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Standby Energy Consumption in Ukraine

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Vladlena MARTSYNKEVYCH

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List of Abbreviations

CO_2 – Carbon Dioxide

EC – the Commission of European Union

FSU – Former Soviet Union

GEEA - Groups for Energy Efficient Appliances

GHG – Greenhouse Gases

GPD – Gross Domestic Product

IEA – International Energy Agency

ICT – Information and Communication Equipment

MEPS – Mandatory Minimum Energy Performance Standards

Mtoe – Million Tones of Oil Equivalent

MW – Megawatt (1MW =1000 kilowatts)

MWh – Megawatt-hour (1MWh = one hour of electricity consumed at a constant rate of 1MW)

SCS – State Committee of Statistics of Ukraine

Sft – Tons of Standard Fuel – Coal (coefficient 0.7 is used to convert 1t of oil equivalent into 1t sft equivalent)

TPES – Total Primary Energy Supply

TW – Terawatt (TW=1000 GW)

TWh – Terawatt-Hour (1 TWh= one hour of electricity consumed at a constant rate of 1TW)

UAH – Ukrainian Hryvna (current rate USD $ 1= UAH 5.05)

VAs – Voluntary Efficiency Agreements

WEO – World Energy Outlook

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THE CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS submitted by:
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The current research is the first study of standby energy consumption in households in Ukraine. It provides insights to the scope of the problem and the opportunities to improve the situation. Standby power refers to power consumed by appliances when they are not performing their primary function and are switched “off”. Measurements of 50 households were performed. Standby power was measured and a questionnaire was used to find out the behavioural patterns.

The combined standby power use is about 23.4 W per household, resulting in national 1.3 TW h per year and 0.8% of the national electricity consumption respectively. The CO_2 emissions from standby account for 0.1% of the emissions in Ukraine per year. Different scenarios show the possibilities to reduce standby consumption and CO_2 emissions from 10% to 70% under different conditions.

The main determinant of household electricity consumption is the number of appliances it has. It has been found that the majority of the fifty respondents knew about standby power and has been using it consciously. While purchasing, the main attention is on the price of the appliance, and half of the respondents look for energy efficiency labels.

Levels of standby power use are lower in Ukraine than in developed countries. However, the tendencies are such that the penetration level is growing, and, particularly, of new appliances with standby modes. Current levels of standby power use are higher than required by national and international standards. Existing technologies could significantly reduce standby power use. It is pointed out that there is a need for national standards enforcement, raise of public awareness and price incentives for the reduction of standby power consumption.

Keywords: standby power, consumption, Ukraine, residential, electricity

1. INTRODUCTION

1.1 Background information

Energy efficiency improvements are considered to be an important option in reducing greenhouse gases emissions, securing the energy supply, and attaining a sustainable energy system (Metz *et al*. 2001). Improving energy efficiency is "the cheapest, fastest and most environmentally friendly way to meet a significant portion of the world's energy needs" (OECD 2007). Relevant improvements and benefits can be achieved through the energy conversion sectors, in end-use of heat and fuels, using energy-intensive materials, but also due to the end-use of electricity (Blok 2005). Particularly, residential energy consumption should be taken into account. Residential electricity use is comprised of the sum of individual end-uses, with the most important of them being heating, food refrigeration and storage, lighting, consumer electronics, laundry and cooking appliances (IEA 2003). However, the research focuses on the appliances that are or may be consuming electricity in standby modes. Therefore, household appliances or equipment will be characterized by the term "appliances".

For the last three decades, the numbers of the energy-using devices have grown rapidly (Owen 2004). Electrical appliances are the fastest growing electricity users, after automobiles (IEA 2003). The design of appliances has become more suitable and convenient for the consumer. However, energy is wasted due to the "standby mode", being at the convenient 'ready' state for instant use, or kept to communicate with other parts of the integrated network (IEA 2006b). While the appliance is connected to the power grid, it may consume electricity even when it is not switched on, but plugged in. Among the contemporary common appliances with standby power use are computers, washing machines, televisions, VCRs, microwave ovens, and all devices with external power supply (such as chargers for mobile telephones, etc.). The charging function of portable and rechargeable devices can be mostly categorized as low power mode energy use (McAllister and Farrell 2007). In addition, any appliance with a remote control, such as many audio products, will certainly consume standby power (IEA 2006b).

Internal or external transformers, televisions, VCRs, microwave ovens use standby energy, as well as appliances with remote control, memory, and clock display (Meier *et al.* 2004). Although standby energy consumption cannot be completely eliminated without eliminating appliance features, which can be reduced by a more energy-efficient design of appliances and certain efforts made by consumers: unplugging, changing the mode of the appliance during standby to a mode of lower power-consumption, and conscious purchase of appliances with a low standard standby power use (Ueno *et al.* 2006).

In summary, when appliances are not fulfilling their primary functions, they still consume standby power, and the possible saving of electricity from this energy consumption part may be significant in total aggregation for the household, and in turn, on the national level. For some appliances, electricity consumption in standby is very high, but the technologies available can reduce standby power use at relatively low cost (IEA 2003).

Being the fastest growing sector of energy use, total electricity in the residential sector in EU-25 has grown by 10.8% in the period 1999-2004, at almost the same rate as the economy (GDP) (Bertoldi and Atanasiu 2007). The researches on the standby use calculations state that the average standby power use varies from 20 to 90 W per home in OECD countries, ranging from 4 to 10% of total electricity use (Meier *et al.* 2004), and around 10% of the national electricity use in the United States (Ross and Meier 2000). Even though appliances are not fulfilling their primary functions, their standby use is responsible for about 1% of total carbon CO_2 emissions in OECD countries (Meier *et al.* 2004).

1.2 Motivation of the present study

Electricity consumption in Ukraine was 150 TW h in 2006 (IEA 2006c). The residential sector is responsible for 29% of the total consumption (IEA 2006d). So, there is a great potential in reduction of the energy consumption due to end-use energy efficiency implications. The necessity for energy savings is supported by the Energy Strategy until 2030 for Ukraine (MFE 2006) that predicts future increase in energy consumption in the residential sector.

Moreover, there is a tendency of rapid increase in appliances penetration in the country (IEA 2006d). According to IEA (2006d), the number of appliances in the households since 2000 has risen three or even four fold. This is directly related to energy consumption, and consequently, CO_2 emissions.

The former State Committee for Energy Conservation of Ukraine developed labelling procedures for appliances for certain groups of products (refrigerators and freezers, clothes washing and drying machines, dishwashing machines, electric grids, water heaters, lights, air conditioners). Being based on European standards for appliances, Ukrainian standards for appliances should ensure a high level of energy efficiency. However, there is a necessity to enforce their implementation and to broaden the list of household appliances (MFE 2006; IEA 2006d).

The available data about Ukrainian household energy consumption and domestic equipment are poor and only through systematic measurements and reporting will it be possible to establish energy consumption characteristics for each appliance type. If such devices continue to increase their penetration, the assumption of current research was that the electricity consumption should increase proportionally. Therefore, the potential for energy savings due to standby power use cuts and benefits from it have been evaluated, using different scenarios and precautionary measures applied with a known level of uncertainties.

Thus, the main goal of the thesis is to show the present status of standby energy consumption for household appliances and equipment, and estimate the saving potential for electricity in buildings in Ukraine based on the data obtained from on-site measurements.

1.3 Aim and objectives

The aim of the research is to estimate the national standby energy consumption in Ukraine, to identify possibilities to lower its use and to evaluate CO_2 emissions reduction potential accordingly. The main objectives may be formulated as follows:

- collect and analyze data through measurements of standby energy consumption for different appliance categories and to estimate the national value based on the information about appliances' penetration;
- identify the behavioural factors influencing the use of standby or low power modes;
- estimate the energy saving potentials in households and CO_2 emissions reductions possibilities through different scenarios;

- and provide recommendations for improvements and implementation of energy saving activities due to standby consumption reduction.

1.4 Structure of the thesis

The research contains a review of the present situation and reduction practices connected to standby power use in different countries, as well as a practical and an analytical part to describe the survey conducted.

The literature review in Chapter 2 seeks answers to the following questions: - the identification of the problem of standby energy consumption, - possible solutions, successful examples of their implementation, environmental benefits, - possibilities for improvements in appliance energy effectiveness in Ukraine due to a decrease in standby energy use.

Methodology in Chapter 3 is comprised of quantitative data collection through the measurements of appliances onsite in households. A questionnaire has been developed to formalize measurements and as a backup for the analysis highlighting the factors influencing the standby modes use. To clarify the determinants of electricity consumption at the household level, the relevance and importance of different variables connected to behavioural patterns have been assessed with the help of relevant qualitative statistical methods and tools.

Chapter 4 presents the results of the research and the discussion of them. According to the research objectives, value for standby power use in Ukraine has been calculated as 1.3 TW h per year, which is 0.8% of the total national electricity use.

Behavioural variables have been analyzed for the purpose to find the most significant relationship with standby power consumption rates in households. It has been found that the "number of appliances" variable has the highest correlation with electricity consumption, and no other factors reveal a great impact. Most of the standby electricity consumption in households is consumed consciously, knowing about "electricity leakages". Possibilities to save costs and to decrease payment have been indicated as the main reason for energy savings in households. Finally, while purchasing the appliances, most attention is given to price, and the energy efficiency is only in the 3^{rd} -7^{th} places.

Different scenarios of energy savings due to standby power use decrease have been proposed and evaluated. The magnitudes of possible standby power use cuts, and, as the result – decrease in national CO_2 emissions have been discussed. In different scenarios electricity savings have ranged from approximately 10% (400 GW h/ year) to 70% (1138 GWh/ year).

According to my calculations, the present “energy leakages” have been translated into CO_2 emissions amounting to 0.1% of the total national CO_2 emissions. Considerable reductions have been projected in three scenarios ranging from 18 (10%) to 59 (70%) thousand tons of CO_2 from standby if certain regulations were in place and, naturally, as the result of a change in consumers' behaviour. The discussion has elaborated the present situation in Ukraine and the energy policy practices that are used to influence the level of household electricity consumption.

Finally, relevant conclusions have been made. Recommendations for future research, as well as to the government of Ukraine and to households as the representatives of the final end-users have been proposed.

2. LITERATURE REVIEW

For the review various pieces of academic literature were analyzed and consulted. The available literature indicates the urgency and high actuality of energy efficiency improvements, and standby energy consumption reduction as part of it. The data from OECD and IEA countries relating to energy efficiency and standby energy use are abundant and easy to access. However, there are gaps and not enough emphasis made on the particular field of interest in Ukraine.

The topic of the "standby" energy consumption was identified in the 1990s. The definition of this phenomenon appeared later and is also known as "leaking electricity" (IEA 2001). According to the International Energy Agency (2001), appliances in the "standby mode" are when they are not in use or not performing their primary function. Nevertheless, there are differences existing within this mode that are important to discuss.

The rapidly growing consumption rate in the residential sector causes to search the easy-to-implement mitigation possibilities aiming to lessen energy use. Especially the main concern is related to the increased penetration of appliances in households. Even though the standby energy use may not be significant in values per each appliance, the cumulative impact results in increasing carbon dioxide emissions. Thus, reductions of this end-use part may result in significant benefits on the national and global level helping combat climate change.

To understand the overall picture related to the issue of the standby energy consumption and the possibilities to reduce it, first, the problem of energy consumption and its relation to the standby modes will be identified and discussed in this Chapter and the possibilities to reduce it and potential positive impacts will be evaluated. Ukrainian background information and current situation with standards for appliances, energy efficiency state policies and current trends will be analyzed. All aspects are described in the examples of the developed countries as well as in the relation to the developing countries and countries with economy in transition, particularly, Ukraine.

2.1 Problem identification

2.1.1 General trends in energy and electricity consumption

"Electricity Information" publication by IEA (2006a) provides evidence that electricity consumption has been growing in countries of OECD. The annual percentage change for the years 1973- 2004 was as high as 3% for the residential sector, comparing to the industrial, transport, agriculture and fishing sectors with 1.7, 2.0, and 2.0 percentage change rate respectively. Being vitally important in the industry, residential and commercial/public service sectors, these three account for 34, 28 and 30% respectively in electricity consumption, almost 88% of electricity consumption in OECD.

From the year 1960 till 1973 the growth in electricity consumption by final consumers of electricity or end-users has been 7.8% for that period, while the drop in growth rate has been observed between 1973 and 2004, and resulted in only 2.6% growth of electricity consumption during these years (IEA 2006d). However, while the electricity consumption by industry is decreasing, consumption by residential and commercial sectors is increasing (IEA 2006a).

The same tendencies can be seen in the non-OECD countries (IEA 2006b). Nevertheless, for our research the main interest is related to the countries of the former USSR (from here - FSU) within non-OECD countries. Total primary energy supply (TPES) of the FSU in 2004 constituted about 9 % of the world TPES, while the total energy production of the region represented 13% of global energy production, mostly used for export (IEA 2006b). The crucial issue is that even though the GDP of the FSU countries has grown the ratio of the TPES/GDP and accordingly, energy intensity remains very high and equals 2.0 (IEA 2006b). "World Energy Outlook 2004" (WEO) (IEA 2004) forecasts fall of energy intensity in countries in transition up to the level of 2.2% per year for the period 2002-2030 due to improvements in end-uses and transition to more lighter industries, still it will considerably exceed the energy intensity level in OECD countries (up to 90% in 2030).

In total, final energy consumption in 2004 grew 2.4% comparing to the year 2003 in non-OECD countries. Looking at the breakdown of the total consumption, the shares by industry and residential sectors remained the most important in 2004 (IEA

2006b). As the demand for electricity grew in 2004, its generation in FSU countries increased by 2.3% in 2004 respectively (IEA 2004b).

The WEO 2004 (IEA 2004) while describing regional trends related to the world primary energy demand comes to the conclusion that the increase in it will be connected to the developing countries between years 2002 - 2030. It will be based on the rapid economic and population growth, industrialization and urbanization processes. Half of the savings in global electricity demand in the services and residential sectors come from developing countries (IEA 2004). Energy use by final sectors like transport, industry, households, services, agriculture, and non-energy uses will grow by 1.6% a year till 2030 (IEA 2004). Finally, according to WEO (IEA 2004), the residential consumption will grow at the average annual rate of 1.5% worldwide (IEA 2004).

To solve the major energy-related problems like energy dependency of the countries, finite fossil fuel resources and the commonly adopted climate change notion, actions for energy efficiency improvements should be proposed and implemented. "Action plan for energy efficiency: realizing the potential" (EC 2006) clearly states that Europe continues to waste at least 20% of the energy due to inefficiency and Europe needs more than double the improvements rate compared to recent years (EC 2006).

2.1.2 Standby energy consumption by appliances

Around thirty years ago there was no problem with standby energy consumption because the appliances were designed to be switched "off" by disconnecting them from the power source (IEA 2001). Then the consumer appliances appeared, like audio or video appliances with standby functions of remote control, time-keeping and memory (IEA 2001). The amounts and the complexity of such appliances have been growing, and their aim was to respond to the request at any time for the convenience of the consumer.

The most important task is to define the modes in which appliances can be and that will be used in the research, taking into consideration the controversies and different approaches to this issue. According to Reiner *et al.* (2004), power modes can be grouped into three basic categories: "on", "sleep", and "off". These modes can apply both to the users' perception of the state of the device and to the actual power use level (Reiner *et al.* 2004). "On" modes are either active (performing a principal function), or immediately "ready" to perform it, because “ready” can often make a transition into “sleep” without the user interaction. It need not be used for a large portion of time, though may be used on devices without such control. True “off” modes usually require a mechanical switch to be engaged. “Sleep” modes occupy the space between, and usually offer substantial power savings while retaining connectivity and responsiveness to several signal sources, including remote controls and networks. While devices that are “off” usually lack any network connection, those that are merely in a “sleep” mode need to retain some responsiveness, which requires energy (Reiner *et al.* 2004).

The standby power level can occur in the “on”, “sleep”, or “off” mode, depending on the device. The definition given by International Electrotechnical Commission (standard 62301) defines “standby” mode as “the lowest power consumption mode which cannot be switched off (influenced) by the user…” (IEC 2005; Rainer *et al.* 2004). Figure 1 gives the description of the modes the appliance can be in (Meier 2002). So, there is evidence that the majority of the electric appliances nowadays have two low power modes being not in direct use – “sleep” (plugged in, not in use) and “off”(plugged in only) that are also called “low power modes”. The blue field shows energy use by appliance and its distribution within different modes. Even though energy use in active mode is the highest, due to the time appliance spend in low power modes, energy consumption may be equal to the active mode, or even higher than in active mode.

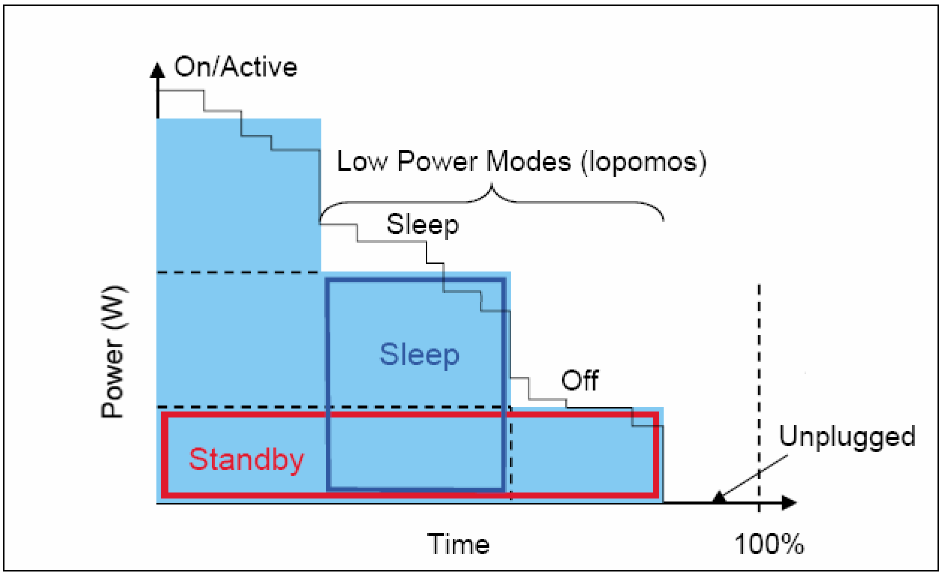


Figure 1 Graphical description of low power modes

Source: Meier *et al.* 2002

Appliance standby energy consumption is estimated to be the fastest growing end-use in the countries of OECD reflecting a strong anticipated increase in ownership of appliances with standby functionality from 8.1 appliances per household in 1990 to 21.2 per household by 2020, and the share of electricity consumption will grow from 3.1% of total residential demand in 1990 to 10% in 2020 (IEA 2003). This projection was modelled even taking into account the current policies for energy efficiency improvements in these countries (IEA 2003).

Household appliances are diverse with different standby and off-mode consumption. Consumption particularly may differ according to the manufacturer, type of product, technical characteristics, etc. According to research by Gueret (2005) for the International Energy Agency, the consumption by the some household appliances in the standby mode appeared to be higher than in their relatively brief operating time (VCRs, set-top boxes, audio and hi-fi equipment, office equipment). So, the research showed that the "standby and idle-mode" electricity consumption of consumer electronics, in IEA countries and the miscellaneous end-uses is responsible for the consumption of 61,1 TWh in 1990 and 120 TWh in 2000. The numbers are high even taking into account that television, lighting, cold appliances, washing machines and cookers were excluded from the research. So, in 2000 it was about 5.2% of the IEA residential electricity demand, resulting in 250 $MtCO_2$ increase in GHG emissions (Gueret 2005).

According to Gueret (2005), the contribution of the appliances to the residential electricity consumption is less in the developing countries than in the OECD countries. However, the situation will change within short time period. This will happen because of lower present energy efficiency there and lower ownership rate, but it is growing more rapidly and therefore will significantly contribute to electricity consumption (Gueret 2005).

2.1.3 Household appliance markets

Characterizing the appliances, there are some categories of new appliances that evolve rapidly and penetrate very quickly in the households, e.g. set-top box[1]

[1] Set-top box was known as a cable converter box, but nowadays, these devices are used to descramble premium cable channels and to receive digital cable channels

penetration is rapidly evolving. If current trends continue, by 2010 electricity use by set-top boxes in the U.S. could approach 4% of total residential electricity use (Rainer et al. 2004).

In OECD countries, as the evidence of Figure 2 shows there is a rapid growth in the imports-exports of the information and communication technologies (ICT) goods (computing equipment, communications equipment, multimedia devices, entertainment, and audio systems) in the OECD countries following a slump period after 2000. Boom in the 1990s was associated with Internet phenomenon and telecommunication technologies spread, but the current recovery is related to the electronic components, audio and video and ICT-related equipment (OECD 2006). According to the data of OECD Information Technology Outlook (OECD 2006), the trade of ICT goods slowed down in 2001 in most developed countries and demand declined. This was based on the relocations of the manufacturing assets into developing countries. However, it recovered in the following years and in 2005-2006 showed a steady growth but with higher growth in some segments and in trade with developing countries (OECD 2006).

The main exporters in OECD in 2004 were China and USA, Germany and Korea. However, new stakeholders on the market appeared and their stacks grew: 75% growth in Slovak Republic, 54% in Czech Republic, 46 and 42% in Turkey and Hungary respectively.

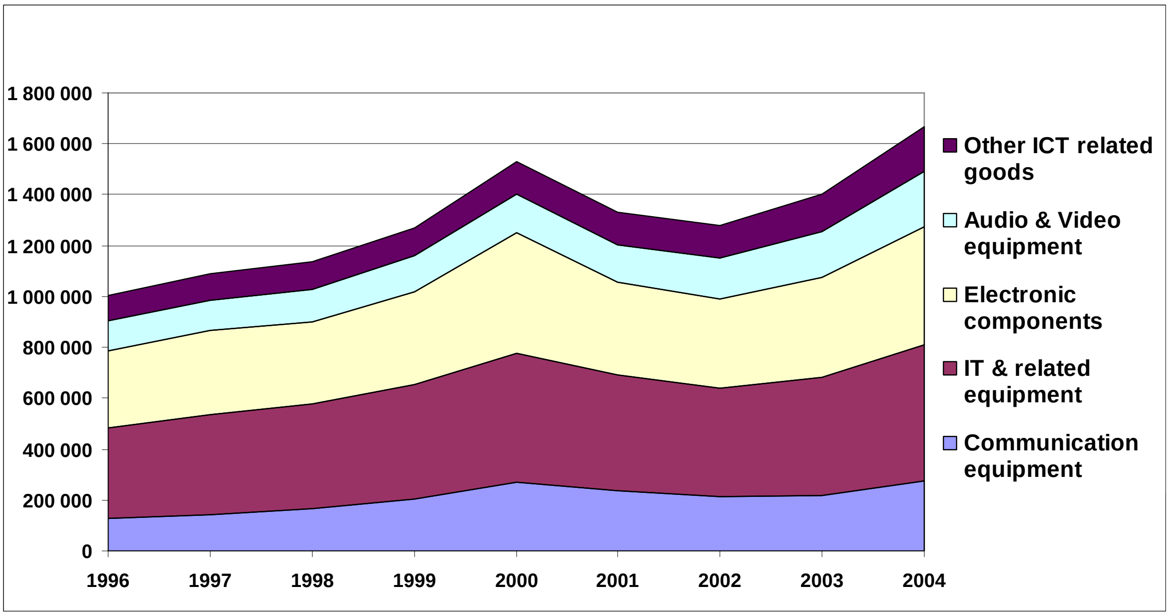


Figure 2 OECD trade in ICT goods, 1996-2004, USD billions, current prices

Source: adopted from OECD 2006

The ICT equipment ownership directly correlates with the overall capital formation. The growth in the 1990s was unprecedented, but some of the segments are still expected to grow significantly – Internet-related, portable and consumer applications. They might have integrated power supplies (copiers, stereo components, computers, etc.), internet and intranet appliances, combined multimedia that may consume electricity while standing by.

The patterns of appliances' purchase and penetration are different in different countries. Figure 3 shows how quickly the growth of the ICT spending is growing based on the annual expenditure growth. In terms of spending worldwide Russia is ranked in the third place and India in the fourth with expenditures of USD 27 billion and USD 46 billion respectively, showing 25 and 23% growth for these countries. Moreover, Ukraine is in the fifth place with 22% annual expenditures growth for ICT products.

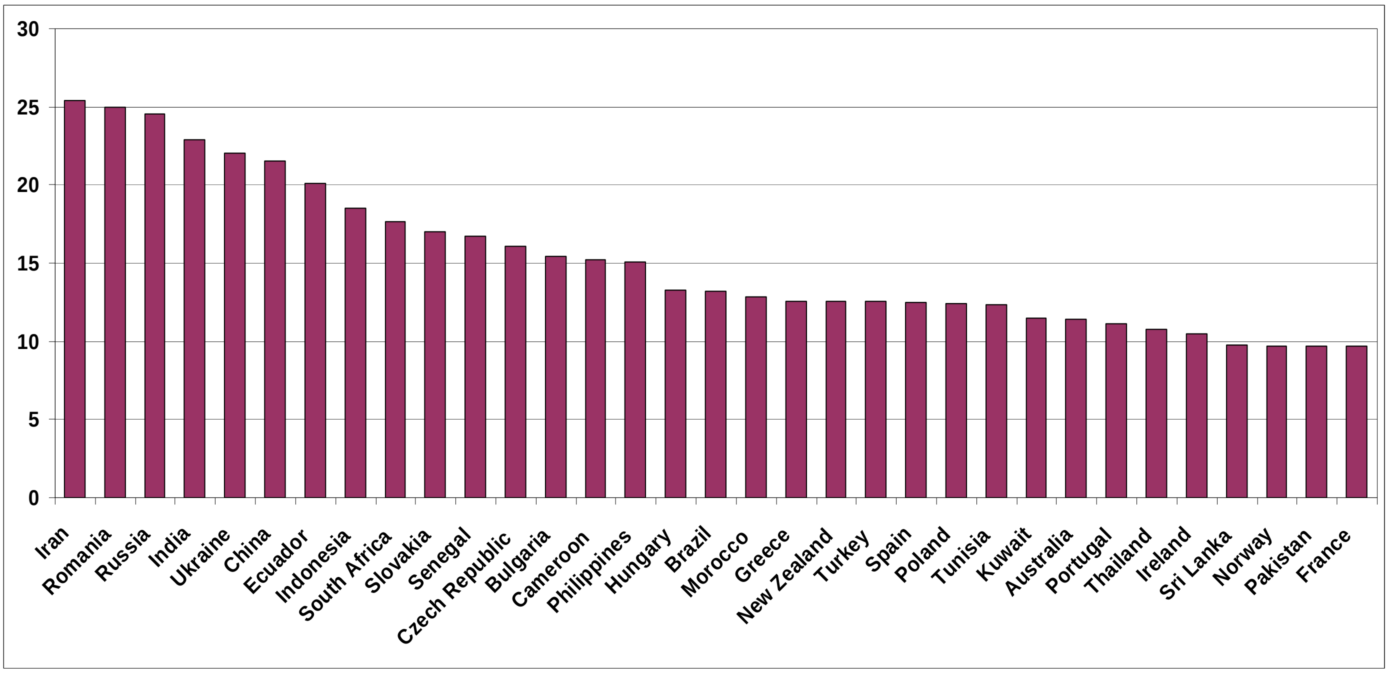


Figure 3 ICT spending growth, 2000-2005, annual expenditure growth, %

Source: adopted from OECD 2006

The forecasts made by IEA in "Cool Appliances" (2003) appeared to be realistic. There is evidence that the total energy demand will grow significantly in households due to growing penetration rate, increase in consumers use and increase in the unitary energy consumption with more complex technologies (IEA 2003). The fact is that less time is needed for the new appliances to be developed and penetrate nowadays (IEA 2003).

Steenblik *et al.* (2006) confirmed that the world purchases of major appliances and equipment - refrigerators, clothes washing machines, lighting, water heaters, air conditioners, computers, fax and photocopying machines increased by roughly 3.7% a year in the decade from 1992 to 2002 and were projected to grow at about 3.8% a year from 2002 to 2005. It is highly difficult to get the aggregated data for the world appliance penetration. Steeblink *et al.* (2006) also distinguished the features characterizing OECD, as mature, and non-OECD, as developing markets. In OECD countries the appliance market is driven by replacements, while the developing countries have high purchase rates. However, there are still great potentials for growth in sales in new Member States of EU, and in Central and Eastern Europe and in the former Soviet Union (FSU) (Steenblik *et al.* 2006).

In most cases, standby electricity consumption is far higher than necessary. However there are many opportunities to reduce it. Most concerns and international efforts should be devoted based on the fact that appliances with standby modes are marketed internationally, involving many countries. And while the equipment proliferation continues to grow, standby power consumption will increase. The emphasis should be made on the opportunities to cut standby energy consumption worldwide as the way to eliminate energy losses and reduce GHGs emissions.

2.2 Possibilities to reduce and benefits from standby energy use reduction

There are many possibilities proposing energy efficiency improvements in appliances that can bring many environmental benefits at low or negative cost to society, help lowering energy use and expenditures of the consumers without reducing the quality of the service, and even reducing necessity for energy investments (Gueret 2005). The main proposals for are related to minor technological changes from manufacturers' side, policies implementation from governments, and behavioural change from consumers. However, considerations of costs and benefits will stay crucial in decisions and measurements application (IEA 2001).

2.2.1 Barriers on the way to improving energy efficiency

Authors widely discuss the possibilities to reduce standby energy consumption in relation to the barriers in implementation of these improvements (IEA 2001; IEA 2003; Gueret 2005; OECD 2007). Among those there are market barriers connected to the manufacturers on one hand and consumers on the other.

First, it is important to understand the situation with manufacturers. From the side of industry power management it includes application of more stringent power requirements of standby modes and minimization of the amount of time that appliances spend in this mode (IEA 2001). However, these changes may be evaluated as unnecessary by the manufacturers as they are connected to the design costs (power switch changes), component costs (power supplies, voltage regulators, integrated circuits, visual displays) or manufacturing costs (Gueret 2005; IEA 2001). For these reasons, manufacturers simply ignore the product efficiency development (IEA 2001).

Secondly, the consumers' side should be taken into account. Price sensitivity in the highly competitive market may be an obstacle, because it will affect the consumers (Gueret 2005). Consumer awareness should be improved, providing demand for more efficient appliances and stimulating manufacturers to apply the changes (Gueret 2005). However, the consumers have certain "inertia" (Jensen 2005) in the behavioural change; time is needed for replacing of electric appliances, and investments should be made in certain energy saving measures.

The European Commission (EC 2006) recognizes that there must be great efforts needed to overcome barriers, which are related to the appropriate and cost-reflective price signals to improvement of energy and overall economy efficiency. The improvements in financial tools and economic incentives targeting all sectors should be implemented. The most important elements are increased awareness and behavioural change. Finally, energy efficiency issues should be addressed on the global level and thus, international partnerships and technology change are needed.

On the opposite, the arguments can be raised that the price increase in most cases is modest and affordable, mainly addressing future payback to consumers with less electricity bills (IEA 2001). Especially these improvements may be reasonable if the prices were set right reflecting CO_2 emissions through emission trading schemes and energy taxes.

2.2.2 Policy tools

The policies, be they standards, labels, incentives or mandatory Minimum Efficiency Performance Standards (MEPS), may be effective policy tools in standby energy use reduction (EC 2006; Gueret 2005; IEA 2003). For instance, the European Commission has been promoting various aspects of energy efficiency through a number of programs and directives for a much longer period already with the most important: Eco-design Directive, Energy Star Regulations, Labelling Directive, Directive on Energy End-use Efficiency and Energy Services (EC 2006). Special attention will be devoted to standby energy losses within the framework of Labelling and Eco-design Directives in 2007 by The Commission of the European Union (EC 2006). The full list of adopted measurements according to EC is available in the Appendix 1 and Appendix 2 shows the priority product groups (14 of them) for minimum energy performance standards implementation and the progress in their planned adoptions and investigations.

IEA and other countries worldwide adopted Demand-side Management (DSM) that includes procurement of energy-efficient appliances, labelling of appliances and infrastructure development for this type of products (IEA 2001; IEA 2003).

In sum, according to Gueret (2005), the main policy measures are:

- Mandatory minimum energy performance standards (MEPS);
- Energy labelling;
- Voluntary efficiency agreements (VAs);
- Information awareness raising programs;
- Other: procurements programs, financial incentives, and taxes.

The policy tools listed above are called by Meier in his book “Saving electricity in a hurry” (2006) as the measures for “saving electricity slowly”. In contrast, he describes the examples when the countries were transposed to a very short terms to tackle the shortfall of the electricity. In these cases such policy tools as Mass Media campaign and enhancement of the existing policy measure may help predict and eliminate the shortfalls. (Meier 2005).

Currently, technical regulations and standards relating to energy performance vary widely from country to country. Many countries have adopted and followed standard setting schemes for the big appliances (European Union, Canada, United States). These schemes are in place and bringing positive results, but there is still room for further improvements.

Blok (2005) proposes to use standards setting in a dynamic process that will help to make standard flexible for changes in time. Programs like Top Runner in Japan showed the bright example of such scheme. In this program, the leader on the market provokes other manufacturers to follow his example applying improvements. In Australia the approach is based on revisiting best world regulatory practices, and the country sets its own standards up to the most stringent level (Blok 2005). These are good examples of the continuous dynamic improvements taking place on the governmental level.

According to the recommendations made in the publication by IEA "Cool Appliances: Energy Strategies for Energy Efficient Homes" (2003), the minimum-energy performance standards (MEPS) were proposed that will include the 1 W target on standby power in the MEPS and label setting process for appliances (Blok 2005). Steenblik *et al*. (2006) reports that at least 51 countries, including the EU and its 25 Member States, had established MEPS for household appliances or office equipment, and 57 had established either mandatory or voluntary labelling schemes to encourage consumers to purchase the most energy efficient goods. A growing number of developing countries — particularly in Asia, South America, Africa and the Middle East — have established energy labelling schemes in the past decade, often building upon the experience of OECD countries (Steenblik *et al.* 2006).

Today, almost all OECD country governments regulate the minimum energy performance of at least one, and usually several household energy-using appliances and types of office equipment (Steenblik *et al.* 2006). The most common approach is to impose mandatory MEPS, which remove the least efficient appliances from sale; however, some countries (most notably, the EU, Switzerland, Japan and Korea) have also used energy performance targets, under which manufacturers are instructed, or voluntarily agree, to attain some prescribed energy performance thresholds for their products (Steenblik *et al.* 2006). Among non-OECD countries, China, Chinese Taipei, India, Iran, Israel, Jamaica, Malaysia, the Philippines, Russia, Saudi Arabia, Singapore, Sri Lanka, Thailand and Tunisia regulate the energy performance of at least one household appliance. Many other countries, particularly in South America and south-east Asia, but also in parts of non-OECD Europe, Africa and the Middle-East are in the process of developing appliance energy performance regulations (Steenblik *et al.* 2006).

Seal-of-approval labels are voluntary and selective, and are awarded only to products that meet relatively strict environmental requirements, including requirements related to energy performance. “Energy Star” has proved to be among the most internationally successful of the government-administered seal-of-approval programs covering the maximum of the appliances available (Steenblik *et al*. 2006).

However, there are some obstacles in the policies implementation. According to the research by Blok (2005), it is really hard to measure the consumption of small appliances, while the main focus usually is connected to the big appliances in the households. There are more that 120 types of “small” appliances (microwaves, coffee machines, electric toothbrushes, audio equipment, and external charges). Small appliances are responsible for quite a large share in electricity consumption in households, e.g. in Netherlands, up to 20% of electricity consumption. Therefore, the broadened policy that will cover most appliances and implementation of best-practice design guidelines is needed (Blok 2005), and as well as international technology and policy collaboration (Gueret 2005; OECD 2007).

Other obstacles for implementation of the measures on the international level are: - differences in the measuring energy performance for testing procedures; - differences in the countries classifications and descriptions the products related to energy consumption; - differences in definitions of energy performance or efficiency; - differences in standard specifications and requirements for energy performance; - different scheduling of the regulations (Steenblik *et al.* 2006).

Many measures even in a short period of time can effectively address standby modes when there is a threat of shortfalls (Meier 2005). However, in a normal sequence of life, the recommendations just to switch off the appliances will not work when keeping in this modes are the matter of convenience for consumers, or even worse - the manufacturers recommend not to turn off some of them (equipment to receive digital TV, for new downloads of software) (Owen 2004). Owen (2004) suggests that in this case the consumer education and promotion of the policy measures related to the corporate Codes of Conduct, labelling, standards are required to ensure the energy demand is minimized in future (Owen 2004).

Research by Stead (2005), based on analysis of Eurobarometer surveys provides evidence about intentions and public disposition towards the implementation of different policies aimed at energy efficiency implementation in countries of the European Union.

The least support was given to taxes, more support for regulations, but most support for public information and financial incentives (Stead 2005).

2.2.3 Benefits from energy efficiency improvements

Overcoming the barriers discussed in Section 2.1.1, the countries, industries and consumers may obtain great benefits (EC 2006). While the country level improvements will help reduce imports of the fuels and dependency on it, strengthened competitiveness of industries, opportunities to export improved technologies, positive employment effects, and, of course, environmental improvements could also be achieved (EC 2006). The evidence of connection between the energy sector and environmental benefits particularly correlate to the reductions of greenhouse gases emissions particularly, proposed by many authors and researchers evaluations of future scenarios.

European Commission (2006) proves that realizing the 20% potential till 2020, according to its Action Plan for Energy Efficiency (EC 2006), will result in savings of approximately 390 M toe, and will lead to huge energy and environmental benefits. Improved appliances, being the main compound of the residential sector, offer enormous energy saving potentials. Table 1 shows the full potential scenarios for end-use sectors, the additional savings from new policies and measures and the strengthened old ones. These potentials equal to realistic energy savings of 20% up to 2020, and 1.5% or 390 M toe per year.

Table 1 Estimates for full energy saving potential in end-use sectors in European Union

Source: EC 2006

Sector	Energy consumption (M toe) 2005	Energy Consumption (M toe) 2020 (Business as usual)	Energy Saving Potential 2020 (M toe)	Full Energy Saving Potential 2020 (%)
Households (Residential)	280	338	91	27%
Commercial buildings (Tertiary)	157	211	63	30%
Transport	332	405	105	26%
Manufacturing industry	297	385	95	25%

The projection of the WEO 2004 (IEA 2004) makes a prognosis that global energy-related CO_2 emissions will increase by 1.7% per year over 2002-2030, going along with the increase of primary energy consumption, and will reach 38 billion tones in 2030. That will constitute 62% increase comparing to the 2002 level. Table 2 gives the visualization of this forecast in relation to the regions of the world. Developing countries will be responsible for two thirds of the emissions. In 2010 the level of energy-related CO_2 will be 39% higher than in 1990 (IEA 2004).

Table 2 Energy-related CO_2 emissions (million tones) in different regions and in the world

(Source: IEA 2004)

	OECD		***Transition economies***		***Developing countries***		***World***	
	2002	2030	2002	2030	2002	2030	2002	2030
Power sector	4793	6191	1270	1639	3354	8941	9417	16771
Industry	1723	1949	400	618	1954	3000	1076	5567
Transport	3384	4856	285	531	1245	3353	4914	8739
Residential and services	1801	1950	378	538	1068	1930	3248	4417
Other	745	888	111	176	605	1142	1924	2720
Total	12446	15833	2444	3501	8226	18365	23579	38214

Talking about the residential appliances and their electricity consumption, around 30% of all electricity generated in OECD countries, produce nearly 12% of the energy-related carbon dioxide (CO_2) emissions (Gueret 2005). Thus, having great potentials in efficiency improvements, according to IEA's "Cool Appliances" (IEA, 2003), related CO_2 reductions would reach 322 $MtCO_2$ in 2010 and 572 $MtCO_2$ in 2030 if the best available technologies through policies leading to a Least Life-Cycle Cost for end-users would be implemented. This would be equal up to 642 TW h of savings by 2010 and 1,110 TW h that is 24% and 33% of the total related electricity use to this date correspondingly in comparison with level of year 2003 (Gueret 2005).

Concerns about the costs for the improvement can be eliminated by the fact that there will be payback through running costs over appliance's lifetime. As Gueret (2005) states, "each ton of CO_2 avoided this way would save consumers $65 in the US and €169 in Europe". For the developing and economies in transition the situation should be similar (Gueret 2005).

The contribution of residential appliances' uses to overall electricity consumption is usually less in developing than in OECD countries – as well as their absolute level per capita (Gueret 2005). Nevertheless, relative potential savings for domestic appliances in developing countries should be higher than in OECD countries at least in the short and medium term. This is because the average level of efficiency is lower there, both as a result of lower income and less developed markets, and few of these countries have implemented measures to improve appliance efficiency; also, the ownership rate of appliances is lower, but growing more rapidly than in IEA countries (Gueret 2005). Basically, the WEO 2004 assessment (IEA 2004) states that developing countries will be responsible for 70% of the increase in global CO_2 emissions from 2002 to 2030 and the potential for improvements is high according to WEO 2004 (IEA 2004).

WEO (IEA 2004) described the energy future in Reference and Alternative Scenarios. The World Alternative Policy Scenario elaborates "a more efficient and more environmentally-friendly energy future" than does the Reference Scenario (IEA 2004). Attention is given to the problem of the end-use efficiency improvements in WEO 2004 (IEA 2004) Alternative Scenario. Evaluation of the energy use impact and new policy measures in residential buildings were made. The research showed that policies aimed improvements in most OECD countries are in place, however, the developing and transition economies countries have to adopt the positive experiences and broaden the coverage of measurements for more equipment types. The Alternative scenario also shows a possible decrease of world energy use due to residential sector may be as significant as 11% higher comparing to the Reference scenario. There is a potential like in no other energy sources (IEA 2004).

2.3 Ukrainian trends

2.3.1 Background information

There is a great necessity in Ukraine to implement and improve energy efficiency. According to the Ministry of Fuel and Energy of Ukraine in its "Energy Strategy for Ukraine until 2030" (2006), Ukraine is considered to be country "partially provided with domestic traditional primary energy resources" and has to rely on imports of the energy sources. Over the period from 2000 to 2005, the energy dependence of Ukraine on imports of organic fuels, including conventionally primary nuclear fuel, was 60.7% compared with an average of 51% for the EU countries (MFE 2006). The energy supply level of the country is described by a specific primary energy consumption rate expressed in tons of standard fuel per capita. Under the estimations in the MFE of Ukraine it appeared lower (4.3 sft /c) than in the world leading economies (the U.S., EU-15 and Japan), but higher than that for the most developing industrial economies (including China, India and Turkey) in 2005 (MFE 2006).

The technological level of the country based on power consumption rate in kWh per capita in 2005 was 3.789 kWh/ capita, this number is around 3 times lower than for world leading economies (MFE 2006). The historic tendencies show that the energy supply level and technological level were significantly higher back in 1990 and then declined. Starting from 2000, a stable growth trend for these economic indicators has been registered (MEF 2006) and improvements have taken place. However, there is a high necessity for more efficient improvements.

Overall fuel-and-energy efficiency of an economy is described by primary energy consumption to GDP ratio is known as GDP energy content, which has drastic value particularly for Ukraine. In 2004 the efficiency of energy resources consumption in Ukraine was 2.4 times lower than the global rate, 2.6 times lower than in 26 OECD countries and 3.1 times lower than in the 25 countries of the European Union (Revenko 2007). This ratio is lower even in the neighbouring Russia and Belarus (MFE 2006). As to the MFE in Ukraine (2006), the reasons for this phenomenon are: excessive consumption of energy sources in industries and growing imports of fossil fuels into Ukraine; technological lagging; shadow economy impacts and low internal prices for energy. These facts are also confirmed by United Nations report (2007) about Ukraine.

There is the evidence, that many efforts should be devoted to the improvement of the situation. The Energy Strategy until 2030 describes the main trends and primary goals that should be achieved. Among the objectives is the reduction of energy for production and use that should be achieved based on improved energy efficiency (MFE 2006; IEA 2006d).

Since Ukraine proclaimed its independence, energy consumption in most sectors and in industry has decreased because of economic decline, but also because of energy efficiency implications. Nowadays, the most energy consuming sectors continues to remain industry in the first place and residential sector in the second. Figure 4 shows the shares of the sectors in total energy end-use. Thus, while the part of total consumption for industry is declining, the share of the residential sector remains stable. However, according to the WEO estimates, energy demand in the countries with economy in transition (including Ukraine without Russia) will increase by about 1.4% per year till 2030 (IEA 2006d).

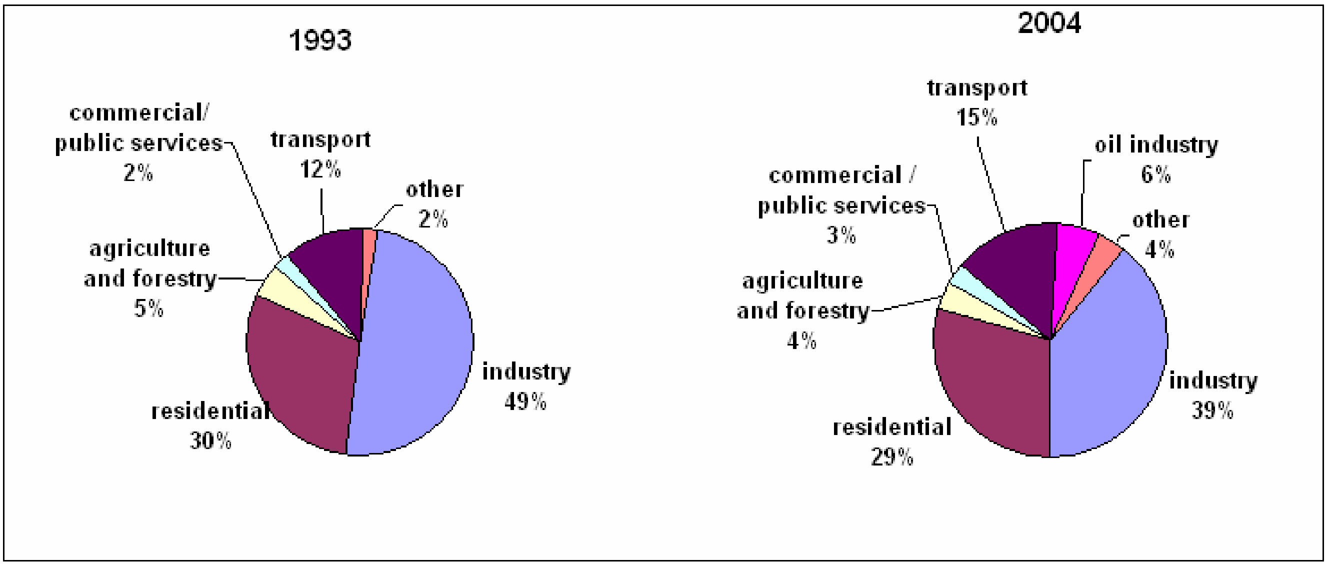


Figure 4 Total energy end-use by sectors in Ukraine, 1993 and 2004, %

Source: adopted from IEA 2006d

Energy consumption by the residential sector decreased insignificantly in the 1990s, according to the data available (IEA 2006d). That is because of the wrong pricing of the energy and governmental subsidizing of the households. Many of the consumers did not pay for the electricity in full amounts and this fact influenced the behaviour of the consumers (IEA 2006d). However, the most important impact was caused by the absence of the meters of the energy consumers (IEA 2006d). Consumers did not have the incentive to save energy and cut consumption.

For the last 10 years the residential and industrial sectors have remained the largest electricity consumers of energy in Ukraine. In 2004 industrial sector accounted for 54% of electricity consumption, the residential sector for 20%, community/ public services and agriculture/forestry – 11 and 3% respectively (IEA 2006b). Among other reasons for stability in the electricity consumption, like autonomous heating systems installations in households and establishment of the offices in the flats, particularly wide penetration of household appliances can be mentioned (IEA 2006d).

According to the Ukrainian government forecasts (MFE 2006), till 2030 the total electricity demand in the country will increase approximately by 123% (from 176 milliard kW / year in 2005 to 395 milliard kW /year in 2030). Figure 5 provides the evidence of the electricity consumption growth by consumer groups. The highest growth – more than 3 times, is expected in the agricultural, residential, commercial and utility sectors (MFE 2006c; IEA 2006d). Industry will remain the largest consumer. Transport and industry growth will not be so rapid because of the efficiency measures implemented (MFE 2006).

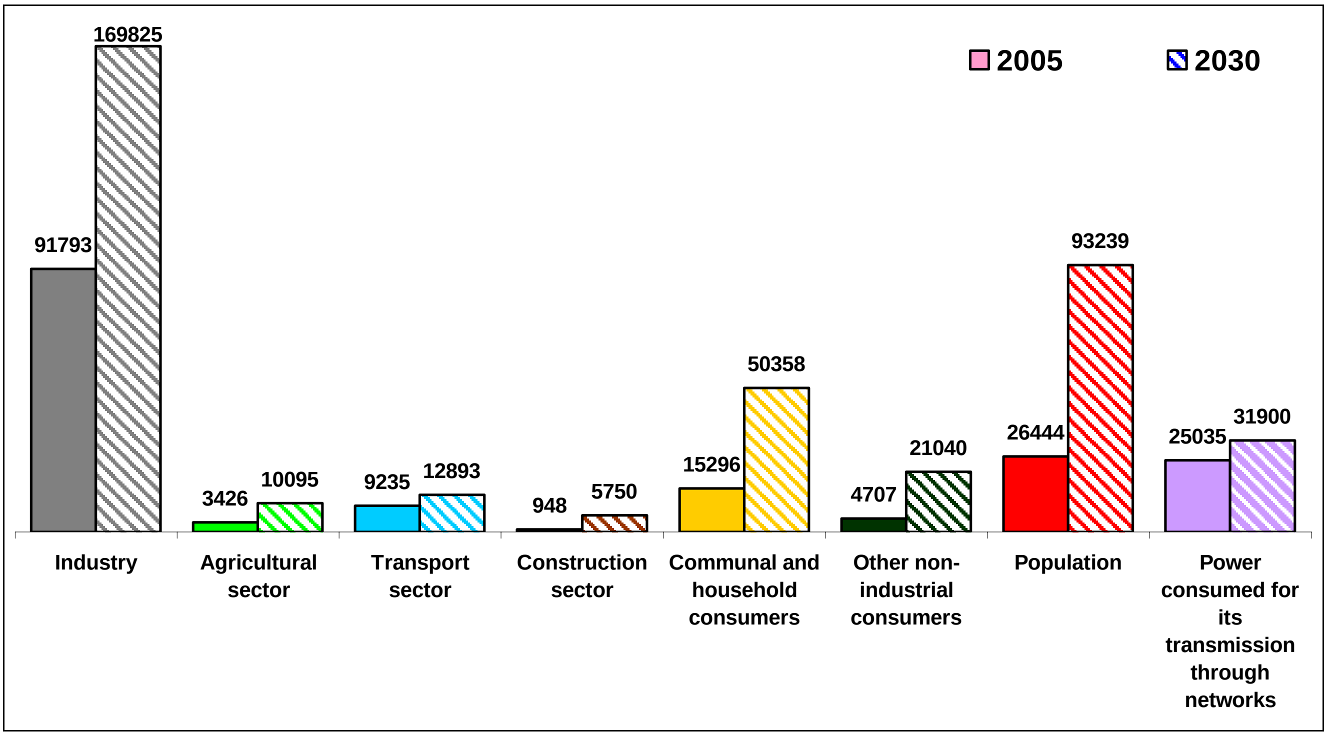


Figure 5. Electric power consumption by consumer groups in Ukraine, million kWh, 2005-2030

Source: MFE 2006

2.3.2 Energy efficiency potential in Ukraine and the residential sector

In the Energy Strategy until 2030, very ambitious goals for energy consumption reduction and GDP energy content decrease by 50% are prescribed till 2030 due to improvement of energy efficiency. As to the scenario, savings are equal to saving 223 million tons of oil equivalent (IEA 2006).

The state program for saving energy in Ukraine has a detailed description of the short-term goals with energy saving potential approximately 42-48% compared to the 1990 year energy demand (IEA 2006d). All calculations used the existing technologies without specific improvements. In Figure 6 the structure of the energy-saving potential is shown. Around 21 % of the general energy savings are expected from the fuel and energy sector, 57% - in industry, 11% - in municipality improvements and 7% - in transport (MFE 2006).

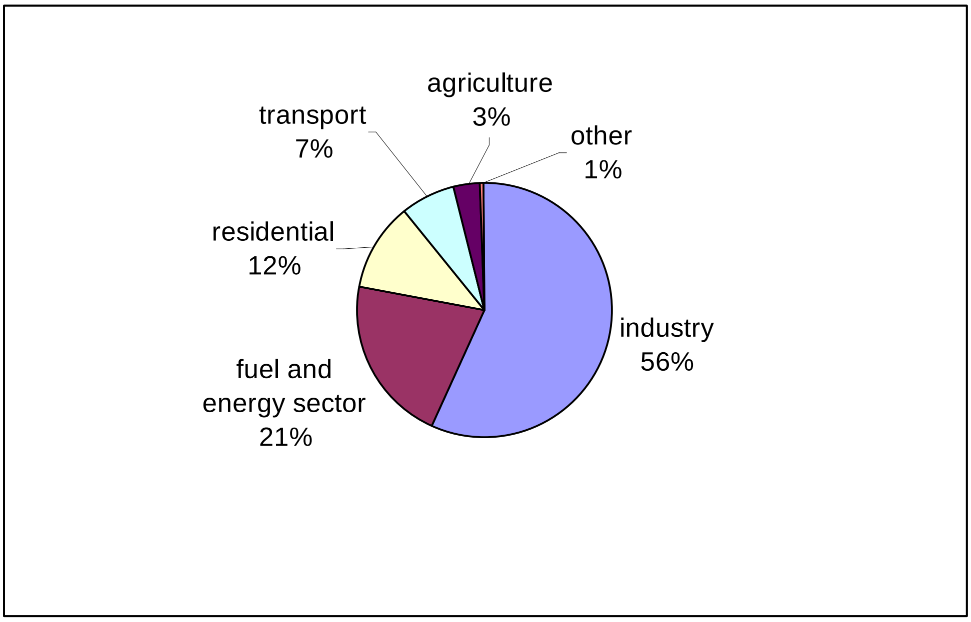


Figure 6. Structure of energy efficiency potential in Ukraine

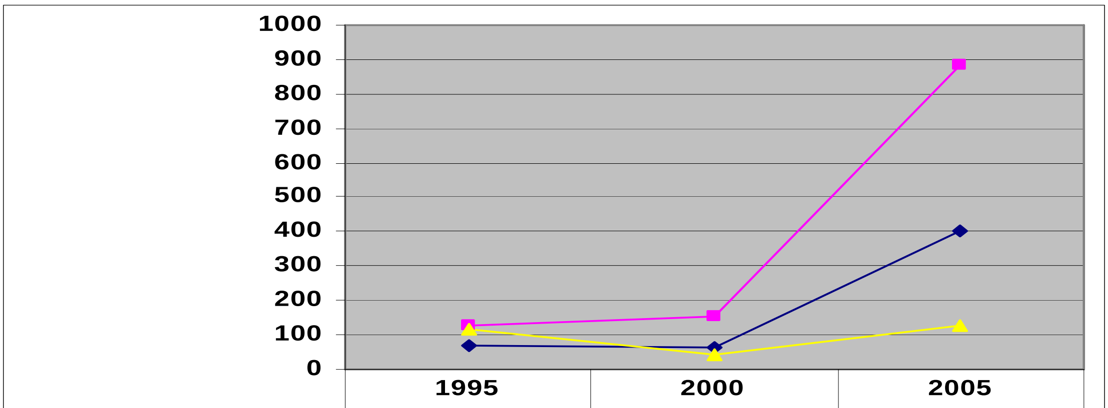
Source: MFE 2006

Therefore, in the Energy Strategy for Ukraine there are calculations summarizing in which sectors the energy savings can be applied (MFE 2006). However, IEA criticizes these calculations on the basis that there are no real estimations of the total energy savings and investments needed for this. IEA also states that there is more potential savings in the residential sector in the countries of OECD and in the countries with economies in transition, including Ukraine (IEA 2006d). Specifically, this potential may be related to standby energy use reductions.

The estimations made for the OECD countries clearly show the calculated reduction, while for the developing countries and countries with economies in transition, including Ukraine, such data is unavailable (Gueret 2005). However, the potential savings are expected to be high.

2.3.3 Electric appliances in Ukraine

There is a real "boom" in appliance acquisition all over Ukraine connected with the increased level of salaries and general income in the households (IEA 2006d). Thus, the penetration of electric appliances has grown up to 3 or 4 times for the period of 2000-2004: sales of washing machines and vacuum-cleaners have increased in 5 times, refrigerators and television sets – 3 times (IEA 2006d). It is clear that such magnitudes of the appliance penetration will influence electricity consumption, and that is why there is a necessity for energy efficiency standards to be developed and adopted. Figure 7 shows appliances' retail sales of durables with potential standby energy use in Ukraine within three chosen years. From 1995 a stagnation period for all appliances and even decline for radio receivers and washing machines' sales can be observed. However, in 2000s and until 2005 the situation drastically changed and a rapid growth of durables can be observed that confirms the statements made in IEA report (IEA 2006d) with even higher magnitudes for TVs.



	1995	2000	2005
Washing machines	67	61	400
TVs	126	156	885
Radio	118	40	128

Figure 7 Retail sales of durables in Ukraine for 1995, 2000, 2005, thousand items
Source: adopted from State Committee of Statistics of Ukraine 2006

There is already existing standard system in Ukraine based on the "Law about Standardization" from 2001 and some standards were inherited with the legal base from the Former Soviet Union. In 2003 the new standards for electric appliances and labelling system were adopted (IEA 2006d). They were based on the EU Directive 92/75/ EEC for labelling of appliances. Thus, the standards for refrigerators and freezers, washing machines, dishwashing machines, electric stoves, water boilers, lights, conditioning have been established (IEA 2006d).

The label on appliances should identify their class and energy efficiency. However, even being adopted, the standards are not working. The new standards for extended appliances' groups were developed, but not adopted (IEA 2006d). In 2005 the "Law about Energy Saving" was adopted by parliament and it provides the mandatory labelling of the household appliances as the basic policy in energy saving (IEA 2006d). There is a need for clarification of some standards and cooperation with manufacturers for the process to be effective.

There is a big gap in the energy efficiency that even the adopted standards are not enforced, while the positive examples of the European countries show very good results in energy savings due to the implementation of the energy efficiency standards with relatively low costs. According to the estimations made by Suhodolya (2005), in Ukraine from the electricity spent in the residential sector, 40% is spent on electric appliances, 30% - on lights, and more than 12% - on cooking. Moreover, 15-20% of the electricity consumed is wasted due to the reluctance of consumers (Suhodolya 2005), basically, when the appliances are in low power modes or on standby. The leakages of electricity can be eliminated up to 75-80% compared to the existing level (Suhodolya 2005).

To sum up, Ukraine has improved its energy efficiency policies and strategies. Since 1995s there have been changes that led to improvements of 30% of energy efficiency; though, they have to be more sufficient. Standards have been developed and the departments responsible for this were organized. However, there are barriers preventing energy efficiency implementations. Among those, subsidies for certain groups of the population, improper pricing of energy, absence of meters, lack of awareness and reluctance of the population and manufacturers of the appliances.

3. METHODOLOGY

3.1 Research design

The methodology of the research has been designed to obtain the analysis of residential standby electricity consumption and to represent a bottom-up approach. We use bottom-up estimate when the appliances of all ages are measured in residences, the average annual standby consumption for appliance is then multiplied by the number of those appliances found in the households in Ukraine – the penetration rate (known from official statistical data) (IEA 2001). After the quantitative standby power use data analysis, relevant scenarios to decrease these "energy leakages" have been developed. The qualitative part reveals the possibilities for energy savings as part of the behavioural change on the household level.

Standby energy consumption by the residential sector includes consumption by appliances in the households (IEA 2006b). The household, according to the State Committee of Statistics in Ukraine (2004), is a group of people living jointly in the residential area, having a common economy and spending money jointly. It should contain employed persons, and thus, it may be considered as a part of the total residential consumption.

The definition for standby energy consumption has been used according to the International Standard on Household Electrical Appliances, concerning the measurement of standby power (IEC 2005). Standby power consumption has been defined as "the lowest power consumption while plugged into the mains of power supply". Basically, this is the feature that has been measured and calculated.

However, the standby modes for appliances also include ***"low power modes"*** when the appliances are ***plugged in*** but not switched on and while these appliances are ***switched on*** but not in full operation, i.e. in ***standby mode*** (Meier 2002). A key issue for the energy consumption of most electronic devices is a set of possible power modes and the distribution of time spent in each mode over the course of a year (Reiner *et al.* 2004).

Measurements of different low power modes have been made, but due to the difficulties in their division for certain appliance groups, standby power use according to IEC (2005) was followed. The details of this choice are discussed in Chapter 4.

Experience of researches in China (Meier *et al.* 2004) and other countries (McAllister and Farrell 2007) has been used in the construction of the methodology for the current research. The choice to follow example of these researches is connected to their explicitness of methodology and easiness to apply it. In the research by Meier *et al.* (2004), the limitations were evident: a) the size of sample is very small - only 28 households were measured for the pilot project in Guahgzhou (however, with the intention to extend the sample in future), b) also small appliances were not measured and c) rural areas were not included. Nevertheless, its results of this research are considered meaningful (Meier *et al.* 2004). The present research used the positive experience and recommendations of the Chinese research and moreover, the sample was broadened (50 households are included in the sample) and small household appliances are included in measurements.

3.2 Data collection methods

3.2.1 Field measurements

The data was derived from the measurements gathered while visiting households. The larger appliances – TVs, microwaves, washing machines, personal computers, as well as smaller ones were measured for making the estimations more comprehensive, e.g. cordless phones, mobile phone chargers, and other components of home office equipment (see Chapter 4 for the whole list of appliances).

The focus was made on the residential buildings of middle class families[2]. The sample consisted of 50 urban households in Kyiv, Dnipropetrovs'k, and Cherkasy. Households were encouraged to participate in the survey on a voluntary basis, thus, it is a sample of convenience and not a representative one.

The measurements were conducted with end-use recording equipment SparoMeter NZR 230 (Denmark). The measurements were expected to be in the range from 1 to 10 W. The meter for measurements has resolution of 0.1 W, which is considered to be satisfactory according to the International Electrotechnical Commission (IEC 2005).

The data obtained was analyzed with the help quantitative and qualitative methods. For that, statistical tools were used within Excel and SPSS applications. Excel

[2] By middle class family – representatives of middle and lower-ranked management, skilled workers, craftspeople, and people who run their own business are meant

was used for numerical data analysis and SPSS was implemented while analyzing questionnaire results.

3.2.2 Questionnaire

The questionnaire was developed for formalizing the measurements. Among the household members, the person responsible for purchases was interviewed. The questionnaire was aimed to reveal behavioural variables and household details (see Appendix 3):

- household information (size of building/flat, family size, electric bills, availability of appliances, etc.);
- clarification of the typical usage patterns – how much time the product spends in each mode;
- motivation for the use of appliances in different modes and attitude to the energy-saving and energy efficiency improvements/relations.

The data of measurements and standby consumption has been adjusted to behavioural patterns in use of appliances and household details. According to the results achieved, recommendations have been proposed for the reduction of standby mode electricity consumption for different target groups (future researchers, households, and the Ukrainian government).

3.3 Data analysis

Field measurements and questionnaire results have been analyzed and evaluated according to the goals of the research. Following sections include the detailed descriptions of the analysis sequence and focuses made in Chapter 4: measurements data analysis, questionnaire insights, energy saving potentials and CO_2 emissions reduction potentials.

3.3.1 Analysis of measurements

The main objective of the data evaluation was to evaluate standby energy use in Ukraine. To make the calculations more explicit, such steps for data evaluation were used:

1. calculation of average consumed power in standby mode per appliance category and each appliance type separately (e.g. monitors, desktop computers, printers, etc. within office equipment category):

   $(X_1 + X_2 + X_{n+1})/N * t$ = Ave SP per appliance type ***(W h/day)***,

   Where X_1, X_2, X_{n+1} – consumption of each appliance within category,

   t – average hours for appliance in standby mode per day (obtained from questionnaire),

   N – number of appliances met,

   Ave SP – average standby power consumption per appliance;

2. adjustment of standby consumption according to the penetration of the appliances on the national level per year (calculations for each appliance category is presented in Section 4.1.1):

   Ave SP_{year} * 365 * P = Nat SP per appliance group per year ***(kWh/year),***

   Where Ave SP_{year} – average annual standby per appliance category,

   P – penetration rate of the appliances in the households in Ukraine (national statistics data),

   Nat SP – national standby power use for each appliance category yearly;

3. the national average standby power use evaluation by equation:

   $\sum$ Nat $SP_{appliances}$ = Nat Ave SP (GWh/year)

   Where Nat SP shows the standby power consumption for every appliance separately and Nat Ave SP is the result of all appliance groups standby consumption summation, and means the national average standby energy consumption.

However, to prove the result obtained, second method of the national standby power evaluation have been used. The first method described above is based on the step by step evaluation and is a sum of all calculations made for different appliances. However, the national standby power consumption can also be evaluated according to this equation:

N_{hh} * Ave SP_{hh} * 365 = Nat Ave SP (GWh/year)

Where N_{hh} – number of households in Ukraine,

Ave SP_{hh} – average standby power use per household, Nat Ave SP - national average standby energy consumption.

3.3.2 Questionnaire analysis

The objective of the questionnaire during the measurements of households was to collect data about:

- awareness of standby power in appliances and energy labels;
- attitude to using standby mode;
- reasons for possible decrease in standby modes use;
- the relationships/correlation between the main information about households (number of members, house type, last payment, etc.) and standby power consumption;
- the most important criteria influencing appliance purchase.

3.3.3 Evaluation of the energy saving potential and reduction of CO_2 emissions

For evaluation of the energy saving potential, four scenarios have been constructed and the calculations made. Three scenarios are based on:

- different parameters on standby energy use – average standby calculated according to measurements, 3 W and 1 W;
- calculations are related to the time in standby mode per day 5, 10 and 20 hours in standby;
- adjustment to the present penetration for appliances is applied;
- the yearly energy savings are calculated.

Generalized equation may be presented as follows:

SP * t * P * 365 = standby energy consumption (GW h per year), where

SP – standby power use rates (average current, 3 and 1 W),

t – time component (5, 10 and 20 hours per day),

P – current penetration rate of the appliances in Ukrainian households.

Thus actually, different scenarios show the differences in the current standby use and how standby energy use can be reduced in case the measures are implied and in place in Ukraine if the penetration rate of appliances will increase in time; what savings can be made by applying standards. All assumptions made are possible to reach by the available technologies and possibilities of standards application, and also behavioural change of the consumers.

In section 4.3.1 the choice of home office and entertainment appliances groups for scenarios development is grounded. Meaningful results and differences in scenarios represent energy saving potentials. Further analysis show the possible reductions that corresponded to the energy savings from standby power use.

3.4 Limitations of the study

The study had the following limitations:

- Immediate measurements have been performed that limited the scope of appliances (refrigerators and freezers have not been measured);
- The sample is not representative because of the size and the choice of households was not random. However, it shows general tendencies in standby energy consumption in the Ukrainian society;
- Measurements were conducted onsite only in urban residencies (not including rural areas);
- Technical characteristics of appliances are difficult to integrate in the study (age, type and size of the appliances – monitors, TV sets, etc.).

4. RESULTS AND DISCUSSION

Results and data presented in this chapter were obtained through measurements in 50 urban households that took place during May-June 2007 in Ukraine. Important national statistic numbers (household number, penetration rates) were used from official agencies - State Committee of Statistics of Ukraine and other reliable sources.

Because of time and resource limit, and also the novelty of the research, it was a sample of convenience and not a representative one. However, the goal was to perform as many measurements of appliances with standby power as possible so that the average standby power consumption could be derived within the appliance category.

The sequence of the results analysis presentation and their discussion will be according to the main questions of the study:

- to collect data for standby power usage and to make consumption calculations within appliance categories and also total national value;
- to analyze behavioural factors influencing the use of standby;
- to estimate energy saving potentials and CO_2 emissions reduction possibilities in the residential sector in Ukraine through different scenarios of standby energy use decrease.

The list of appliances with standby power use that could be in households has been formed. However, it could be expanded, in case other appliances associated with standby modes were found – remote controls, digital displays, and external power supplies. Because of the specifics of the measuring equipment – SparoMeter NZR 230 (that allows appliance to be plugged into the main and shows the power consumption immediately on its display), measurements were performed immediately during households visit, and results recorded respectively.

However, this type of measurements has certain limitations related to the impossibility to perform immediate measurements particularly, for refrigerators and freezers in households. Thus, refrigerators and freezers were not included, and will not be analyzed in the current research.

The survey focuses on the standby power use of the larger (TVs, DVDs, etc.), as well as smaller appliances (cordless phones, mobile phone charges, computer equipment) that could be connected to the mains. Meier *et al.* (2004) was used as the main reference to conduct the research, however, with small appliances included.

According to the observations and measurements performed, on average there are 9 appliances per household. Special attention should be devoted to small devices (McAllister and Farrell 2007). Therefore, mobile phones chargers were included into the measurements.

Measurements of the different standby modes the appliances could be in have been attempted. Different low power modes definitions were discussed in Section 2.1.2. However, the difficulties with identification of "off" and "standby" itself as different low power modes appeared in practice. Difficulties were related to the absence of "off" mode itself within some appliance categories (mostly printers and VHS). Thus, the decision was made to focus on the standby energy use determined by the IEC definition (2005): "the lowest power consumption while plugged into the mains of power supply." To make analysis of appliances more clear they will be viewed as components of the office, home entertainment, kitchen, and washing appliances' subdivisions (see Table 3).

Following Section 4.1 represents the analysis of the standby power use in households. Appliance types and their categories have been analyzed separately. The final national value of standby power use has been evaluated with two methods:

a. as the total sum of all standby power consumption from all appliances, and

b. obtained from average standby power use in household.

Section 4.2 contains analysis of the questionnaire. It reveals behavioural aspects and factors influencing the standby power in households in Ukraine. In Section 4.3 different scenarios of energy saving potentials are evaluated with specific conditions applied. In turn, saving potentials have been translated into the CO_2 emissions reductions showing magnitudes of them in three scenarios proposed. Finally, the comparison of the results with experiences from other researches is presented in the Discussion section. Current situation with standby power use is related to the factors that may affect it (energy labels, government policy, etc.)

4.1 National standby energy consumption projection for Ukraine

Subdivision of the appliances can be seen in Table 3. Data in the table were obtained according to the methodology Section 3.1.3 and equations described in it. Excel[3] application was used for analysis of numerical data.

[3] Microsoft Excel 2000 Professional. Issued 2000. The Microsoft Office Corporation, USA

Table 3 Statistics of standby power measurements and standby consumption by appliances

Appliance groups	# Items	Standby power (W)			Average hours in standby	Average standby consumption (Wh/day)	Average annual standby consumption (kWh/year)
		Min	Average	Max			
Office appliances							
Monitor	29	0.2	2.2	4.6	12.7	27.9	10.2
Desktop computer	29	2.1	4.7	11.8	12.6	59.2	21.6
Laptop	5	0.4	1.6	3.4	6.0	9.6	2.5
Printer	13	2.7	4.9	9.7	11.8	57.8	21.1
All-in-one (printer-scanner-copier)	2	3.0	3.3	3.6	12.0	39.6	10.5
Scanner	5	4	9,1	12	17.0	154.7	56.5
Modem	13	2.5	5.5	7.9	18.8	103.4	37.7
Speakers	30	0	4.2	16.9	14.4	60.48	22.1
Router/hub	2	4	4.6	5.1	11.0	50.6	18.5
Washing appliances							
Washing machine	18	0	1	4.5	7.1	7.1	2.6
Dishwashing machine	3	0	0.3	0.5	22.7	48,5	17.7
Home entertainment							
TV	71	0.3	6.1	14.1	13.7	83.6	30.5
VHS/VCD/VCR recorder/player	17	2	5.4	10	8.8	47.5	17.3
DVD recorder/player	12	0.6	4.3	19.8	15.0	64.5	23.5
Hi-Fi	22	0	3.6	18.2	13.1	47.2	17.2
Satellite/cable set top box	11	2.1	5.4	11.5	18.7	101.1	37.0
Video game	2	1.2	1.2	1.2	0	0	0
Batteries' charger	5	0.7	1.7	2.4	2.0	3.4	1.2
Cell phone charger	59	0.1	0.4	2	5.1	2.1	0.7
Radio	7	0.6	2	3.5	16.9	34.0	12.4
Cordless phone	27	1.2	2.1	3.8	24.0	50.4	18.4
Kitchen appliances							
Microwave	18	0.1	1.4	3.2	23.8	33.2	12.1
Cooking fan	24	0	0	0	0	0	0
Coffee-maker	7	0	1	10.1	0	0	0
Miscellaneous							
Air conditioner	3	1	1.2	1.4	0*	0	0
Aquarium air pump	2	2.8	3.5	4.8	24.0	84	30.1
UPC	2	12.3	12.3	12.3	24.0	195.2	71.2
Heater	1	0.7	0.7	0.7	24.0	16.8	6.1
Massage chair	1	3.7	3.7	3.7	24.0	88.8	32.4
Kitchen multifunction device	3	0	1.0	3.0	0	0	0

* - at the moment of measurements were not in use

Table 3 presents the vital statistic data for the following analysis of standby power use by appliances: a. about the number of the appliances found and measured in households during research, b. values of maximum and minimum for measured standby power to see the range, c. hours appliances spend in standby mode, and d. the average standby power value calculated respectively.

After calculations and having the results of standby energy consumption for different appliance groups, the next step was to make a projection on the national level using penetration rates of durables in households nationwide. However, these data was available and in open access only for several appliances in the State Committee of Statistics of Ukraine (2007). Among them there are TVs, audio equipment, washing machines and mobile phones and no information about other appliances. Thus, for the rest of appliances, penetration rates from countries with the similar patterns of appliance acquisition were used. Based on the data from Euromonitor (2006) showing similarities in Ukrainian and Bulgarian acquisition patterns, data on penetration from Bulgaria before it entered the European Union in 2007 were chosen.

Table 4 consists of the vital information about the total number of households. As also can be seen, urban households exceed rural households almost twice. Average size of the households in Ukraine is 3.2 people/household were defined according to the last national census that took place in 2001 (SCS 2004).

Table 4 Number of households in Ukraine

Urban	Rural	Total	Average size
9 217 156	4 262 170	***13 479 326***	3.2

Source: State Committee of Statistics 2004

4.1.1 Standby consumption by appliance types

Following subsections provide data and discuss them for different appliance groups separately to make the evaluation more comprehensive. Peculiarities for different appliance categories and penetration rates were taken into account.

Office equipment

For the households possessing home office equipment its share in total standby electricity consumption was considerable. Among appliances investigated and measured in the research there were personal computers and monitors, laptops and related appliances – printers, scanners, speakers, modem and hub for internet-using households. According to Euromonitor (2006) 7% of Ukrainian households possess personal computer. Thus, the assumption was made that computer accessories have the same penetration level.

According to the Ministry of Transport and Communication (MTC) (2007), there are 9 million people in Ukraine having access to Internet. This constitutes 19 % of the total population. However, taking into account that most of the internet users are corporate users (88%), the households' share is only 12% for internet connection (Yurish 2000; Budde 2007).

Penetration data for laptops is hard to find not only in Ukraine, especially taking into account relatively low level of personal computers acquaintance in Ukrainian households (7%) (Euromonitor 2006), comparing to other European countries (Netherlands – 75%, Czech Republic - 27%, Russia – 10%). Router and hubs are mostly used for corporate users, and are not the direct interest of the research, even though some data on standby power consumption were obtained during measurements in households. Thus, the share of the standby energy consumption from laptops and router/hubs were not counted in the current research.

Table 5 gives a projection of the home office appliances standby energy consumption on the national level. The penetration rate of 7% was applied to all appliances in this category and almost 950 thousand households possess computers respectively. The final national standby consumption by office appliances is 170 GWh per year.

Table 5 Office appliances' national standby consumption calculations

Appliance	Average household standby (kWh/year)	Households with computer	National standby consumption (kWh/year)
Monitor	10.2	943 553	96 242
Desktop computer	21.6		203 807
Printer	21.1		199 090
All-in-one (printer-scanner-copier)	10.5		99 073
Scanner	56.5		533 107
Modem	37.7		355 719
Speakers	22.1		208 525
		Total (GWh/year)	**170**

Washing appliances

Among washing appliances clothes washing machines and dishwashing machines were measured. According to the SCS of Ukraine information about durables presence in households (2007), the penetration rate of washing machines is 78%. There is no consistent data on dishwashing machines for Ukrainian households, but from the experience of Bulgaria, dishwashers' penetration levels do not exceed 1.7 % (Chobanova 2004), and there might be approximately the same rate in Ukraine.

Table 6 National standby consumption calculations of washing appliances

Appliance	Average household standby (kWh/year)	Households with appliance	National standby consumption (kWh/year)
Washing machine	2.6	10 513 874	27 336 073
Dishwashing machine	17.7	229 149	4 055 929
		Total (GWh/year)	**32**

As it can be seen from Table 6, the average standby of the clothes washing machine is 2.6 kW/year for which mostly responsible are machines with watches, lights and other indicators. While in case of washing machines, the national standby consumption can be considerably high due to its level of penetration, the overall standby consumption may increase significantly for dishwashing machines with a rise in their penetration.

Considering washing machines, previously there were semi-automatic machines in households, but only the new automatic models can be the consumers of standby power. As can be seen in the Section 2.3.3 about household appliances' boom, the purchase of the washing machines has been present since 2000. And this fact was also confirmed by the questionnaire that revealed that 75% of washing machines were purchased less than 5 years ago and only 25% were older than 5 years. All of the machines analyzed were automatic clothes washing machines.

Additional information derived from the questionnaire about washing machines was the energy class identification. The majority of the household members could not identify energy class because the appliance did not have any label identifying it.

However, if the label was present, in 84% of the cases it was “A”, 11% - “B”, and 5% - “C” energy use classes.

Home entertainment

Home leisure appliances are considered to be the major consumers of standby energy (these include TV sets, audio equipment, etc.). Table 7 shows calculations of the home entertainment appliances’ national standby consumption values. Especially, this notion is related to the penetration rates of this equipment: for TVs – 96%, HiFi – 27%, radio – 44% and mobile phones – 81% as to State Committee of Statistics of Ukraine (2007), satellite receivers – 78%, VHS/VCD/VCRs – 23% and DVD players – 6.2% according to Chobanova’s (2004) data about Bulgaria. Related data about video game and battery charger is hard to find and that is why they are not be included in the total standby for home entertainment.

There is 25% stationary phone grid coverage within the population of Ukraine, and with phone equipment respectively. For the cordless phone[4] the penetration can be equal to 21% from all phone sets from the research experience of McAllister and Farrell (2007).

Table 7 Home entertainment appliances’ national standby consumption calculations in Ukraine

Appliance	Average household standby (kWh/year)	Households with appliance	National standby consumption (kWh/year)
TV	30.5	12 940 153	394 675
VHS/VCD/VCR recorder/player	17.3	3 100 245	53 634
DVD recorder/player	23.5	835 718	19 639
Hi-Fi	17.2	3 639 418	62 598
Satellite/cable set top box	37.0	10 513 874	389 013
Cell phone charger	0.7	10 918 254	7 643
Radio	12.4	5 930 903	73 543
Cordless phone	18.4	2 830 658	52 084
		Total (GWh/year)	**1 053**

[4] Cordless phone – cordless phone connected to fixed line

Table 7 supports the results of the other researches that leisure and entertainment equipment constitutes the main part of the standby power consumption in households and on the national level (Bertoldi and Atanasiu 2007). Of course, the main contributors are TV sets and satellite/cable sets with 30.5 and 37.0 kWh/year that are used on standby. For VHS and HiFi systems the amounts of energy consumed in standby may sometimes even overwhelm the consumption in active ("on") mode.

Kitchen appliances

As the refrigerators, freezers and other electric equipment were not included into the research frame; for the kitchen appliances measured the most important thing was to pay attention to microwave ovens. Coffee-makers, toasters, teapots and cooking fans were measured if found in households, but the majority of them did not have standby. An exception is one coffee-maker (10.1 Wh) and one kitchen unit[5] (3 Wh).

As to the microwave oven, the level of penetration was evaluated around 30 % according to the Bulgarian data (Chobanova 2004), and the survey data showed the similar – 34% out of the households measured had microwaves. Thus, Table 8 resumes the yearly standby power use from microwaves in Ukraine equal 49 GWh.

Table 8 Kitchen equipment national standby power consumption

Appliance	Average standby (kWh/year)	Households with appliance	National standby consumption (kWh/year)
Microwave	12.1	4 043 798	48 929 953
		Total (GWh/year)	**49**

Miscellaneous appliances

In this category of household appliances air conditioners, UPC, and other minor appliances (e.g. small heaters and massage chair) were identified during household audits. Despite of the lack of penetration levels for these appliances, presence and possibility to distinguish them is very important for the consumers and the measures to be in place. For now they are not included into the national standby energy consumption calculations, but there is still a possibility for further researches with them. Some of them may considerably contribute to energy consumption in households (uninterruptible power supply (UPC), aquarium pump, etc.). Air conditioning equipment appeared in Ukraine just recently and is not widely spread and used in households (unlike in offices and the public sphere, where they are widely used).

4.1.2 Results summary and national value

Finally, Figure 8 provides the evidence on the yearly distribution of standby power use in Ukraine within different appliance groups – office, entertainment, kitchen and washing appliances. The major consumption share belongs to home entertainment appliances which, according to the projection made, equal 1053 GWh per year. The second group of domestic appliances that contribute considerably to standby power use is home office equipment – 170 GWh per year, followed by kitchen and washing appliances with 49 and 32 GWh per year of "energy leakages". The total standby energy consumption from all sectors evaluated is equal to 1.3 TWh per year.

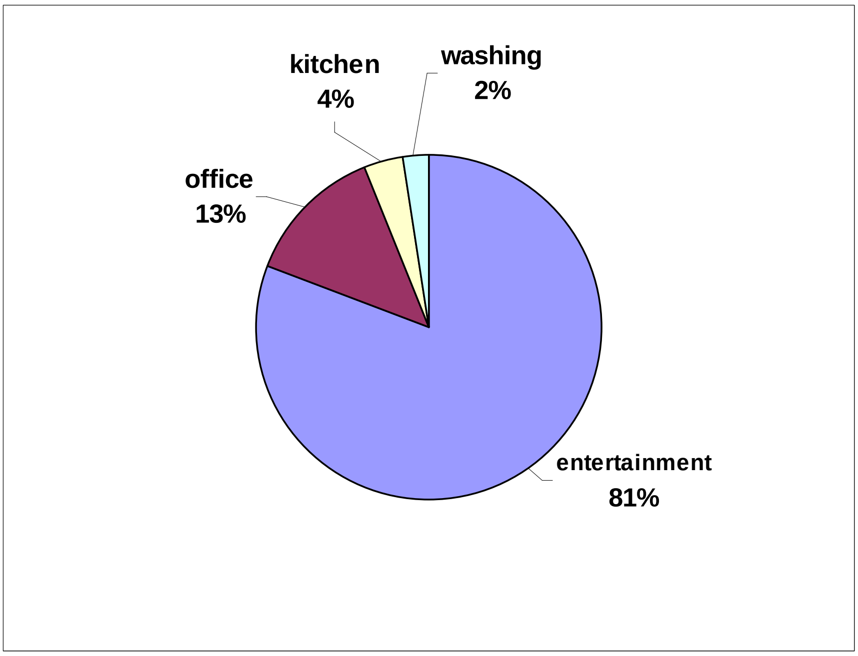


Figure 8 Annual standby energy consumption by appliance groups in Ukraine, %

The other method to evaluate the national standby power value is related to the use of average standby power value per household (as adopted from Lebot *et al.* 2000). Table 9 gives the detailed calculations and assessment of energy demand from standby in the residential sector in Ukraine, with average standby power per home of 23.4 W.

[5] Kitchen unit – kitchen multifunctional device

Table 9 also summarizes further calculations of energy demand from standby power in residential sector in Ukraine. With this method, standby in the residential sector is responsible for 0.8% of total national electricity use.

Table 9 Assessment of energy demand from standby power in the residential sector in Ukraine

Number of households*	Standby per household, W	Total demand standby, MW	Total energy standby, TWh/year	Total national consumption, TWh/ year 2004**	Standby % of national electricity
13 479 326	**23.4**	**3154**	**1.2**	**149.52**	**0.8**

* - Source: SCS of Ukraine, 2004
** - Source: IEA 2006c

Comparison of the two methods enforced the results of the national value calculation and showed slight difference in them. The final sum of standby energy consumption for all appliances' groups is equal to 1.3 TWh per year. Though it differs from the one calculated using different method in Table 9, this number is more realistic than the number obtained in Table 9 (around 1.2 TWh/year). That is because the second method uses averaged numbers for calculations, rather than figure 1.3 TWh per year was obtained with more comprehensive method. Still, the percentage of the national electricity is the same (0.8%) and approaching 1%.

4.1.3 Standby consumption in households

Households vary by number of appliances and standby energy consumption respectively. Figure 9 shows the distribution of appliances and their frequencies in households. The average number of appliances with standby modes is around 8.9 with standard deviation 4.1.

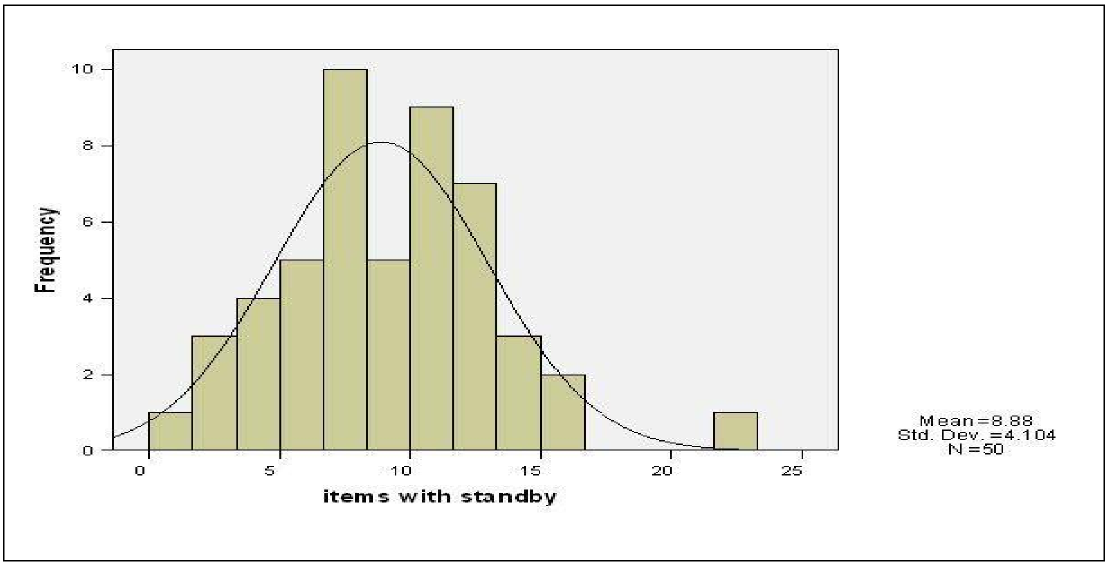


Figure 9 Appliances with standby modes in Ukrainian households

As the recent data for the household spending on utilities, and electricity particularly, are not available in official sources, the calculations were made based on the example of the current sample of audited households. During households visits the average monthly payment amounts for electricity were requested. Table 10 contains data obtained and generalized on 50 visited households. The average electricity uses, standby power consumption and average monthly electricity payments in households were provided.

Table 10 Average indicators for total and standby electricity usage and costs in households

	Total electricity	Standby	% on standby
Consumption, kWh/year	2530.8	114.3	4.5
Costs, UAH/year	607.38	27.5	4.5

Thus, as can be seen from Table 10, standby electricity use and household payments for it constitute around 4.5% from total electricity consumption and costs for it. Costs were calculated according to current tariff for electricity at the rate of 0.24 UAH per kW (USD cents 0.05) (Kievenergo 2007), not taking into account subsidies and differences in payments for various social and housing groups (retired, poor, single, homes with electric ranges, etc.).

4.2 Qualitative analysis insights

It is clear that standby energy consumption depends on the standby power usage of all appliances, but it also depends on the patterns of the appliances use. For most appliances that do not have an "off" switch, being plugged into the mains means constantly "leaking electricity". In most developed countries, most appliances are plugged in 24 hours a day (Meier *et al.* 2004). However, it was interesting to observe some of the behavioural patterns in Ukrainian households with the help of the questionnaire and personal interviews that took place during household visits for measuring.

During the survey, it was revealed that some Ukrainian families tend to disconnect certain electric and electronic appliances from the grid for safety reasons and supply disruptions. However, there are some appliances, particularly, cordless phones, that are constantly plugged in 24 hours a day.

There is also a tendency that the practice of unplugging is losing its popularity (Meier *et al.* 2004), and that it also true for Ukrainian households. First of all, the aesthetic reasons may play a role – inhabitants do not want to see cords in their living space, and this also may secure kids' access to them. And the last, but not the least reason is the convenience of remote control and other pre-programmed services that advanced appliances may propose.

So, the following analysis and discussion will focus on the questionnaire answers from 50 households (8 private houses and 42 flats). First, awareness of standby power in appliances and energy labels will be traced. Secondly, it is important to find out the attitudes to using standby mode in households. The next step will reveal the intentions in decrease of the electricity and standby modes use and reasoning for that.

With the help of the statistical tools in the SPSS 14.0[6] application, the relationship and correlation between the main information about households (number of members, house type, last payment, etc.) and standby power consumption was conducted. The main tendencies will be discussed.

As to the household appliances, the recent years show that the purchasing power of consumers has increased and there is a real appliance boom observed (IEA 2006) mostly for TV sets, washing machines and radios. Thus, it is highly interesting to trace

[6] SPSS 14.0 for Windows. Issued 2005. The SPSS Inc. Chicago, USA

the covariance of behavioural patterns and standby consumption, and also to distinguish the main decisive criteria for consumers while purchasing appliances, which is done in the following section.

4.2.1 Statistical analysis of the information collected through questionnaire

Standby power consumption background

The consumption of electricity and particularly its standby consumption share may be related to the general information about households, as well as to the behaviour of the household members.

The following variables were expected to influence the households' standby power consumption:

- number of appliances in household;
- size of the household (number of members);
- type of the building;
- knowledge about electricity consumption by appliances even when they do not perform their primary functions;
- whether there are multiple sockets in the households for possibility to disconnect all appliances at once from the mains;
- and attention to the energy efficiency labels while purchasing appliances.

Relevant statistic tests and methods were used to determine the relationship and correlation between these variables and consumption in household. Results from Table 11 represent statistical data analysis of variables.[7]

Variables of 2 types were used for analysis – interval/scale (for consumption rate kW/year; number of appliances, etc.) and nominal/categorical (for questions with answers' choice). Thus, tests for these types of variables have been used respectively. Eta coefficient has been used when X variable was categorical and Y variable was interval. To make the Eta coefficient credible, the F-test has been also performed for

[7] While interpreting, such scale of strength of relationship coefficients should be used: 0.0 – no linear association, 0.01 – 0.09 – very small, practically zero, 0.10-0.29 – low to moderate relationship, minor, 0.30 – 0.49 – moderate to substantial, medium, 0.5 – 0.69 – substantial to very strong, major relationship, 0.70 – 0.89 – very strong, huge, 0.90+ - near perfect (De Vaus 2002). And these interpretations may apply both to positive and negative relationships (De Vaus 2002). A significance level is very high when it is approaching 0.001 and rather significant when approaching 0.005.

these variables. The “0” hypothesis (“there is no correlation between these variables”) as component of F-test have been applied. Through test fulfilment, it has been rejected or not, providing (or not) credibility to Eta coefficient test results. Pearson’s R was applied when both variables were interval and Spearman’s – when both variables were ordinal.

It is also interesting to find reasoning for the absence of correlation between other factors and consumption in households. Table 11 shows the summary of different tests performed.

Table 11 Summary for the different statistical tests

Variables	**Standby consumption kW/year**	**Appliances with standby**	**Members in household**	**House type**	**Knowledge of standby**	**Multiple sockets**	**Attention to labels**
Appliances with standby	**1-high 2-very high**	x	1-low 2-very low	1-low 2-very low 3-rejected 4-low	1-very low 2-very low 3-not rejected 4-low	1-low 2-high 3- not rejected 4-very low	**1-substantial 2-very low** 3-not rejected 4-low
Members in household	1-low 2-very low	1-low 2-very low	X	**1-substantial 2-very high** 3-rejected 4-low	1- very low 2-very low 3-not rejected 4-very low	1-low 2-very low 3-rejected 4-low	1-low 2-very low 3-rejected 4-low
House type	1-moderate 2-very low **3-rejected 4-very high**	1-very low 2-very low 3-not rejected 4-low	**1-strong 2-very high 3-rejected 4-low**	x	1-low 2-very low	1-low 2-very low	1-moderate 2-high
Knowledge of standby	1-very low 2-low 3-not rejected 4-very high	1-very low 2-low 3-ejected 4-very low	1-very low 2-very low 3-not rejected 4-very low	1-very low 2-very low	X	1-very low 2-very low	1-very low 2-very low
Multiple sockets’ use	1-low 2-low 3-not rejected 4-very high	1-very low 2-low 3-not rejected 4-very high	1- low 2-very low 3-rejected 4-very low	1-very low 2-very low	1-very low 2-very low	X	1-very low 2-very low
Attention to labels	1-low 2-low 3-not rejected 4-very high	1-substantial 2-low 3-rejected 4-very low	1- low 2-very low 3-rejected 4-very low	1-substantial 2-high	1-very low 2-very low	1-very low 2-very low	x

1-stands for coefficient value (for Pearson’ , Spearman’s, Eta tests)
2-significance value
3-for “0” hypothesis rejection or not (F-test)
4-significance value of 3

Summary of the statistical analysis:

- high significant correlation ratio between consumption rate and number of appliances, showing direct relationship;
- members in household correlate with house type significantly;
- house type variable did not have high correlation with consumption rate, but it was strongly supported by "0 hypothesis rejection (meaning that there is a correlation) rejection. So it may be considered that there is a correlation.
- knowledge of standby, multiple sockets use and attention to labels variables correlations with standby power consumption rate in household were not confirmed by "0 hypothesis rejection" (meaning there is no correlation);
- no other significant correlations were observed within these variables.

General findings were that number of members in a household and the type of house, and other variables do not make a difference for the standby power consumption, because other factors should play a role. However, this assumption has not been completely proven. Number of appliances in standby mode has significantly correlated with consumption level in household (R=0.618, sign.=0.000), showing direct and strong relationship of these variables, but no significant correlation with other variables has been observed relating standby power use.

Behavioural and opinion questions analysis

Some interesting facts were revealed while asking general questions about the patterns of purchase, consumption, labels, and criteria for purchase. Thus, it is important to discuss them.

To the question if the respondents pay attention to the energy labels on appliances while purchasing them, 46 % answered positively, 44 % - negatively, and 10 % - replied "sometimes". However, respondents often mentioned that these labels, even if they wanted to see them, are not widely available. Most of the appliances in the market are sold without labels.

It is interesting to mention that within the respondents asked if they know about standby power consumption, 48% answers were positive and 52% were negative. To the question about use of multiple sockets with one common switch in households as the switch for appliances, 52 were positive and 48% negative.

To make the analysis more comprehensive and for further analysis, consumption data (kWh per year) was broken down into 5 equal intervals: ranging from 1st interval – indicating the lowest standby consumption per year and to 5th interval – with highest value of yearly standby consumption. Due to this, it has become possible to get case processing summaries. Table 12 shows how knowledge about standby consumption by appliances and consumption (by ranked intervals) relate.

Table 12 Case processing summary for knowledge about standby and its consumption

Question /answer		Consumption					total
		1	2	3	4	5	
Do you know that appliances may consume electricity in standby mode?	Yes, % (% within do you know that…)	25,0	16,7	16,7	12,5	29,2	100
	No, % (% within do you know that…)	11,5	19,2	23,1	26,9	19,2	100

From Table 12 it can be seen there are astonishing sequences between knowledge about standby power and its consumption. Within households where respondents positively answered (with knowledge about standby) the question there was less standby consumption and more standby consumption almost equally – 25% for 1st rank (less consumption), and 29% - 5th rank (with significant consumption). Thus, the conclusion can be made that people consume less or more standby power consciously.

It was found out that multiple sockets are used in the households. Almost every second household had it in places with many appliances for the purpose to switch everything at once then not needed.

The results reported in Table 13 shows that respondents indicated that they use appliances all the time at the same place and often just forget to unplug them. Among other reasons mentioned were that the appliances are still considered in use, they turn into standby only during user leave, and it will be easier and much quicker to continue work. Even though some respondents indicated the matter of convenience to have appliances on standby and not to lose programs, others replied that they do not leave appliances on standby at all.

Table 13 Answers to the question: "What is the reason for leaving appliances on standby?"

Answers proposed				
No socket change	No time to unplug	Just forget	Other	all
17	7	11	14	1
34%	14%	22%	28%	2%

A question about the main criteria for appliances while purchasing them was asked and the answers were given for different appliance groups. The following graphs show the difference within appliances' groups.

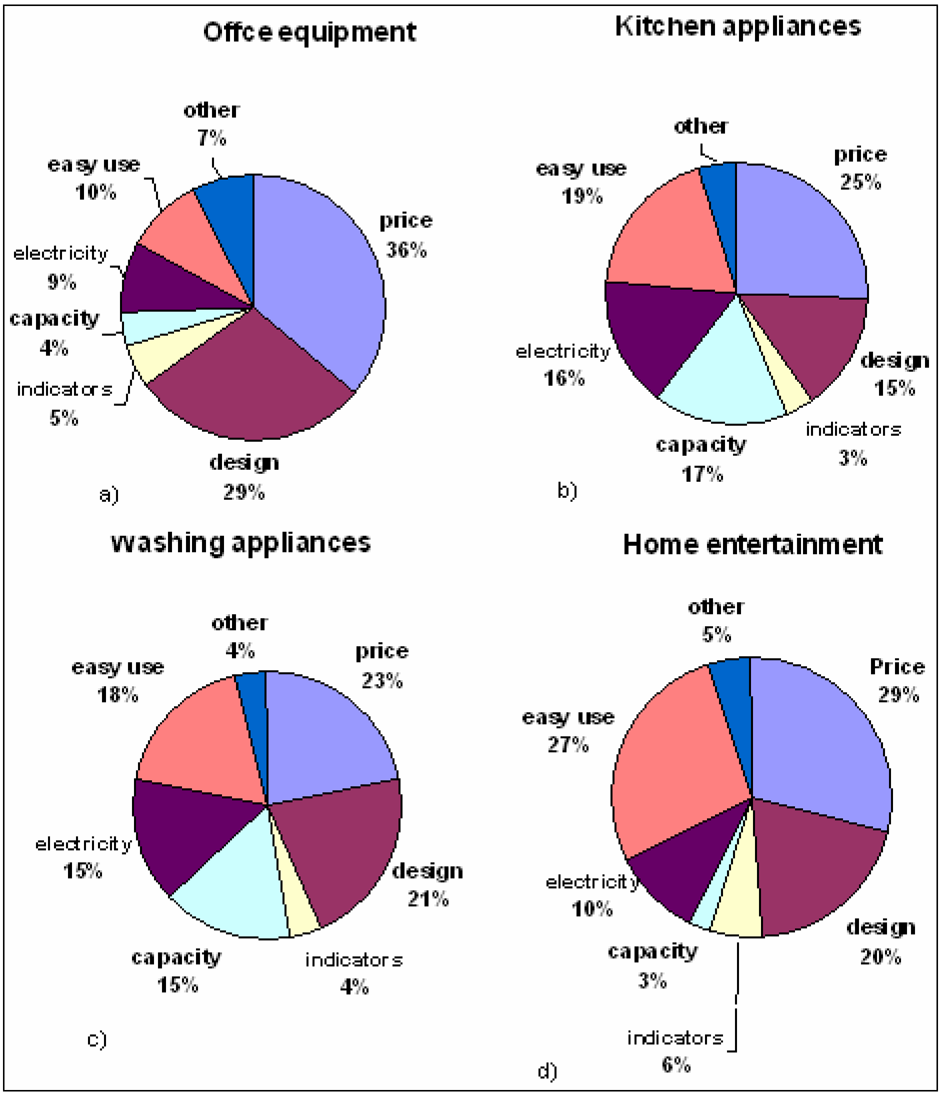


Figure 10 Criteria for purchase of different appliances

According to Figure 10, in most cases, the main criteria were the price of appliances in respondents' answers: for office equipment – 36%, kitchen – 25%, washing and home entertainment – 23% and 29 % respectively. Also the following criteria appeared to be important: for office equipment - design and easiness in use, for kitchen – capacity and easiness in use, for washing – almost all criteria were mentioned, for home entertainment – design and easy use. Electricity consumption was also included as the main criteria while purchasing equipment, however, the first place was given to price in most cases. Among other criteria indicated there were: producer, quality and multifunctional abilities of appliances.

The last question in the questionnaire was about the necessity to save electricity for the purpose to find out the public opinion on this particular issue. Most of the answers were related to the family budget and the possibilities to reduce expenses on utilities payments. Among other reasons there were saving resources, the fact that leaving appliances on standby mode may be dangerous, and also the wish not to build nuclear plants.

4.3 Energy saving potentials and reduction of CO_2 emissions

4.3.1 Energy saving potentials

For the evaluation of the energy saving potential, different scenarios have been constructed. Many appliance types described above have standby power use that exceeds international adopted standards. However, the larger part of it could be eliminated due to a simple design change in appliances (Meier *et al.* 2004; IEA 2003). Three scenarios have been developed to show the possible energy use reductions if the appliances had 1 W and 3 W standby power usages. Adjustments of time the appliances spend in standby mode have been also made. Therefore, 5, 10 and 20 hours in standby mode for appliances have been evaluated.

According to Section 4.1, the most standby energy consuming appliance categories are the home office (170 GWh per year) and home entertainment equipment (1053 GWh per year). Therefore, the main emphasis is particularly on these appliances.

The average rates of appliances' consumption from these groups are much higher than recommended. For example, TV set average standby power use is 6.1 Wh in the sampled households, while the standby consumption recommended by Groups for

Energy Efficient Appliances (GEEA) criteria (2006) is supposed to be 1W or less in standby.

Kitchen and washing appliances' average standby consumption have been identified on the level of 1.4 W for microwave and 1 W for washing machine due to measurements. For microwave and washing machine standards should be lower than 1 and 3 W, and 0.3 W or less in "no load" mode for cell phone charges (GEEA 2006). Though improvements can be made with these equipment categories, they were not included in the current scenarios for energy savings.

Different scenarios show how standby energy use part can be reduced in case the standby reduction measures are implemented in Ukraine. 3 and 1 W scenarios assume that power is in 1 to 3 W ranges, while scenario with average standby power use for appliance types represents the current situation in Ukrainian households. The time assumption was imposed and calculations were related to the 5, 10 and 20 hours plugged in for standby consumption mode. These assumptions are reachable due to the available technologies and possibilities of standards application, and also behavioural change of the consumers.

Thus, for the scenarios calculations, assumptions can be generalized as follows:

- three parameters of energy use and appliances' performance may be proposed (present average standby power use from Table 4.1; 3 W and 1 W);
- time assumptions were related to 5, 10 and 20 hours in standby mode;
- penetration rate applied is equal to present saturation level of appliances in Ukrainian households.

The main comparison was made with the reference total. This number (1223 GWh per year) is the sum of present standby consumption in Ukrainian households by home entertainment (1053 GWh/year) and office equipment (170 GWh/year). Saving potential as is evaluated through comparison of the present standby consumption for home office and entertainment appliances in Ukraine. Figure 11 represents 3 scenarios for standby energy use and saving potentials calculated compared to present state consumption. The possible savings are determined representing difference between the current standby energy use and in scenarios.

It is obvious that decrease in standby energy use up to 1 W and 3 W in all cases had positive impacts for the energy savings, comparing to the present state situation. Especially brightly it can be seen for 5 and 10 hours/day standby power use, Scenarios 1 and 2. While standby consumption decreases due to the power consumption cuts and the hours in standby mode minimization (5 and 10 hours), the saving potentials are increasing.

Scenario 3 in case with average present standby power consumption (Ave) per 20 hours shows negative saving potentials. However, this is due to the fact that current average time the appliances spend in standby mode is less than 20 hours per day. Even though the Scenario 3 has the largest time share in standby, if the improvements are made in appliance design, there is a huge potential for energy savings.

Energy savings may be due to time change in standby mode and average consumption reduction (823.8 GWh per years in Scenario 1 and 424.2 GWh per year in Scenario 2). The best energy saving results were obtained within Scenarios 1 and 2, where the consumption had decreased up to: Scenario 1 (5 hours in standby) - 206.1 (3W) and 84, 7 GWh per year (1W), and Scenario 2 (10 hours in standby) – 412.1 (3W) and 169.3 (1W) GWh per year.

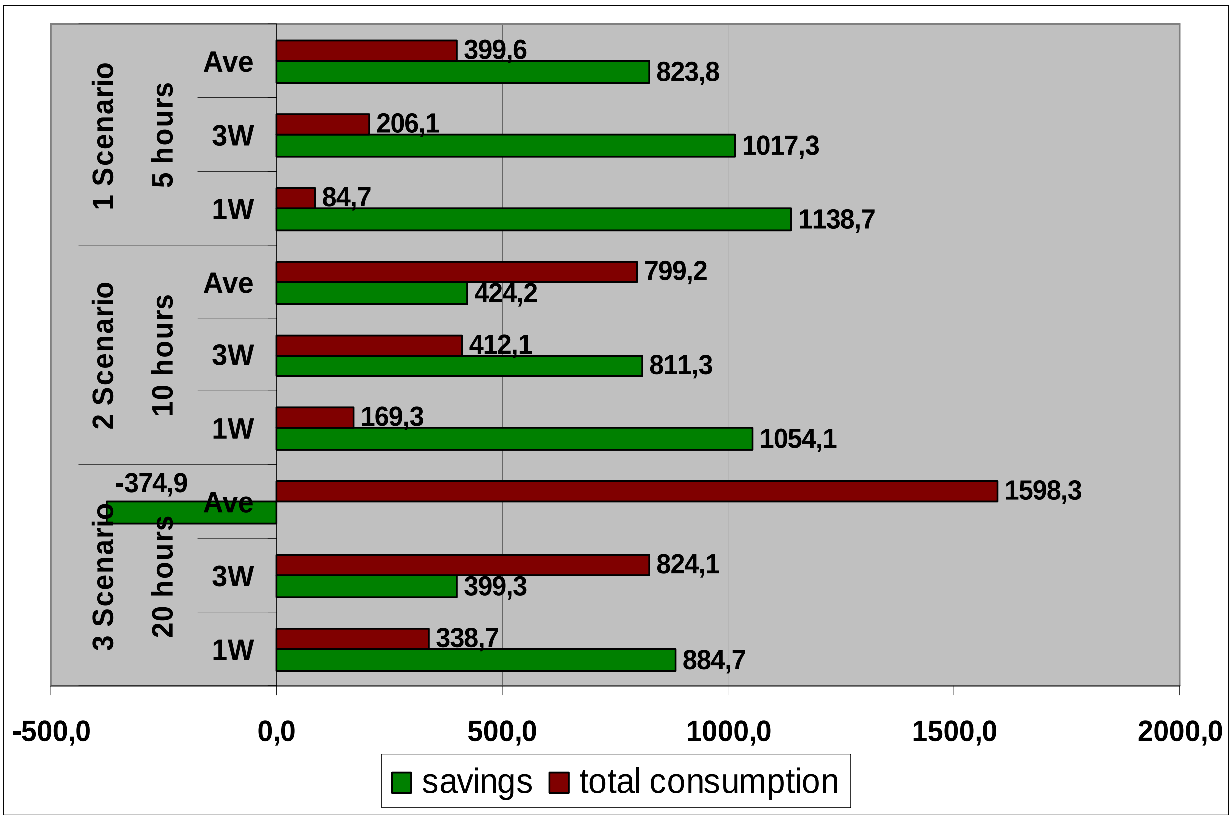


Figure 11 Standby energy use and saving potentials scenarios in Ukraine, GWh per year

Scenario 3 (20 hours in standby) does not have savings with present average power consumption and negative trend in saving means even further increase in energy consumption if the appliances will be on standby for 20 hours/day. However, the decrease in standby power use to 1W and 3W has also considerable savings - 399.3 (3W) and 884.7 (1W) GWh per year.

4.3.2 Potentials in CO_2 emissions reduction

Having distinguished in the Section 4.1.2 national value for standby energy consumption equal to 1.3 TW h per year, it is possible to estimate the amounts of CO_2 emissions it is responsible for. As to the report by IEA (2006d), total country emissions in 2004 were equal to 305 million ton (Mt) CO_2.

Table 14 represents the present standby energy consumption from all appliances in households of Ukraine.

Table 14 Assessment of CO_2 emissions from standby power in the residential sector in Ukraine

Total energy from standby GWh/year	Total energy from standby T joule	CO_2 emission ratio t CO_2/ T joule *	National CO_2 emissions M tons**	CO_2 from standby M tons	Standby as % of national CO_2
1.3	4 680	51.9	304.85	0.2	0.1

*-Source: IEA 2006d
**-Source: IEA 2006c

As it can be seen from Table 14, the residential sector in Ukraine is responsible for 0.2 M tons of CO_2 emissions in Ukraine yearly, taking into account the calculated number of standby energy usage – 1.3 TWh per year. And this number corresponds to 0.1% of the national CO_2 emissions.

Further analysis will show the possible scenarios and magnitudes of CO_2 emissions decrease on three Scenarios example following the same pattern as in Section 4.3.1. Certain electricity savings calculated in Subsection 4.3.1 may correspond to a reduction of GHGs and particularly, CO_2.

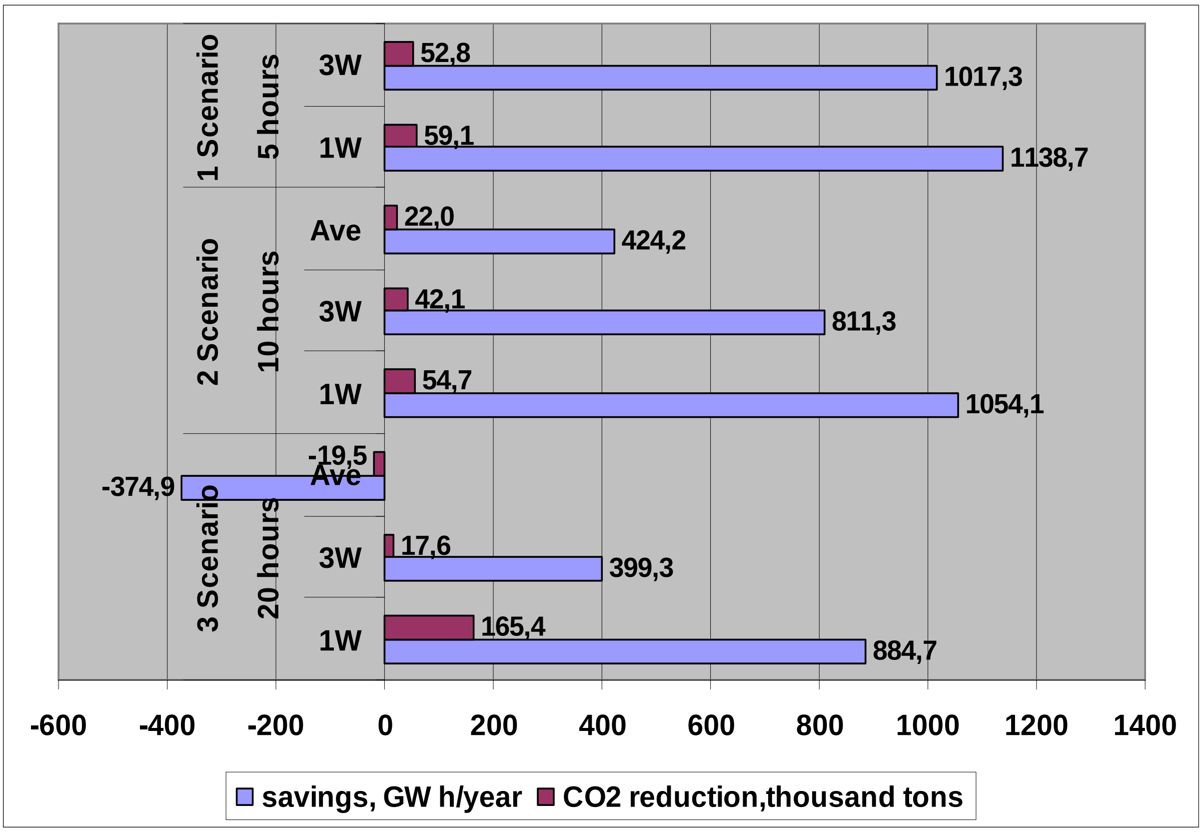


Figure 12 Potential CO_2 emission reductions from different scenarios in Ukraine

As Figure 12 shows, the magnitudes of the possible energy savings due to different energy saving Scenarios vary from 165 to 22 thousand tons of CO_2 only due to the standby energy use reduction in home entertainment and office equipment as the part of the residential electricity consumption. The negative energy savings and CO_2 emissions reductions in Scenario 3 should not be counted as this phenomenon appeared only because present average calculated standby was less than calculated one due to less hours in standby for appliances nowadays. However, the average present standby energy consumption rate represents meaningful reductions in Scenarios 1 and 2 due to time in use decrease (59 and 22 thousand tons of CO_2 emissions cuts respectively). Scenario 3 showed that standby power use on the present level will have even more emissions in case the time for appliances in this mode will increase.

The most realistic is to reduce the appliance standby power use to 3W, and when these measures will be applied there will be reductions in CO_2 emission ranging from 18 thousand CO_2 (in Scenario 3) to almost 59 thousand tons CO_2 (in Scenario 1).

4.4 Discussion

This is the first field measurement of standby power use in Ukraine, which is the main contribution to this field. However, the survey is not representative because only 50 households in urban areas were measured and the sample of convenience was used. Strength of this study is that it included some of the major and smaller appliances found in households (e.g. mobile phone chargers, battery chargers, etc.).

However, in the calculations even the average present standby power use (Section 4.1) major difficulties were encountered concerning penetration rates availability on the national level. Therefore, the penetration data from Bulgaria were used supposing similar appliance acquisition patterns. However, actual standby power consumption might be higher due to the uncertainties with penetration rates and the constantly rising variety and presence of appliances in households. However, results have been analyzed and the relevant conclusions have been made.

On average, standby power in Ukraine is 23.4 W per household, while in OECD countries it ranges about 20-90 W per household (Bradley and Yang 2006). According to Section 4.1.2, the average annual consumption from standby power is 114.3 kWh per household, representing 4.5% of the total electricity consumption in the sample of households.

However, the cost share (4.5% of total electricity payment) is rather modest because the prices for electricity are very low for the residential sector in Ukraine (0.24 UAH for kW, which is approximately USD 0.05 cents) (Kievenergo 2007). Even though the main concerns of respondents about saving electricity were connected mostly to the decrease of payments for electricity (Section 4.2.1), there are no real price incentives for economy for consumers. Thus, IEA in its report (IEA 2006d) advises the Ukrainian government to raise electricity prices to provoke rational energy use by end-users. The present electricity prices do not cover long-term costs, while higher prices will make energy efficiency improvements financially more justified (IEA 2006d).

The average number of appliances in Ukrainian households audited was 8.9. However, the list of the appliances from Lebot *et al.* (2000) demonstrates that their quantity might be much higher (15 appliances only within video appliances type, 11 - within HiFi, 14 – within information and technology).

Table 4.11 represents the assessment of the energy demand and CO_2 emissions from standby power within home entertainment and office appliances in the residential sector in Ukraine that appeared to amount to 0.1 % of total emissions in Ukraine. Although this rate is substantial, while comparing to the average emissions from standby in OECD it appears to be rather modest (in 2000 it was reported on the level of 0.6% in OECD countries) (Lebot *et al.* 2000). However, it shows the tendencies of future increase in standby power use and emissions from it when the penetration of appliances grows.

Energy savings, as well as emission reductions potentials were considerable according to the calculations made for different scenarios (from 10% to 70 %). However, they might be much higher if all appliances are included, i.e. not only home entertainment and office equipment. It might affect the demand side and production of electricity. And that would be very important, taking into consideration the necessity to strengthen the country's energy security and decrease dependency on imports.

Standards for appliances are present in the national legislation and approved for the major appliances in 2005 (IEA 2006d) based on the examples of European Union standards. However, standards have not received enforcement and hardly work nowadays. As a result, the elementary requirement for them is not being properly being properly fulfilled - energy efficiency labels are rarely available. The extended standards and requirements for more appliance types are also developed, but not adopted by the government. The main concerns may also be related to the issue that most of the appliances are not produced in Ukraine, but are imported from other countries (supposing from China and other Asian countries).

Research conducted by Bartiaux and Gram-Hanssen (2005) about factors influencing standby consumption reveals that the electricity consumption is based on energy policies (including public campaigns, taxes, etc.). In Ukraine, the first steps with energy policy improvement were made with the development of the Energy Strategy of Ukraine for the period until 2030 (MFE 2006). Thus, for now governmental control and international cooperation is needed to enforce the process and compliance with regulations and energy efficiency standards, with respect to standby power use as its substantial part.

5. CONCLUSIONS AND RECOMMENDATIONS

This first survey of standby power usage in Ukrainian households demonstrates that standby power is already a significant end-use of electricity and there are many opportunities to decrease its share and emissions of CO_2 from it respectively.

In the answer to the main questions of the study, the ***main findings*** are:

1. As to the calculations made, in total, standby energy consumption accounts for 1.3 TW h per year and is responsible for 0.8% of the national electricity use. The main components of standby power consumption as distinguished were home entertainment appliances with 1053 GWh per year national consumption, home office equipment – 170 GWh per year, followed by kitchen and washing appliances with 49 and 32 GWh per year respectively.

2. Qualitative aspects enlightened the main issues and practices that generate standby electricity consumption: consumption is highly correlated with number of appliances in the house and relationships with other variables were found to be insignificant; 46% of the respondents knew and paid attention to energy efficiency labels and 52% did not; 48% knew about standby power consumption and 52% did not; in most cases appliances are put on standby energy consciously; every second household uses multiple sockets to disconnect appliances from the grid at once; the main reason for not unplugging the appliances is "no change" place of its usage; the main criteria in appliance purchase is the price; the most frequently indicated reason for electricity saving necessity is the possibility to reduce payments.

3. Energy saving potentials could be substantial if the measures and standards were to be implemented. In different scenarios they were ranging from 400 (10%) to 1138 GWh per year (70%).

Consequently, "leaking electricity" may be translated into CO_2 emissions that were found to be 0.1% of the national CO_2 emissions nowadays. Emission reduction potentials range from 18 to almost 59 thousand tons of CO_2 in different scenarios.

Specific findings

It has been found that 46% of surveyed household representatives pay attention to energy labels. However, in most cases, they are not in place. As the experience from other countries showed, once the energy efficiency label is present on an appliance, there is a higher chance the consumer will pay attention to it and it will affect the decision and final choice, and the general public awareness will improve (IEA 2003).

From the analysis of the behavioural patterns, it clearly appeared that the majority of households were conscious of the electricity consumption and particularly of the standby consumption. For those who knew about standby power consumption the levels of low standby consumption were almost the same (25%) as for the high level of standby consumers (29%). The reluctance and inertia of consumers may be mostly related to the absence of price incentives. Electricity in Ukraine is too cheap for consumers (0.24 UAH per kW) and this fact does not provide them incentives to perform saving measures. However the situation might change because of the growing prices for imported energy carriers.

Recommendations

According to the results and experience of the current research, the following recommendations and suggestion are proposed for future research, households and the Ukrainian government.

Suggestions ***for future research*** include broadening the scope of the appliances in the research of the residential sector as well as extending size of the sample. The representative sample will improve the results making national estimations more reliable and less dependent on official data.

A great potential for energy savings is still expected in the public service sphere. Investigating the energy use in public sphere will be highly valuable for estimation because cost-benefit analysis of the energy saving and emissions reductions due to standby power consumption will give proper arguments and help find reasoning for energy conservation.

Also a comparison of consumption in “on” and standby modes might show that some of the appliances are actually consuming more being in standby mode, rather that being in use.

Recommendations ***for the Ukrainian government*** can be summarized as follows:

The government should take steps to strengthen the policies related to residential appliances and equipment – as minimum - according to the existing standards.

It would be useful to take into account the positive international experience for developing standards for domestic appliances. Policy measures should be extended to a wider range of appliances, and further - to all end-uses in households. Afterwards, regular updates of standards are needed (every 2-3 years).

International collaboration is needed as there is a high rate of imports into Ukraine of all types of electronic appliances (transparency and comparability in appliance energy performance standards, test procedures and labelling).

The government should stimulate the manufacturers, retailers and consumers to use policy instruments such as information initiatives (labels, information campaigns, etc.), certification, voluntary agreements, and technology procurement programs for raising public awareness and as an effective complements to standards.

Moreover, we need public campaigns and educational measures for energy saving activities in households, as well as in other end-uses.

As the current price for electricity in Ukraine is very low, there is no economic initiative for consumers to save it. There is a necessity to adjust the price of electricity so that it reflects more accurately the process of energy production and its environmental consequences.

Finally, currently observed and future expected rapid growth of appliances in the residential sector should be addressed, and particularly, standby power consumption of home entertainment and home office equipment.

Recommendations ***for households*** are mostly related to raising their awareness of the necessity of the energy efficiency measures as the possibility to reduce the negative impacts of energy production. Being aware and making conscious choices of energy efficient appliances, they will stimulate manufacturers to turn out more efficient products. And, rational energy use will help to prevent the necessity to use strict methods from the government's side (price raise, subsidies cuts, etc.).

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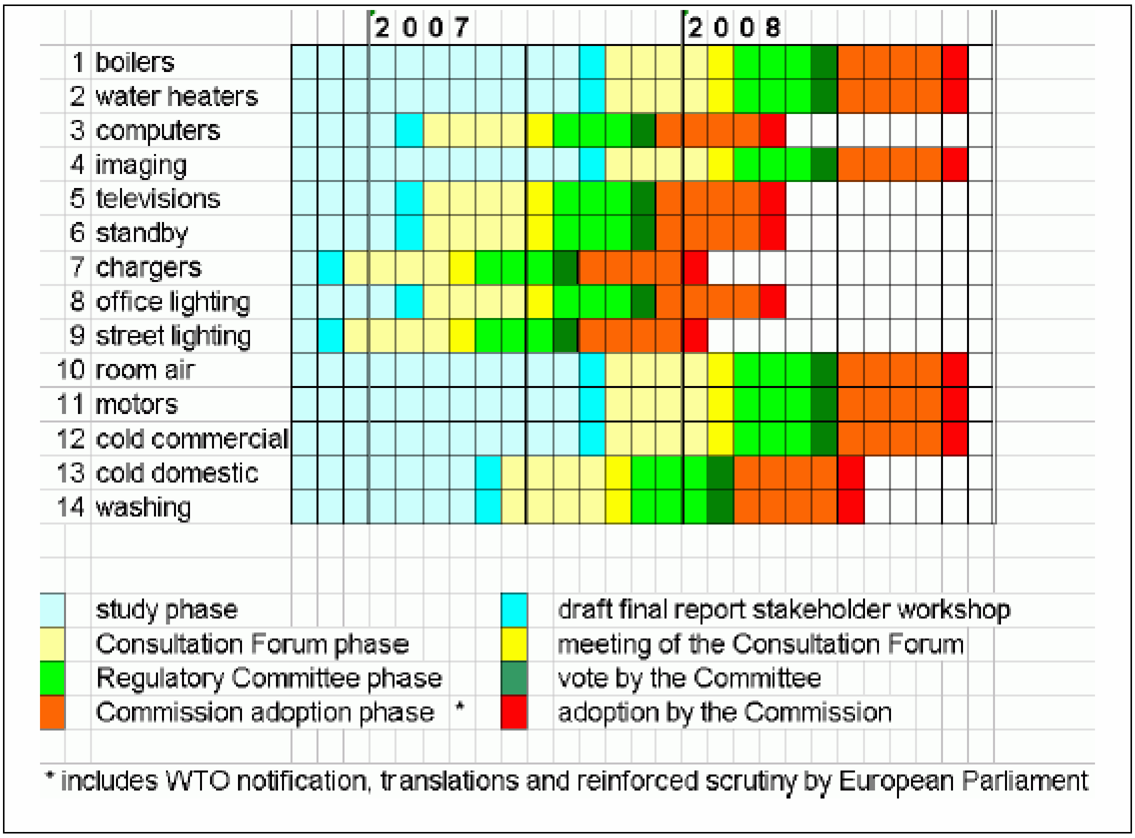
APPENDIX 1 European legislation on energy savings

(Source: EC 2006)

- Directive on energy performance of buildings
- Directive on the promotion of cogeneration
- Directive for the taxation of energy products and electricity
- Directives on energy efficiency requirements for boilers, refrigerators and ballasts for fluorescent lighting
- Directives for labelling of electric ovens, air-conditioners and refrigerators and other appliances
- Regulation on Energy Star labelling for office equipment
- Directive on Eco-design requirements for energy using products
- Directive on energy end-use efficiency and energy services
- Since 2001, the European Commission's DG TREN has been running the Manage Energy programme, which aims at supporting the work of actors working on energy efficiency and renewable energies at the local and regional level. Its main tools include training workshops and online events, as well as providing additional information on case studies, best practice, European legislation and programs and educational material aimed at different sectors of the 7-16 year old public.

APPENDIX 2 Priority product groups for minimum energy performance standards

(Source: EC 2006)



APPENDIX 3 Questionnaire for the household standby energy consumption research

Questionnaire #:______ Date________________________(day/month/year)

Household address: City __________________ Street __________________

Type of building (tick): ***Single family house*** □ ***Multi-occupancy building*** □

What is the area of the flat/house? __________m^2

Contact information: tel. __________________ e-mail __________________
(in case you would like to obtain the result form)

Hello, my name is Vladlena. I am conducting the research about the standby energy consumption in Ukraine as a part of my Master thesis in the Central European University. The research topic is very new and undiscovered, and particularly important is discovering the energy saving potential in households due to standby energy reduction (when appliances are not in use). This is a practical research with metering conduction. Information about your address will be kept confidential. The research interests are only to take measurements, have your opinion on relevant questions, analyze the results and provide recommendations.

For further information and in case of questions, please, contact me though:

Tel.: (+38066) 731-26-57, (+38044) 410 55 23

1. Household details

1.1. Who is responsible for the household purchases? Please, give this questionnaire to this person.

1.2. How many persons live in the household in the following age groups?

Age 10 and less	
Age from 10 to 18	
Age from 19 to 65	
Age more than 65	

1.3. What is the highest level of education in household?

Secondary school	
Secondary specialized school	
College degree	
University degree	

1.4. What was your last pay slip for electricity: monthly(UAH / kWh)_________

yearly (UAH / kWh) _________

2. Office appliances

2.1. Do you have a personal computer?

Yes □ No □ (→ if no, go to section 3 Hot appliances)

2.2. When you are not using the following equipment, do you usually (choose the right answer in the table)? For how long in hours/day (please, indicate the appliances you own)?:

Device	**Unplug**	**Turn off** with the on/off button	**Leave on standby** (sleeping modes)	**Leave on**
Monitor				
PC				
Laptop				
Printer				
All-in-one (printer-scanner-copier)				
Scanner				
Copier				
Modem				
Speakers				
Router/hub				
Other (indicate):				

2.3. Do you leave your computer on without using it?

□ Yes □ No □ do not know

If yes, what is the reason for leaving it on?

□ no need to boot it each time

□ worried about damaging it

□ tasks running (download, backup, etc.)

□ other (specify)_________________________

2.4. Is the electricity saving handler active on your monitor (placing inactive monitor to low power sleep mode)?

□ Yes □ No □ do not know

2.5. Is the electricity saving handler active on your computer (placing inactive computer to low power sleep mode)?

□ Yes □ No □ do not know

3. "Hot" appliances

3.1. When you are not using following equipment, do you usually (tick only if you own the appliance)? Please, indicate approximate time per day in this state in each box (hours).

Device	**unplug**		turn **off** with the on/off button		leave **on standby** (with active interface)		leave **on**	
Microwave								
Cooking fan								
Toaster								
Dishwashing machine								
Other:								

4. Washing appliances

4.1. Do you have a washing machine?

Yes, semi-automatic □ Yes, automatic □ No □ (→ go to section 5 Home entertainment)

If yes, please indicate the age, capacity and specify the energy class (A, B, C, D, E, F, G, X-old type) if known:

Age			**Capacity**		**Energy class**
Less than 5 years	**From 5 to 10 years**	**More than 10 years**	**5 kg or less**	**More than 5 kg**	

4.2. How many clothes loads per week do you usually perform?

□ less than 1 □ 1-2 □ 3-4 □ more than 5

4.3. Do you usually unplug your washing machine then not in use?

Yes □ No □

If not, how many hours/day it is plugged in_________, or on standby____________?

4. Home entertainment

4.1. When you are not using the following equipment, do you usually (tick only if you own the appliance)? Please, indicate approximate time per day in this state in each box (hours).

Device	**unplug**		turn **off** with the on/off button		leave **on standby** (eg. turn it off with remote control)		leave **on**	
TV								
VHS/ VCD/ VCR recorder/player								
DVD recorder/player								
Hi-Fi								
Satellite/cable set top box								
Video game								
Batteries' charger								
Mobile phone charger								
Radio								
Cordless phone								
Other (indicate):								

5. General Points

5.1. When you buy your electronic/electric appliances, do you pay attention to the energy label on it?

Yes □ No □ Sometimes □

5.2. Do you know that some appliances use energy even when they are turned off with the ON/OFF switch button but not unplugged?

Yes □ No □

5.3. Do you use multiple sockets with a switch to disconnect all appliances?

Yes □ No □

5.4. What is the reason for leaving the appliances plugged in and on standby?

□ I do not change the socket and usually use the device in this place

□ do not have time to unplug

□ just forget to unplug them sometimes

□ other reasons (specify):____

5.5. Tick the criteria (several if needed) that you consider being important when you purchase a new appliance:

Criteria	Appliances			
	Office	Kitchen	Washing	Home entertainment
Price				
Design/style				
External dimensions				
Capacity				
Electricity consumption				
Ease of use				
Other (specify):				

5.6. In your opinion, why do you think it is necessary to save electricity? (please, specify)____

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APPENDIX 4 Summary for the different statistical tests

Variables	Standby consumption kW/year	Appliances with standby	Members in household	House type	Knowledge of standby	Multiple sockets	Attention to labels
Appliances with standby	Pears. R = 0,618, sign=0.000	x	Pears.R= -0.141, sing=0.328	Eta=0.174, sig=0.227, F=5.224, sig=0.036, t=±0.548, sig=0.227	Eta=0.087, Sig.=0.546, F=0.406, Sig=0.533, T=±0.548, Sign=0.591	Eta=0.376, sig=0.007, F=0.406, sig=0.533, t=±0.548, sig=0.591	Eta=0.410, sig=0.506, F=0.406, sing=0.533, t=±0.548, sig=0.591
Members in household	Pears. R= 0.232, sign.= 0.105	Pears.R= -0.141, sig.=0.328	X	Eta=0.535, Sig.=0.000, F=1.457, Sig=0.245, T=±0.232, Sign=0.819	Eta=0.087, Sig.=0.546, F=0.406, Sig=0.533, T=±0.548, Sign=0.591	Eta=0.121, Sig.=0.404 F=1.457, Sig=0.245, T=±0.232, Sign= 0.819	Eta=0.189, Sig.=0.751, F=1.457, Sig=0.245, T=±0.232, Sign=0.819
House type	Eta=0.359, Sig.=0.117, F=4.454, Sig=0.051, T=±5.051, Sign=0.000	Eta=0.087, Sig.=0.546, F=0.406, Sig=0.533, T=±0.548, Sign=0.591	Eta=0.535, Sig.=0.000, F=1.457, Sig=0.245, T=±0.232, Sign=0.819	x	Spearm.= -0.201, Sign.= 0.162	Spearm.=0 .201, sign.= 0.162	Spearm.= 0.343, Sing. = 0.015
Knowledge of standby	Eta=0.066, Sig.=0.051, F=4.454, Sig=0.051, T=±5.051, Sign=0.000	Eta=0.087, Sig.=0.546, F=0.406, Sig=0.533, T=±0.548, Sign=0.591	Eta=0.087, Sig.=0.546, F=0.406, Sig=0.533, T=±0.548, Sign=0.591	Spearm.= -0.201, Sign.= 0.162	x	Spearm.=- 0.038, Sign.= 0.791	Spearm.= -0.014, Sign.= 0.924
Multiple sockets use	Eta=0.246, Sig.=0.398, F=4.454, Sig=0.051, T=±5.051, Sign=0.000	Eta=0.066, Sig.=0.051, F=4.454, Sig=0.051, T=±5.051, Sign=0.000	Eta=0.121, Sig.=0.404, F=1.457, Sig=0.245, T=±0.232, Sign=0.819	Spearm.=0. 201, sign.= 0.162	Spearm.= -0.038, Sign.= 0.791	X	Spearm.= -0.083, Sign.= 0.788
Attention to labels	Eta=0.231, sig=0.179, F=4.454, sing=0.051, t=±5.051, sig=0.000	Eta=0.410, sig=0.506, F=0.406, sing=0.533, t=±0.548, sig=0.591	Eta=0.189, Sig.=0.751, F=1.457, Sig=0.245, T=±0.232, Sign=0.819	Spearm.=0. 343, Sing. = 0.015	Spearm.= -0.014, Sign.= 0.924	Spearm.=- 0.083, Sign.= 0.788	x

Coefficients: 0.0 – no linear association, 0.01 – 0.09 – very small, practically zero, 0.10-0.29 – low to moderate relationship, minor, 0.30 – 0.49 – moderate to substantial, medium, 0.5 – 0.69 – substantial to very strong, major relationship, 0.70 – 0.89 – very strong, huge, 0.90+ - near perfect (De Vaus 2002).

Significance: very high when approaching 0.001, rather significant when approaching 0.05.