Author : **Martin Zalesak**

Company: Tomas Bata University Zlin
Faculty of Applied Informatics

Address: Mostni 5139
760 01 Zlin
Czech Republi

Phone: ++ 420 576 035 261
Mobile: ++ 420 736 672 122
Fax: ++ 420 576 035 279

Title**:** **CPossible impacts of intelligent technologies application in residential buildings on energy efficiency**

Key points: **Energy performance of buildings, intelligent technologies, intelligent buildings, thermal properties of buildings**

Content: Energy Performance of Building Directive (EPBD) 2002/91/EC is implemented in European member states at present. The EPBD deals mainly with values of thermal properties of buildings, boilers and air conditioning systems inspection as a main source of energy savings. But the savings could be hardly achieved without proper control of HVAC, lighting and home appliances operating - ie. without building control system application. Aplication of a relevant control system should be an undevidable part of new buildings as well as existing buildings retrofit.Moreover substantial savings in existing buildings could be achieved even by simple application of intelligent control technologies in existing buildings, with acceptable economical parameters. The article provide analyses of the impact of EPBD on buildings, describes technical potential of savings and technical potentials of intelligent systems application in residential buildings. There are shown in the article results of overall energy consumption modelling in several typical buildings stocks, based on implementation of energy savings measures. Results of economical evaluation of modelling are discussed in the article, with practical conlusions and recommendations.

Scope and signification of the article: The scope of the article responds to EPBD implementation in member European states and smart house technologies possible implementation as per CENELEC "SmartHouse Code of Practice CWA 50487:2005", and its possible impacts on the residential buildings sector.

Contents

1 Existing situation in building stock

Building stocks in the EU

- 160 million buildings;
- 454 million inhabitants;
- 40% of Europe's energy consumption;
- 40% of its carbon dioxide emissions

Regions acc. to EPBD

Region		
Cold	**Moderate**	**Warm**
Finland **Sweden** **Baltic states**	**Other countries**	**Greece** **Italy** **Portugal** **Spain**

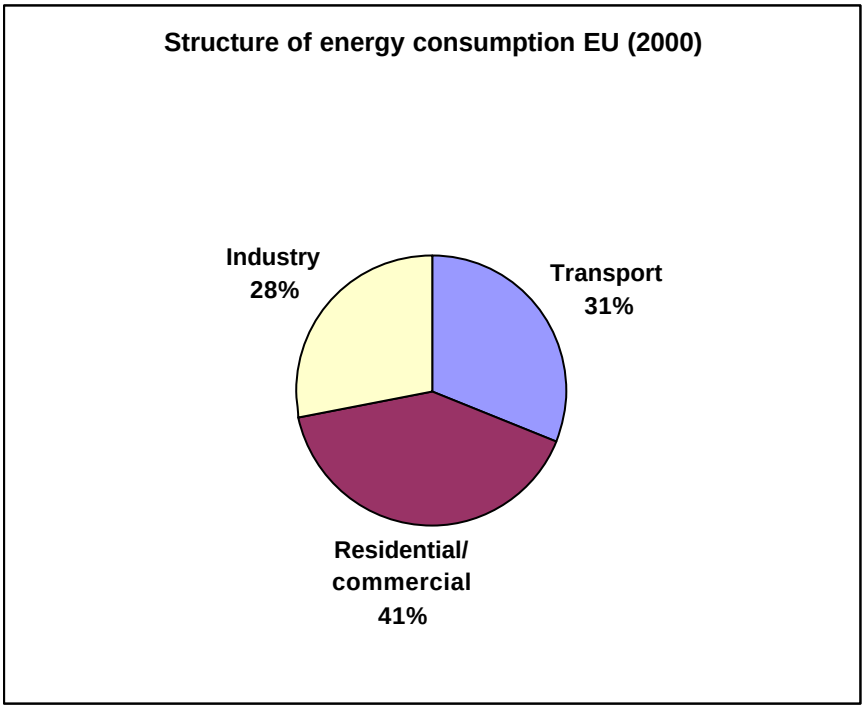
Heating degree days

	Heating degree days
	(K.D/a
Warm	1800
Moderate	3500
Cold	4500

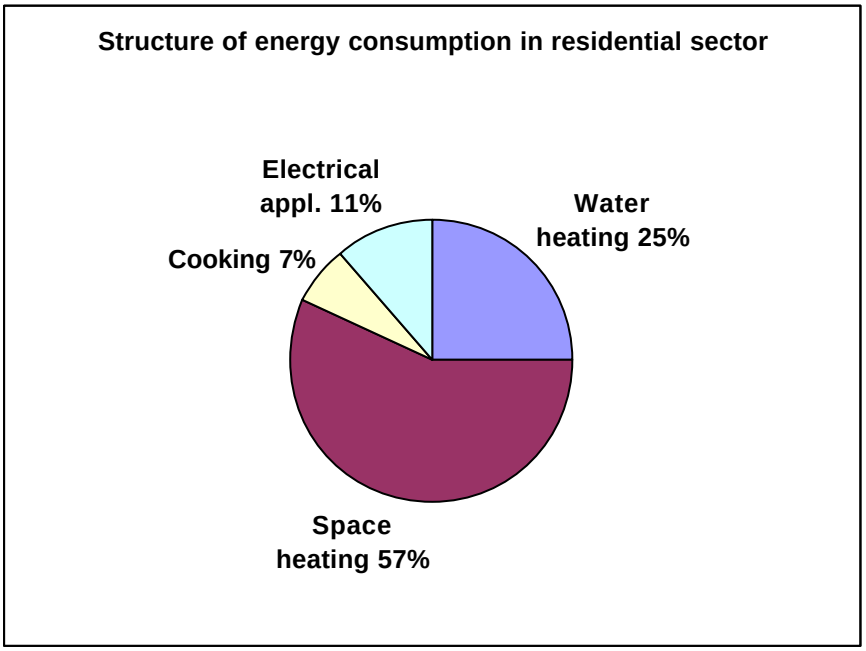
The floor area of buildings stock in EU 15 (before 2005)

		Floor area					
Zone	**Building age**	**Total**	**One family house**	**Appartment house < 1000m²**	**Appartment house > 1000m²**	**Small non residential buildings < 1000m²**	**Non residential buildings > 1000m²**
		Mil. m²	Mil. m²	Mil. m²	Mil. m²	Mil. m²	Mil. m²
Cold	< 1975	534	220	109	59	55	92
	1975 - 1990	154	63	31	17	16	27
	>1975	120	31	26	14	18	30
Moderate	< 1975	9145	4607	1242	669	780	1848
	1975 - 1990	2551	1290	348	187	216	511
	>1975	1708	670	181	97	226	535
Warm	< 1975	3116	1197	769	414	319	416
	1975 - 1990	1945	748	480	259	199	259
	>1975	1175	399	256	138	166	216
Total		**20448**	**9225**	**3442**	**1854**	**1995**	**3934**
Total		**40898**					

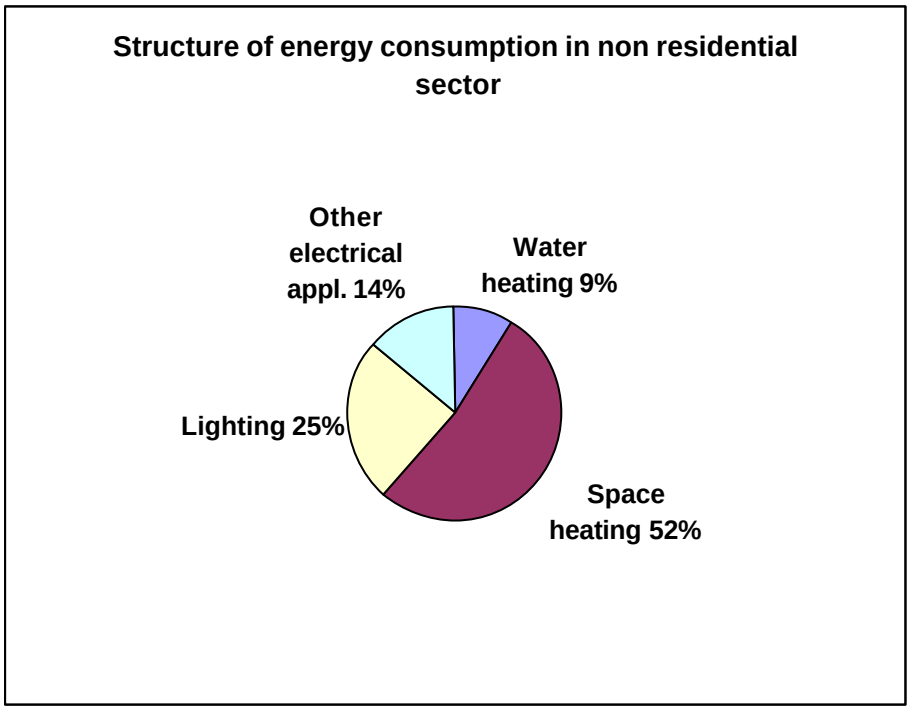
The proportion of the energy consumption in EU



The proportion of the energy consumption in residential buildings in EU



The proportion of the energy consumption in nonresidential buildings in EU



Thermal properties of Europen building stock

Regions acc. to EPBD

Region		
Cold	**Moderate**	**Warm**
Finland **Sweden** **Baltic states**	**Other countries**	**Greece** **Italy** **Portugal** **Spain**

		Floor area					
Zone	**Building age**	**Total**	**One family house**	**Appartment house < 1000m^2**	**Appartment house > 1000m^2**	**Small non residential buildings < 1000m^2**	**Non residential buildings > 1000m^2**
		Mil. m^2	Mil. m^2	Mil. m^2	Mil. m^2	Mil. m^2	Mil. m^2
Cold	< 1975	534	220	109	59	55	92
	1975 - 1990	154	63	31	17	16	27
	>1975	120	31	26	14	18	30
Moderate	< 1975	9145	4607	1242	669	780	1848
	1975 - 1990	2551	1290	348	187	216	511
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	1975 - 1990	1945	748	480	259	199	259
	>1975	1175	399	256	138	166	216
		20448	9225	3442	1854	1995	3934

2 Energy related directives in residential buildings

Promoting energy efficiency in buildings in the European Union

The main legislative instruments affecting the buildings sector are

1/ Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.

2/ Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

1/ Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings (EPBD)

The aim

- decrease energy consumption by implementation cost-effective savings potential of around 22% of present consumption in buildings by 2010;
- it represents 55 Mtoe energy consumption;
- it represents about 20 % of the Kyoto Protocol target;
- validation of comparative assessments of the likely running costs of different buildings in different countries as a mean of assistance to complete Single European Market in non residence buildings

Directive lays down requirements as regards:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- the application of minimum requirements on the energy performance of new buildings;
- the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- energy certification of buildings;
- regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

Adoption of a methodology

This requires every government to apply a methodology which calculates the energy performance of buildings. These calculations must be based on a general framework incorporating the following items:

(*a*) thermal characteristics of the building (shell and internal partitions, etc.); these characteristics may also include air-tightness
(*b*) heating installation and hot water supply, including their insulation characteristics;
(*c*) air-conditioning installation;
(*d*) ventilation;
(*e*) built-in lighting installation (mainly the nonresidential sector);
(*f*) position and orientation of buildings, including outdoor climate;
(*g*) passive solar systems and solar protection;
(*h*) natural ventilation;
(*i*) indoor climatic conditions, including the designed indoor climate.

The positive influence of the following aspects shall, where relevant in this calculation, be taken into account:
(*a*) active solar systems and other heating and electricity systems based on renewable energy sources;
(*b*) electricity produced by CHP;
(*c*) district or block heating and cooling systems;
(*d*) natural lighting.

For the purpose of this calculation buildings should be adequately classified into categories such as:
(*a*) single-family houses of different types;
(*b*) apartment blocks;
(*c*) offices;
(*d*) education buildings;
(*e*) hospitals;
(*f*) hotels and restaurants;
(*g*) sports facilities;
(*h*) wholesale and retail trade services buildings;
(*i*) other types of energy-consuming buildings.
This methodology can be set either at national or regional level, and must be regularly updated and easy to understand. It may include an indicator of the CO_2 emissions from the building.

Setting of energy performance requirements

The minimum energy performance requirements must be based on the calculation methodology.

Considerations
- general indoor climate conditions;
- local conditions;
- designated function and age of the building

Buildings differentiated
- new buildings;
- existing buildings;
- different categories of buildings.

Requirements must be reviewed at least every five years - reflect technical progress.

The following categories of buildings could be excluded:
- buildings with historical and monumental merit;
- buildings used as places of worship and for religious activities;
- temporary buildings with a planned time of use of two years or less;
- industrial processes;
- workshops and non-residential agricultural buildings with low energy demand;
- non-residential agricultural buildings if covered by a sectoral agreement on energy performance;
- residential buildings intended to be used less than four months a year;
- stand-alone buildings with a total useful floor area of less than 50 m^2.

Expected level of requirements

Estimated *U*-values (W/(m^2.K)) **acc. to EPBD for different climatic regions**

	Region		
	Cold	**Moderate**	**Warm**
Roof	**0,13**	**0,23**	**0,43**
Fasade	**0,17**	**0,38**	**0,48**
Floor	**0,17**	**0,41**	**0,48**
Windows	**1,33**	**1,68**	**2,71**

New and renovated buildings

New buildings
Rules are applied to all new buildings

Renovated buildings
Major renovations means

- total cost of renovation is 'higher than 25% of the value of the building, excluding the value of the land upon which the building is situated';
- alternatively 'those where more than 25% of the building shell undergoes renovation'.

Renovated buildings with total useful floor area of over 1000 m^2 upgraded are to meet minimum requirements, which should be technically, functionally and economically feasible. The requirements may be set either for the renovated building as a whole, or alternatively for the renovated system or components.

Energy performance certificates

A energy certificate not older then 10 years must be made available for buildings (part of building with a common heating systém), which are

- constructed;
- sold;
- rented out.

The energy performance certificate must include ;

- reference values such as current legal standards and benchmarks ;
- recommendations for the cost effective energy saving investments which can be undertaken in the building.

Publicising the certificates
Buildings with a total useful floor area over 1000 m^2, either occupied by a public authority, or regularly visited by a large number of people, must display in a prominent place clearly visible to the public

- current energy certificate;
- range of recommended and current indoor temperatures;
- when appropriate, other relevant climatic factors may also be clearly displ

Inspection of boilers

Options:

- measures to regular inspection of boilers fired by non-renewable liquid or solid fuel o an effective rated output of 20 to 100 kW. Such inspections can also be extended to boilers using other fuels. Boilers over 100 kW must be inspected every two years - gas boilers up to four years. For systems with boilers higher capacity than 20 kW and over 15 years old - inspection of the entire heating installation including an assessment of the boiler efficiency and size compared to the heating requirements of the building. Advice must be provided to the users on the replacement of the boilers, other modifications to the heating system and on alternative solutions.
- governments is to ensure that there is existing a provision of advice to users on the replacement of the boilers, other modifications to the heating system and on alternative solutions, which may include assessment of the efficiency and appropriate size of the boiler - in that case government have to produce a report reflecting the implentation such an advice.

Inspection of air conditioning systems

Regular inspections of all air conditioning systems with an effective rated output of more than 12 kW including an assessment of the efficiency and sizing of the air conditioning, compared to the cooling requirements of the building. Appropriate advice must be provided to users on possible improvements or replacements, and on alternative solutions.

Independent experts

The inspection must be carried out in an independent manner - by qualified and/or accredited experts. These can operate as sole traders or be employed by public or private bodies.

2.2 Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

Objectives

The aim
improve energy efficiency delivered by energy services to citizens and businesses.
It includes:

- contribution to security of energy supply, by managing overall demand by dissemination of energy efficient technologies and techniques;
- boosts innovation ancompetitiveness.

The way

- setting national indicative energy savings targets;
- removal institutional, financial and legal barriers to energy efficiency;
- establishment of conditions to develop and promote a market for energy services, together with delivering other energy efficiency improvement measures to help final customers.

The energy saving target is 9% by 2017.

Categories of applicants

There are three categories:
A/ Providers of energy efficiency measures, energy distributors, distribution system operators and retail energy sales companies.
B/ Every energy user - apart from those already involved with the EU carbon emissions trading scheme.
C/ The armed forces, but only when irrelevant to military action

Application

A/ Beginning in 2008, each government shall aim to achieve in 2017 an overall 9% indicative energy savings target, to be achieved via costeffective, practicable and reasonable measures.

B/ By 30 June 2007, governments must set an interim target for 2011, upon the realism of which the Commission will give a formal opinion. Responsibility for oversight, verification and reporting will be given to one or more new or existing authorities or agencies, as designated by governments. After 2011, the Commission may promote a directive to further develop white certificates.

Public sector

Information energy consumers about the exemplary role and actions of the public sector in saving energy of public sector. Such actions may include laws and/or voluntary agreements, and should concentrate upon the most cost-effective measures. Designated agencies will be responsible for ensuring the public sector fulfils its exemplary role. These agencies must co-operate with the Commission in the promotion of awareness of best energy saving practices, including on public procurement.

Energy distributors, distribution system operators and retail energy sales companies.

Information aggregated statistical information annually regarding will be provided for their final customers and the designated energy agencies.It must be sufficiently detailed to properly design and implement energy saving programmes. It must include current information on end-user consumption including:

- load profiles;
- customer segmentation;
- geographical location of customers.

Governments will ensure that these businesses do one or more of the following:

- offer competitively priced energy services to customers;
- offer their customers competitively priced energy audits, and/or energy efficiency improvements;
- make finance, equivalent to delivering the above, available to fund energy audits.

Governments must ensure that any organisation can offer and implement energy services, energy audits and improvement measures.

Governments obligations

Governments must ensure

- availability of energy savings intention and measures;
- availability of appropriate qualifications, accreditation and certification schemes for the providers of energy services, energy audits and energy efficiency improvement schemes;
- deminishion of impúedition or restrictions of usage of financial instruments for energy savings - unless these are of a clearly fiscal nature;
- must offer model contracts for financial instruments for energy efficiency improvement;
- removal any tariff incentives which unnecessarily increase the volume of transmitted or distributed energy;. They can impose public service obligations regarding energy efficiency on those operating in the gas and electricity sectrors;
- energy efficiency subsidy funds which are open to any company. If created, these must include promoting energy auditing, financial instruments for energy savings, and (where appropriate) improved metering and informative billing. They must target end-use sectors with higher transaction costs and higher risks. They can offer loans, grants or financial guarantees so long as they do not compete with commercially-financed energy efficiency improvement measures. It is up to governments to decide which consumers should benefit.
- availability of efficient, high-quality energy audit schemes for all customers, regardless of size.
- that customers have meters that provide actual overall and time-of-use consumption levels. Such meters must always be installed for new or refurbished buildings, or when an existing meter is replaced - although such provision must be "financially reasonable and proportionate to the potential energy savings". It also requires governments to ensure that all energy bills are provided frequently, based on actual consumption, and easily comprehensible. The bill should also, where appropriate, provide information on past consumption levels and comparable premises, together with contact details including websites for consumer and energy efficiency advice agencies.

Energy Efficiency Action Plans (EEAPs)

The first must be submitted by June 30 2007, with subsequent plans by June 30, 2011, and June 30 2014 The EEAPs must describe the measures to reach the 9% indicative targets; the 2007 report must contain an intermediate target for 2011. The later reports will analyse progress to date, if necessary setting out additional measures to address any shortfalls on the target, increasingly using harmonised efficiency indicators and benchmarks, to evaluate both past and future performance. From 2012 the Commission can propose extending the period of application for targets. If insufficient progress has been made, these should address the level and nature of the targets.

ANNEXES

The directive contains six Annexes (see Article 15). These set out:

I The methodology for calculating the national indicative energy savings target (Article 4)

II A conversion table detailing the energy content of fuels in kilojoules, kilogrammes of oil equivalent, and kilowatt hours

III An indicative list of examples of eligible energy efficiency improvement measures, covering the buildings sector, industry, surface transport, cross-sectoral measures(e.g. standards and norms to improve energy efficiency including in buildings, energy labelling schemes, intelligent metering systems) and "horizontal" measures (e.g. regulations, taxes, information campaigns).

IV A general framework for measurement and verification of energy savings. This covers measuring energy savings via top-down and bottom-up calculations, and how energy savings

should be normalised; the data and methods that may be used; how to deal with uncertainty; consistent measurement of the longevity of each energy saving measure, to be finalised by 17 November 2006; how to deal with the multiplier effect of energy savings, and how to avoid double counting in mixed top-down and bottom-up calculations; and how to verify energy savings.

V An indicative list of markets for which benchmarks can be calculated. These include the markets for: appliances, information technology and lighting for households; domestic heating technology, including heating, ventilation, heat insulation, air-conditioning and windows; industrial ovens; motorised power in industry; public sector institutions; and transport services.

VI A list of eligible energy efficient public procurement measures (see Article 5).This includes acquisition, replacement or retrofitting energy consuming equipment, vehicles and buildings - both purchased or rented.

3 Potential of energy savings in relation of both control and information systems

According to the European energy commissioner, a cost-effective savings potential of around 22% of present consumption in buildings can be realised by 2010.

It may be achieved by implementation of the following measures:

- legislation;
- awareness of all energy users about energy related consequences and modern energy savings materials, technologies, means and technics;;
- implementation by DSM methods and energy saving measures;
- energy measurement and evaluation means;
- application of modrrn technical materials means;
- effective methodes of energy management .

Expected energy savings technical potentials in building stock acc. to /7/.

Measure	Sector of Application	Annual Saving by 2010	Annual Saving by 2010
		(M tonnes CO2)	(MWh)
Improve Thermal Insulation	Domestic	100,00	53866667
	Commercial/Public	20,00	10773333
	Industrial	56,00	30165333
Improve Glazing Standards	Domestic (as per FIZ/CPIV Report)	94,00	50634667
	Commercial/Public/Industrial	25,00	13466667
			0
Improve Controls	Domestic		
	Commercial/Public	67,00	36090667
	Industrial	20,00	10773333
Improve Lighting Efficiency	All	50,00	26933333
TOTAL		**432,00**	**232704000**

According to the experience with the energy saving measures due to implementation of efficient control and information systém could be achieved 8 - 10% saving of total energy consumption in residential buildings.

Energy consumption and expected savings by introduction of control and monitoring means

Zone	Building age	Total	One family house	Appartment house < 1000m^2	Appartment house > 1000m^2
		Mil. m^2	Mil. kWh	Mil. kWh	Mil. kWh
	< 1975	534	66000	16350	8850
	1975 - 1990	154	9450	3720	2040
Cold	>1975	120	2480	1560	840
	< 1975	9145	1474240	186300	100350
	1975 - 1990	2551	258000	41760	22440
Moderate	>1975	1708	100500	10860	5820
	< 1975	3116	299250	99970	53820
	1975 - 1990	1945	74800	38400	20720
	>1975	1175	19950	10240	5520
Warm		20448	2304670	409160	220400
Total			**2934230**		
Total energy savings			**234738**		

4 Possible impacts of implementation CENELEC "SmartHouse Code of Practice CWA 50487:2005" /9/

The apects of the smart house technology are briefly mentioned in the Code of Practise. Itis mentioned that, smart house technology creates possibility for efficient energy management and energy savings. On the other hand the applied technology itself and its usage could actually cause significant increases in power consumption by facilitating and encouraging the use of multiple appliances and systems. That is why smart houses should be energy efficient and ideally more efficient than conventional houses. Smart house should be designed to allow intelligent management of heating and lighting management and should regulate energy consumption depending on occupancy of the house.

The diference of clasical control systém and smart house technology control system is mainly in flexibility of energy supply according to the actual situation in building exploitation and efficient usage of combined clasical heating and cooling systém with utilization of energy renewables technologies. As per Code of Practise, where possible, green energy sources should be exploited with 'local' energy generation provided where practical and economic. Solar and wind energy should be considered coupled with efficient heat management systems (e.g. re-distribution of unused heat, grey water, etc). Biomass energy and sustainable build are also concepts that this Code of Practise recommends smart house designers should address. The householder should have a transparent system showing their energy usage so they have the means and incentive to regulate their consumption.

Clasical problem of low energy houses is overheating and necessary cooling in summer period of theyear. The possible energy impacts are not available due to short time application both smart house technologiesand low energy housees application .

5 Conclusions

As was it shown EU pays enormous effort to energy saving measures in building stock, in which the major role plays residential sector. One of very important medium cost measure is an application of modern control and monitoring technologies, which might be basic means for efficient energy managemnt systém. Smart house technology is ready and proven; no extra research and development is necessary. All that is missing is the suitable publicity and pilot projects. As stated in /10/ "the average cost in many member states of saving a unit of off-peak electricity in the domestic sector is estimated at around 2.6 eurocents per kWh. This should be compared to the average off-peak price for delivered electricity of 3.9 eurocents per kWh. In other words, saving energy is 33% less expensive than seeking to satisfy the demand for energy services with new supply sources. For that matter, we should note that the average on-peak price is 10.2 eurocents per kWh. So saving on-peak electricity cuts costs by almost three-quarters. The buildings sector in Europe is complex because it includes a wide range of buildings types for a wide range of uses. Thus, understanding how energy is used in buildings is complex. Buildings are not simply the sum of a lot of parts but they are a system, with the different parts interacting. The European Union through the efforts of the Commission, the European Parliament and the Council of Ministers has taken a strong leadership role in promoting energy efficiency in buildings. The buildings sector - which cuts through the residential, services (commercial and public) and industrial sectors – is effectively the largest of the end-use sectors. Any Europe-wide or national effort to improve energy efficiency, to meet climate change targets or energy security objectives cannot overlook buildings. Not only are they the largest energy consuming sector but also the savings are highly cost-effective. And because so many of the energy efficient technologies – insulating materials, control systems, etc. - are sold across borders, there is a good rationale for a European-wide effort."

6 Literature

1/ Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.

2/ Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

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