (cold, audiovisual, cooking…) have seasonality consumption, which means that their consumption varies a lot during the year. This parameter needs to be taken into account for the calculation of the annual consumption if the set of data does not represent a whole year. The daily average load curve also

will change from month to month and therefore need a description of the period used to calculate it.

Therefore it was decided that the database would contain the monitoring data, the households and appliances information's characteristics and a set of pre-calculated values for each appliance. All these values would be directly accessible through a tool offering a preset of queries. The set of values pre-calculated from the 10 minutes data and the appliance characteristics that are available through the database are:

- Unique ID to identify the appliance.
- Type of appliance, Model, Brand, Age and all the relevant details.
- Country, starting date and duration of the monitoring campaign.
- Household description : number of persons, area in m², age of the household.
- Pre-calculated values :
  - Annual consumption : one value in kWh/year.
  - Monthly consumption : one value per month monitored given in kWh/day for the month.
  - Daily average load curve : 24 values in W.
  - Daily average load curve per month : 24 values in W for each month monitored.
- If applicable: Standby power in W. The annual consumption will be calculated in conjunction with the standby rate (the number of hours per year in which the appliance is in the standby mode). If the standby rate is not known, the only available data will be the power.

For the time being the database contains information collected from previous monitoring campaigns ("Historical database"), such as EURECO, CIEL, Ecôdrome, ECUEL, French Guyana, the French lighting campaign and the standby campaign, as well as all the collected data from the REMODECE project.

About 11500 single appliances were measured in all countries. Time series data with 10 minutes integration period has been collected for each major appliance group in all countries, and was formatted according to the common format. All the collected measures are available from the created European database, available from the project web-site under: http://www.isr.uc.pt/~remodece/database/login.htm . This European database stores the characterisation of residential electricity consumption by end-use and by country. It contains information for at least 100 households monitored per country, and information from the 500 households surveyed in each country, as well as data from previous monitoring campaigns carried out in Europe. There is the possibility to display graphically the daily average load curve for the appliances by selecting them in the result page. The database has been updated as more results have been collected during the project duration. All the data available from the

previous monitoring campaigns («historical data») and new information from the REMODECE campaign was imported into the database. Figure 2.7 shows the front page to access the database.

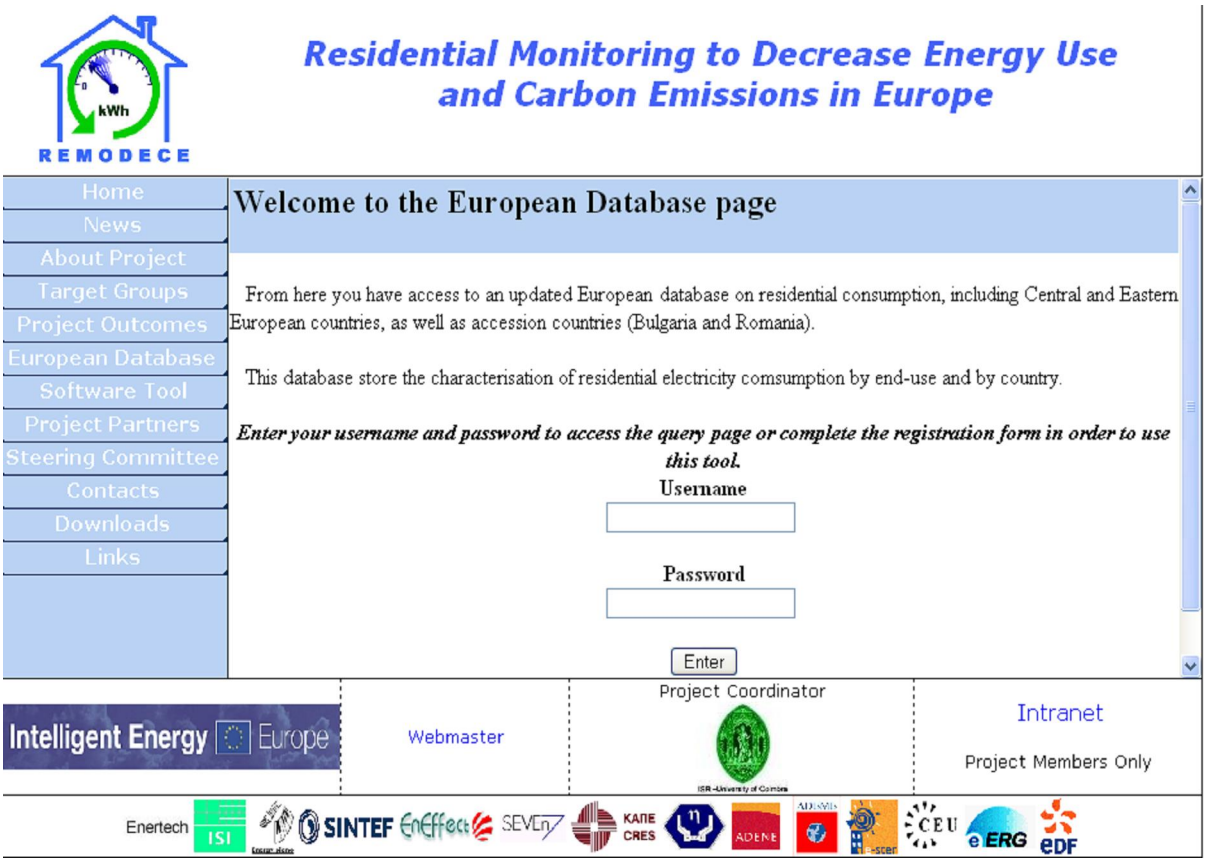


Figure 2.7: Front page of REMODECE database.

2.6 Data treatment

For the analysis of the monitoring campaigns carried out, the Useload software tool (Developed by Sintef) was employed. This powerful software analysis tool has been improved and adapted for the REMODECE Project. Several features have been added, to comply with the specifications of the REMODECE methodology. Useload has been used for the analysis of the collected monitoring data, and for the evaluation of the potential electricity savings in the residential sector that can be implemented by existing means through very efficient appliances and reduced standby consumption. Useload was originally developed by SINTEF in a join project with financial support from EDF (France), Defu (Denmark), Electricity Association (UK), VTT (Finland) and SINTEF (Norway). The main purpose of Useload is to analyse metered time series of energy consumption to find load curves that describes the behaviour of customer types, taking temperature dependency into account and considering the dependency of season- and day- types. Useload can be used to find coincident peak demand in a network. The load can be segmented into different customer dependent appliances and end-uses.

3. DESCRIPTION OF THE SURVEY

The objective of the survey was to obtain reliable, representative and internationally comparable energy related data, using surveys based on questionnaires The survey was based on the collection of at least 500 questionnaires per country, addressing both quantitative and qualitative data, as the objective was to collect data on the type of appliances and lighting people have at home, and also to understand their behaviour concerning the electricity use in their houses and their choices when buying new equipments. Therefore, both technological aspects and behavioural aspects have been analysed in the survey. The collected questionnaires have been aggregated in one aggregate file per country, which was stored in the EU database.

In order to avoid a biased sample and to increase the rate of response, it was decided not to use an online questionnaire alone. Therefore a mix of techniques such as: face to face interviews, telephone interviews, internet (web-based platform), direct email contacts (emailing lists) and mail, has been used to collect the questionnaires in the several countries, to make it more successful and more representative. The extensive survey has been carried out throughout different regions, covering large cities and country side, thus guaranteeing regional representativeness. In addition the extensive survey targeted different classes of the society, with different levels of graduation and living standards, living either in flats or in single family houses.
The questionnaire was originally developed in English and has been translated into the national languages of each partner's countries. It was released late in 2006 and has been collected during the year 2007. The questionnaire takes less than 30 minutes to be completely filled in. The response rate is difficult to calculate because an internet based questionnaire was used. However for the questionnaires delivered through mailing lists, the response rate reached around 90%. In general people who have been approached for the interview were quite receptive and very interested to collaborate. Although the large majority of respondents gave credible answers to the questionnaire, during the face to face interviews it was brought to our attention that some of the interviewed were influenced by the options presented, giving convenient answers that reward them as being "energy consciousness" or having a "green image. The questions which dealt with technical details of appliances or specific consumptions had high percentages of invalid answers (respondents who did not know/not answered).

3.1 Survey characterization of the residential sector

Total electricity consumption in the residential sector for the EU-27 was about 799TWh in 2005 [ODYSSEE]. The 12 countries of the study represent about 61% of the total EU

residential consumption. The results presented in this report are for the 12 countries involved in the REMODECE survey research.

The average monthly electricity consumption per household per country is presented in Figure 3.1. As it was expected, Norway households show the highest electricity consumption per month, followed by France. Both Norway and France have high penetration of electric space and water heating due to low electricity rates. Surprisingly, Germany presented quite low electricity consumption values per household per month, but this average value should be taken with care, because the German sample targeted a large percentage of old people. The electricity consumption of the household is dependent on the number of youths living in the house.

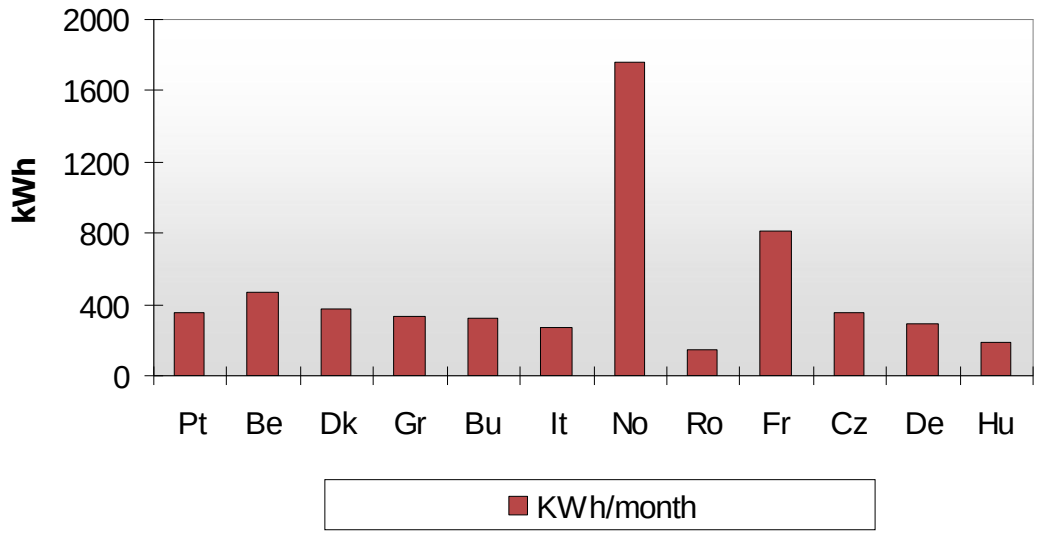


Figure 3.1: Average monthly electricity consumption per household per month.

The ownership rate for electrical appliances in the EU-12 has been estimated as shown in Figure 3.2. The average ownership rates are weighted by the number of household in each country and corrected for ownership in each country. It is important to note that these are conservative figures, and in some cases the penetration rates are most likely to be higher.

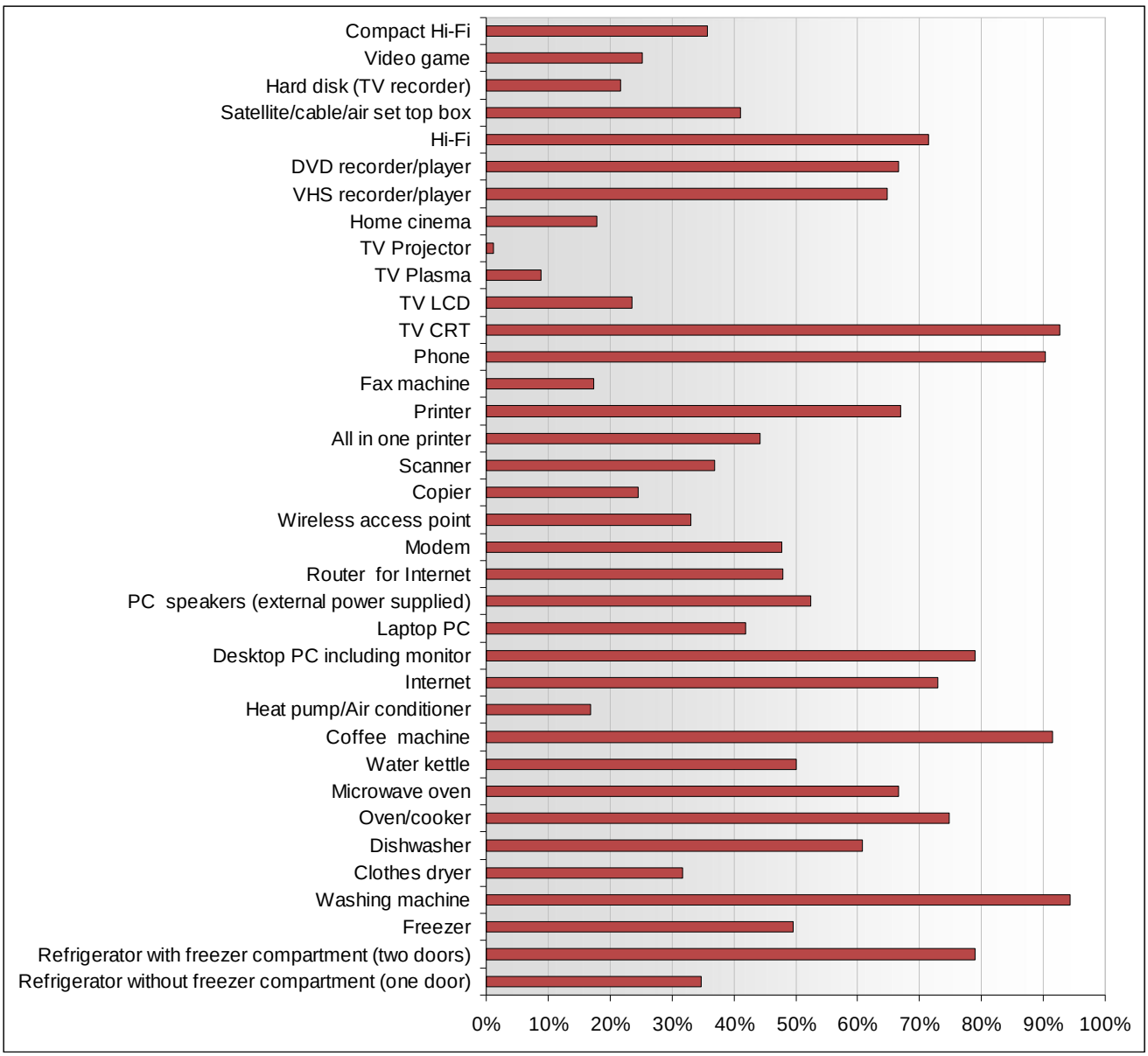


Figure 3.2: Estimated average ownership rate by the main end-use by 2007, [REMODECE 2006-2008].

The number of households with double or triple refrigerators has been increasing in recent years. It was possible to conclude that the number of households with more than one refrigerator in Belgium, Norway, France and Germany is quite high, representing about 71%, 60%, 28% and 32% respectively. One reason for this high share is because people keep the old refrigerator running in the garage to cool beer and other drinks instead of disposing it in a proper manner by calling the local waste management facility and ask about disposal of "white goods.

There is a very high internet penetration rate, being Norway, Denmark and Belgium the countries with the highest penetration rates in the order of 90%. Romania has the lowest

penetration rate (47%). The vast majority of the households with an internet connection have a broadband connection.

The ownership rate for desktops, laptops, monitors and printers is generally quite high. The reason for this high penetration rate together with the high penetration rate of internet is the high degree level of our sample, originating a somewhat deviated sample. Czech Republic presented the highest rate for desktops (96%) and monitors (92%), Italy presented the highest ownership rate for laptops (92%), scanners (57%), modems (85%) and speakers (92%), Denmark presented the biggest rate for printers (86%), multiprinter (57%) and copiers (34%), Greece presented the highest rate of fax (44%) and Norway presented the highest rate of Router/hub (75%). Germany presents ownership rates quite lows, especially laptops, scanners, copiers, fax, modem and routers, probably due to the sample used.

Regarding the operating state in which the office equipment is kept while is not being used, households seem to behave pretty well with computers and monitors, as the vast majority of respondents mentioned they do turn off the equipments. Only few percent of households admit they keep their computers on the stand-by mode and on the on-mode, when it is not being used. Households do not behave so well with fax machines, modems and routers/hubs, because they fear to loose the pre-definitions and have to reprogramme them if they turn them off.

As the survey questionnaire did not ask about the number of appliances of each type in the household we got an average ownership rate of CRT televisions of 93%. However, based on official statistics and based on the questionnaires from the monitoring campaigns, most of the households have several TVs and therefore the ownership rate should be higher.

Roughly 40% of the households do not turn off the television with the on-off button, keeping it on standby mode. For the home cinema, Germany has the best behaviour with 87% of the households turning off with the button. The worst behaviour is from Bulgaria where only 25% turn off the equipment.

Although VHS Players/recorders are a type of equipment that in future will vanish from our houses, nowadays it is still common in a considerable number of households. Regarding the use of this equipment, France has 73% of households who turn off with the button while in CZ only 37% of the households turn off the equipment.

As the market for DVD Players/recorders is evolving fast, by replacing the old VHS in the households, the type of use of these devices is very important. The results show that Germany has, the best behaviour with 78% of the households turning it off with the button,

and Bulgaria presents the worst behaviour, with only 39% of households turning it off with the button.

Hi-fi systems are present in a considerable number of households and it is a kind of equipment that generally has significant standby consumption. If we compare these results to the ones of the VHS and DVD Players/recorders it is noticeable that the respondents have a better behaviour towards this kind of equipment.

The satellite/cable set top box is present in a small number of households in Belgium, Romania, Bulgaria and Hungary and is more common in the remaining countries. There is however a wide variation of behaviours: in Norway and Romania only 21% of households turn it off with the button, while in Belgium 78% do it.

Hard disks are a type of technology that is expected to have a growth in their sales in the future, as a replacement for DVD/VHS players/recorders. However it is the type of equipment that is present in fewer households according to our survey. In Italy we find the best behaviour (97% turn off with the button) and in Norway the worst (47%).
Video game consoles are a steady growing market and the respondents tend to turn off this equipment with the button.

Generally speaking, Denmark and Eastern European countries (except CZ) present the worst behaviour in what concerns leaving the entertainment equipment on the stand-by mode, instead of turning it off with the button. This poor behaviour will have consequences in the final electricity consumption of stand by loads of the households. Belgium and Germany are the countries presenting the best behaviour when it comes to turning off the devices with the switch when they are not being used.

Because of increasing global temperatures and increasing standards of living, air conditioning is increasing fast. The ownership rate of air conditioning is about 17%. Germany did not present any results since the share of air conditioning in private households is rather small up to now. The European market is being invaded by very low efficient air conditioning units from China, which can not be sold in the China market because of strict legislation but can be sold in Europe. To fight this situation, air conditioning regulation needs urgent attention from policy makers. Air conditioning is mainly used in the southern countries to cool part of the house, being Greece the country with the highest penetration rate followed by Italy. Surprisingly, Norway is the third country in the ranking.

The average (EU-12) age structure for white appliances is presented in Figure 3.3. An overall conclusion that can be taken is that the age structure is quite similar for all the countries, except for Denmark, where a significant percentage of equipment is under 5 years,

in opposition to the remaining countries. It should be noticed the high percentage of cooling appliances with more than 10 years present in Bulgaria (48%) and in Italy (45%).
One reason for the high percentage of recent appliances within the Danish households is the intensive Danish energy-saving policies, where several energy efficiency incentive programmes are available that help households to change their old inefficient appliances by new more efficient ones.

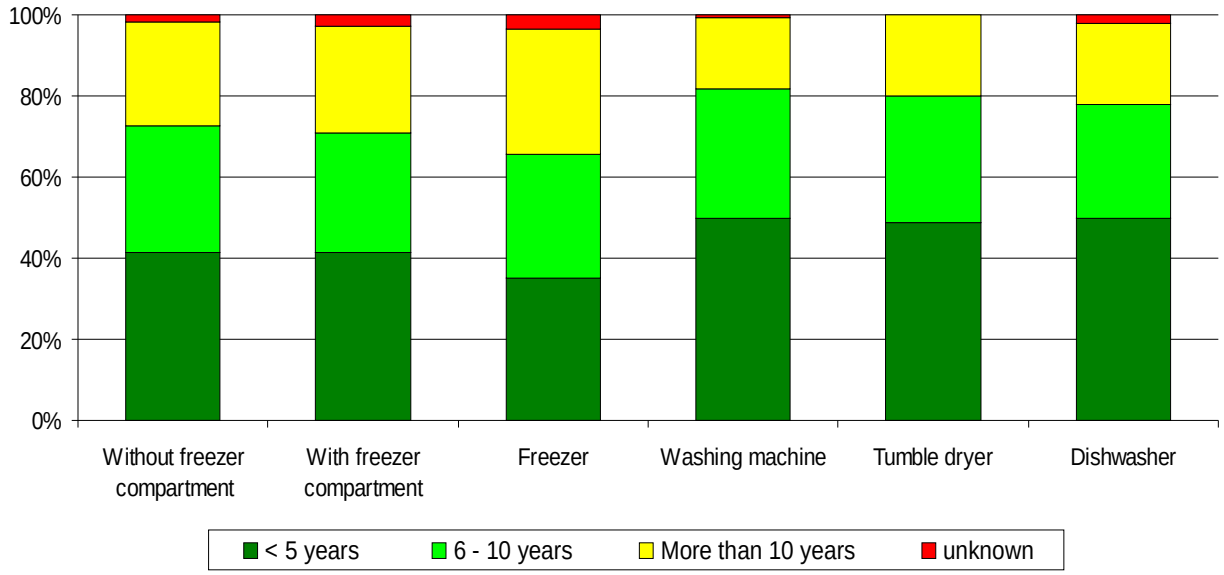


Figure 3.3: Age structure of appliances.

Around 50% of washing machines, tumble dryers and dishwashers are less than 5 years in the EU-12. The widespread use of these appliances, especially tumble dryers, is more recent in several countries, in particular in the Eastern European countries.

Regarding the efficiency class of white appliances, it should be noted that most countries have a big percentage of unknown labelled equipment. The average value for the EU-12 ranges from 43% for dishwashers to 55,6% for freezers, as can be seen in Figure 3.4.

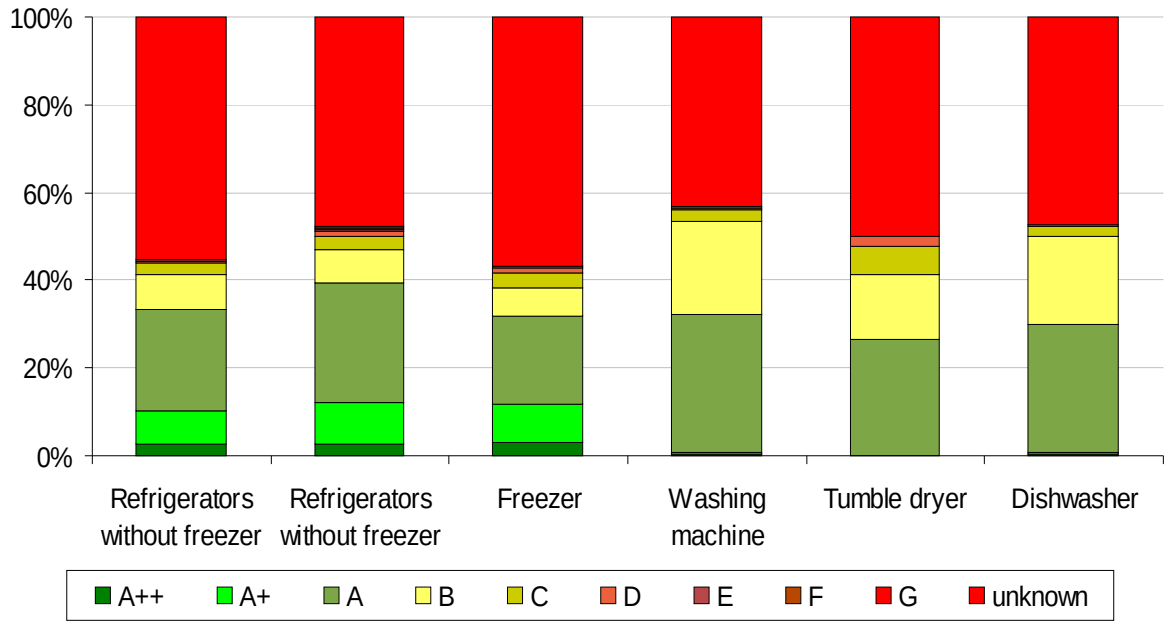


Figure 3.4: Average efficiency class of white appliances in EU-12.

A large number of percentages of answers related with the equipments specifications were unknown. It can be assumed that this lack of knowledge is related with the age of the equipment. People tend to forget about the efficiency class of their older appliances, and some older appliances were brought before 1993. Therefore, appliances in the *unknown* category are considered of the type D or below. The rational for this assumption is that if people do not know about the efficiency class of their appliance is because it is too old and therefore their efficiency class should be low, or they are not keen on the issue and therefore the decision criteria when buying one appliance is the price and not the efficiency class.

Considering that about 50% of households own a relatively new washing machine (less than 5 years) and taking into account that labelling of washing machines is in place for more than 5 years in all countries except Bulgaria (2006) and Czech Republic (2004), it would be expected that the percentage of people who do not know the efficiency class of their washing machine would be much smaller. This could be interpreted as a sign of malfunctioning of the labelling programmes.

The share of A++ and A+ appliances is still very low, representing around 10% of the cooling appliances in EU-12, and less than 1% of the washing machine and dishwashing, and being insignificant for tumble dryers. A large percentage of households do not have the eco button and a significant percentage that do have this function, do not use it very often. This practice should be broadly disseminated because many households are not aware of the real advantages of the ECO button.

Lighting shares about 18% of the total household electricity consumption and represent a significant savings potential. Besides it is easy to identify usefulness lighting consumptions and obtain significant electricity savings.

The total average number of lamps per household is 27. On average there are 4 compact fluorescent lamps per household. The largest share is incandescent lighting representing about 50% of the total number of lights installed. Low wattage halogen lamps are the second most used lamps. This may be explained by the fact that this type of lighting is used in false ceilings with a high number of light points. Fluorescent and compact fluorescent lamps have small percentages (only in Belgium these two combined are more than 30% of the total lighting lamps). The disaggregation of lighting per type of division at EU-12 can be seen in Figure 3.5.

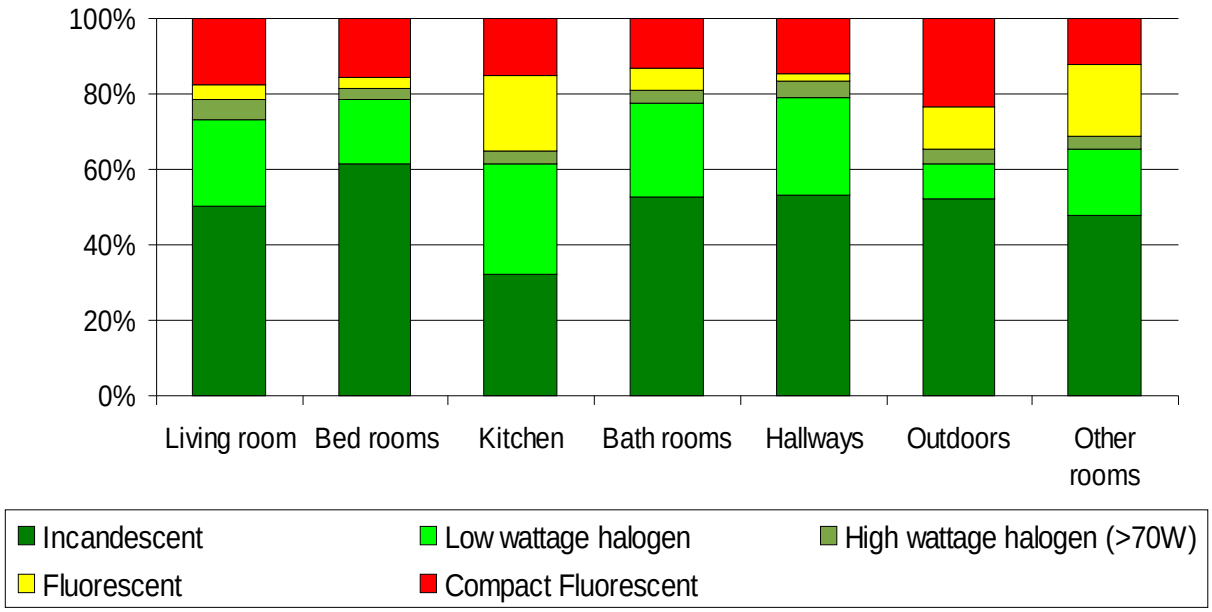


Figure 3.5: Disaggregation of the type of lighting per type of division.

Incandescent and halogen lamps are by far the most widely used lamps. The share of compact fluorescent lamps is not yet very significant. They are mainly used in outdoors applications not only they are more efficient but also these lamps last longer. Figure 3.6 shows the disaggregation of the type of lamps in EU-12. As it can be seen there is a large potential for the application of CFLs in the households for the replacement of the incandescent lamps, which represent 50% of the total lamps installed within the house. Initial cost of the bulbs is higher but the investment can be recovered from the electricity that they will pay for themselves several times over, as they last much longer than incandescent bulbs and use less power to produce the same lighting flux.

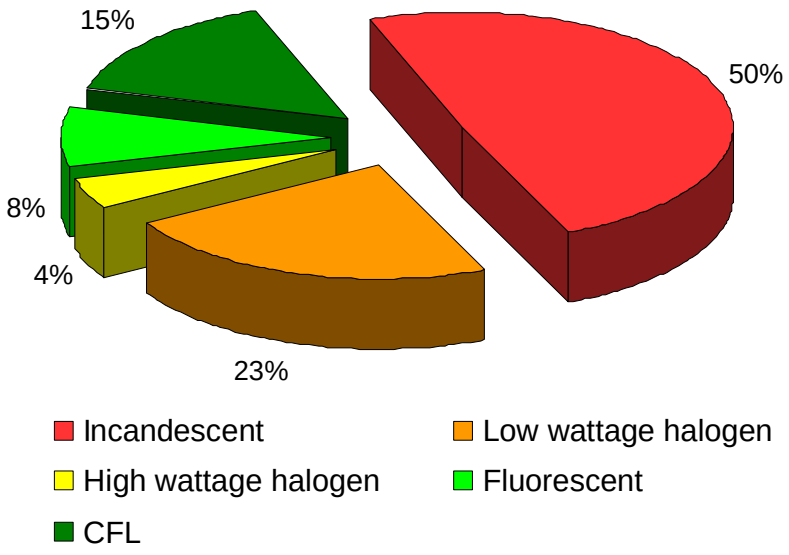


Figure 3.6: Disaggregation of the type of lamps in EU-12.

3.2 Behavioural aspects surveyed

3.2.1 Cold appliances

- More than half of the households only defrost their cold appliances once per year, and 10% had never defrosted their appliances.
- Hot food is still being put inside the refrigerators before it cools down in some countries like Denmark, Germany and Hungary.
- Regarding the thermostat adjustment, the large majority of respondents, more than 85%, have the temperature set to medium. Czech Republic and Portugal have the biggest share of refrigerators working in the coldest settings (21% and 16%), Germany has the best behaviour with 22% in the warmest settings.
- Covering the dishes before introducing them in the refrigerator is a widespread practice among all countries.
- When asked if they check the energy label when purchasing cold appliances, most of the respondents said yes. Surprisingly, in Norway about 44 % of the respondents said not to check the energy label followed by Greece. In Denmark and in Germany, the energy label has an important role when purchasing a cold appliance. There are still some work to carry out towards raising the awareness on the Energy Label Scheme, involving not only end-users but also the retailers and shop assistants.

3.2.2 Washing machine

- Although there is a relevant percentage of equipment that does not have the ECO button, the respondents that have appliances with it, tend to not always use it. Only 20% always use the Eco-button.
- The vast majority of the households always use the washing machine at over 75% of its capacity.

3.2.3 Tumble dryer

- Surprisingly, both in Greece and in Italy the tumble dry is widely used in autumn and winter, although these are southern countries. In Portugal, where climate conditions are similar to Italy and Greece, households behave pretty well as they tend to avoid the use of tumble dryer. Belgium, Denmark, Norway and Greece are the countries where the tumble dryer is more widely used. In all countries the frequency of use is significantly reduced.

3.2.3 Dishwashing

- Looking at the results of the questions related to behaviour, it seems that households behave relatively well with dishwashing. However better practices related with water savings should be disseminated as households do not seem to be aware of the potential water savings.
- The only country where the practice of feeding the dishwasher with hot water is largely implemented is in Romania. However this practice should be disseminated, especially in those households which have solar panels installed.
- As the dishwasher electricity consumption is directly dependent on the water temperature of the washing, it is important to survey about the temperature usually used to dishwashing. Although in most countries there is a relevant percentage of “don't know” answers there's an overall tendency to use 50º C to do the washing.
- To rinse the dishes can be a water wasteful practice, but at the same time can save electricity, if by using this practice less intensive programmes are then used to do dishwashing. Rinsing should always be done with cold water, and with the minimum water. The results show that rinsing the dishes is a very common practice all over the countries, with the exception of Belgium and Germany.
- The results obtained showed that Romania has the worst behaviour, with 80% of the households using the dishwasher at half the capacity, followed by Bulgaria with 19%. These two countries are also the only ones with households who use the appliance at 25% of its capacity (2%). In the remaining countries there's an overall

environmentally friendly behaviour, as the vast majority of the respondents always use the appliance at over 75% of its capacity.

3.2.4 Cooking

- In Denmark about 60% of the households defrost their food in the refrigerator. On average most people defrost food outside the refrigerator. Microwave defrosting is also a widely used method.
- The use of lids while cooking can have significant impact in the energy consumption for cooking. Develop the habit of "lids-on" cooking enable lower temperature settings.The best results are from Portugal, Belgium, Norway and Hungary. The worst behaviour is from Denmark where 42% never use lids and only 8% use them always.
- Although pressure cookers are a very efficient way to cook, it seems that its use is in remission. Most people when buying kitchen appliances do not consider buying a pressure cooker due to perceived safety reasons. The survey results show that the pressure cooker, in most cases, is not widely used.

3.2.5 Office appliances

- User's behaviour has a significant impact in the consumption of office equipment. In some countries users leave the computers on when they are not used because they did not want to boot the PC: Belgium, Bulgaria, Italy, Norway and Romania. In other countries like Portugal, Denmark, Greece, France, Czech Republic, Germany and in Hungary people point out they do not turn it off because they have some tasks running. Romania and Germany are the only countries where people mentioned the concerns about damaging the PC.
- When asked about the power saving mode in the computer, the vast majority has the save mode active on their computers/monitors, although the share of positive answers in each country is lower for the computers than for monitors, probably due to the fact that computers are left on with some tasks running which do not require the monitor to be on.
- Although the majority of the sample has the power save mode active on their computer/monitor, there are still some myths and misconceptions about the use of screen saver, as 50% of households think that the activation of the screen saver does save electricity.
- There is not a clear trend about the importance of the energy star label when purchasing an office appliance. The knowledge about the energy star label is scarce among households, and it is not a buying factor in most cases.

3.2.6 Home entertainment

- It is expected that LCD will be the dominated technology in the future. When buying a new TV, people tend to prefer LCD technology over the others, except in Czech Republic where plasma TVs are preferred by 65% of the respondents. Plasma TVs continue to captivate users being the preference type of TV for around 40% of households. Households have difficulty distinguish Plasma from LCD screens.
- Regarding the use of chargers, people do not know that letting the charger plugged in consumes electricity even if it is not being used. Nevertheless 60% of the households mention that they do not leave chargers on without being used! This result is impressive and is a result of the biased sample. People who did reply to the questionnaire have a good knowledge and are keen on energy issues.
- In order to prevent standby consumption, multiple sockets with a single switch to disconnect all appliances from the grid are available in all countries. However their use is not widespread among households. Italy presents the biggest number of households using a multiple socket with a switch (70%), but, on average, about 50% of the respondents do not use the multiple sockets with a switch to disconnect all appliances from the mains, avoiding standby consumptions.
- There are about 40% of the respondents who do not know that there are appliances which still use electricity after switching off with the button.

3.2.7 Air conditioning

- People tend to keep the outside doors and windows closed while using the air conditioning. However in Norway, Bulgaria and Romania people admit not to care if windows and doors are open.

3.2.8 Lighting

- Except for Romania, where 65% of the respondents leave the lights always on in unoccupied rooms, generally there is a concern in turning off the lights in rooms that are unoccupied. About 45% of the respondents never leave the lights on.
- On average 40% of the respondents replace damaged lamps with low consumption light bulbs most of the times, and another 40% never or rarely replace damaged lamps with CFLs. The high price is pointed as the main reason for not having adopted CFLs. A significant percentage of the households in all countries consider their lighting quality being the second most important constraint for buying CFLs. There was also mention of the problems of fitting CFLs to the existing armatures.
- Some admit to burn lights longer if they are using efficient light bulbs because the lamps have lower consumptions. However the largest share of respondents mention not to change their habits because of low consumption light bulbs.

3.2.9 General points

- The most important criteria for buying a new domestic appliance is the price, followed by the electricity consumption, and by the ease of use. The design/style and external dimensions are mentioned as the less important.

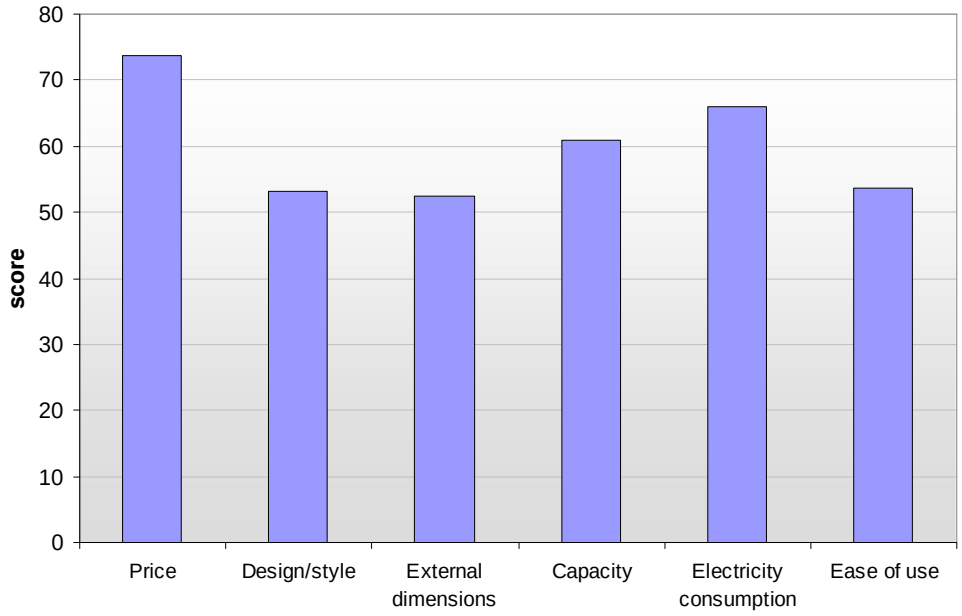


Figure 3.7: Criteria for buying a new domestic appliance.

- The main criterion for saving electricity is to obtain economical savings, followed by security of supply and greenhouse effect. War risk due to electricity crisis is the less important concern for households.

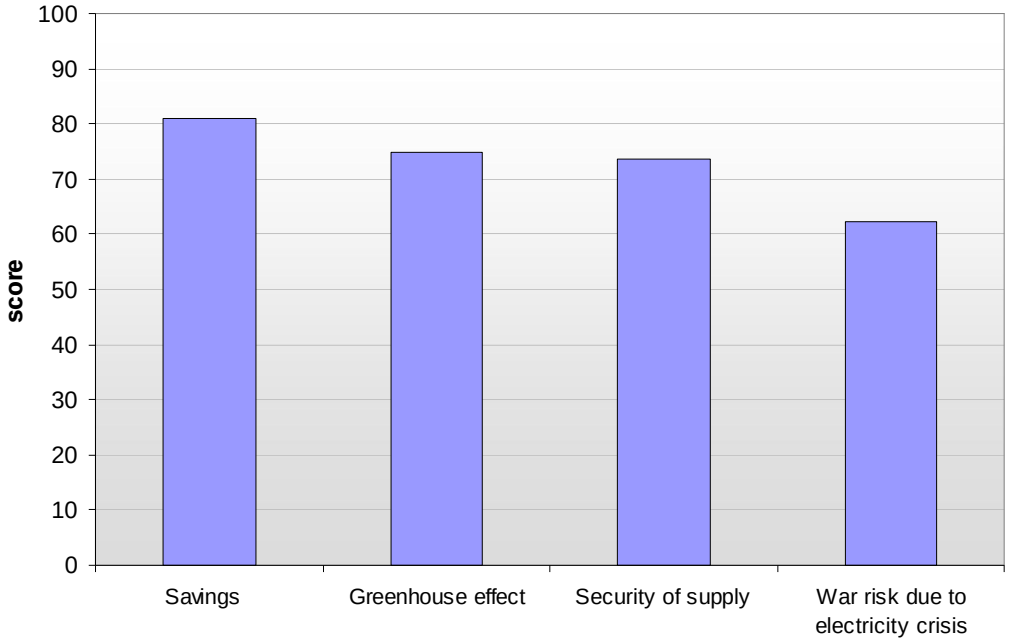


Figure 3.8: Criteria for saving electricity.

3.3 Conclusions

The best information sources to spread information about electricity savings in the residential sector seem to be TV announcements and written media, such as magazines and newspapers. Comprehensive information campaigns are very important to increase the household's awareness, for the proper selection and operation of appliances.

4. DESCRIPTION OF THE MONITORING CAMPAIGN

The measurement campaigns have been carried out as a "thorough" campaign in the new EU countries and Norway, focusing on appliances with a high consumption of electricity. In the old EU countries, having performed earlier measurement campaigns, the REMODECE measurement campaigns were carried out as a "light" measurement campaign, focusing on new electronic loads, standby consumption and lighting. Detailed intrusive audits have been carried out in at least 100 households in each country, based on the developed common methodology. A total of 1300 households have been monitored, and 12310 single appliances have been measured. However, only 11459 appliances have been analysed. The difference between the number of appliances measured and number of appliances analyzed is due to poor quality on some of the measurements: measurements have been omitted when few measurements were available or if the measurements were carried out in only one country.

Monitoring campaigns have started in early 2006 in France, Hungary, Italy and Portugal. In the remaining countries monitoring has started later, in the fall of 2006, beginning of 2007. The monitoring campaigns finished by early 2008 in the vast majority of countries, but lasted till June 2008 in Italy and Denmark because of several constraints with the monitoring equipment. Table 4.1 shows the total number of households in each participating country. The number of households per country are used for aggregation and weighting of the values for analysis.

Table 4.1: Number of households in participating countries.

Country	Abbreviation	Number of Households
Belgium	BE	4 439 652
Bulgaria	BG	3 066 809
Czech Republic	CZ	~4 500 000
Germany	DE	39 767 000
Denmark	DK	2 516 682
France	FR	27 161 000
Greece	GR	3 689 737
Hungary	HU	~3 900 000
Italy	IT	~23 907 410
Norway	NO	2 214 770
Portugal	PT	3 839 300
Romania	RO	8 231 000
Total	EU-12	127 233 360

~Estimated values by Sintef.

Carrying out monitoring campaigns is a complex task, since it requires a lot of resources for finding and choosing the right equipment, buying or renting equipment, installation, data retrieval and data handling (control, repair and storage). Some of the lessons learned from the campaigns are:

- Many households were interested in the results and wanted to receive feedback about the use of their appliances.
- Carrying out measurement campaigns can bring technical challenges to be carried out in meaningful way.
- To measure all the individual appliances present at households needs a lot of monitoring devices: some times cluster monitoring of the summated load of several appliances instead of individual end-use monitoring is necessary.
- It is very time consuming to do a careful data handling.
- The monitoring campaign delivered many interesting results.

4.1 Monitoring Problems

Monitoring campaigns, because of its complexity, is a very time consuming effort which can face some difficulties. In particular, during the REMODECE measurement campaign, the following problems were encountered:

- Monitoring the mains supply, the total load electricity consumption, gives important information. However it requires suitable monitoring equipment and it is often difficult or impossible to install measuring devices in the switch board. It is always valuable to know the relation between end-use loads and the total load as well as the residual. It is probably the only way to know what is standby with accuracy.
- Insufficient number of devices for carrying out all the necessary measurements in the due time. It is impossible to measure separately all peripherals alone because the number of data recorders will be too many and they are not available (expensive). This was the case for home cinemas, DVD, satellite/cable set top box, TVs, computers, printers, scanners, etc. The pragmatic solution found was to record the load of the sum of every set of appliances and if possible to record separately on some appliances of special interest - this means for example using one data recorder for computers and peripherals, and another for Television peripherals.
- Difficulty in installing the measurement devices when in site. For example, to monitor air conditioning that has not a plug, and that is directly supplied from the mains, requires more sophisticated equipment than to monitor loads that can be unplugged from the socket, and install the meter in between.
- Finding households that are willing to participate in the monitoring. In some countries, cooperation with the utility has been sought in order to find volunteers for the measurements, others made announcements in the radio, and others obtained the

collaboration of consumers associations. In some countries, the households which let their appliances to be metered, received feedback about the results of the monitoring in the form of an "energy performance certificate" (in Czech Republic for e.g.), and a diagnostic short report (in Portugal for e.g.).

- Inadequate formatting of the metering equipment and bad communication among the devices installed caused problems in some monitoring data obtained.

Hopefully these problems did not influence the results significantly because the UseLoad software, used to perform the analysis, has the capability of automatic error detection and correction. Some obvious measurement errors have also been manually removed.

4.2 Methodology

Not all participating counties have performed measurements on all appliances because of shortage of appropriate monitoring devices on one hand, and absence of some devices within the visited households on the other hand. Where measurements and/or ownership information was missing, EU average values are used when aggregating to (multi)national level. The approach for evaluating the potential electricity savings is to replace the old inefficient appliances (Present State) by the best available technology present in the market (BAT) and considering the best practice use of application (BP).

As it was mentioned above, the measurements are roughly cleaned of errors, first manually by each partner and then automatically by the software. The consumption of two weeks of measurements is multiplied with a factor to account for the number of utilization days in the year to obtain the yearly consumption. This factor equals the number of weeks in the year minus two weeks for vacation etc. Refrigerators, freezers and water heaters are treated to be on for the whole year, and air conditioning is defined to have a utilization period of 3 months per year. The resultant value is called yearly consumption per appliance [kWh/appliance/year]. The yearly consumption per appliance is then multiplied with the appliance ownership to obtain the average yearly consumption per household [kWh/household/year]. Finally the yearly consumption per household is multiplied with the number of households in the country to obtain national and multinational consumption per appliance [GWh/appliance]. This is the Present State (PS) of residential electricity consumption.

Besides the PS, also the BAT and/or BP need to be established for the calculation of the national savings by replacing the existing inefficient appliances. The power (Watt) used by the best technology of an appliance BAT/BP is mainly found from scanning and analysing the collected measurements. In some instances manufacturer specifications and collection of information from databases like Top Ten and Eco-design studies have been searched. Hence,

the BAT/BP is a combination of Best Available Technology and Best Practice or most "economical" use of the appliances. In the rest of the report this combination is referred to as BAT only, even if most of the savings are allocated to a Best Practice.

The BAT (Watt) per appliance is the same for all countries, but the aggregate values will depend on the country specific hours of utilization of the appliance and of the ownership level. The annual energy demand of BAT appliances are found by multiplying the BAT power (Watt) with the load factor (utilization hours) of the country. The Present Sate is country specific, is based on data from the monitoring campaigns, and is also based on previous campaigns, for some appliances.

Structural effects as change of load patterns due to possible change of behaviour are not integrated in the calculations, as these would require additional efforts and it would be too difficult to evaluate with accuracy. Also, market transformation is not taken into account. It may take several decades to replace inefficient equipment with more efficient equipment. Old equipment may also be replaced with larger sized equipments using more energy. Such examples are TVs and refrigerators. Possible future development of even more efficient technologies is not analysed within this project.

The saving calculations are specific for each group of appliances, mainly due to different use of the appliances. Manually operated appliances must be treated different from automatically operated appliances. Shortly, the power (Watt) of BAT appliances is found from other projects [B. Schlomann, 2008], and in the Top Ten internet site. In most instances the BAT is found by scanning the metered appliances [REMODECE database] to find the best practice.

Annual energy demand using BAT is then calculated by multiplying the BAT power with the load factor of each country. In this way the load pattern of each country is applied. In addition the BAT calculations assume that the standby consumption is reduced to a minimum (0,5 W). After these calculations, which are performed per appliance, per household and per country, the average BAT [kWh/household] is calculated for all countries. This is multiplied with the ownership level and the number of households in the countries to obtain aggregated values [GWh], using the same method to compensate for missing values as used for calculating the Present State.

4.3 Key numbers from monitoring campaign

Some key results from the measurement and the analysis campaigns are shown in Table 4.2 Based on the measurements carried out, next table shows the estimated yearly average energy consumption per appliance and yearly average energy consumption per household. The average household values are corrected for appliance ownership. Because not all households own all appliances, or some households may have more than one of each type of

appliance, these values are different from the *appliance* values. The total average household consumption is about 2700 kWh per year, excluding space and water heating consumption.

Table 4.2: Average annual electricity consumption per appliance and household, considering ownership rates. Results from the REMODECE monitoring campaign**.**

Appliance **Unit**	Average Yearly Appliance Consumption **kWh/appliance**	Ownership	Average Yearly Household Consumption **kWh/appliance**
Chargers	13	100 %	13
Refrigerator without freezer compartment	384	35 %	134
Refrigerator with freezer compartment	451	79 %	355
Freezer	543	50 %	269
Washing machine	184	94 %	174
Clothes dryer	347	32 %	110
Dishwasher	234	61 %	142
Desktop PC including monitor	276	79 %	218
Laptop PC	56	42 %	23
Router for Internet	58	48 %	28
Wireless access point	72	33 %	24
Printer	33	67 %	22
TV CRT	124	93 %	114
TV LCD	186	22 %	42
TV Plasma	400	9 %	35
DVD recorder/player	23	67 %	15
Hi-Fi	46	72 %	33
Satellite/cable/air set top box	75	41 %	31
Air conditioner	372	17 %	63
Oven/cooker	301	80 %	241
Microwave oven	33	67 %	22
Water kettle	70	50 %	35
Vacuum cleaner	65	100 %	65
Lamps	487	100 %	487
Total (kWh per household)	**4833**		**2695**

4.4 Electricity end-use consumption in the residential sector

Figure 4.1 shows the distribution of yearly electricity consumption for a typical (average) European household. Refrigeration, including refrigerators and freezers, is the group of appliances requiring the largest part of the total household electricity consumption, with a share of 28%. Lighting is the second largest electricity end-user with a share of 18%. Other appliances such as vacuum cleaners, radios and chargers, represent about 3% of the total household electricity consumption. Standby consumption which represents about 11% of the total consumption is embedded in all end-uses, but is mostly concentrated in office equipment (includes Internet plus communications) and entertainment appliances.

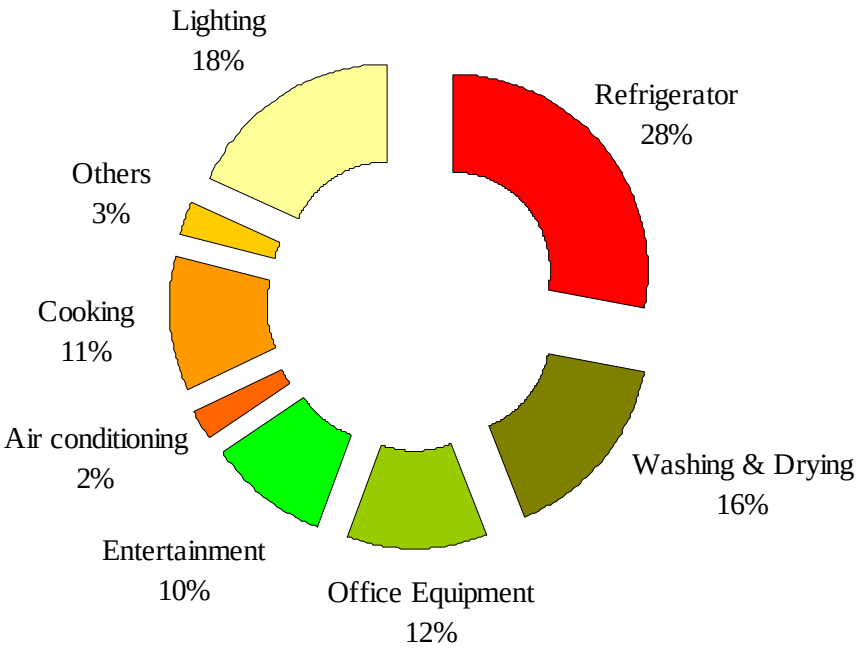
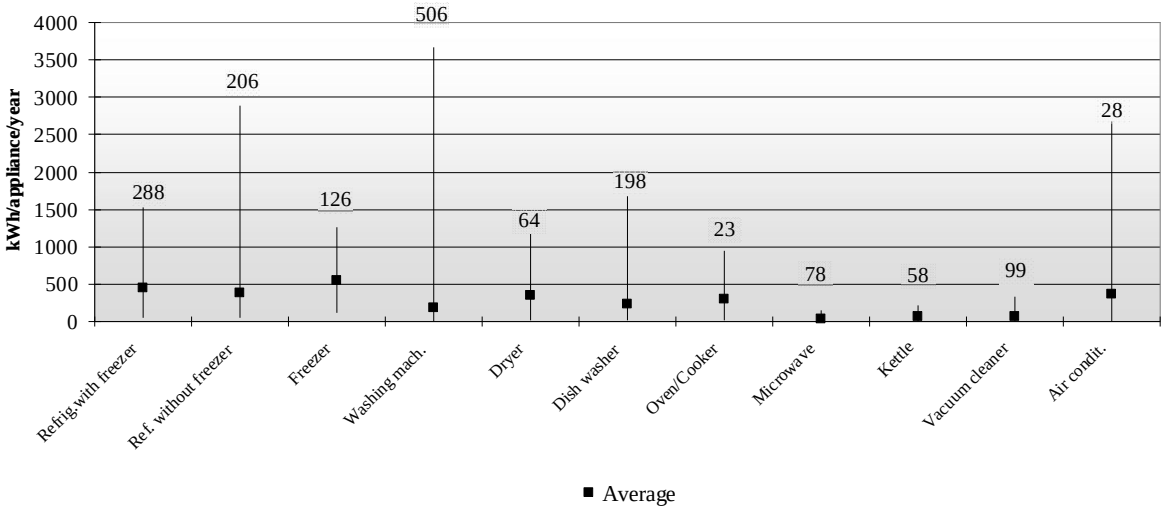


Figure 4.1: Electricity consumption breakdown in the residential sector in the EU-12, excluding electric space heating and electric water heating [REMODECE campaign].

Figure 4.2 show estimates of yearly energy consumption for all the audited equipments: average, minimum and maximum consumption values per appliance are presented as well as the total number of equipments monitored, at the top of each bar. The values presented are not corrected for ownership levels in the different countries.



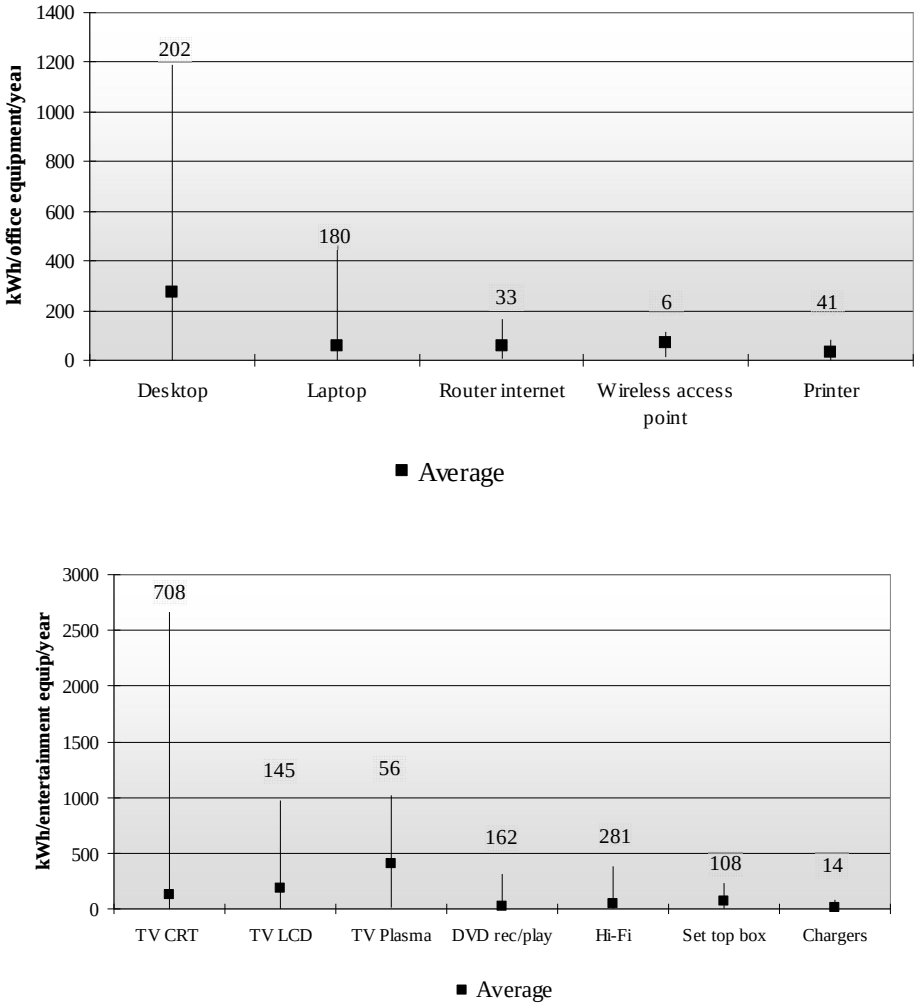


Figure 4.2: Results from measurement campaign – Annual electricity consumption range for different groups of appliances.

Without correction for appliance ownership, the total appliance consumption would be about 4800kWh per year. That means that if a household had installed one of each of the appliances listed, and the appliances had an average usage pattern, the yearly consumption would be as high as 4800 kWh per household. A more realistic value (2700 kWh per household) is obtained when ownership levels are taken into account, as it can be seen in Table 4-1.

On average, conventional CRT televisions use about 125 kWh electricity per year, and LCD TVs use about 190 kWh, while Plasma TVs use even more electricity: 400 kWh per year. Plasma TVs are usually larger than LCD TVs, which in their turn are larger than CRT TVs. The higher consumption is mainly related with the larger sizes of Plasma TVs, but can also be explained by different usage pattern as discussed later. On average lighting is estimated to use about 487 kWh. Air conditioning uses about 370 kWh per year assuming a use of 3 months per year, although its penetration is still small. A desktop PC uses about 276 kWh, while laptop PCs only use about 60 kWh per year. Much of the difference may be

explained with the type of technology used in laptops, but also the usage pattern can explain this significant difference in the consumption Laptops because of the need to ensure long periods with battery supply, are optimized for low power consumption, including automatic switching to low power modes when there is no keyboard or processor activity. In laptops, monitors are also significantly smaller than in desktops.

Most of the differences between the minimum and maximum values can be explained by different usage pattern and by the different technologies. For appliances that are automatically operated, it is difficult to find a reasonable explanation for the large variations apart from some differences due to different sizes and technologies. In some cases it may be that the appliance has not been normally used in the measurement periods and/or that the estimated minimum values for the yearly consumption is only the standby consumption. Old appliances (e.g. refrigerators and freezers) can have a much poor performance.

4.4.1 Energy demand per appliance type

Based on the monitoring aggregated data, next figures show the load curves for a typical European household for a typical week day of the year. This information is based on the monitoring campaign.

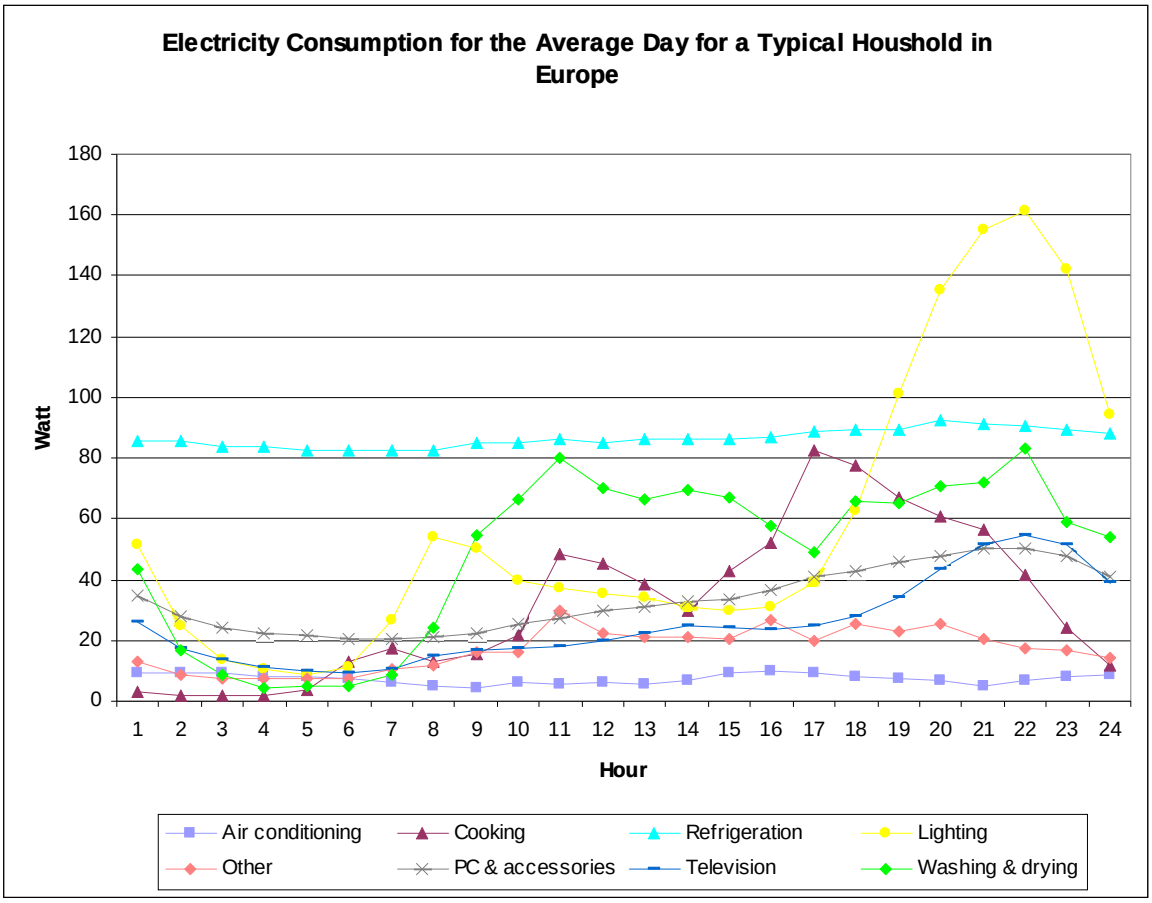


Figure 4.3: Electricity consumption in group of appliances for a typical household on a typical day of the year**.**

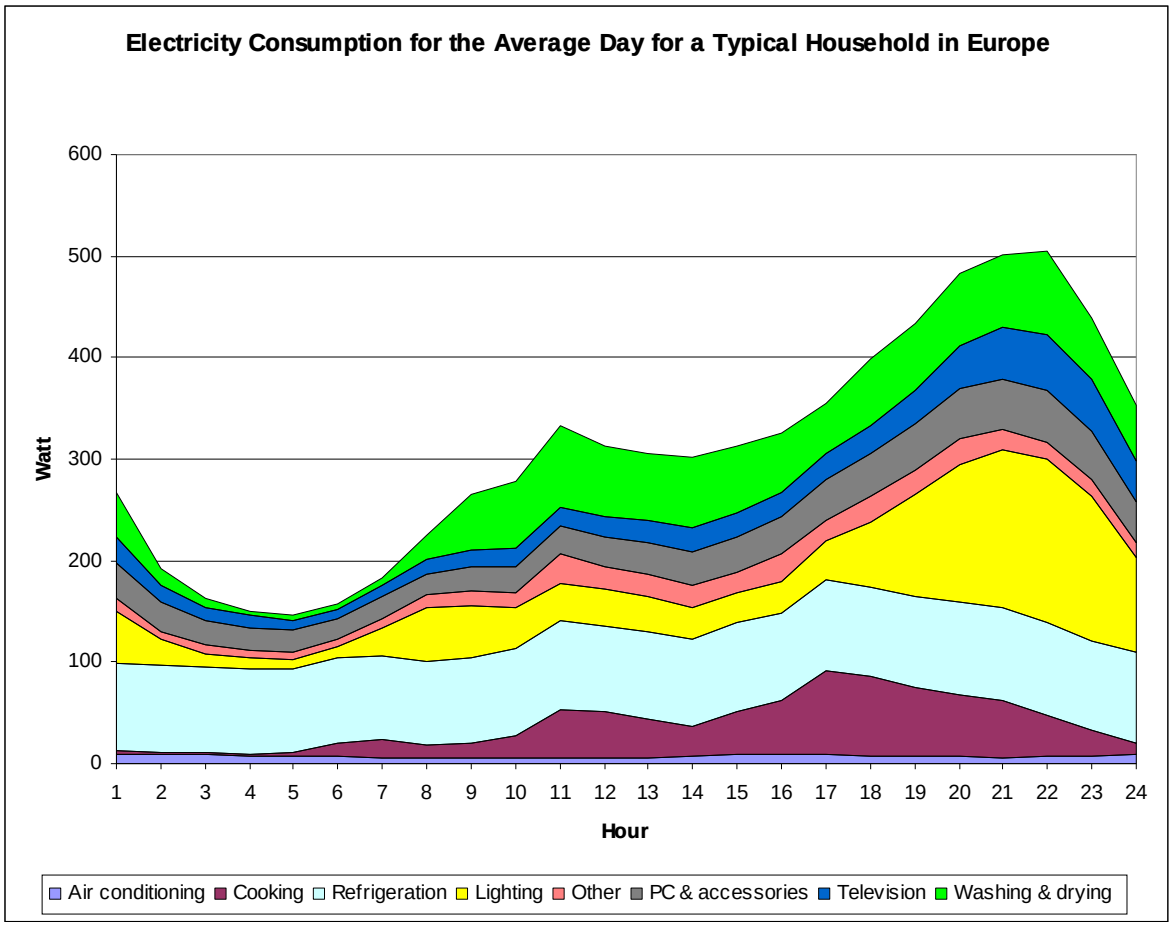


Figure 4.4: Electricity consumption in group of appliances for a typical household on a typical day of the year.

The standby electricity consumption for the appliances measured under the REMODECE project is presented in Table 4.3. Measurements were taken both of load curves of equipment clusters (entertainment and office equipment), as well as spot measurements of the low power modes for different types of electronic equipment in the households.

These are values for the typical household. As it was already mentioned before, standby mode is defined as the electricity consumption of the appliances during the periods when the appliance is connected to the mains supply but is not performing its primary use.

Table 4.3: Standby energy consumption – results from the measurement campaign.

Appliance	**Spot measurements**	**Average standby power considering ownership**	**Considering Ownership At EU-12**
Unit	**W**	**W**	**kWh/year/household**
Microwave oven	2,2	1,5	11,2
Desktop PC including monitor	6,4	5,0	38,7
Laptop PC	2,1	0,9	6,7
Router for internet, Modem, Wireless access point	8,0	3,8	29,4
Scanner	6,3	2,3	17,8
All in one printer	4,4	1,9	14,9
Printer	4,8	3,2	24,6
Fax machine	4,0	0,7	5,3
Phone	2,8	2,5	19,4
TV CRT	3,1	2,9	22,0
TV LCD	1,8	0,4	3,2
TV Plasma	1,6	0,1	1,1
TV Projector	37,5	0,4	3,2
Home cinema	2,7	0,5	3,7
VHS recorder/player	4,9	3,2	24,3
DVD recorder/player	3,8	2,5	19,4
Hi-Fi	4,7	3,4	25,8
Satellite/cable/air set top box	6,4	2,6	20,2
Hard disk (TV recorder)	2,1	0,5	3,5
Video game	1,5	0,4	2,9
Compact Hi-Fi	2,8	1,0	7,7
Total	113,9	39,8	305 kWh/Year

Some of the new electronic appliances have a relatively high share of standby consumption. In such appliances standby may be the electricity required[2] to keep information (such as storing TV stations in set top boxes, etc.) in the appliance memory. On average the standby electricity consumption per household and per year is about 305kWh, which is about 11% of the total annual electricity consumption per household. Standby power is roughly estimated to be about 40 W per household. It should be noted that standby represents about half of the electronic loads consumption.

Many appliances with standby energy demand were not part of the metering campaign of REMODECE. These appliances are for example:

- Electrical toothbrush, shavers and other toilet requisites.

[2] Can be avoided by using ”non-volatile” electronic components storing information even if the power supply is disconnected

- Electrical tools with chargers: Drill, saw, screwdrivers and other tools.
- Electronics as DAB radios, Amplifiers, Pc-games hardware, Musical instruments, Video games, Home cinema etc.
- Some kitchen equipment.
- Garden equipment with chargers.
- Home security systems.
- Garage door openers.

4.5 Electricity Savings Potential – Technical potential savings

The potential electricity savings that exist in the residential sector in Europe has been evaluated. For this evaluation the Best Available Technology (BAT) and Best Practice (BP) was considered in the estimation of the savings potential. The BAT was found either by scanning and analysing the collected data for best practice and based on manufacturer specifications, analysing previous studies like EuP studies and consulting Top Ten web-sites. The methodology for calculating yearly energy demand for BAT is presented in Appendix II. Hence, the BAT potential impact is a combination of Best Available Technology and Best Practice, or the most economical use of the appliances. In this report this combination is referred as BAT only, even if in same cases most of the savings are allocated to Best Practice.

The annual electricity savings in a typical European household, by switching to the BAT per type of appliance is presented in the Figure 4.5.

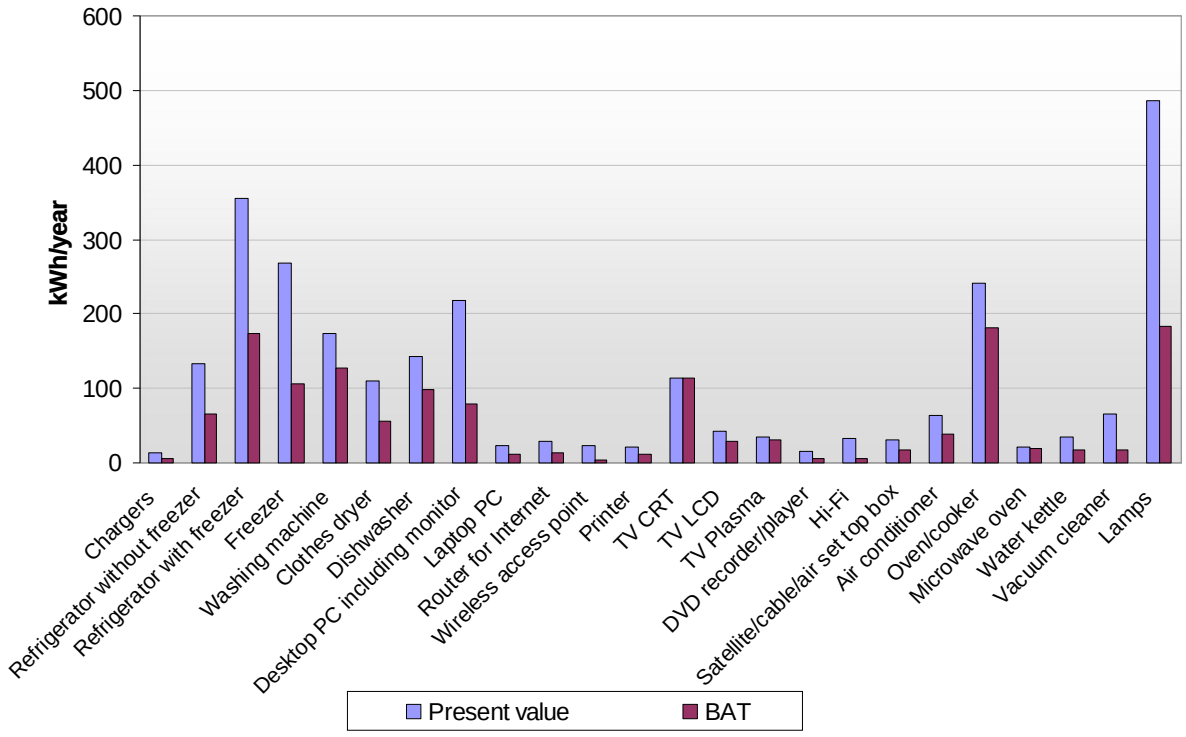


Figure 4.5: Electricity savings potential per household and appliance, by switching to the BAT.

The savings from switching from present state to best available technology were estimated to be about 1.300 kWh/year/household. The aggregated annual electricity savings by using best available technology in European households for the EU-12 countries of the study were found to be 165 TWh per year, representing a 48% savings potential.

These electricity potential savings will translate in 72 million ton CO_2 emission savings per year by switching from present technology (PV) to best available technology (BAT). For calculation of the saved CO_2 emissions, a factor of 435 ton CO_2/GWh is used as a common value for Europe except Norway. The factor is calculated as the European average CO_2 emissions of electricity production under average generator efficiency using the average mix of fuel.

At European level (EU-27), the electricity savings would translate into 268 TWh, that is 116 million ton CO_2 emission savings.

4.6 Discussion of results

For assessing the quality of the estimated values for the different appliances, the number of measurements per appliance and confidence intervals calculated with standard statistical methods are shown in Table 4.4. Generally a high number of measurements give a more significant and accurate estimate than just a few measurements. In total we have many measurements of the appliances with higher energy consumption, like washing machine, TVs etc., and we can state that we have fairly accurate estimates of the consumption in these appliances. Even if we have performed many measurements on lamps, lighting is one of the most uncertain estimates. Some countries have measured all lamps, and some have measured the most frequently used lamp and some have measured a random selection of lamps. Even in the same room there are large variations in the load profiles of different lamps. Depending on the measurement method used, the distribution of uncertainty may be different. Because of that, we have not calculated standard deviation or confidence interval for lamps.

A small confidence interval indicates a significant estimate, which is due to a low standard deviation in the energy consumption. In general we must be aware that within each appliance, there are a lot of makes and models with different yearly consumption (e.g. energy efficiency classes). Also, the use of some appliances is varying a lot among different consumers. A high confidence interval indicates a large uncertainty, probably associated with the fact that there are too few measurements for this appliance type.

Table 4.4: Statistical analysis of measurements, not corrected for ownership.

Appliance	**Total Nº analyzed**	**Measured Yearly**	**Confidence Interval**	**Confidence Interval**
	Nº	kWh	kWh	%
Chargers	14	13	18	136 %
Refrigerator without freezer compartment	206	384	19	5 %
Refrigerator with freezer compartment	288	451	20	4 %
Freezer	126	543	37	7 %
Washing machine	506	184	9	5 %
Clothes dryer	64	347	85	24 %
Dishwasher	198	234	16	7 %
Desktop PC including monitor	202	276	22	8 %
Laptop PC	180	56	7	12 %
Router for Internet	33	58	12	20 %
Wireless access point	6	72	44	61 %
Printer	41	33	9	28 %
TV CRT	708	124	8	7 %
TV LCD	145	186	17	9 %
TV Plasma	56	400	74	19 %
DVD recorder/player	162	23	4	16 %
Hi-Fi	281	46	4	8 %
Satellite/cable/air set top box	108	75	10	13 %
Air conditioner	28	372	322	87 %
Oven/cooker	23	301	90	30 %
Microwave oven	78	33	8	24 %
Water kettle	58	70	16	22 %
Vacuum cleaner	99	65	15	22 %
Lamps	7849	487	-	-
Total	*11459*	*4833*	-	-

Based on the values in Table 4.4, we can have confidence in our estimates of refrigeration and washing appliances, but not in clothes dryers because of the relatively small number of appliances measured. The estimates for PCs are also trustworthy, but not for other devices connected to the PCs. Our estimates for conventional (CRT) and LCD TV's are good estimates, and to a less extent for plasma TVs. Air conditioners have a very high confidence interval, again because of the few measurements carried out. Other devices have moderate or high confidence intervals.

The estimates of Best Available Technology and/or Best Practice are uncertain. As it was seen, it is difficult to compare laboratory tests and manufacturer information with measured consumption in such appliances. In some cases it was found that the measured consumptions are even lower than the consumptions claimed in different information sources for BATs. For example room temperature can strongly influence the consumption of refrigeration appliances.

A lot of new appliances consuming much less energy than the appliances on the market today are under development and they will be commercialized soon, offering additional opportunities for saving electricity. One example is the OLEDs Televisions, which under normal viewing conditions can result in reduced power consumption of up to 40% per panel square inch compared to conventional LCD panels. No backlight is used with the organic materials displays.

As already mentioned, our estimates are probably too high due to biases in the measurement campaigns. As an example, the consumption in Norway is reduced by almost 30 % if the measurements are corrected for this bias. The same adjustment procedure for appliance ownership needs to be applied for the other participating countries.

4.7 Conclusions

The measurement campaign was performed in about 1300 households in 12 different countries. About 11 500 single appliances were measured and analyzed. The appliances were grouped into 24 appliance groups or “end-uses”.

The consumption has been extrapolated from the two weeks measurement period to one year. The average measured values are also called the consumption per appliance. Most of the calculations are corrected for appliance ownership, obtaining the consumption per household. The aggregated consumption per end-use and per country and for all participating countries is obtained by multiplying the consumption per household with the population number per country.

When ownership is taken into account the total energy demand per household per year is on average about 2700kWh (including air condition and cooker/oven, but excluding space heating and hot water). This is called the Present State consumption.

Best Available Technology and Best Practice have been identified mainly from the measurements carried out. In some cases other information sources have been used. By replacing the existing appliance stock with the Best Available Technology, the savings in the EU-12 coutries have been estimated to be 165TWh per year, representing about 72 million ton avoided CO_2 emissions.

Due to the low ownership rates on some appliances, the multinational average consumption for these appliances is reduced. As an example, the consumption in air conditioners is reduced from about 370 to about 60 kWh per household per year when ownership is taken into account.

Based on the monitoring campaigns carried out, the standby consumption for the measured appliances within the household, sums up to about 305 kWh per household per year, which is about 11% of the total consumption per household. For all participating EU-12 countries it sums to about 40 TWh per year.

By changing to Best Available Technology and/or Best Practice, the households can reduce the consumption of about 48% that is about 1300TWh per year. In the EU-12 the aggregated savings are roughly estimated to about 165 TWh, leading to a emissions reduction of 72 million ton CO_2 per year, using the standard emissions factor (0,435 kg CO_2/kWh). It is necessary to perform model calculations to obtain a better estimate of the emission savings. It is also necessary to perform more field measurements, especially of energy efficient equipment (there is little field data on A+ or A++ appliances) and lamps to get more knowledge about the use of and energy consumption in such appliances. Such measurements will permit to obtain better estimates of the potential savings by replacing old inefficient equipment.

Through this project a comprehensive database of measurements has been established. Hopefully this can serve as a base for future energy analysis and decision making. In some cases, more measurements are necessary where they have not yet been performed or where there are too few (e.g. air conditioners). It is also necessary to perform measurements to observe changes over time. One example is that more energy efficient appliances often are replaced with larger sized appliances or higher lighting levels (rebound effect), and the potential energy savings may be lower than it was estimated.

5. STRATEGIES FOR MARKET TRANSFORMATION

To take advantage of the energy-saving opportunities identified, new minimum efficiency standards need to be defined for some applications and tightened for other appliances (e.g. refrigerators and freezers) and some policy incentives changed. Current regulations and fuel subsidies, for example, often favour consumption over efficiency. But many steps are not taken, because energy users lack information nor do not value efficiency enough to change their buying habits.

Apart from the technological parameters related to energy consumption in the household sector, policy analysis include the examination of different approaches including, technology procurement, revision of the energy label ratings A-G and expansion of the label in order to include more products, tough mandatory minimum efficiency standards, awareness campaigns and white certificates. Concrete suggestions at various levels are discussed towards successful market transformation, including behavioural changes in the equipment selection and operation.

5.1 Problems identified

Although there are some supportive instruments available in most countries, they seem not to be adequate and satisfactory. The energy labeling alone proved to be inadequate to promote energy efficient appliances. The need for accompanying measures such as raising awareness and information campaigns in what concerns the benefits of efficiency as well as incentives to the end users, are considered to be necessary, in order to achieve market penetration of efficient appliances. This need is even more important in countries where the electricity price is low (BG, NO) and the economic gain of using energy efficient appliances is not so obvious to consumers. In these countries the savings from the purchase of high-energy efficient appliances are not comparable with the price difference, being the pay back time relatively long for the households criteria.

Some countries report problems regarding the electricity taxation. Specifically, in Denmark the taxes on electricity consumption for domestic customers are very high (all taxes plus VAT together constitute more than half of the domestic electricity price). Anyhow, only a small part of the taxes imposed are used to promote and support electricity savings. In Belgium the electricity prices are high, and there is no political will to impose higher taxes, while in Czech there are some problems identified in the existing tariff structure. Basically, the tariffs for residential customers differentiate between use of electric energy “only” for standard purposes (lighting, domestic appliances) and also for meeting heat energy needs (hot water preparation, heating). As a result, those who use electricity just for basic purposes, may have as much as two times higher unit price of energy supplied/consumed than those who use it also for production of heat for the same amount of electricity consumed. Such a practice

does not motivate household consumers to use electricity in a rational way. Another problem identified in Bulgaria, is that there is no effective procedure for verification of the compliance with the ordinance of labelling. Moreover it is assumed that there is a practice of false labels. This includes misrepresentation of information, false and misleading information, etc.

Some countries such as Portugal and Greece report that there is a lack of high efficiency appliances in the market such as A++ refrigerators, washing machines and dishwashers which are not easily available in the market.

5.2 Recommendations

Following sections present a set of policy recommendations to promote energy efficiency based on the findings of the monitoring and surveying campaigns. Some of the recommendations are general while others are specific for each type of appliance.

5.2.1 Revision of the energy label ratings A-G and its enforcement

Since the introduction and implementation of the energy labelling Directive, European consumers have become familiar with the A-G energy label, but on the other hand, in everyday life there are a large number of households who do not know about the efficiency level of their appliances, as the project survey suggests. The A-G label scheme during the years has achieved a high recognition due to its simplicity, transparency and comprehensibility and it is considered to be a valuable instrument that can promote energy efficiency and deliver significant energy and carbon dioxide savings within the community. Thus it is very important that the energy label and its main characteristics should be retained in any future attempt of adapting the energy label. However, A-G ratings have become obsolete, as the improvement in energy performance that many products have undergone in the last years, is significant. The best examples of this are in the refrigeration and washing machines labels: for refrigeration new labels were uniquely introduced at A+ and A++ and in the European washing machine market, virtually all of the products are now A-rated [ecee, 2008]. Therefore, there is a need to adapt the existing labelling scheme in order to update it in a flexible and more dynamic way, but always bear in mind that the changes made should not confuse the consumers.

Feeling this need and in general the need for renewal, the European Community has made a call for stakeholders consultation on the revision of Energy Labelling Framework Directive 1992/75/EEC. This consultation is now closed and many stakeholders such as National Governments and Administrations, European Associations and Groupings, Industry and others have expressed their opinion on a series of matters. Among others the matter of adapting the energy label towards a more dynamic scheme was raised. Many of the stakeholders (e.g. ANEC, BEUC, CECED, ECEEE, Eurocommerce, FIEEC) recognized the need of updating the energy label on their comments and some of them (e.g. CECED) suggested the exact changes that need to be made. Now the consultation is closed and the forthcoming revision is expected soon.

Some other possible solution could be placing the energy label placed on well visible part of the labeled products. As it is already known the energy labeling directive assures the mandatory exhibition of the energy labels at the selling points. The provision of accurate, relevant and comparable information on the specific energy consumption of household appliances is considered to influence the consumer's choice in favor of those appliances which consume less energy. By placing the energy efficiency label on the domestic appliance, the importance of the information it bears would be outlined and the electricity consumption would become one of the main features of the appliance. Thus, this is a way to reinforce the significance of the energy class and make the consumers realize that energy efficiency is indeed a feature which is bonded with the entire lifespan of their appliances. They must become aware of the fact that their decision whether to buy or not an efficient appliance is something which will affect them not only while buying the appliance by adding an extra cost, but for all the years that they will own and operate it.

Additionally for re-enforcing the energy labeling scheme inspections of the selling points should take place in order to assure that energy labels are correctly exhibited and to assure that the retail staff is informed adequately about energy labels so as to be able to provide right information to the consumer.

5.2.2 Expansion of the energy label in order to include more products and setting more ambitious Minimum Energy Performance standards

Up until now, the energy labelling scheme referred to white appliances, light bulbs and air-conditioners. Recent market surveys [Schlomann, 05], have shown that the household electronics market has increased significantly in the EU countries in the last years. In the REMODECE project, the ownership levels of different appliance types in EU level were calculated based either on data gathered from the surveys or from national statistics. The ownership levels for the metered electronic devices are displayed in the Table 5.1.

As it can be seen most of these appliances have high ownership percentages. Nevertheless, one must bear in mind that some of the ownership levels, e.g. for desktop PCs + monitor, are presented to be in general higher than they really are, because in the monitoring campaign it was tried to monitor households who owned ICT equipment.

Table 5.1: Ownership rates for ICT equipment.

Appliance Groups	**All Countries Average ownership level (%)**
Desktop PC including monitor	78,9
Laptop PC	41,9
Router for Internet	47,9
Wireless access point	33 ,0
Printer	66,9
TV CRT	92,6
TV LCD	22,5
TV Plasma	8,8
DVD recorder/player	66,6
Hi-Fi	71,5
Satellite/cable/air set top box	41,1

Taking into consideration the increasing number of electronic loads in the households, an expansion of the energy labelling scheme should be considered, in order to include other goods such as TVs and entertainment equipment in general. Moreover the survey showed that in most of the participating countries the knowledge of the Energy Star label is poor, and therefore an extension of the scope of the label should be considered.

Another aspect of the electronic appliances is the standby consumption which is proven to be an important contributor to their total annual consumption. From the analysis of the metered data it was found that the share of the annual standby consumption in the total annual consumption of some appliances was relatively high. For example for CRT TVs, DVDs and Desktop PCs + monitors this share was around 10% and for Hi-Fi it was around 17% [Table 5-3]. The potential of energy savings that lies in these standby consumptions can be achieved with setting stricter requirements for standby power, besides of course with consumer behavioural changes that can also lead to significant energy savings. Labelling of electricity consumption, including low power modes, appears to be essential to raise consumer awareness.

In this scope, on 8th of July 2008, the European Union (EU) member states have endorsed the European Commission's proposal for a regulation reducing standby energy consumption by household and office products. The regulation lays down energy efficiency requirements for all products sold in the EU, thus cutting the EU's standby electricity consumption by almost 75 percent by 2020. The rule applies to all electric devices used in households and offices, such as television sets, computers and microwave ovens. Depending on the functionality of the product, it sets a maximum allowed standby power consumption of either 1 or 2 watts for the year 2010. As of 2013, the admissible power consumption level

will be lowered to 0.5 or 1 watt, [http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1117&].

The above mentioned proposal is a very positive step and there should also be an attempt to upgrade existing Minimum Energy Performance Standards (MEPs) based on the EuP studies as well as to develop new MEPs based on lifecycle cost considerations.

MEPS are urgently needed for air conditioning equipments being sold in Europe: Residential air conditioning loads are increasing fast in Southern Europe and are already a major contributor to summer peak demand in Mediterranean countries. The European air conditioning market has been flooded with very low cost and very inefficient units, therefore needing urgent attention. Banning low efficient units coming from Asia (low efficient air conditioning units that are not allowed in China and Japan are invading the European market).

The selection of the most efficient equipment needs to be ensured through minimum efficiency standards. Behaviour changes can strongly mitigate not only the consumption, but in some conditions even the need for air conditioning. A good example is the use of night ventilation for free-cooling in the summer.

5.2.3 Recommendations for raising awareness about labelling schemes

Through the survey conducted in the framework of the REMODECE project, it became obvious that even though energy labeling is a well known and accepted scheme that is active for quite some years now, work still needs to be done in the area of consumer's awareness and enforcement. The results of the surveying campaigns might not be fully representative of the situation in each country due to the relatively modest samples analyzed, but they are for sure an indicative of the trend. In specific, two trends that were established from the survey are that there is lack of awareness first in what concerns energy labeling and second in what concerns Energy Star products.

- **Inform consumers with awareness campaigns in any form (TV spots, brochures etc) about the importance and the benefits of buying energy efficient appliances**

In all the countries of the consortium, except Denmark (the country with the highest awareness level) where the percentages are between 15% and 25% depending on the type of the appliance, the vast majority of the people answers: "I don't know the energy efficiency class of the appliances I own". The leading countries in people who answers "don't know" are Bulgaria, Greece, Germany, Belgium, Portugal, Hungary, France, Italy and Norway and then follows Romania and Czech Republic. Depending on the electric appliance (fridge/freezer, washing machine, tumble dryer, dish washer) the percentages vary from 30% to 80%. Some of the worst examples are: for freezers in Bulgaria and Portugal, with the percentage climbing up to 80%, for washing machines Bulgaria and Greece with 60% and for dish washers Greece, Germany and France with almost 55%.

- **Inform consumers about the importance of choosing Energy Star products when it comes to office equipment and organize training programs for retailers giving them also sales arguments**

Energy Star products save energy by incorporating advance technologies that use less energy than standard models. In specific for office equipment, the energy is saved through special energy-efficient designs, which allow them to use less energy to perform regular tasks, and automatically enter a low-power mode when not in use [www.energystar.gov]. In the surveying campaign when people were asked about the importance of the Energy Star label when purchasing office equipment, the awareness level showed big variations among the participating countries. In Germany, Belgium, Hungary, France and Romania people stated that they don't know whether or not they buy Energy Star products in percentages that varied between 8% and 45%. That fact indicates that there is lack of awareness not only among the consumers but among the retailers as well. The consumer's lack of awareness can also be seen by the percentages of people that answer that they never choose to buy Energy Star office equipment. Italy and Czech Rep have percentages reaching almost 60%, France follows with 50% and the rest of the countries have percentages between 10% and 40%.

5.2.4 Recommendation based on behavioural trends

One of the most effective ways to save energy and achieve the reduction potential in the residential sector is probably through behavioral changes. From the analysis of the data collected in the surveying campaigns, consumers' behavioral trends were established through a series of questions that were included in the questionnaires. The identified "false" behaviors (pretending rational behaviour) were related with most of the domestic appliances and many of these behaviors could change through awareness raising campaigns which will focus on behavioral matters. Some suggestions per type of appliance, of what the awareness campaigns could address are:

- ***Fridge/freezers***

For fridge/ freezers some of the false behaviors had to do with putting inside the fridge warm food or not covering the dishes before placing them inside the fridge. In most of the countries the majority of the answers were of the right behavior but in few countries there were some exceptions with the false behavior standing out a little more. Such cases were Hungary (49%), Denmark (36%), and Germany (23%) with putting warm food inside the fridge and Belgium (75%) and Czech Republic (71%) with not covering the dishes. In these cases proper advice must be given in the awareness raising campaigns.

- ***Washing machines/ dish washers/ tumble dryers***

The usual loading of the washing machines is an issue to be addressed in the awareness campaigns. One way of saving energy is by washing in full loads. The survey showed that in

most of the countries the percentages of the washing machines loaded up to the 50%-75% of their capacity vary from 10% to 50%. In Romania this percentage is climbing up to almost 94% so extra notice should be given in this country on the importance of using the machines only when full loaded.

- ***Home entertainment***

In Germany, France, Norway and Belgium the percentage of people turning of the TV with the on/off button are quite reasonable, varying from 65% to 80%. In the rest of the countries people tend to leave their TVs in standby mode more often (e.g. 90% in Bulgaria, 85% in Romania). Nevertheless, in all the countries exists potential for changing behavior in what concerns the standby mode so this is something that should be included in all the countries' information campaigns.

- **Office equipment**

Also for office equipment one of the most important issues that must be addressed in the awareness campaigns, is the handling of the standby consumption. Among the devices checked in the surveying campaigns, modems and routers were the ones left on "on mode" and "standby mode" more frequently than all the other devices. Desktops, laptops and monitors are also left on standby mode in percentage that varies between 9% and 27%. In Romania with 21% and Germany with 13% there were some significant percentages of respondents who leave the computer on due to worries about damaging it. Such misconceptions must be eliminated through information campaigns. Another misconception that exists has to do with the use of the screen saver, as in some countries (e.g. Italy (93%), Czech Republic (82%) and Bulgaria (81%)) people wrongly think that the activation of the screen saver saves energy.

- **Air-conditioning**

Leaving doors and windows open while cooling or heating a room and setting the temperature lower than 26^{o}C during summer months are issues that must be included in the awareness raising campaigns. In Greece only 23% of the people set the temperature of the air-conditioning above 26^{o}C. And there are a 13% of people that sets the temperature equal or below 18^{o}C, which is a totally wasteful behavior.

Standby power consumption can be relevant for air conditioners and should also be addressed in the awareness campaigns. Most air conditioners have a power consumption in standby (0.2 to 10 W) to allow electronics to check for incoming operating signals (some have remote controls and/or a timer switch), but some models also have sump heaters installed. Sump heaters are small electric heating elements that prevent compressor wear during cold start-ups. These heaters may consume up to 20 to 70 Watts in 'off-mode', so without the end-user knowing it. It is believed that approximately 1 out of 10 models have a sump heater [MEEUP].

- **Lighting**

According to the survey there are people that never choose to replace damaged light bulbs with CFLs. In some countries this percentage is relatively high such as in France with 37% or Bulgaria and Hungary with a percentage around 30%. In the rest of the countries the percentages are lower varying around 10%. The fact that there are people nowadays refusing to use CFLs, shows that not only they are not well informed about the benefits of their use but most like they have many misconceptions about CFLs. From the people who never choose to replace damaged bulbs with CFLs most of them say the higher price as the main reason for doing so. Others complain about the lighting color quality. The awareness raising campaigns should focus about their lifespan, which is much longer than incandescent bulbs (6 to 12 times longer), improved lighting color quality (now warm white models are available) and of course their running costs which are much lower.

In Romania 65% of the people, answers that they often or always leave the lights on in unoccupied rooms. This is a very high percentage not seen in any other country (in the rest of the countries this percentage is around 5%) so additional attention should be given in this country in order to change this false behavior. Of course attention should be given in the rest of the countries as well, since there are people who answer that they "sometimes" leave the lights on in unoccupied rooms (Norway with 72%, Germany 59% and the rest of the countries between 30% to 40%).

New LEDs lamps are entering the residential market, but their present application is negligible. These new lamps can displace the growing share of inefficient incandescent halogen spot lamps with energy savings of over 80%. However, their cost is still quite high, typically 5-10 times the value of the incandescent halogen lamps, which they are supposed to replace. Market transformation can be achieved through a combination of information campaigns about the advantages of this new technology (the superior overall performance in terms of efficiency, very long lifetime, and minimal environmental impact), coupled with financial incentives to partially offset the large initial investment.

- **Overall Considerations**

An overall point that should be underlined in all the awareness raising campaigns independent of the country, is the matter of efficiency together with sufficiency. It is not only important to inform and motivate people in buying energy efficient equipments, but also to draw their attention on sufficiency. A very common trend nowadays is to oversize the equipments bought, either due to certain lifestyle image that people want to maintain or due to the fact that for some appliances (e.g. flat TVs) the price doesn't differentiate that much if you go to the larger size. Buying larger units is very common for fridges and TV sets. According to the REMODECE monitoring analysis it was found that conventional televisions use about

125 kWh, LCD TVs uses about 190 kWh and for Plasma TVs it was found that it uses 400 kWh in average. In average, plasma TVs are bigger than LCD TVs, which are bigger than CRT TVs, and much of the consumption differences were explained by size. It can be seen that although there is a shift towards LCD and Plasma TVs, which are more efficient than conventional CRT TVs, and that is a good thing, because of choosing larger screens, the consumption of flat TVs is appearing to be larger compared to conventional TVs consumption. So, it is well understood that sufficiency plays an important role in saving energy and it should be addressed in all awareness raising campaigns.

Finally taking into consideration the successful example of the German awareness raising campaign (Initiative EnergieEffizienz), it is important to make sure in all the countries where the awareness raising campaigns will be organized, that all the engaged parties (private, public, energy agencies etc.) must be involved in order to achieve the best dissemination results

5.2.5 Incentives to consumers

- **Combine technological advancement (introduction of new products) with financial incentives: speed-up of market introduction.**

From the monitoring analysis it was found that the biggest share of savings potential among the metered appliances lies in the following categories: in cooling appliances (for refrigerators with freezer compartment the savings are estimated to be 182kWh/year/household and for freezers 162kWh/year/household), in desktop PCs including monitors where the savings are 139kWh/year/household, in oven/cookers with 60kWh/year/household and in lighting with 303kWh/year/household. Thus for these categories of appliances incentives for switching to best available technology should be given, as they will deliver important reduction to electricity consumption. An additional solution could be the example of Italy where from the year 2010 the sale electrical appliances in classes below “A” will not be allowed any more and from 2011 it will be also banned to sale incandescent light bulbs and appliances without on/off power switch. For lighting, one other possible solution in order to speed up market transformation could be the establishment of taxes related to inefficiency into the price of the lamp. According to that solution an incandescent light bulb will have the higher price, due to tax impose while efficient CFL or LEDs lamps will be tax free, leading to a low price.

- **Financial or other type of incentives for replacement of old appliances, older than 10 years.**

In the survey campaign the age structure of a number of appliances was examined. In most of the countries white appliances such as fridge, freezers, washing machines, tumble

dryers etc. were found to be older than ten years in percentages that in some cases reached 50%. The only country that has very low percentages (1%-3%) of appliances older than ten years appears to be Denmark. So, in the rest of the countries the issue of giving incentives to consumers to replace their old appliances deserves to be carefully addressed to promote the scrapping of old inefficient appliances.

Possible type of incentives is listed below:

- Reducing VAT on highly energy efficient products may not be the best solutions, as this measure lowers the price of the product to the eyes of the consumer and creates a false perception that energy efficient products don't have an extra cost (people usually retain the gross price of a product and don't look whether the reduced price is the result of a reduced VAT or not). The signal that should be sent out is exactly the opposite, meaning that energy efficiency has a value. So, it is better if the financial incentive is given in an indirect way in the form of personal tax credits or rebates.
- If the incentives given to consumers are in the form of rebates and subsidies, then it must be assured that they will be given only for appliances with small market penetration and only for best available technologies. It is also important when giving a subsidy to have a fixed amount of money (xxx euro/appliance) in order to avoid over sizing, as people tend to buy larger appliances if the amount of the subsidy depends on the size.

Utility energy efficiency programmes have been in place for many years. The early schemes were known as demand-side management (DSM) programmes and were implemented by vertically integrated utilities answerable to utility regulatory authorities in the form of public utility commissions (PUCs). Under such schemes, utilities were required to allocate a certain proportion of their revenue to finance energy efficiency efforts, which were commonly delivered in the form of rebates aimed at lowering the cost of more efficient energy-using equipment at the point of purchase [P. Waide & B. Buchner, 2008]. So, demand side management programs from utility companies, also considered in the ESD directive, can lead to giving incentives to consumers. These incentives could be some of the aforementioned like rebates and subsidies for replacement of old appliances or for buying state of the art energy efficient appliances and lighting. Another possible solution for utility companies could be to amend electricity prices with a view to reward energy savings:

- In open markets if utility companies have a fixed revenue independent from electricity consumption (the income is decoupled from the sales), introduction of the proper taxation could lead to escalated electricity prices that reward energy savings (change in behavior, efficiency).
- Introduction of smart metering technology. In general a smart meter identifies consumption in more detail than a conventional meter; and optionally, but generally,

communicates that information via some network back to the local utility for monitoring and billing purposes. From the consumer's point of view an advantage of a smart meter could be the fact that the consumer could have a display of the consumed electricity and this way would be able to connect possible "wrong behaviors" (e.g. using an air-conditioning unit instead of a ceiling fan, leaving the lights on in unoccupied rooms, standby loads, etc.) with increased electricity consumption.

Another type of incentive for market transformation could be the one that CECED suggests and addresses the manufacturer's side. In specific CECED suggests that tax credits should be given to manufacturers. The tax credits philosophy is to grant to the manufacturer a fiscal benefit for each new eco-efficient product, for example Class A+ or A++ refrigerators, manufactured and sold that is above what was manufactured and sold in a reference year. The consumer would benefit from buying a technologically advanced product in a highly competitive market. By reducing the amount of taxes paid, producers of household appliances will have the resources to offer new products at competitive prices, which, combined with appropriate marketing and information campaigns, will lead to consumers replacing their appliances at a quicker rate [CECED, PP 06-08, Manufacturers tax credits – A "win-win-win" scenario for government, consumer and industry.

5.2.6 Public sector's exemplary role

The public sector of each country, in particular social housing, should play an exemplary role, since it will help low income families to decrease their electricity costs. Other public buildings in the services sector can also improve awareness in the selection of energy-efficient equipment (e.g. in what concerns lighting, A/C, office equipment).

Moreover in the context of the Energy Service Directive, Member States shall ensure that the public sector fulfils an exemplary role. The public sector may, for example, initiate energy-efficiency pilot projects and stimulate energy-efficient behaviour of employees. To this end, they shall communicate effectively the exemplary role and actions of the public sector to citizens and/or companies, as appropriate. Finally the ESD can help residential customers realize energy savings and their monitoring and verification.

One powerful market mechanism is via the system of white certificates, which can create dynamic energy services in the residential sector. There is increasing political interest in market-oriented schemes to promote energy savings in the sectors not covered by the EU Emissions Trading Scheme (EU ETS) and one suggested route is a tradable white certificate (TWC) scheme. Each certificate represents a certain amount of energy savings achieved through, for example, better insulation of a building [Energy Efficiency (2008), 1:283-295].

A (tradable) white certificate scheme does not replace but complements existing policies and measures, and aims to contribute to achieving current or newly formulated EE

targets in a cost-effective way. As a representative market-based instruments in the European internal market it builds upon experiences with similar types of schemes such as the EU emissions trading scheme (ETS) and green certificate schemes [EuroWhiteCert].

In Europe several countries have already implemented a WhC scheme or are seriously considering doing so. Italy has started a scheme in January 2005; France a year later. Great Britain has combined its obligation system for energy savings with the possibility to trade obligations and savings (only among the obliged parties and through bilateral contracts). Denmark and the Netherlands are, or at least have been, seriously considering the introduction of a WhC scheme. Flanders (Belgium) has implemented an energy saving obligation for energy grid companies without tradability of certificates [EuroWhiteCert].

With respect to energy efficiency in the household sector WhC scheme can be implemented in projects promoting the use of energy efficient lighting and energy efficient household appliances, including air conditioning. An example of such a scheme is the promotion of the use of CFLs in the household sector that has been applied in France by ADEME, EDF and others relevant parties.

6. TIPS TO SAVE ENERGY

The most effective strategy for improving household energy efficiency is to first target home's envelope – walls, attic, windows, and doors. Then reduce the energy consumption of equipment, such as appliances, lighting, entertainment, heating, cooling. Finally, consider renewable energy sources: solar water heating and photovoltaic, wind power, etc.

Below, several tips to save energy for each type of appliance are presented.

6.1 Heating/cooling

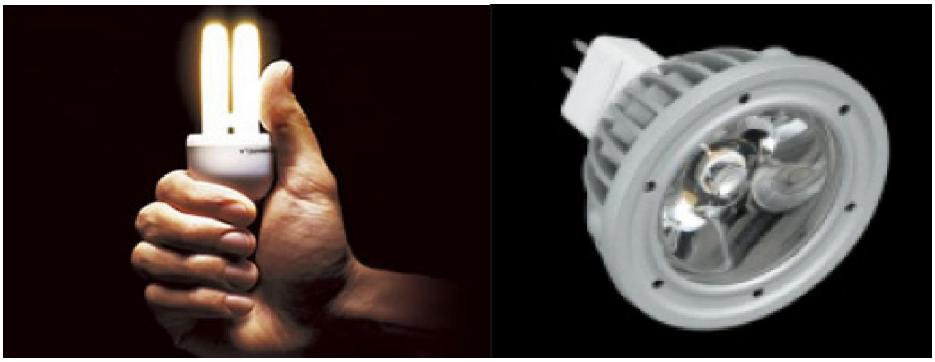
Heating/cooling is an important load in household electricity consumption. Because electricity is a high quality and expensive form of energy it is important to consider the following aspects: use district heating where available (Central and Northern Europe); avoid resistive heaters and prefer high efficiency heat pumps which cost more but can reduce the electricity consumption by 65-80% and can be used also for cooling; use closed fireplaces, instead of open fireplaces, using wood/pellets for much higher efficiency and better indoor air quality; and use a high efficiency controller and circulator if you have natural gas central heating which running costs are higher than heat pumps.

Some tips to save electricity with heating/cooling are:

- Reduce infiltration in windows and doors.
- Use selective energy-efficient windows.
- During the night close the curtains and window shutters.
- Use heat pumps with a high efficiency (Coefficient of Performance (COP) >4).
- In central heating systems replace your existing circulator pump with an A-rated equivalent pump.
- During the summer use night ventilation for free cooling.
- Always close the windows when your are heating or cooling your house.

6.2 Lighting

Lighting typically accounts for about 18% of the total house electricity consumption. Conventional incandescent bulbs are very inefficient and should be replaced. Compact fluorescent lamps (CFLs) save 75% of the electricity and last much longer (typically 6 to 12 times). CFLs are now available in different colors e.g. warm white, required for example over the dining table or in rooms where you are painting, studying and redecorating. Halogen lamps (both 230V and 12V) used in down-lighters, spot lamps etc. are nearly as inefficient as incandescent lamps. Halogen lamps should be replaced by the new LED lamp. LEDs price is high but it is a good investment in case the lamps are burning every day.



Some tips to save electricity with lighting are:

- Use daylight – it provides the best light quality, and it is free of charge!
- Use good fluorescent lamp tubes for general direct or indirect lighting e.g. in kitchen, washing room or garage.
- Switch off halogen light transformers at the main plug.
- Replace your indoor and outdoor incandescent lamps with CFLs. Initial cost of the bulbs is higher but you will recover your investment from the electricity that they will pay for themselves several times over, as they last much longer than incandescent bulbs.
- Consider using new LEDs lamps to replace halogen lamps.

6.3 Refrigeration and freezers

They use around 28% of the total household electricity consumption. Careful selection and intelligent use are key factors to save electricity. A+ or A++ Fridges and freezers are a good investment because their extra cost is quickly recovered.

Some tips to save electricity with refrigerators and freezers are:

- Keep your refrigerator at 2,7°- 4,4° C and your freezer at -18°C.
- Keep your fridge away from the oven, dishwasher, direct sunlight or other sources of heat. Allow enough space above and behind (at least 10 cm) it so air can flow.
- Keep your refrigerator filled to capacity, but not too much to the point where doors cannot be closed or air cannot circulate.
- Do not put uncovered liquids in the refrigerator. The liquids give off vapors that add to the compressor workload.
- Allow hot food to cool off before putting it in the refrigerator.
- Don't open the door more frequently than you need to. Don't leave the door open.
- Defrost your food taken from the freezer inside the refrigerator to save energy.
- Maintain the coils in the back of the fridge clean to ensure efficient air exchange. Dirty coils on the back can waste up to 30% of the electricity it uses.
- Check the condition of the door gaskets by placing a money bill against the frame and closing the door. If the bill can be pulled out with a very gentle tug, the door should be adjusted or the gasket replaced. Make sure the door seal is clean and tight.

6.4 Washing Machines, Dryers and Dishwashers

Washing machines and dishwashers represents around 16% of the total household consumption. Always choose the higher efficiency rated machine available (A or A+). In terms of features, look for a clothes washer with several water level options (to adjust to different loads) and for pre-soaking capability. In dishwasher look for the eco-cycle, which allows natural drying of the dishes, saving a significant amount of energy, and in clothes dryers look for units with automated moisture sensors to reduce drying time.

Some tips to save electricity with your washing and drying machines are:

- Use cold water washing whenever possible (or the coolest wash temperature that provides acceptable performance).
- Dissolving powder detergents before you add it to the washer is good practice for all wash temperatures, especially if used in cold water.
- Wash a full load rather than several smaller loads, and try to group clothes by fabric and color, and by how dirty they are.
- Use the sun and wind whenever you can; it's the most environmentally friendly dryer of all!
- Do not overload the dryer; it means a longer drying time (using more electricity).
- Always clean the lint filter after use. A clogged filter consumes more energy and may become a fire hazard if unattended.
- Don't use the "rinse hold" feature on your dishwasher when you only have a few soiled dishes.
- Wash only full loads of dishes – but do not overload dishwasher.
- Scrape food off dishes and rinse them with cold water before placing them in the dishwasher.
- Use higher temperature or pre-wash cycle only in the cases of burned-on or dried-on foods.

6.5 Cooking

Cooking represents on average 11% of the total electricity consumption in a household with electric cooking. Cooking is mostly done using either natural gas or electricity. Electric ovens are much more efficient than gas ovens, where gas hobs have some efficiency advantage over electric cook tops. Electric cooking does not produce harmful combustion gases, being better in terms of indoor air quality.



Some tips to save electricity with your cooker are:

- For induction cook tops special pots and pans are required.
- Develop the habit of "lids-on" cooking to permit lower temperature settings.

- For boiling minimize the water used for cooking to avoid having to heat more than is needed.
- Begin cooking on highest heat until liquid begins to boil. Then lower the heat control settings and allow food to simmer until fully cooked.
- There is no need to preheat the oven for broiling or roasting.
- When preheating an oven for baking, time the preheat period carefully. Five to eight minutes should be sufficient.
- For small amounts of food use the microwave oven whenever possible, as it draws less than half the power of its conventional oven counterpart and cooks in a much shorter amount of time.
- Use the self-cleaning cycle only for major cleaning jobs. Start the cycle right after cooking while the oven is still hot, or wait until late in the evening when electricity usage is low.

6.6 Hot Water

One of the largest energy users in your home, next to heating and cooling system, is the hot water system. Water heating is mostly done using either natural gas or electricity.

Some tips to save electricity with your hot water system:

- Reduce your water heating bill by 10 percent by lowering the water heater temperature from 60°C to 50°C.
- Locate water heaters as close to the points of hot water usage as possible. The longer the supply pipe, the more heat is lost.
- Insulate your hot water supply pipes to reduce heat loss.
- Consider buying a water heater insulation kit, which reduces the amount of heat lost through the walls of the tank.
- Repair any leaky faucets promptly.
- Take showers instead of baths.
- Use sink stoppers instead of letting water run while shaving and washing dishes.
- If rooms requiring hot water are widely separated, it may be more efficient to install two or more smaller heaters rather than one central water heater.

6.7 Entertainment and office equipment

Computers and other home electronic equipment represent one of the fastest growing areas of home energy use. Our Play Stations and electronic gadgets keep several large power plants in business. These appliances represent **22%** of the total household consumption.

Some tips to save electricity with your electronic loads:

- Prefer LCD TVs to Plasma TVs
- Do not buy oversized units –Larger sizes use more energy.
- Turn TVs, computers, etc. **fully off** when not in use.
- Use Inkjet printers, which can use 95% less energy than laser printers.
- Instead of turning on the TV or video games, go ride a bike or play your favorite sport with some friends.
- Consider using laptops instead of desktops, because they use less electricity.
- Always buy, at least, Energy Star labeled equipment, and check for the ECO label.
- Replace your old transforming which spends about 6-10W in standby mode to a new which spend less than a 1W on standby mode.
- Set the computer and screen to go in sleep mode e.g. after 10 minutes out of use.

6.8 Standby consumption

In the standby mode the equipment is connected to the supply, but it is a non-operational mode when compared to the intended use of the appliance's primary function.

There are basically two methods to reduce the standby power consumption: behavioural and technical:

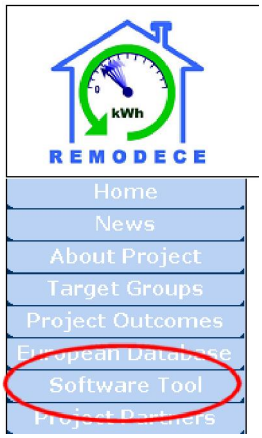
- The first one involves better consumer awareness and education about stand by electricity consumption, and changing behaviour.
- The second method of reducing standby power consumption in many appliances is the adoption of technological innovations.
- It is estimated that redesigning appliance circuits can reduce standby power consumption up to 90 per cent.
- Use of intelligent power strips to cut stand by (master-slave type) is a very effective way to reduce consumption.
- Installing a switch in the switching board of the house that cuts off all the circuits for loads that can be turned off.
- You can reduce your electricity bills by as much as 10% - simply by unplugging appliances or switching devices off at the power point they are connected to when not in use. It’s good for your wallet and for our planet.

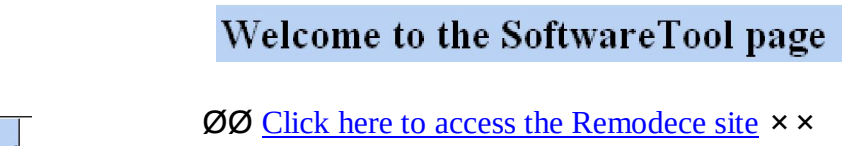
7. Home Energy Saver Software Tool

7.1 Introduction

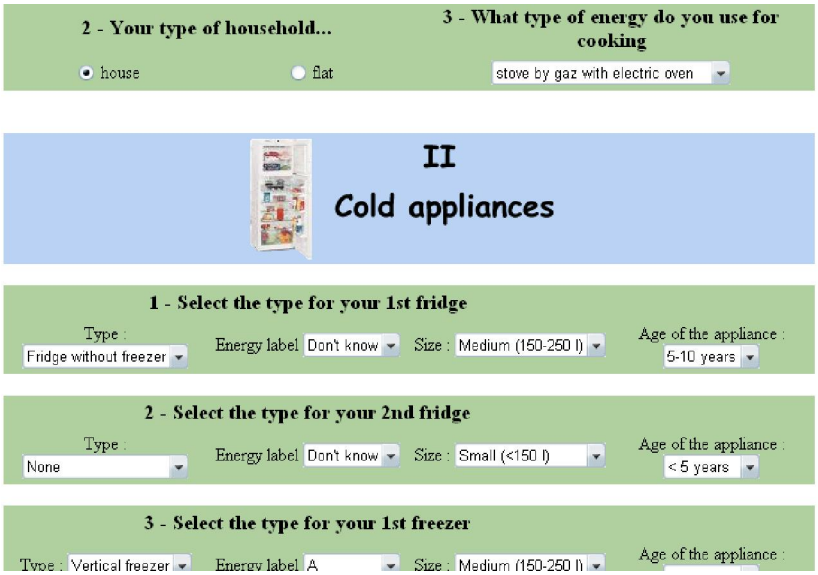
The tool will use the electrical consumptions calculated from the monitoring campaign carried out in all the partners countries and therefore will enable a cross comparison of the energy performance of similar households in the different countries involved.

Developed in the framework of the European REMODECE project, the software tool enables to evaluate the consumption of households and give advices on how to reduce it. It is available on the project's website under: http://www.isr.uc.pt/~remodece/.





Based on national values derived from the REMODECE monitoring campaign in each participating country, this tool will give an accurate way to compare households that have different types of equipment.

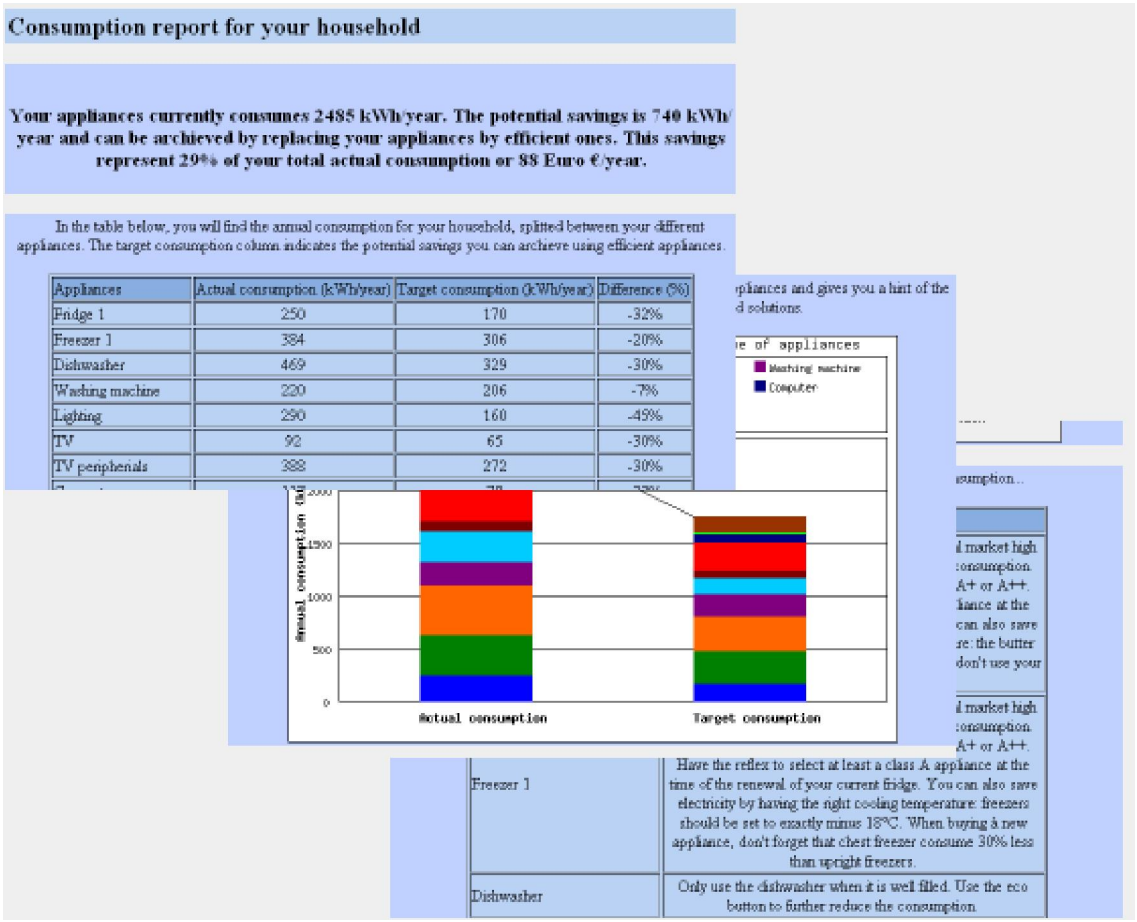


7.2 How to use it?

It takes about 15 minutes to answer questions regarding the electrical appliances within the house and the way households use them. At the end of the process an evaluation of the present situation is received as well as a list of possible improvements to be made. No technical skill is needed to fulfil the questionnaire.

Once entering on the REMODECE website, the "Software tool" link appears in the left panel. Select the type of window in which you want to display the questionnaire. For new users, select your country in order to switch to your mother tongue or enter the session ID saved during a previous use. The tool is based on information about the user's household (type of appliances, number and type of light bulbs…) that will be asked by the software within the questionnaire page. The reliability of the calculation will depend on the accuracy of the replies. The information is retrieved by a calculation module in order to display an evaluation of the household consumption split between the different appliances. Using the best available technologies for each type of appliances, the calculation module will then present the possible savings and the way to achieve them.

The user is asked to specify his country at the login page in order to use the right consumption values in the calculation module. The country name will also be used to display the tool in the language of the user. This feature will allow all non English speaking persons to use the tool in their native language. The tool is available in the following languages: Belgium (French and Dutch version), Danish, French, German, Greek, Italian, Norwegian, Portuguese, Czech, Hungarian, Romanian and Bulgarian. An analysis report will be produced at the end.



The previous report page displays the results in numerical and graphical formats. Each appliance is studied separately in order to show the most consuming appliances. The last part of the report lists all the improvements that could implement in the household

At the end of the report you can save your session to access it later or to modify your answers in order to compare different types of households.

What is the next step ? **Take action !** In order to help you choosing the most efficient appliances, you can use the Top Ten database (http://www.topten.info/).

8. CONCLUSIONS

This project contributes to an increased understanding of current and impending electricity use by European households resulting from different types of equipment, consumers' lifestyles, and comfort levels. The project evaluated how much electricity could be saved by the use of the most efficient appliances and by the reduction of standby consumption. The research focused mainly new electronic loads such as: entertainment, information and communication technologies, stand-by consumption, lighting, as well as air conditioning in some Southern Europe countries. In Central and Eastern Europe, because of lack of reliable data, white appliances have also been targeted.

A large-scale monitoring campaign in 12 countries and a consumer survey have been carried out: 100 households have been audited per country and 500 detailed questionnaires have been collected in each country. The measurement campaign was performed in about 1300 households and the survey involved the collection of 6000 questionnaires. About 11 500 single appliances were analyzed. The appliances were grouped into 24 appliance groups or "end-uses". The time interval for the measurements was 10 minutes during a period of about two weeks. The collected data, both from monitoring and from the survey, is accessible from the European Database developed, which is online from the project web-site.

The average electricity consumption per household per year was estimated to be 2700kWh, excluding electric space and water heating. From the measurements carried out, besides conventional uses (e.g. White appliances and lighting) with a large share of the electricity consumption, it can be concluded that electronic loads (office equipment and entertainment) which have been growing at a very fast rate, are now a key contributor to the electricity consumption representing 22% of the total electricity consumption. In basically all types of loads monitored there is wide range of performance levels, in the models available in the households.

By changing to the Best Available Technology and Best Practice, the households can reduce their electricity consumption by about 1.300kWh, representing 48% of their total consumption. The aggregated savings for the participating EU-12 countries are roughly estimated to about 165TWh. The estimated reduction of electricity consumption is translated into 72 million ton of avoided CO_2 emissions per year. At European EU-27 level the savings potential would amount to around 268TWh. Standby consumption represents a significant share of the total household consumption, being responsible for about 11 % of the total household consumption, mostly concentrated in entertainment and office equipment. The standby consumption may be even slightly higher if all the appliances having standby consumption within the household had been monitored.

This study increased the level of knowledge about electricity use in the European Union. However, it is also necessary to perform more measurements, especially of energy efficient equipment, more recent electronic appliances, and different types lamps to get more knowledge about the use of – and energy consumption in such appliances. Such measurements will permit to obtain better estimates of the potential savings by replacing old inefficient equipment as well as to design suitable strategies to tap those savings.

Regulation changes, information campaigns, with clear and simple messages targeting households, combined with incentives seem the best effective way to stimulate market transformation towards more energy efficient appliances, in the residential sector. Toughest European Minimum Energy Standards on lighting and appliances, and its rapid implementation are needed. The minimum standards should be fixed at levels based on lowest lifecycle considerations that achieve a substantial reduction, in a timeframe which industry will be able to deliver.

Key measures to save energy at home include:

- Phasing out indoor and outdoor incandescent lamps with CFLs and LEDs. Initial cost of the bulbs is higher but investments will be recovered from the electricity that they will pay for themselves several times over, as they last much longer than incandescent bulbs. New LEDs lamps need to be considered to replace incandescent halogen lamps. LEDs are rarely used in the residential sector, but can now displace the growing share of inefficient halogen incandescent spot lamps. At a later stage during the next decade, LEDs have the potential to become the dominant lighting technology, because of the superior overall performance (efficiency, lifetime, environmental impact).
- Promotion of Class A or higher efficiencies (A+, A++) appliances, including the accelerated replacement of old appliances.
- Promotion of energy efficient behaviour in the operation of home appliances and lighting.
- Promotion of Energy Star labeled office equipment
- Turn off (TV, DVD, Hi-Fi, Computer, monitor, printer, etc.) instead of leaving them in stand-by.
- Promotion of the use of renewable energies (e.g. sun and wind for drying clothes, solar water heating, biomass for fireplaces).
- If required choose a high efficency air conditioner (COP > 4)
- During the summer use night ventilation for free cooling.

The project results are being disseminated through a combination of channels, including:

- web-site **(www.isr.uc.pt/~remodece)** online since April 2006)

- an **Electric Appliance Energy Guide** in the national languages of each partner downloadable from the website,
- press releases, publications in key international energy efficiency conferences, in trade and technical magazines
- one dissemination workshop in each country.
- **HOME ENERGY SAVER** software tool, available from the project web-site that enables users to analyze the potential savings in their homes.

9. ACKNOWLEDGMENTS

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The REMODECE Project wants to acknowledge SAFE, Switzerland, one member of the Steering Committee, who has been actively involved in the project.

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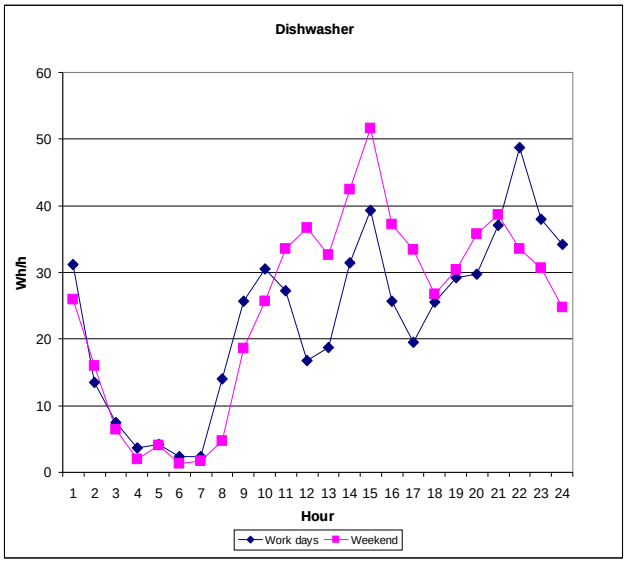
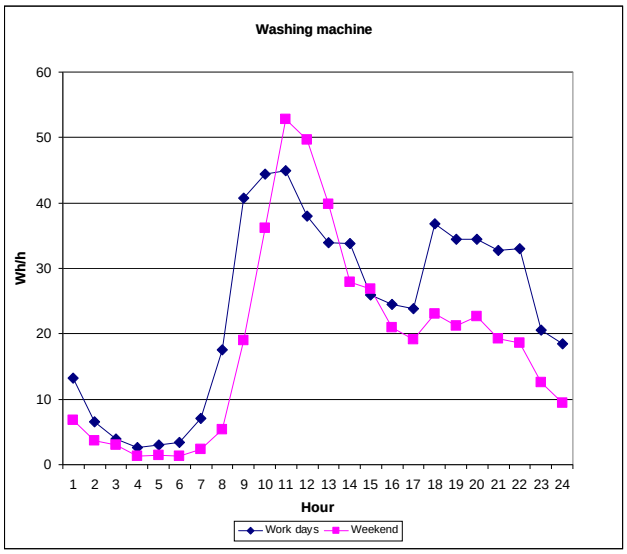
APPENDIX I – APPLIANCES LOAD CURVES

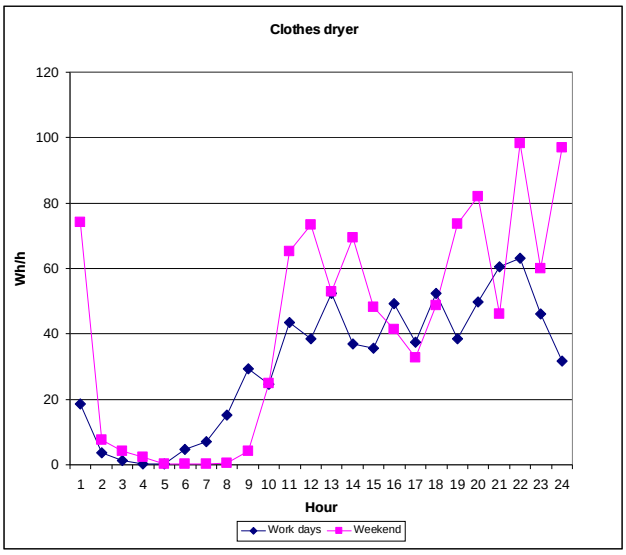
This appendix shows load curves for all groups of applications. The data shows average values based on metered data from all countries that have participated in the project. The values shown are split up in workdays (Monday – Friday) and weekends (Saturday and Sunday), and have the unit of Watt (Watt hour/hour – average consumption during hourly intervals).

Dishwashers, Washing machines and clothes dryers

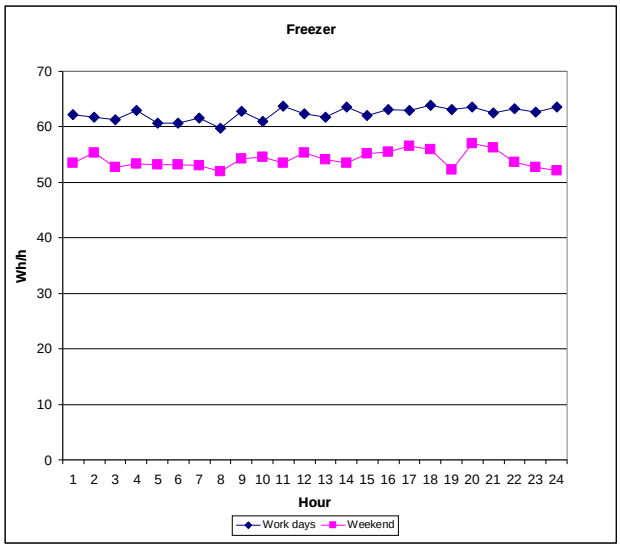


These types of applications are mainly used during afternoons. Peaks are at 15:00 hours and at 22:00 hours. There are different patterns for weekends and working days, there is more activity at weekends, at least for drying. Night-time consumption is low, although traceable.

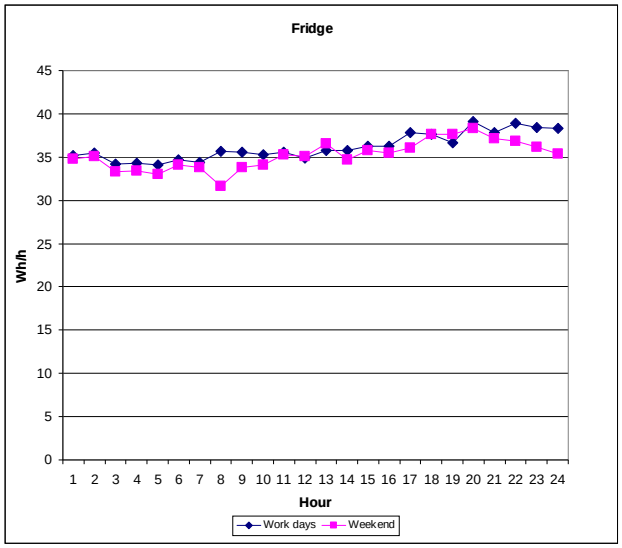


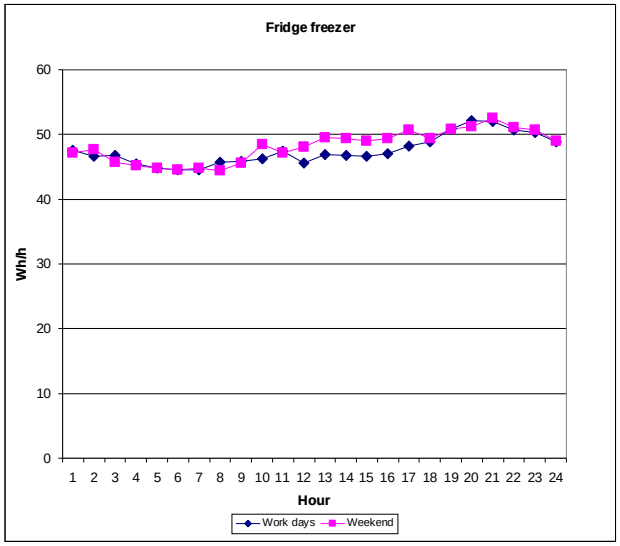


Refrigerators, freezers and combinations

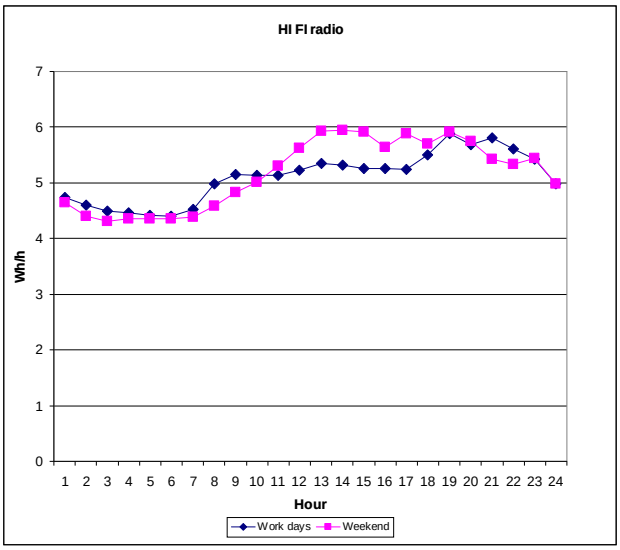


These types of applications are automatically turned on and off dependent on when the thermostat indicates too high temperature. Therefore the consumption is relatively flat. The fridge freezer (refrigerator with freezer compartment) has a greater distribution of energy demand during the day, maybe due to more use of this appliance (opening of the door).

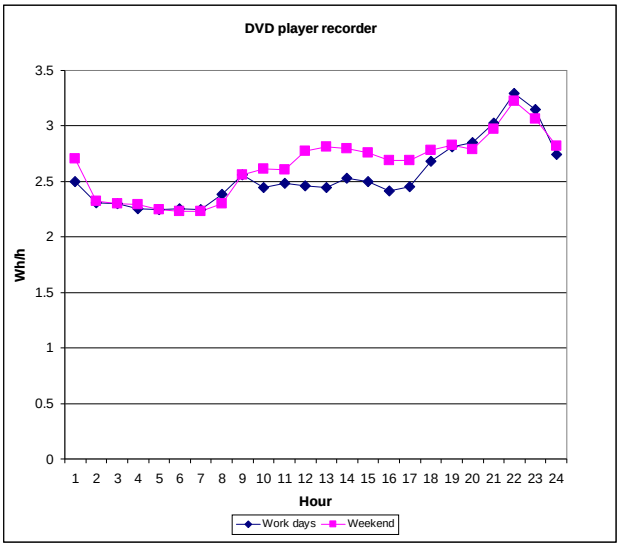


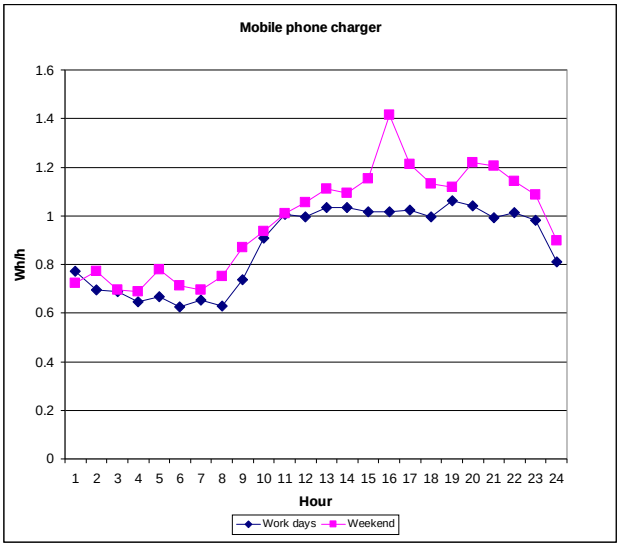


Electronic equipment

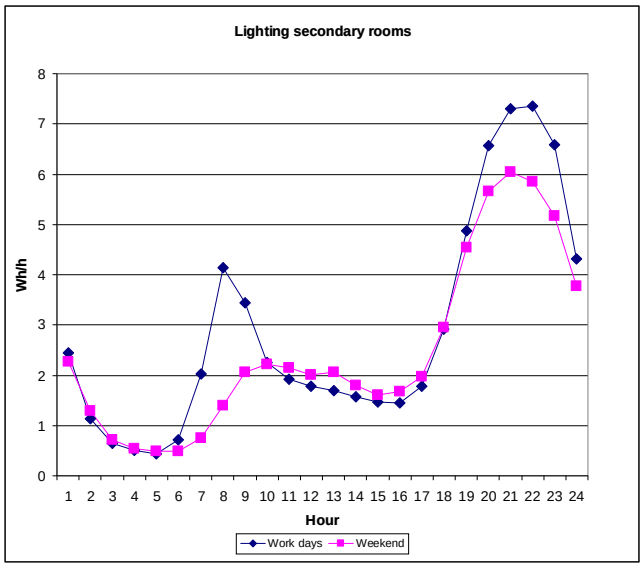


These types of applications are mainly used during afternoons, when people are home from work. There are clearly signs of standby energy, as a lot of the energy is used during off peak and nights.

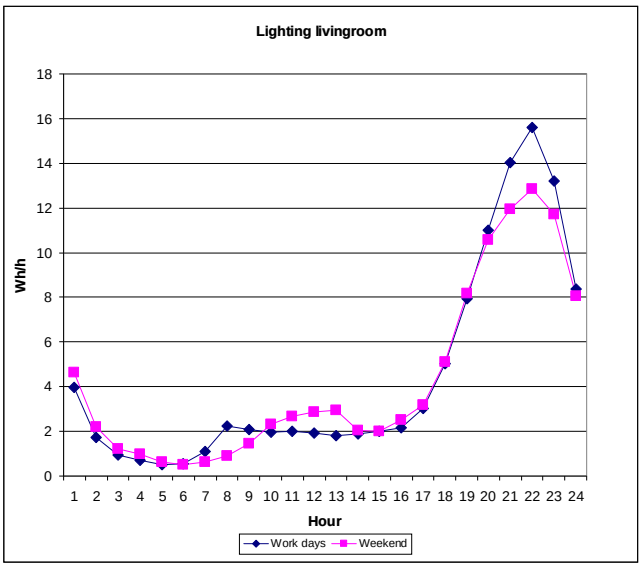




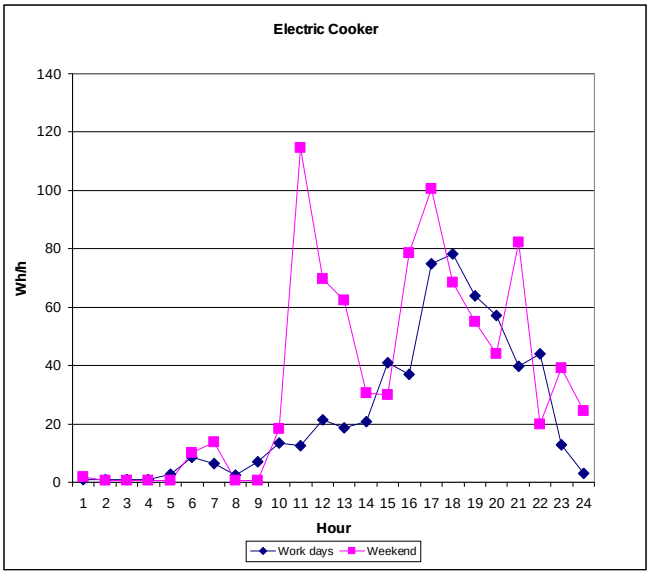
Lighting



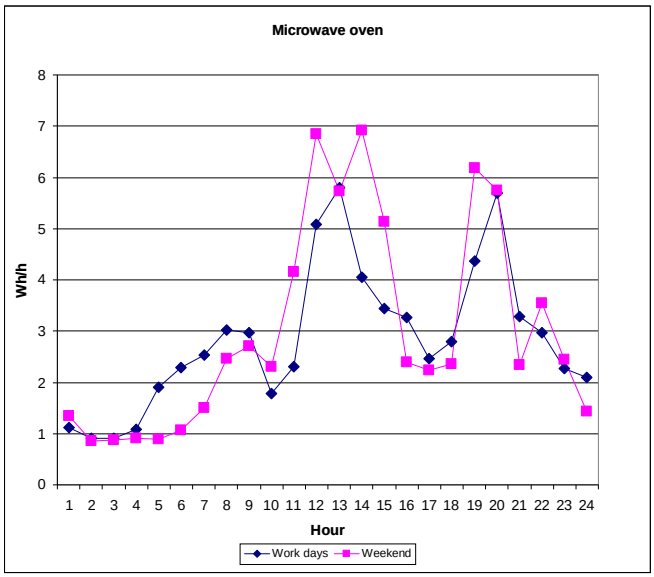
Lighting is clearly used during afternoon hours. Some lights are on during nights, but people tend to shut off lights when they leave a room unoccupied. Note the difference between living room and other rooms during week days. People do not turn on lights in the living room during morning hours.
The values shown are for the average bulb, this is the reason of the low power consumption.

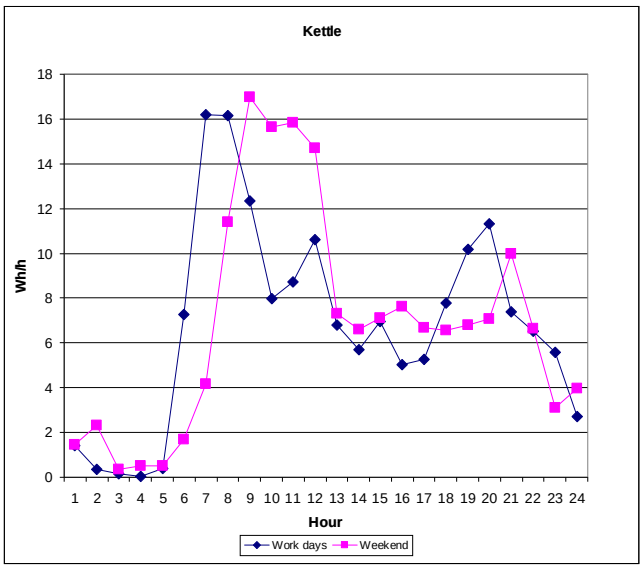


Cooker and other kitchen equipment

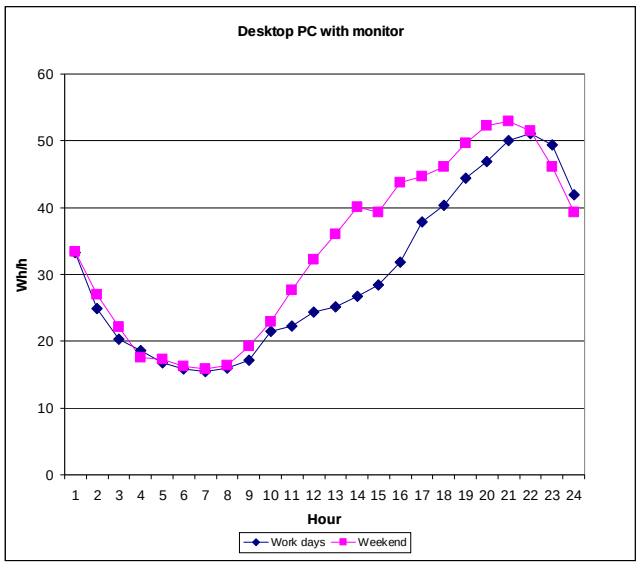


These types of equipment are used when people are preparing food for dinner and other meals. Dependent on country habits the time might vary a little. Note the difference between weekends and work days.

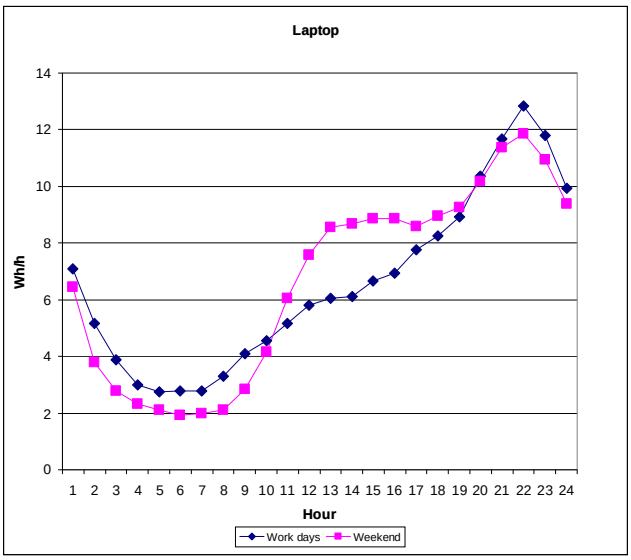


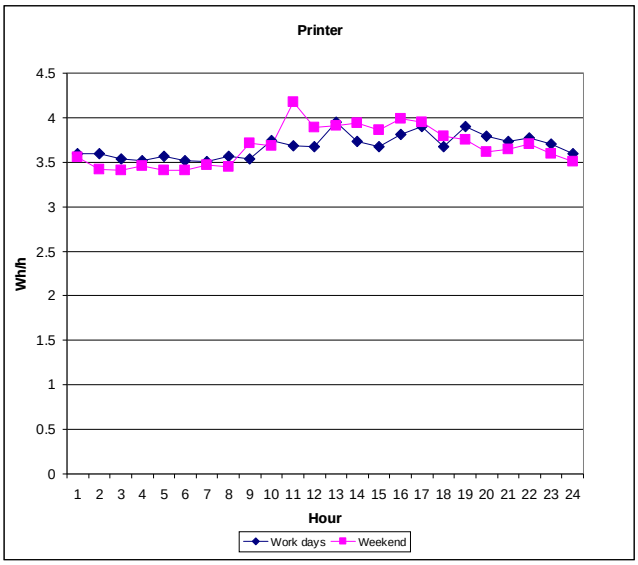


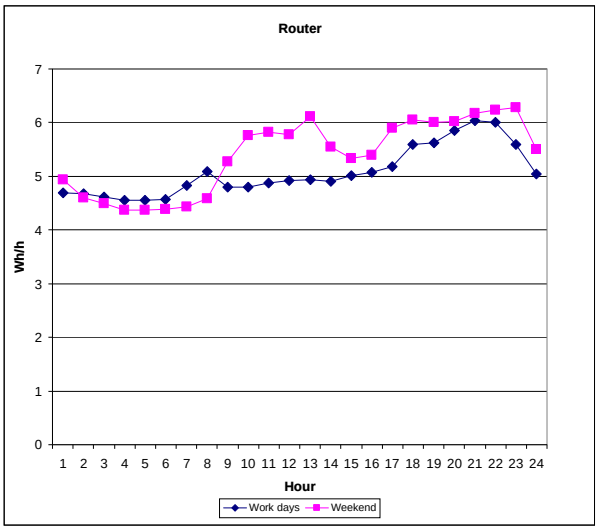
PCs and peripheral equipment

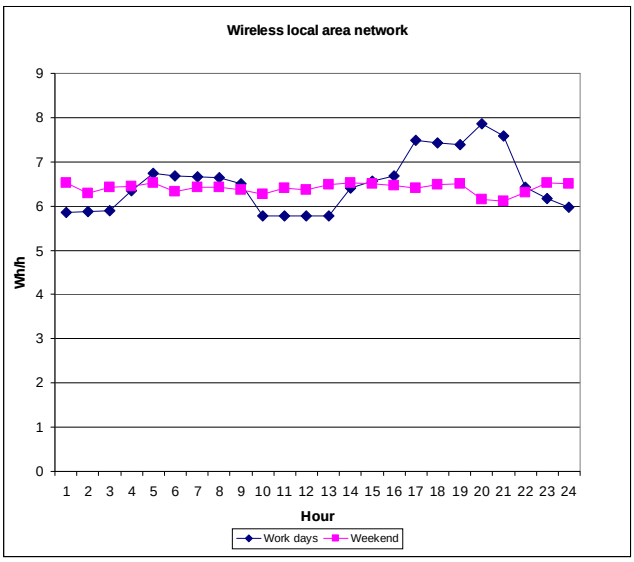


PCs (including monitor) and laptops are used during afternoons, peak hours are at 22:00 hours. Clearly these appliances are more used during early afternoons during weekends. Peripherals are on most of the time since they must be available for use by the PCs at any time.

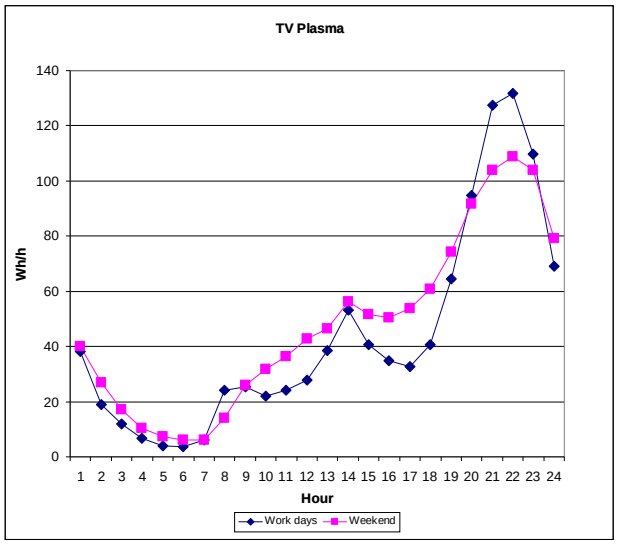




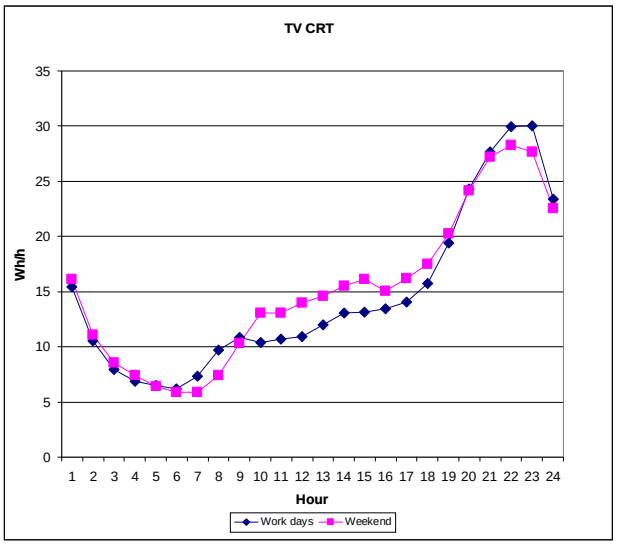


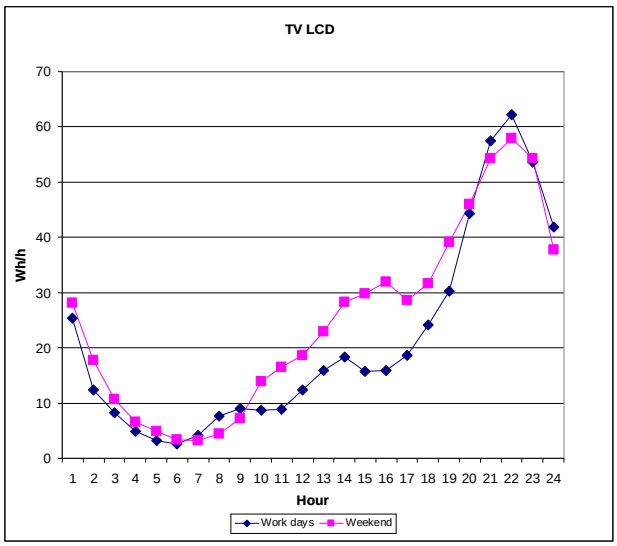


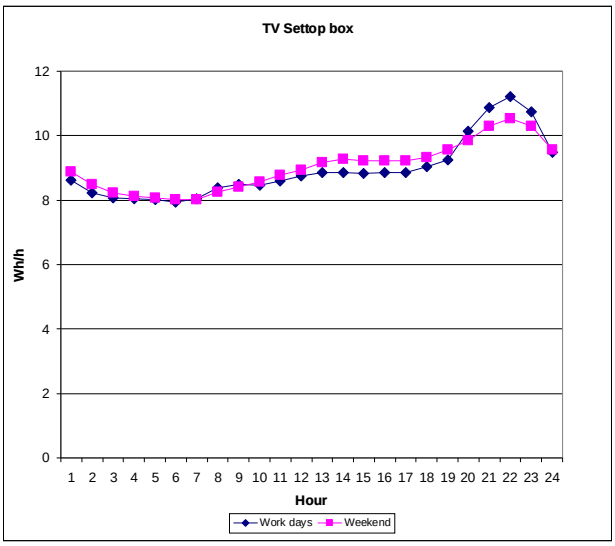
TVs and peripherals



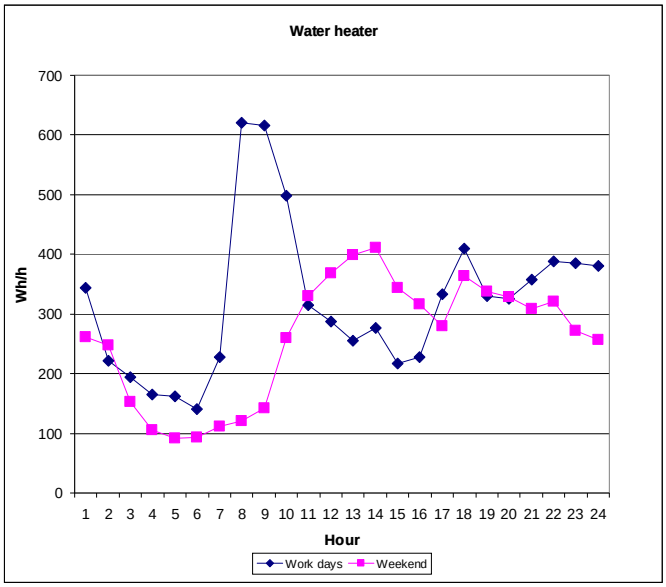
These applications are used most during afternoons. Some activity due to standby mode use is visible during night and mornings.



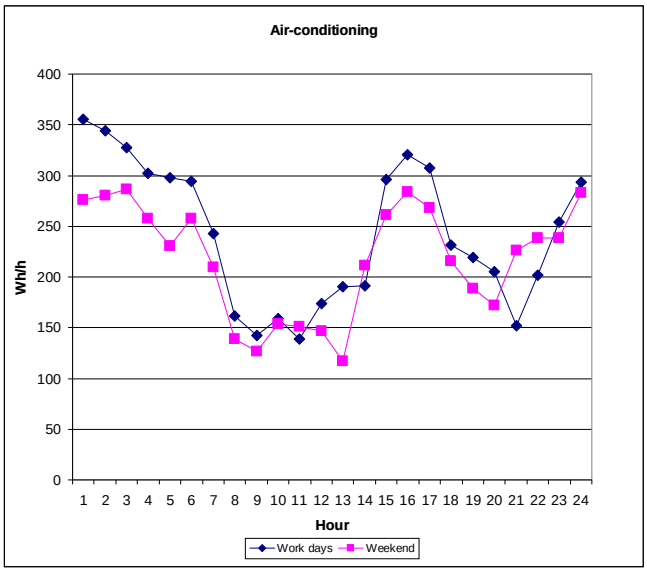




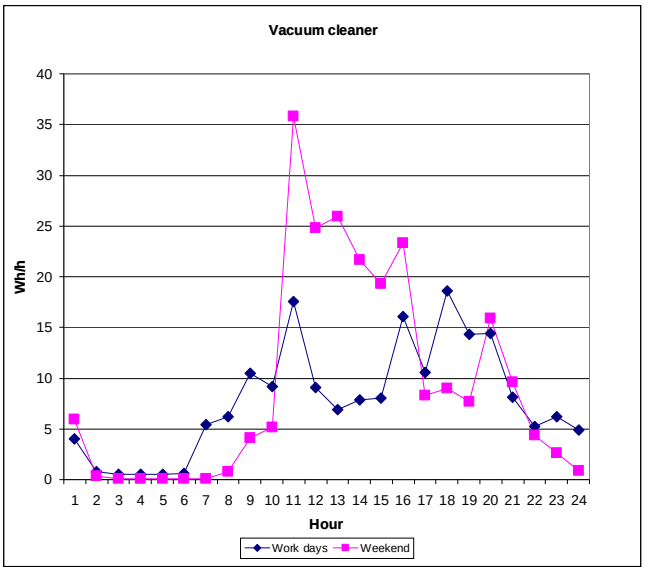
Miscellaneous applications



Electric water heaters are mostly used in Norway. During night hours energy losses are covered. These losses are higher than all other standby losses together. A significant energy demand could be avoided if the energy demand from use of hot water could be served instantaneous, so the need for storing of the hot water could be avoided. Better insulation would also help.



The use of air condition is a growing market in Europe the latest years. In colder countries as Norway heat-pumps have the effect of reducing the electric heating, as the efficiency of heat pumps are much higher than for resistance heating.



The energy used for vacuum cleaning is low. Clearly there is no standby consumption for these appliances.

APPENDIX II – METHODOLOGY FOR EVALUATION OF SAVINGS POTENTIAL

This appendix gives a detailed description of the analysis methods used in this report to aggregate from measurements to national energy consumption and saving potentials.
For each end-use appliance the electricity consumption per year using "Present State" or "Present Values" (PV) and using "Best Available Technology" (BAT) and/or "Best Practice" (BP) is defined. The BAT/BP is found by scanning and analysing the collected measurements, and is also found based on manufacturer specifications or similar information. Hence, the BAT/BP is a combination of Best Available Technology and Best Practice or most economical use of the appliances. In the rest of the report this combination is referred to as BAT only, even if most of the savings are allocated to a Best Practice. The BAT per appliance is the same for all countries, but the aggregate values will depend on ownership level, and on the use pattern (load factor) of the individual countries. The Present Sate is country specific based on data from the monitoring campaigns and on previous campaigns.
The baseline to consider is stock replacement and not the market replacement. From the survey with questionnaires we have the distribution of appliances per efficiency level (stock) for some appliances. The idea of REMODECE is to identify the total savings (technical potential) by replacing installed inefficient technologies by BAT/BP in the market. Structural effects are not integrated in the calculations.

Refrigerators, combinations (fridge/freezers) and freezers
These types of appliances are automatically operated, and are less influenced by manual use.
National Savings = N*(PV-BAT)
Where

- Savings: TWh saved for a country per year
- N: Number of appliances in country
- BAT: Best available technology [kWh/year]
- PV : Present technology, common value for the appliance groups [kWh/year]

Details:

- PV : SINTEF has estimated these values for all countries provided that metered data (including "Household"[3] files) are available
- For metered data older than 6 years, 20% has been subtracted – to handle improvements that have occurred the last 6 years.
- BAT : Common values provided by SINTEF Dependent on the mix of sizes which is unknown – but an expert estimate has been made
- The analysis are divided into 3 classes
    - Refrigerators without freezer compartment
    - Refrigerators with freezer compartment
    - Freezers

As the energy demand of cold appliances is dependent on the size of the individual metered unit, the country's distribution share of the sizes are used to find the country specific values of consumption. The following types of refrigerators are used. The defined division into sizes in litres is used when estimating typical BAT for each country.

1. Volume less than 150 litres

[3] The "Household" files contains some information about the households and appliances monitored

2. Average volume (150-250 litres + "Unknown" in survey)
3. Volume more than 250 litres

When calculating BAT values for annual energy the following values are used [3]:

Size	**Unit**	**Refrigerator without freezer**	**Refrigerator with freezer compartment**	**Freezer**
Small (<150 litres)	kWh/year	153,1	153,1	152,4
Average (150-250 litres)**	kWh/year	189,1	227,2	226,0
Large (≥250 litres)	kWh/year	224,5	257,2	249,0

Washing machines, clothes driers and dishwashers
These appliances are manually operated. The energy demand during single uses of the appliances are considered.

National Savings=N*(PV-BAT)*T

Where:

- Savings: TWh savings for a country per year
- N: Number of appliances in country
- BAT: Best available technology [kWh/use]
- PV : Present technology [kWh/use]
- T: Number of times of use per year

Details:

- In practice the households wash clothes at different temperatures, and lower temperature leads to lower energy demand. When BAT is calculated, the average mix of different wash temperatures and clothes fillings is considered. To simplify, the same average BAT are used for all countries.
- T: Number of times of use per year is determined by scanning the metered data.
- 10 minutes intervals are used when examining the metered data to find the per use consumption.

When calculating BAT values for annual energy the following energy per use values are used. The values are provided by SINTEF as the lowest country specific value for energy per use for all appliances in this category.

Appliance	**Unit**	**Lowest country specific observation**	**Country**
Dish washer	kWh/use	0,83	Hungary
Washing machines	kWh/use	0,51	Italy
Clothes dryer	kWh/use	1,53	Norway

Lighting

These appliances are manually operated, and have a seasonal variation.

National Savings= SP * PV * N

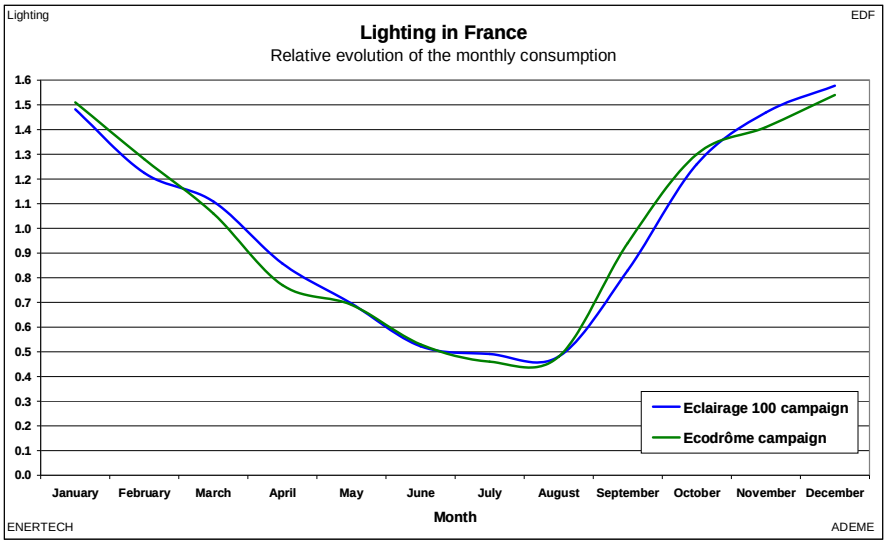
Where

- Savings: TWh savings potential for a country per year
- N: Number of households in country
- SP: Savings potential [percentage]
- PV : Present technology [kWh/household/year]

Details:

- SP: Savings potential are provided by Energy Piano for GLS and halogen lighting sources. The breakdown of the total lighting consumption per country on different lighting sources are primarily based on the survey and secondary on the actually measurements in the 100 homes.
- PV: Present value is calculated as: Load factor * Installed Wattage* 8760 hours. The load factors are found by analysing the measurements and are adjusted for the fact that other lamps could be used less, and for the season where the measurements took place. The installed wattage is based on information from the different countries and the measurements per country.
- Load factors for the metered period, are found by SINTEF based on metered data
- Installed "Wattage" in typical household, are provided by participants – divided into 5 different lamp types and 2 types of rooms:
  - Living room
  - Other rooms
- Seasonal lighting distribution curves are provided by some of the countries and used for estimation of total year load factors.
- When calculating BAT, each type of lamp technology will be estimated separately.

An annual distribution of lighting is used so that metered data from a summer day will be corrected upwards, and similarly, a winter metering will be corrected downwards. The shown distribution is from France. This curve was used for correction of the lighting data for all countries that did not provide a national curve.



Savings potential for lighting is calculated dependent on a scenario that incandescent bulbs and halogen bulbs (high and low voltage) are changed to compact fluorescent light (CFL) that have improved light efficiency.

Saving potential

Lighting Technology	**Multiplication Factor when Changing To Best Technology (Best technology is equal to CFL and fluorescent)**
Halogen high voltage	44,8 %
Halogen low voltage (12 Volt)	32,6 %
Incandescent GSL:	25.4 %
CFL: 0%	100 %
Fluorescent tubes	100 %

Office installations, electronics, air conditioners etc.

These appliances are mainly manually operated. The annual energy demand is heavily dependent on behaviour, as the number of hours of use in individual households varies a lot. Behavioural aspects are treated by estimating the Load factor for each appliance type, the load factor materialises the behavioural aspect.
The energy demand in Standby mode can be reduced considerably, and should be treated separately from the energy demand in ON mode.

National Savings=N*(PV-BAT)

Where:

- Savings: TWh for total country
- N: Number of appliances in country
- BAT: Best available technology [kWh/year]
- PV : Present technology [kWh/year]

Details:

- BAT : Load Factor * 8760 * $Power_{BAT}$ + $StandbyEnergy_{BAT}$
- PV : Load Factor * 8760 * Power + Standby Energy – the load factor was estimated for the ON mode only
- A PC was considered together with the monitor, this is the only cluster that will be analysed
- In the REMODECE project, the standby mode is assumed to be the state where the appliance is not doing the function for which it was designed.

When calculating BAT values for annual energy the following values for power [Watt] consumption in On mode, *when the appliances are in use in a household* - are used. The values are found based on the metered values of all countries in the project. For Air-conditioning, average energy consumption values from Greece are used, and target improvement of COP factor (5,2) is applied. 10 % percentiles are also shown based on data for all countries. The 10 % percentiles may be lower than the lowest values because they refer

to different values. The 10 % percentile refers to all countries, while the lowest value refers to only one country.

Appliance	BIOS Watt [1]	10 % Percentile Watt	Lowest average value of all countries Power when used (Watt)	Country or reference for lowest average
AIRCOND		522	4,5/5,2*1363=1179 Watt [2]	Greece
Charger	3,2	2,6	6,3	France
COOKER		632	1207	Hungary
DVD	45,9	5	6	Bulgaria
HIFI-Radio		5	18,9	Hungary
Vacuum cleaner		594	455	Germany
Kettle		513	625	Hungary
Microwave oven		206	406	Portugal
PC Laptop	36,9	36	57	France
PC desktop incl. monitor	188	96	141	Germany
Printer	347	6	10	France
Router		6	7	Norway
TV (CRT)	74	45	72	Hungary
TV LCD	125	47	82	Bulgaria
TV Plasma	262	168	252	Bulgaria
TV-Set top		9	14	Norway
WHEATER		1775	2000	Norway
WLAN		4,5	25	ALL

In the table values denoted in red are used when calculating best available technology. The values shown are in Watt.
For standby a power consumption of 0.5 Watts is applied for all appliances. This is according to [1]. When calculating the BAT values, the registered energy consumption in standby mode for the dimensioning appliance (the appliance with the lowest power consumption according to the shown table) is changed to the new standby energy. When estimating the new standby energy, the country specific hours in standby mode is used.
The values in the table are used to find the yearly energy consumption for each country, using the load factors of each appliance for each country. We will then find the future BAT energy consumption for the appliance in the country. When finding the BAT energy, reductions in standby consumptions are also found and applied.

APPENDIX III – METHODOLOGY FOR LIGHTING ANALYSIS

The calculation of present value of energy consumption for lighting is based on the following data, where all data are specified for two room types and for five different lamp types.

- Average number of lamps per household
- Average size in watts

These data are filled in by most of the countries. Where missing data, Sintef has used data that are equal to data from France (for average size). For

Room types
Data are defines for two different room types, “Living room” and for “Other rooms”. The reason for dividing in these room types is that households tend to use the lighting different in living rooms as opposed to other rooms. The occupation of living rooms are have a longer time duration than other rooms, and so the use of lamps will be used more often. It is reason to expect that the load factors would be different for the room types, and the results from the metered data showed a significant difference, where the load factor for living room is higher than for other rooms.

Lamp types
Data are defined for 5 lamp types. The reason for dividing between lamp types are mainly that the savings potential are different for the 5 types. Incandescent and halogen lamps can be replaced with more efficient types as CFL (compact fluorescent lamps).
In the table is shown the lamp types along with the corresponding BAT value by replacing with CFL or fluorescent lamp.

LAMP TYPE	BAT PERCENT OF PRESENT VALUE
GLS (incandescent lamps excluding halogen)	25.4%
Halogen 230 Volt low wattage	32.6%
Halogen 230 Volt high wattage	29,1%
Halogen 230 Volt high wattage	44,8%
CFL	100%
Fluorescent	100%

Country	Installed Watt	Load factor	Annual energy kWh/year	Remarks
BE	1144	5.2 %	524	Number of lamps and watt per bulb given
BG	832	5.3 %	776	Total watt installed given
CZ	692	1.1 %	68	Very low factor specified by Seven (Czech)
DE	793	5.1 %	352	Energy estimated by Fraunhofer
DK	1425	7.3 %	908	Number of lamps given, watt per bulb is average
FR	1530	3.4 %	452	
GR	1094	4.8 %	459	
HU	569	4.4 %	221	Average size of lamps not given
IT	1703	6.0 %	901	Average size of lamps not given
NO	1346	8.6 %	1013	
PT	1116	2.4 %	233	
RO	476	3.4 %	143	
ALL	1060	4.8 %	504	Average