WORLD ENERGY COUNCIL | FUTURE ENERGY LEADERS

THE ROLE OF ICT IN ENERGY EFFICIENCY MANAGEMENT

HOUSEHOLD SECTOR | 2018

ABOUT THE FEL-100

The World Energy Council's Future Energy Leaders' Programme – the FEL-100– is a global and diverse network of young energy professionals. The programme serves as a platform for engaging a limited number of ambitious young professionals in national, regional and international activities and events. Its objective is to inspire participants to become the next generation of energy leaders capable of solving the world's most pressing challenges regarding energy and sustainability.

Further details at https://www.worldenergy.org/wec-network/future-energy-leaders/

CONTEXT

Against the backdrop of increasing digitization in the energy sector, this paper seeks to review the potential for ICT (Information and Communication Technologies) in the residential sector in Europe in the context of energy efficiency. The paper looks deep into this topic to understand the supporting trends and existing regulatory framework as well as identifying use cases, levers to improve energy efficiency, and their quantified impact. New areas such as smart metering, feedback programmes and dynamic pricing are reviewed with identification of new implications to consumers, such as on privacy and cybersecurity. Reference is made to distributed generation sources such as solar PV and batteries since these are enabled by ICT tools, nevertheless the focus of the paper is kept on demand side as opposed to supply side efficiency. Case studies on specific regions and applications have been sought to illustrate the potential.

This paper discusses barriers to implementation, imperatives, and potential solutions to move the sector forward. These are the perspectives of the authors involved and will be tracked going forward in future publications.

The paper was instigated by the Energy Efficiency Taskforce of the Future Energy Leaders cohort of the World Energy Council.

EXECUTIVE SUMMARY

Economic and population growth are increasing the demand for energy. Information and Communication Technologies (ICT) have been identified to play an important role in reducing the energy intensity and increasing the energy efficiency of the European Union (EU) economy. ICT will not only improve energy efficiency and thereby help combat climate change, they will also stimulate the development of a large cutting-edge market for ICT enabled energy-efficiency technologies and services that will foster the competitiveness of European industry and create new business opportunities. The aim of this paper is to show the status of ICT as a game changer in Energy Efficiency Management and how it can have a transformational role in achieving sustainable and energy efficient future. The paper also highlights the potential of ICT to significantly increase energy efficiency in the household sector throughout Europe. The FEL Energy Efficiency taskforce has assessed ICT improvement in the household sector and the drivers underpinning the trend, based on EU-27 data resources.

KEY FINDINGS

1. ICT can in fact play a major role in initiating and enabling the EU to reach its energy and environmental targets. Estimates vary from 50% to 125% of the total 20% greenhouse gas reduction required by 2020.

2. Legislation and regulatory pressure will change behaviour to prioritize energy efficiency. Key milestones will be the 20% energy efficiency target by 2020 (as compared against projected energy use in 2020) from the 2012 EU Energy Efficiency Directive and the proposed update to a 30% target for 2030. The Energy Performance of Buildings Directive (EPBD) is one specific example of targeted legislation.

3. The building sector is the largest single energy consumer in Europe, absorbing 40% of final energy. There is a huge potential for efficiency gains in this sector. About 75% of buildings are energy inefficient and, depending on the Member State, only 0.4-1.2% of the stock is renovated each year.

4. Buildings will play a critical role not only in energy efficiency but also in a wider changing energy grid system. Key elements of energy efficiency will be on building performance, smart meters and demand response. All of these will be enabled or enhanced by ICT due to the ability to monitor energy consumption and automate processes. As electric vehicle adoption increases, buildings will play a key role in energy usage for transportation.

5. Creating a market for innovative energy services will be important, incorporating investments in efficient appliances and hardware, and new business models for energy efficiency are enabled with intelligent consumption and production. Providing transparent, real time information with appropriate price signals enabled by smart metering is a near term objective that is being deployed across Europe.

6. Privacy and cybersecurity are areas where regulatory development will need further development as use cases develop. While data protection legislation for smart metering is relatively robust, it will need to be updated with new developments such as electric vehicles. Data protection needs more

clarification regarding which parties can use what data. As other devices in the home are connected behind the meter, these issues are likely to be more complex. There are multiple ways to achieve cybersecurity and ensure more resilience. Certification is one method, but it does not solve the whole problem. There is a need for a more systematic approach.

KEY RECOMMENDATIONS

The following recommendations will continue to improve the role of ICT in energy efficiency management1:

- Providing digestible information, guidelines, specific case studies and decision aids together with appropriate incentives to encourage employment of ICT solutions.
- Despite being difficult to convince customers of the added value of smart metering technology and the modernisation of the electricity grids (specially of metering data is only used for operational changes within utilities), the real advantages will have to be compared with the related costs that will be borne to customers (in monetary terms but also in terms of privacy and other non-monetary issues). Feedback tools and incentives are the correct driver to enable behavioural changes towards a more efficient use of energy.
- Development of standardized methods to measure and analyse performance and effectiveness of ICT products and services.
- Identification and development of new technologies to enable the interaction between clients and appliances, as well as to facilitate programmable self-consumption schemes.
- Creation of informative platforms (such as ENER.FYI2), easily accessible and usable by the common public to incentivize the behaviour shift towards higher energy efficiency.
- Monitoring of implementation and regular evaluation of policies and their impacts on utilization of ICT solutions for energy efficient management.
- Development of internationals or multinational standards and interoperability can help enhance cooperation between stakeholders across the world in order to create a competitive market which is manufacturer agnostic.
- Promote public-private partnerships to increase the utilization of ICT solutions to materialize the potential for improving energy efficiency in the residential sector

[1] Assessing the potential of ICT to increase energy efficiency and fight climate change - key technologies and prospects, available at http://www.itas.kit.edu/pub/v/2009/scwe09a.pdf
[2] Smart electricity grids and meters in the EU

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1. ENERGY EFFICIENCY IN EUROPE

A. TARGETS

Energy efficiency is an integral part of EU Climate and Energy targets set for the next decades.

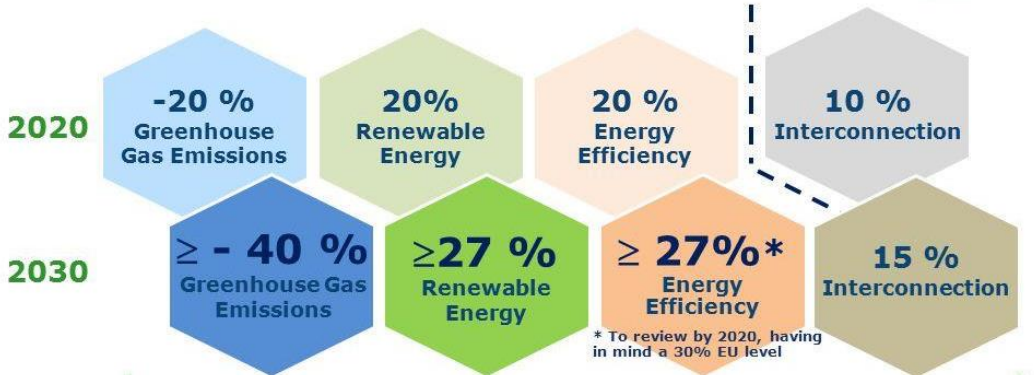

Figure 1: EU 2030 Framework for Climate and Energy

The 2012 EU Energy Efficiency Directive[3] establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, from production to final consumption.

On 30th November 2016, the European Commission proposed an update to the Energy Efficiency Directive in the published Clean Energy for All Europeans proposals, including a new 30% energy efficiency target for 2030, and measures to update the Directive to make sure the new target is met.

New national measures must ensure major energy savings for consumers and industry alike. For example:

- Energy distributors or retail energy sales companies must achieve 1.5% energy savings per year through the implementation of energy efficiency measures.
- EU countries can opt to achieve the same level of savings through other means, such as improving the efficiency of heating systems, installing double glazed windows or insulating roofs.
- Public sector in EU countries should purchase energy efficient buildings, products and services every year, governments in EU countries must carry out energy efficient renovations on at least 3% (by floor area) of the buildings they own and occupy energy consumers should be empowered to better manage consumption. This includes easy and free access to data on consumption through individual metering.
- Monitoring efficiency levels in new energy generation capacities.[4]

Given the trend of increasing energy consumption per household, justified by tendencies such as the use of greater number of appliances, energy efficiency is increasingly important to reduce household energy use.[5]

A smart ready-built environment takes advantage of the full potential of ICT and innovative systems to adapt its operation to the needs of the occupant, to improve its energy performance and to interact with the grid. Smart buildings can play a leading role in transforming the EU energy market, by transforming it into a more decentralised, renewable-based, interconnected and variable system that maximises efficiency and ensures that all resources are used in an optimal way.[4]

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[3] Directive 2012/27/EU of the European Parliament and the Council of 25 October 2012 on energy efficiency
[4] European Commission, Energy Efficiency Directive, 15.09.2017.
[5] Is Europe ready for the smart buildings revolution? Buildings Performance Institute Europe, 2017

B. GAINS IN THE HOUSEHOLD SECTOR

Energy conservation and environmental problems are of serious concern from scientific, socio-economic or cultural point of view. In order to reduce the impacts of energy consumption and carbon emissions to protect the environment, increasing efforts and research studies are ongoing. One of the ways to improve energy efficiency is to tap the huge potential for efficiency gains in the building sector which is the largest single energy consumer in Europe, absorbing 40% of final energy. About 75% of buildings are energy inefficient and, depending on the Member State, only 0.4-1.2% of the stock is renovated each year. Better performing buildings provide higher comfort levels and wellbeing for their occupants and improve health by reducing mortality and morbidity from a poor indoor climate.

Adequately heated and ventilated dwellings alleviate negative health impacts caused by dampness, particularly amongst vulnerable groups such as children and the elderly and those with pre-existing illnesses. The energy performance of buildings also has a major impact on the affordability of housing and energy poverty. Energy savings and efficiency improvement of the housing stock would enable many households to escape energy poverty.

According to the 2015 Report "Energy Efficiency Trends for households in the EU"[6], the energy efficiency gains averaged 25% from 2000 to 2014 in the EU. Nevertheless, these efficiency gains are unevenly distributed within member countries.

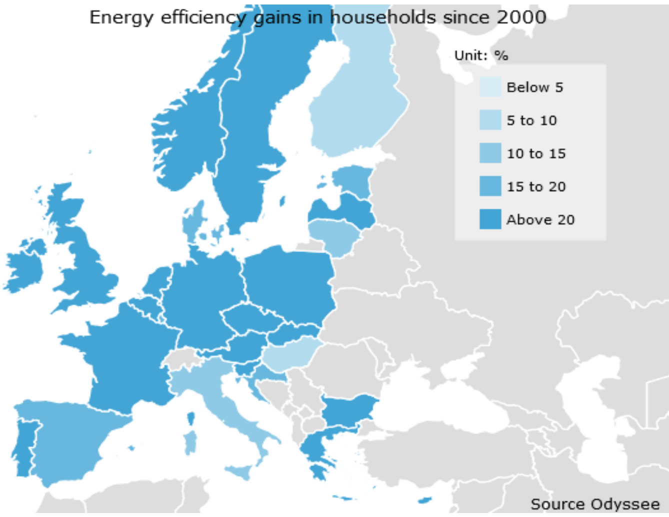

Figure 2: Household energy efficiency gains in the EU since 2000.Retrieved from http://www.indicators.odyssee-mure.eu/online-indicators.html

Final household energy consumption increased by 8% in the EU-27 during the period 2000-2014, at an annual average growth rate of 1.4%. Over the same period, final household *electricity* consumption increased faster, at an annual growth rate of 1.7%. Electricity consumption continued to increase at 2.8% a year from 2014 to 2016.

Space heating represented 59% of total household energy consumption in 2014 compared to 74% in 1990. The share of electricity for lighting and appliances increased from 10% to 19% in 2014 compared to 1990. Water heating remains stable at 17% in 2014.

[6] The Odyssee – Mure Project

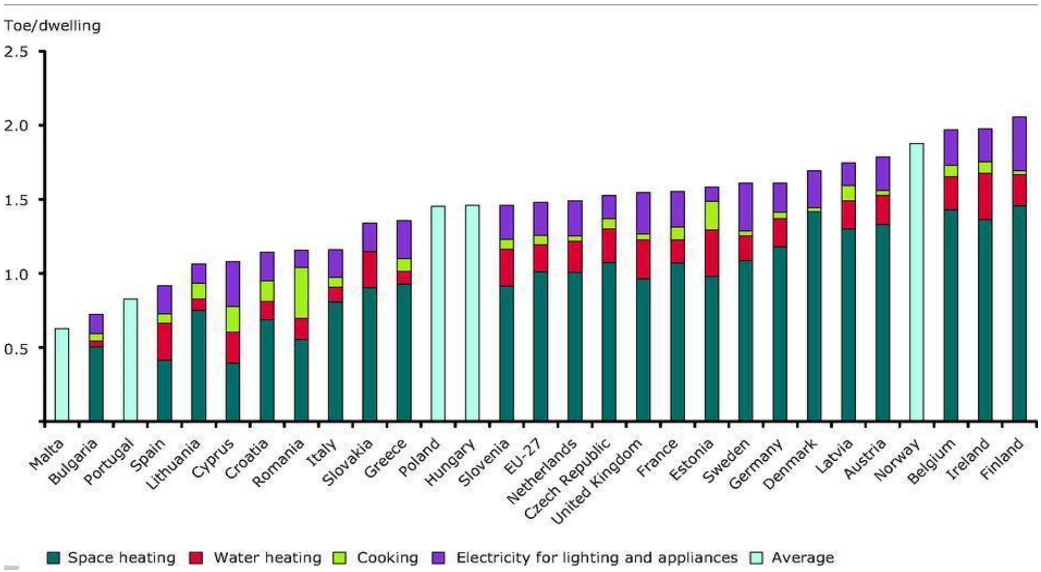

Figure 3: Differences in household energy use between EU member countries. Retrieved from http://www.indicators.odyssee-mure.eu/online-indicators.html

The observed progress in energy efficiency was due to better thermal performance of buildings and more efficient large electrical appliances (especially cooling and washing appliances) and heating systems (condensing boilers and heat pumps). However, part of this improvement was offset by increased number of electrical appliances, larger homes and the diffusion of central heating. The combined effect of these three factors led to an *increase* in the average consumption per dwelling by around 0.4% a year each, offsetting 60% of the energy efficiency improvement achieved through technological innovation.

The penetration of central heating was mainly significant in the southern European countries and in Ireland. Central heating (around 87% of EU dwellings in 2014), which includes district heating, block heating, individual boiler heating and electric heating, implies that all the rooms are well heated, as opposed to room heating, where generally a stove provides heat to the main room only. It is estimated that the replacement of single room heating by central heating increases the energy required for space heating by about 25 % on average.

2. THE ROLES OF ICT IN PROMOTING CONSUMPTION REDUCTION

While automation and energy-optimized systems will doubtless be essential for achieving savings, the adoption of these systems and user behaviour in general will have a major influence on the demand for energy. ICT can play an important role here because it can assist individuals in making more informed decisions and reward socially desirable behaviour. In fact, getting users into the loop can not only help to guide individuals when using energy consuming devices, but also encourage them to make favourable decisions.

ICT can in fact play a major role in initiating and enabling the EU to reach its energy and environmental targets. Estimates vary from 50% to 125% of the total 20% GHG reduction required by 2020[7].

However, in the absence of specific policy measures, to coordinate fragmented efforts and to incentivize action, this potential may not be realized in the timeframe of the EU 2020 targets[8].

On the one hand, ICT is discussed as a technology that enables an increase in energy efficiency, a reduction of energy consumption, as well as a reduction of GHG emissions in general. On the other hand, ICT are energy consumers themselves[9]. The main roles of ICT in the household sector which are joined by the common aim to promote efficient use of energy resources and contribute to reducing GHG emissions are explained in the following four sub-sections.

A. QUANTIFICATION

ICT can provide the quantitative basis on which energy efficient strategies can be devised, implemented and evaluated. ICT will play an essential role in facilitating the implementation of Energy Efficiency policy and in measuring its effectiveness.

EU Energy Efficiency Directive[10] requires that final customers for electricity, natural gas, district heating, district cooling and hot water should have a competitively priced individual meter that accurately reflects their energy consumption and provides information on time of their energy use.

The Directive on the Energy Performance of Buildings introduces a general framework for a methodology to calculate the energy performance of buildings. Such data, if readily accessible, will facilitate the identification of common inefficiencies, best practices and opportunities. The ICT sector can deliver tools that are vitally needed to collect process and manage the data, and present it in a standardised format.

B. INCREASING ENERGY EFFICIENCY WITH IMPROVED ENERGY MANAGEMENT AND AUTOMATION

ICT can enable energy efficiency improvements by reducing the amount of energy required to deliver a given product or service[2].

- By monitoring and directly managing energy consumption, ICT can enable efficiency improvements in major energy-using sectors. This capacity can be exploited to reduce energy consumption of buildings in the EU by up to 17%.

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[7] ICT for Energy Efficiency, DG-Information Society and Media, Ad-Hoc Advisory Group Report, Brussels, 2008
[8] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low carbon economy, 2009
[9] Assessing the potential of ICT to increase energy efficiency and fight climate change – key technologies and prospects, Science and technology options assessment, Directorate General for Internal Policies, 2009
[10] Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

- By delivering innovative technologies that better optimise energy use to actual need, e.g. building occupancy

ICT can reduce wasteful consumption of energy (e.g. Solid-state lighting is one clear example). Emerging solutions in computing such as thin Client (computers without hard disk drives rely mostly on central servers for data-processing activities), grid computing and virtualization technologies promise to reduce redundancies existing in today's computer-based systems.

C. EDUCATE AND CHANGE BEHAVIOUR

ICT allows information on energy consumption of every energy-consuming appliance in a home or a building to be provided in real-time, in a user-friendly way, thereby empowering citizens to take decisions that lead to energy savings.

In addition to information provided by ICT, it is important to educate the users on the ways they can use this information to identify the main consumers in their household as well as understand how exactly they can reduce their energy consumption.

D. PROVIDE NEW OPPORTUNITIES

According to European Commission Fact Sheet[11], consumers are at the centre of the Energy Union. All consumers across the EU will be entitled to generate electricity for either their own consumption, store it, share it, and consume it or to sell it back to the market. These changes will make it easier for households and businesses to better respond to price signals. Accelerating the deployment of smart meters and ensuring access to dynamic electricity price contracts which are essential to bridge the gap between consumers and the market.

According to a VaasaETT study[12] (2011) dynamic pricing can reduce electricity costs by up to 13% by enabling customers to take full advantage of low prices periods. ICT can provide the tools for more energy-efficient business models, working practices and lifestyles, such as e-Commerce, Tele-working and e-Government applications, and advanced collaboration technologies, ICT can reduce demand for energy and other material resources.

ICT can significantly assist in providing new opportunities such as: ICT based Neighbourhood Management Systems will allow peer-to-peer sharing of energy produced through renewable schemes.

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[11] Providing a fair deal for consumers, European Commission – Fact Sheet, Brussels, 2016
[12] The potential of smart meter enabled programs to increase and systems efficiency: a mass pilot comparison, VaasaETT, 2011

3. ENERGY GRID: SUPPLY AND DEMAND MANAGEMENT SYSTEM SUPPORTED BY ICT

ICT has a crucial role in managing supply and demand as well as integrating distributed energy sources into energy grid. In this section the focus will be smart meters and software tools: the elements providing support in energy consumption analysis and potential reduction in the single households and at a system level[11].

A. SMART METERING

Smart metering exploits the capacity of ICT to quantify energy consumption and provide appropriate information to consumers. If consumers can understand where inefficiencies come from, they can act to mitigate or eradicate them completely. In other words, smart metering will provide real-time as well as historical energy data to consumers as actionable intelligence at the right time to enable decision making.
Within Europe and indeed globally, smart metering is viewed as a key building block in the smart grid and the most cost-effective method for increasing end-consumer involvement and engagement[16].

The Commission's benchmarking report[13] expects that smart metering will lead to substantial cost savings in the longer run: the average consumer can reduce their energy costs by around 3%, while some types of consumers could reduce them by up to 10%. The 3% figure is consistent with the findings of the Energy Demand Research Project carried out by four energy suppliers in the UK, on behalf of the Office for Gas and Electricity Markets (see House of Commons Library Briefing). Trials and roll-outs of smart meters in the USA indicate that higher cost savings of 6-12% are possible (OECD Paper). But the evidence from Member States that have extensively deployed smart metering in the EU would suggest savings are likely to be more modest. Finland found the average savings to be only 1-2%, while Sweden gave a range of 1 - 3%. Other CBAs conducted by Member States predicted energy savings to be insignificant or as low as 1% per customer. Some therefore argue that smart meters should only be installed for consumers with high energy usage, reducing the costs of deployment while keeping the average savings higher. Germany, for example, intends to restrict mandatory smart metering to consumers with high energy usage or those living in new buildings.

Figure 4 shows deployment of Smart electricity meter by 2020 across Europe.

[13] Smart electricity grids and meters in the EU Member States, European Parliamentary Research Service, 2015

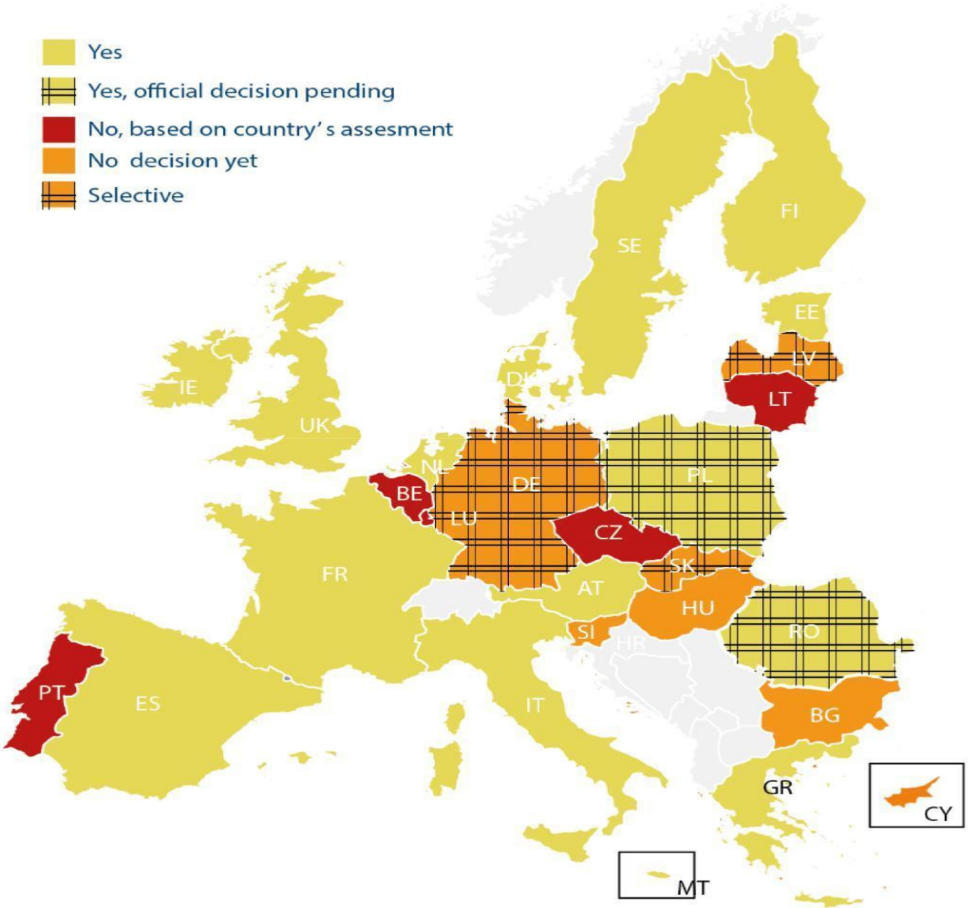

Figure 4: Deployment of smart electricity meters in EU Member States by 2020

Based on the national CBAs[14], the estimated cost of installing smart electricity meters varies widely between different Member States, from € 77 to €776 per customer. The Commission argues this is partly because of inconsistent methodologies in the national CBAs: Member States applied different discount rates and time horizons to assess the economic value of smart metering, while the expected lifetime of smart meters and the speed of implementing the roll-out schemes varied widely. The Commission concedes that differences between national energy transmission systems have some effect on the costs and benefits of smart metering, but remains sceptical about the results of some national CBAs, and is reflecting on ways to develop a more standardised methodology.

Smart metering in Latvia[15]

Though smart metering implementation is not a legal obligation in Latvia, Latvian electricity utility Sadales tiks AS approved and is implementing Smart Metering Program aimed to install smart meters to all the electricity consumers by 2022.

In 2013 after performing cost benefit analysis (CBA) a decision on installation of the smart meters was taken. CBA demonstrated positive economic return at a national level for limited roll out.

The following benefits related to energy efficiency were analyzed in CBA:

- ✓ Reduction of distribution losses by 0.5 % in the period of 10 years;
- ✓ Reduction of households electricity consumption by 5 % by 2024;
- ✓ Reduction of transport fuel consumption related to less need for physical inspections of the smart meters;
- ✓ Reduction of CO_2 emissions related to above-mentioned benefits.

According to CBA the following scenario was chosen for implementation:

[14] European Smart Metering Landscape Report "Utilities and Consumers", USmartConsumer Project, 2016

[15] Latvenergo AS and Sadales tikls AS data, 2013-2017

- ✓ Installation of smart meters to 23 % of consumers in 2015 - 2017;
- ✓ Consumers with annual consumption at least 2500 kWh;
- ✓ Overall electricity consumption reduction by 673 GWh and CO_2 emission reduction by 295 thous.t in 10 years.

After evaluating experience of the first stage a target of **covering 100% of consumption** with smart meters already in 2022 was set based on:

- ✓ Identified new efficiency opportunities in distribution system operator (DSO) operations;
- ✓ Technologies cost reduction;
- ✓ Potential energy efficiency achievements related to consumers opportunity to receive actual and detailed information on their energy consumption and change their consumption behaviour;
- ✓ Electricity market opening and the fact that smart metering provides an opportunity to offer consumers dynamic pricing.

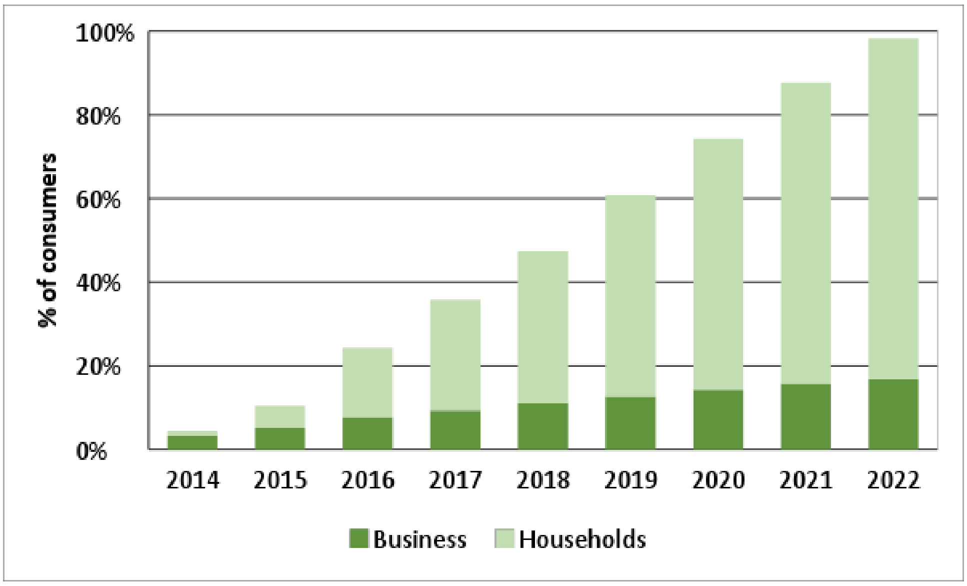

Figure 5: Installation of smart meters in Latvia - actual data by 2016 and approved plan 2022

Different countries throughout Europe are deploying smart meters or adapting and creating a specific regulatory framework to consider its adoption. Due to the regulatory push by the European Union's Third Energy Market Package, most EU Member States have implemented some form of legal framework for the installation of smart meters. It is commonly acknowledged that the functionalities of smart meters are crucial for the future deployment of the full potential of the meter-related services. Several front runner countries have already completed their smart meter rollout, or will be above 75% deployment in 2017, and provide services to consumers.

According to a report from the European Smart Metering Landscape Report (2016)[16], there is a range of feedback tools available in several EU countries, usually provided by energy utilities to consumers in different forms. The development within this market and the services that are offered to end customers are key to achieve actual energy savings. It is clear that without these feedback tools and customer oriented services based on frequent or real smart meter data, there is little or no benefits at all for end clients. The added value of the new metering technology and access to their own information is needed to strengthen customer's position and their active participation. Besides feedback tools that enable customers to regulate their energy consumption, a number of utilities are testing or already operating demand response and direct load control programmes. The main goal is to limit peak load that has to be provided to the market, defer investments on increasing lines and cables' capacities and promoting an active and positive participation of clients, providing also incentives.

[16] European Smart Metering Landscape Report, "Utilities and Consumers", USmrtConsumer Project, 2016

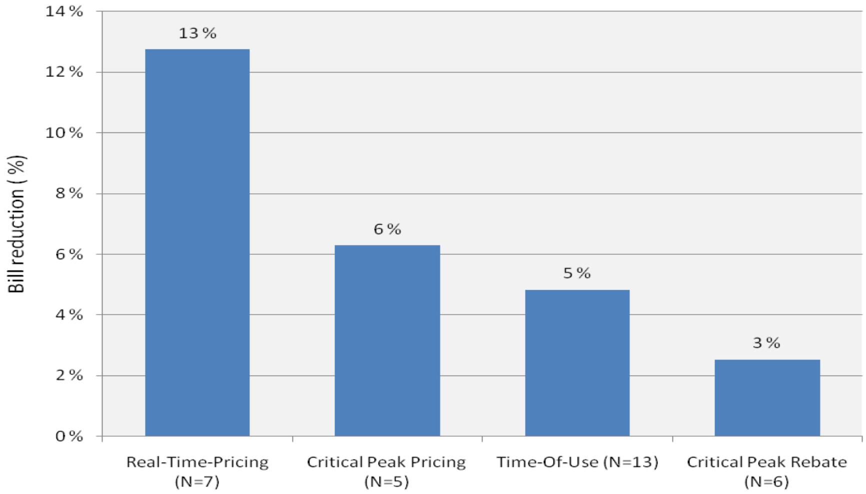

Figure 6: Dynamic pricing's potential for customer financial savings

B. SOFTWARE TOOLS

ICT can also address the complexities of measuring energy performance at a system level: software tools can provide information and data on how to better configure the various elements of a system so as to optimize its overall energy performance in a cost-effective manner. With the imperative need for energy and environmentally conscious design and planning, these software tools will spread from smaller to more complex systems, including urban areas and cities.

4. HOUSEHOLD ENERGY EFFICIENCY AND ICT

In this section, the report will focus first on energy efficiency in the Europe household sector in general, highlighting the importance of this issue.

Today, buildings account for 40% of Europe's total energy consumption. Around 75% of the building stock is energy inefficient. At the current 1% annual renovation rate it would take around a century to decarbonise the building stock to modern, low-carbon levels[17].

The European Commission and stakeholders have set out what ICT can do to improve the energy performance of buildings[18]. One of the ICT roles is being an instrument in achieving more efficient use of energy through simulation, modelling, analysis; monitoring and visualisation tools that are needed to facilitate a "whole building approach" to both design and operate buildings.

Life cycle of the building – the energy usage in different stages[19]

- ✓ Operational stage – **80 %**
- ✓ Impact of decisions made in the early design/renovation stage – **80 %** (of total life cycle energy usage)
- ✓ User behaviour and real-time control – **20 %**

The main reductions of energy consumption by using ICT can be achieved in the following energy consuming systems[20]:

- Heating, Ventilation, Air Conditioning (HVAC) systems: potential efficiency gains enabled by ICT control and monitoring capabilities (e.g. temperature monitoring and heating control, switchable vacuum insulated panels, switchable mirror film on windows, integrated cooling of ICT equipment, integrated control of clean room conditions). Space and water heating, as the main drivers of the energy efficiency improvement, can be leveraged by using ICT tools in order in order to automate and optimize their operation. ICT with a more controlled thermal performance can improve energy efficiency in building;
- Lighting systems: increased energy efficiency of lighting systems through ICT-based lighting technologies (e.g. LED lighting) and control systems (e.g. daylight sensors).

Case study – the opportunities for ICT based energy demand reduction in households[21]

The study is focused on 11 family households in the Midlands region of the UK which are all owner-occupied. The construction year of the buildings ranged from 1900 to 2000, with most houses being constructed in the 1950s and 1960s.
The reduction analysis presented suggests that HEMS/ICT could potentially provide savings similar to those likely to be achieved through expensive and disruptive retrofit measures and also have a higher impact on demand reduction than the replacement of appliances.
How HEMS/ICT might affect the implementation of the lifestyle reduction measures:

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17 Clean Energy For All Europeans, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, 2016

18 ICT for a Low Carbon Economy. Smart Buildings, Findings by the High-Level Advisory Group and the REEB Consortium, 2009

19 ICT applications for energy efficiency in buildings, Report from the KTH Centre for Sustainable Communications, 2011

20 Stallo C., De Sanctis M., Ruggieri M., Bisio I., Marchese M. ICT Applications in Green and Renewable Energy Sector. Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises, 2010

21 COSAR-JORDA, P., BUSWELL, R.A. and MITCHELL, V., 2015. Identifying the opportunities for ICT based energy demand reduction in family homes. EEDAL: Energy E-ciency in Domestic Appliances and Lighting, Lucerne-Horw, Switzerland, 26-28 August 2015

- ✓ **No standby loads** – remote Access to switching or implementing algorithms that learn behaviour using ICT;
- ✓ **Heating only when home** – autonomous control automation;
- ✓ **In use heating** – ICT enabled zonal control of rooms;
- ✓ **No heating over 15^0C** – automated response to key variables such as outdoor air temperature;
- ✓ **Ventilation** – monitoring of windows controlling or advising when they should be closed.

33% energy consumption reduction enabled by ICT

An average of **61% reduction** in current energy consumption is possible across the group, and of that **33%** might be enabled, or enhanced by the application of HEMS/ICT systems.

5. CONSUMERS: FOCUS OF THE MARKET

Rights to more informative, transparent and frequent bills, and to take part in demand response markets, give consumers the power to manage their energy consumption actively. Creating a market for innovative energy services where investments in efficient appliances and intelligent consumption and production pays off, should be the focus of EU Member States and private utilities when preparing for or facilitating the implementation of intelligent metering systems[22]. Submetering systems, feedback programs and various billing opportunities can enable consumers to analyse and reduce their energy consumption.

A. FEEDBACK PROGRAMS

Smart metering itself cannot change consumers' behaviour. Therefore, feedback programs are an important additional element which can provide necessary and comprehensive information on how, when and how much energy is being consumed in the household and allow consumer to be active in reducing energy consumption.

Case study – impact of feedback programs on energy consumption reduction

On a study funded by ESMIG and developed by VaasaETT16, a total of 74 feedback trials were analysed. The study covered total number of 290,000 households from five regions; Australia (3 trials), Canada (12 trials), Europe (35 trials), Japan (3 trials) and USA (21 trials). The majority of the pilots from Europe were conducted in Great Britain. Over 60% of the pilots took place within the last ten years and almost half after 2005.

Feedback pilots are designed to help consumers reduce their overall energy consumption, lowering distribution and supply costs. Feedback pilots overall results - energy conservation 5 – 9 %. Comparing different feedback pilots IHD resulted in highest energy savings.

The remaining channels for feedback, webpage and informative billing, produced almost equal consumption reduction levels (in some cases they were used together in combination). Quite possibly, the key advantage the IHD offers over the remaining forms of feedback is the almost real-time aspect, which enables participants to link their actions to their energy usage practically in real-time.

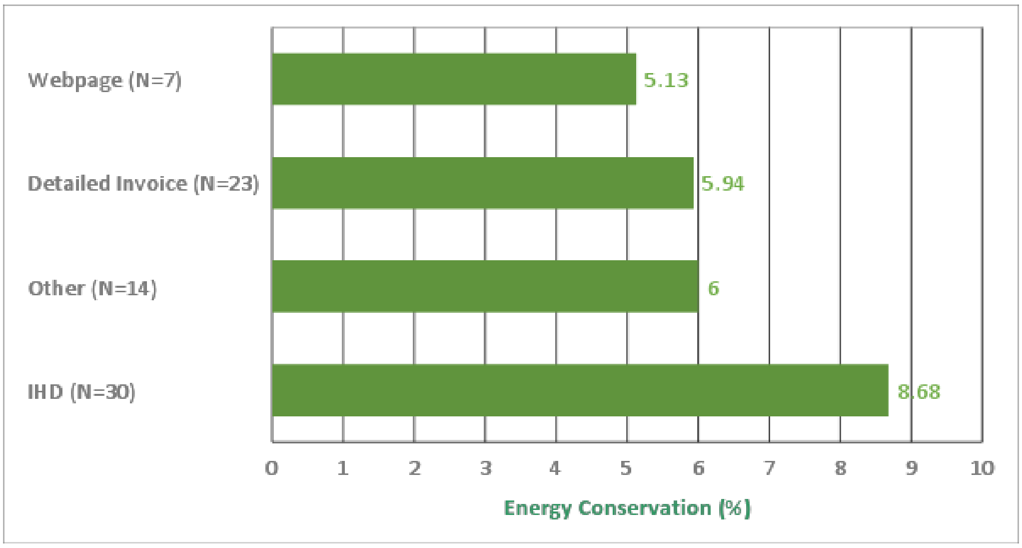

Figure 7: Energy reduction achieved through different customer feedback mechanisms

[22] Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy, Communication from the Commission to the European Parliament and the Council, 2014

In-house displays (IHD) are displays which hang on the wall or sit on a counter and register close to real time information about household electricity consumption. They also provide a variety of other data. For example, the display provided in the trials allows people to set daily budgets for how much they want to spend, informs them of their success, what the current price of electricity is and provides information on how much they have spent so far for specific month. The following IHD feedback programs are commonly available:

- IHDs provide households with real-time and historical information on their electricity usage and costs. Additional feedback content that are sometimes offered on the IHD are peer comparisons (showing the consumption rate of neighbours or consumers with similar conditions), and appliance specific consumption (breaking down the energy usage of individual appliances in the home).
- Ambient displays differ from IHDs as they do not provide specific consumption information, but rather signal to the customer messages about their general level of consumption and/or a change in electricity prices. Many ambient displays have the attributes of being attractive and intuitive which adds to their customer acceptance potential.
- Websites offer an alternative way to provide the consumer with information about their electricity consumption. California and Finland are just two examples of such markets where websites are used for energy consumption feedback. Websites are chosen as a means of providing feedback because they are relatively cheap. They rely on smart meters to collect the necessary consumption data and therefore the granularity of data provided to consumers depends largely on how often the meters are read or how often the information is transferred from the meter to the utility (or retailer).
- Informative billing is an example of indirect feedback. Most residential consumers in Europe now receive estimated bills which are adjusted for the time of year and the household's average consumption. They therefore do not accurately reflect the actual usage for a given month. The difference between the estimated average consumption and the actual usage is made up at the end of the billing period or when a resident changes electricity supplier. Informative billing will invoice for the actual consumption and provides either historical information comparing what the customer used this month to last month or to last year during the same period. The bill may also provide information on how much the household consumed in comparison to other dwellings of the same description. Unlike standard billing in which households receive their bill 4-6 times per year, informative bills can be sent as frequently as once per month.

Feedback pilots are designed to help consumers reduce their overall energy consumption, lowering distribution and supply costs. In comparison with the other feedback channels, IHD resulted in the highest energy savings (as illustrated in Figure 7). The remaining channels for feedback, webpage and informative billing, produced almost equal consumption reduction levels (in some cases they were used together in combination). Quite possibly, the key advantage the IHD offers over the remaining forms of feedback is the almost real-time aspect, which enables participants to link their actions to their energy usage practically in real-time.

B. NEW RELATIONSHIP BETWEEN UTILITIES AND CONSUMERS

The deployment and use of smart meters by electrical, gas and water utilities has clear advantages, which have been systematised by the Romanian think-tank Energy Policy Group[23] as:

- "Having a much better understanding of its customers' energy consumption habits, a supplier will be able to better tailor its products and services. For instance, a customer with a substantial energy demand in a relatively small apartment might be just the right client for energy efficient products – e.g. efficient white appliances and modern and efficient lightening. Moreover, suppliers could offer customized tariff plans, based on the energy demand profile: lower prices for off-peak consumption, better weekend offers for vacation homes and the like. This is advantageous to all parties: customers

[23] A. Covatariu, R. Dudau, "The little smart-meter that could", EPG, 2017

with smart and efficient household appliances; utility companies that can customize their energy products and services; appliance manufacturers, with a growing market for energy efficient products; and also the energy system as a whole, with improved efficiency indicators, lower import dependence, and lower environmental externalities, to mention only of the most obvious gains."

- "Protection of vulnerable consumers. As mentioned above, suppliers will be able to monitor the energy use of their customer base and make customized offers. In the example of a small flat with disproportionately large electricity consumption, demand spikes during cold spells allow the supplier to infer that this may be a vulnerable consumer using electric appliances to heat his home. Accordingly, the utility company will be able to offer social tariffs, specific services and financial terms for this category of customers, thus alleviating their vulnerable consumer situation."
- "A steady monitoring of consumption allows to immediately notice any anomaly or unusual demand spike, which may suggest an electricity theft. Moreover, based on historical consumption data, the supplier will be able, after dealing with those situations, to correctly reimburse the customers that have suffered unfair financial damage."

6. CONSTRAINTS AND BARRIERS FOR ICT

ICT have had several well-known and identified barriers and constraints to achieving their full potential. However, with the changing nature of commercial business models and underlying technologies, emerging factors will become more of an issue.

1. **Detailed awareness of energy consumption and usage**.
   Increased use of ICT and enablers such as smart meters are allowing greater visibility than ever before. However, there are still issues to achieving the full potential from these advancements.
    a. **Rate of deployment** – The deployment of existing technology such as smart meters is likely to be a constraining factor on energy efficiency. In the UK, for example, many household still rely on users providing manual readings every month. Smart metering allows more frequent, real time usage information.
    b. **Granularity of energy usage to appliance level** – Even with smart metering, energy usage information cannot be provided to the appliance level, which limits the actionable insight for user. As home automation increases and the Internet of Things further matures, it can be expected for these home appliance to provide a plethora of data that will improve the ability for energy efficient actions.

2. **Role of standards for 'Internet of Things' in households**. With the increasing proliferation of IoT enabled devices at home, the issue of standards will be more of an issue to ensure interoperability. There is a clear need for an open agnostic standard with collaboration from OEMs, utilities and regulators on matters such as communication protocols and cybersecurity.

3. **Role of the utility**: The utility has an intimate relationship with customers due to the data on energy usage and the trusted relationship. However, the commercial model would need to change to ensure that there are incentives for energy efficiency. Rather than selling purely on the basis of number of kWh consumed, it can be expected to move to an 'energy as a service' subscription model, where energy efficiency is enabled by distributed generation, increased home automation and data analytics. This commercial model will increasingly be expected for utilities enabling widespread adoption of distributed solar and batteries. Without changing this model, users will self-generate most of their power (60-80%) and retain access to the grid for the remaining time. This partial defection from the grid, remains a serious concern for utilities and is why there is such a high degree of confidence in the commercial model changing. Regulation would need to recognize these changes and allow commercial innovation structures. Distributed generation at the point of use would increase energy efficiency due to it eliminating losses with transmission & distribution.

4. Given the utility's customer intimacy and the incumbent advantage of the existing customer relationships, utilities can build an ecosystem of capabilities to enhance energy usage and efficiency. These include partnering with technology providers (e.g. smart home and thermostat providers), installers (e.g. for solar PV) and software companies (e.g. standardizing processes with digital tools, e.g. estimating solar PV requirements from Google Maps image of rooftops). **Performance based Incentives for change**; this would mean moving to a true market enabled pricing for electricity rather than a regulatory based one. The differential in market pricing throughout the day would create a price signal to encourage change in behaviour. However, commercial users rather than residential users would have a greater incentive for efficiency mechanisms such as demand response. This is because the electricity consumption and greater differential in pricing provides greater rewards for changing behaviour and usage.

5. **EU legislation.** Appropriate legislation can provide better investment environment and serve as one of the tools of promoting ICT as well as solving the barriers of more intensive ICT integration. According to BPIE conclusions[4] despite various good examples and some progressive national legislative measures paving the way for a smarter building stock, current EU legislation lacks sufficiently ambitious drivers to push the development of smart buildings. However, the revision of EU legislation on the energy performance of buildings, energy efficiency, the electricity market, and renewable energy is a good opportunity to make significant steps forward.

7. REGULATORY ASPECTS OF ICT

This section focuses on three areas of regulatory interest on the subject of ICT use for energy efficiency:

- The Energy Performance of Buildings Directive (EPBD)
- Data privacy from the use of smart meters on energy usage and billing
- Cybersecurity: Ensuring protection from external threats as ICT is embedded into building energy controls

A. ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE

The Energy Performance of Buildings Directive (EPBD)[24] has the objective supporting the increase of building renovation depth and rates is supported by other EU legislation; inter alia, by the Energy Efficiency Directive and by the European Structural Investment Funds.

EU Roadmap for moving towards a competitive low-carbon economy in 2050

GHG Reduction vs. 1990	2005	2030	2050
Total	-7%	-40 to -44%	-79 to -82%
Power	-7%	-54 to -68%	-93 to -99%
Industry	-20%	-34 to -40%	-83 to -87%
Transport	30%	+20 to -9%	-54 to -67%
Residential and Services	-12%	-37 to -53%	-88 to-91%
Agriculture	-20%	-36 to -37%	-42 to -49%
Other non-GHG emissions	-30%	-72 to -73%	-70 to -78%

High sectorial targets for the buildings sector!

BPIE

Figure 8: Evolution of the expected GHG reduction per sector (BPIE - Buildings modernisation strategy: roadmap 2050)

The obligations arising from the EPBD to set and ensure minimum energy performance requirements for building elements, on one hand, and the EU legislation on ecodesign and energy labelling energy efficiency of products, on the other hand, were found coherent to achieve the 40% reduction target for greenhouse gas emissions in 2030. These targets are established in line with the cost-effective pathway described in the 2050 Roadmaps where the non-ETS sectors (buildings, transport and agriculture) need to cut emissions by 30% (compared to 2005). The improvement of the energy performance of buildings is key to achieve the 2050 target of at least 80-95% reduction requires that the residential and tertiary sectors together reduce their CO_2 reductions by 88 to 91% (compared to 1990 levels).

According to BPIE[4] there are four key indicators describing the ability of further wider development of smart buildings: building performance, smart meters, demand response and renewable energy sources. Significant progress in the mentioned areas is not achievable without ICT which is the basis of smart technologies.

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[24] DIRECTIVE 2010/31/EU, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0031&from=EN

Under the existing Energy Performance of Buildings Directive (EPBD):

- Energy performance certificates are to be included in all advertisements for the sale or rental of buildings
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect
- All new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018)

The high level of energy consumption and GHG emissions in buildings in Europe makes this is an obvious sector to target in order to determine the potential and improve energy performance. While there has already been significant effort to improve energy performance in buildings, considerable potential still remains, as was noted by the European Commission's Communication on the proposal for the recast of the EPBD.

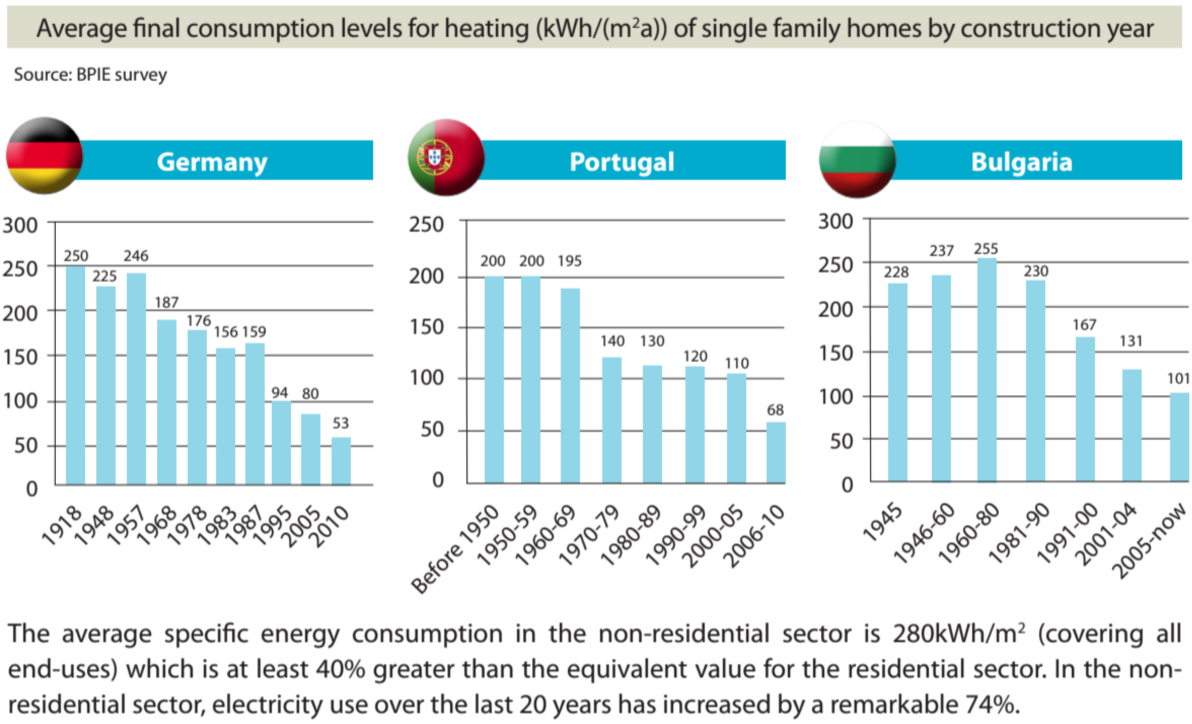

Figure 9: Average final consumption for heating of domestic dwellings

B. DATA PRIVACY

Much work on this subject has already been explored by the EU commission and the affiliated Smart Grid Taskforce Expert Group published their recommendations on Privacy, Data Protection and Cyber security in the Smart Grid Environment on March 2014.

The 'Smart Grid' is defined by the Expert Group as "an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety."

Data is collected from everywhere in a Smart Grid infrastructure, which includes consumers' homes and electric vehicles. Smart metering systems are therefore included in this definition of Smart Grid.

The use of smart grids with smart metering systems, creates new risks for data subjects with potential impact in different areas (e.g. profiling for behavioural advertisement, law enforcement access, and household security) that were previously not present in the energy sector. However, these are typical and already present in other sectors (telecoms, e-commerce and Web 2.0).

Smart metering is also one of the first applications that can be included in the premise of 'the Internet of Things'. The risks posed by the collection and availability of detailed energy consumption data are likely to increase considering the increasing availability of data from other sources, such as geo-location data, data available through tracking and profiling on the internet and video surveillance systems with which smart metering data can be combined.

One of the core deliverables is for all participants in the Smart Grid environment (TSO, DSO, Energy generators, Energy service companies) to complete a Data Protection Impact assessment (DPIA).

The DPIA report is intended so that a Data Protection Authority (DPA) can monitor and oversee the processing of personal data, with strict respect for freedoms and guarantees enshrined in the EU regulatory framework. This balances the necessity to feed granular information to the smart grid with the legal obligation to protect consumers' personal data. Specifically, non-exhaustive examples of personal data would include both billing related and energy usage information:

- Billing related:
  - Household and organisations consumption;
  - Consumer registration data: names and addresses of data subjects, etc.
  - Billing data and consumer's payment method
- Energy usage information:
  - Usage data (energy consumption, demand information and time stamps), as these provide insight in the daily life of the data subject;
  - Amount of energy and power provided to grid (energy production), as they provide insight in the amount of available energy resources of the data subject;
  - Locally produced weather forecast – consumption prediction / forecasts;
  - Demand forecast of building, campus and organisation;
  - Technical data (tamper alerts), as these might change how the data subject is approached;
  - Data and function of individual consumers / loads;
  - Facility operations profile data (e.g. hours of use, how many occupants at what time and type of occupants);
  - Frequency of transmitting data (if bound to certain thresholds), as these might provide insight in the daily life of the data subject;

The following examples show possible scenarios for accessing personal data and are framed within the EU Smart Grid Taskforce:

<u>Illustrative example 1</u>

The utility makes a website available that allows the consumers to access their consumption data online. The consumers have to subscribe to this service and give their consent. The personal data – by definition – has to be transmitted from the smart meter to the central systems in a secure way in order to mitigate to a satisfactory level the risk of a possible breach.

<u>Illustrative example 2</u>

Smart meters register consumption data every 15 minutes (configurable). The data concentrator collects this 15 minutes reading once a day and sends it back to the backend systems. These readings might be considered private information in such a way that they can be illegitimately used to assess sensitive information regarding the behaviour of each client.

<u>Illustrative example 3</u>

Implementing Smart Charging of Electric Vehicles, calls for an interaction and corresponding information exchange between DSOs, Charge Spots, EVs, EV drivers and new market participants. To the latter, one could count a Charge Service Provider (CSP) which deals with fulfilling the charge wish of the EV driver and a Charge Spot Operator (CSO), which deals with the operation of the Charge Spots. Without measures, one could derive the charge locations of an EV throughout time. If this could be coupled to an EV driver, it would then become personal data as it reveals the whereabouts of the latter.

C. CYBERSECURITY

There has been much attention on the subject of cybersecurity in the energy sector. In an EU conference in Germany on the subject ("High Level Roundtable on Main Challenges for Cybersecurity in the Energy System", March 2017), the following issues were identified:

1. The customer is the owner of the data and it must be clear who collects the data. While, the ongoing procedures (see DPIA) are good, data protection needs more clarification regarding which parties can use what data.
2. Smart Meters themselves will not be the main problem but rather other devices in the home that are connected behind the meter.
    a. Major question is of growth of these decentralised devices behind the meter
3. Certification is one way to ensure more resilience, but it does not solve the whole problem. There is a desire to have a harmonised approach.
    a. Twelve Member States are using cyber security certification mechanisms presently and want to avoid a fragmented market.
4. Importance of having a cybersecurity network code, which would be joint for DSOs and TSOs. The cybersecurity network code should fit all IoT devices which are critical for energy and which would clearly define the requirement from physical energy security point of view.
5. There is a challenge of sharing of locally produced electricity amongst neighbours (despite eventual local/national regulatory obstacles). Cloud system could be a solution, because they are better than the existing systems.

8. CONCLUSION

This paper discussed the role of ICT in household energy efficiency. During 2000-2014, energy efficiency in the household sector has increased by 28% in EU-27 Countries at an annual average rate of 3.4% per year. In 2013, energy savings reached 200 Mtoe for the EU as a whole in comparison to 2000; this represents the equivalent of 17% of the final energy consumption and over the total energy consumption of a whole country like the UK in 2016 or the equivalent of oil products consumption of a country like India. This increase is mainly driven by application of ICT diffusion for more efficient building, space heating technologies and electrical appliances. Over the same period, energy savings for households is over 70 Mtoe.

Furthermore, there is high potential for further improvement through low cost ICT applications, driven by large corporations.

9. ANNEX I: ENERGY EFFICIENCY POTENTIAL

The economical realizable energy efficiency saving potential in EU-27 is approximately 410TWh (both electrical and thermal), which represents 2733TWh of the total energy use in the region illustrates energy efficiency saving potential in EU-27 with economical and realizable potential in electrical and thermal energy demands.

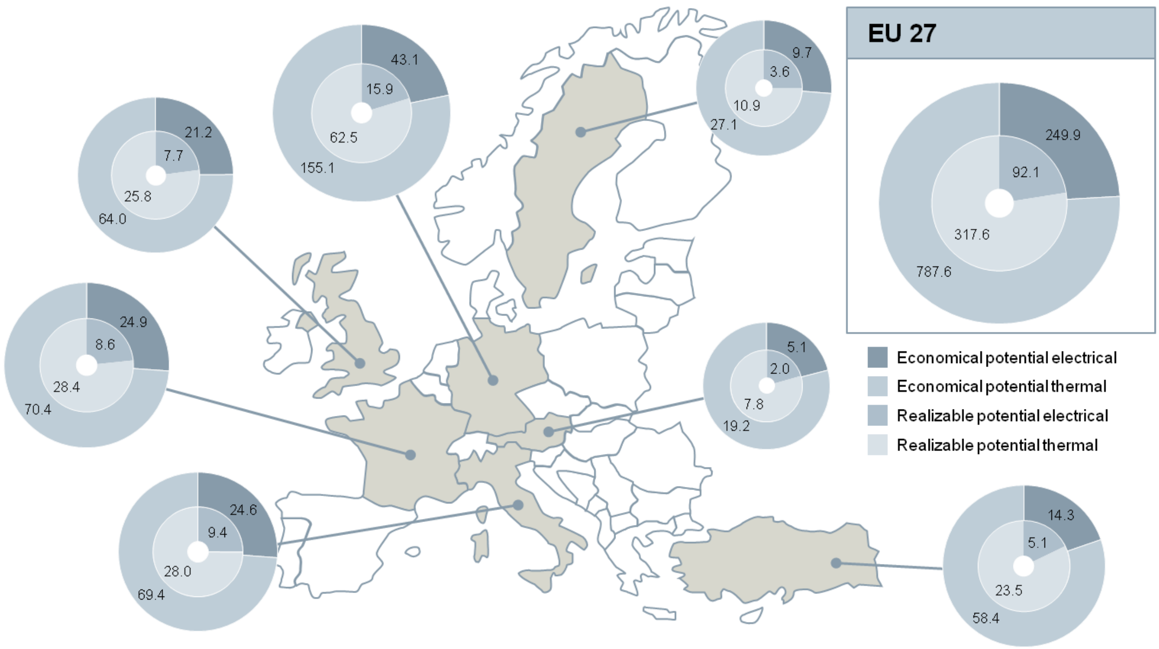

Figure 10: Energy Efficiency saving potential across Europe. Retrieved from Energy efficiency technologies: overview report, World Energy Council, 2013

The diagram in figure 11 illustrates the Technical, Economical, Realizable and Realistic potential of new technology applications, such as ICT, in improving energy efficiency. Each listed potential summarised a unique area in focus of study for the application[25]. The publication defines the terms as follows:

- “Technical potential” includes the utilization of the best available energy efficiency technologies without taking in consideration economic constraints
- “Economic potential” covers the employment of energy efficiency technologies when the use of the technology is economical and the life cycle of the technology is considered.
- “Realizable potential” considers that energy efficiency technologies are usually applied when a certain payback time is fulfilled.
- “Realistic potential” involves some other barriers like political, financial, adequate timing etc.

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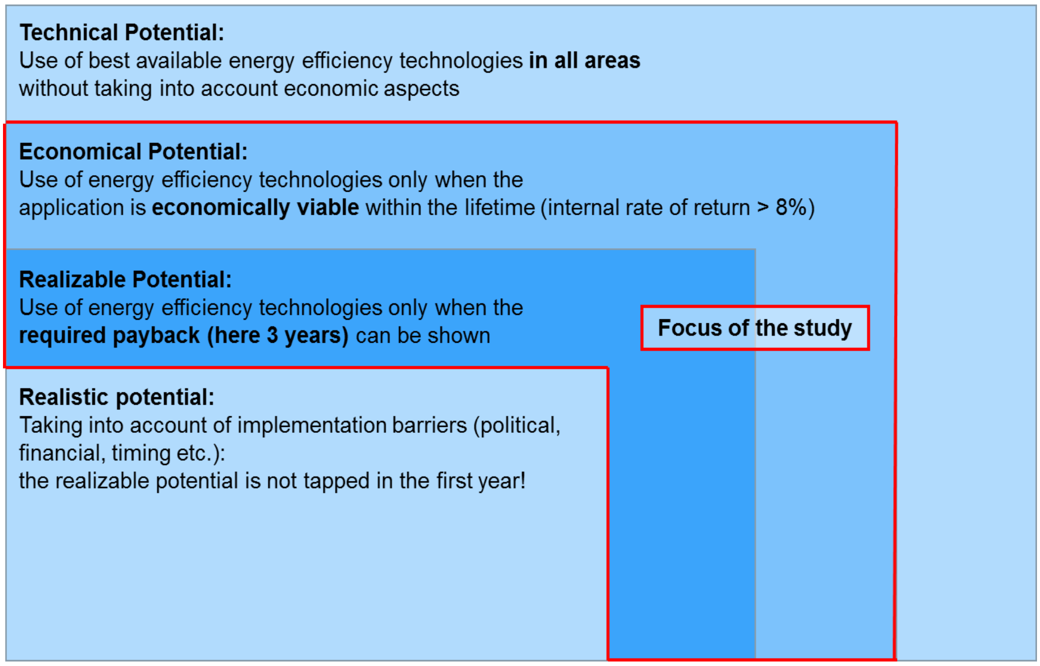


Figure 11: Definition of potential with the focus of the assessment on economic and realizable potential of new technology application, including ITC solutions. Retrieved from https://www.worldenergy.org/wp-content/uploads/2014/03/EE-Technologies-ANNEX-I-Energy-Efficiency-Potentials-and-Barriers-for-Realization.pdf

An example for energy saving potential calculation is presented in figure 12:

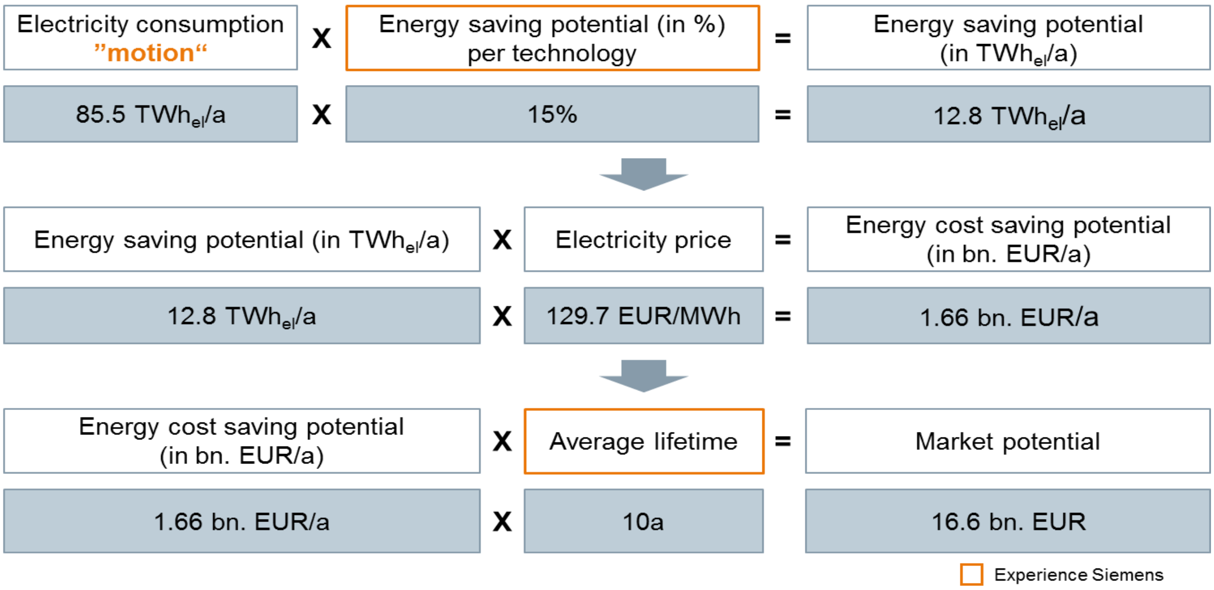
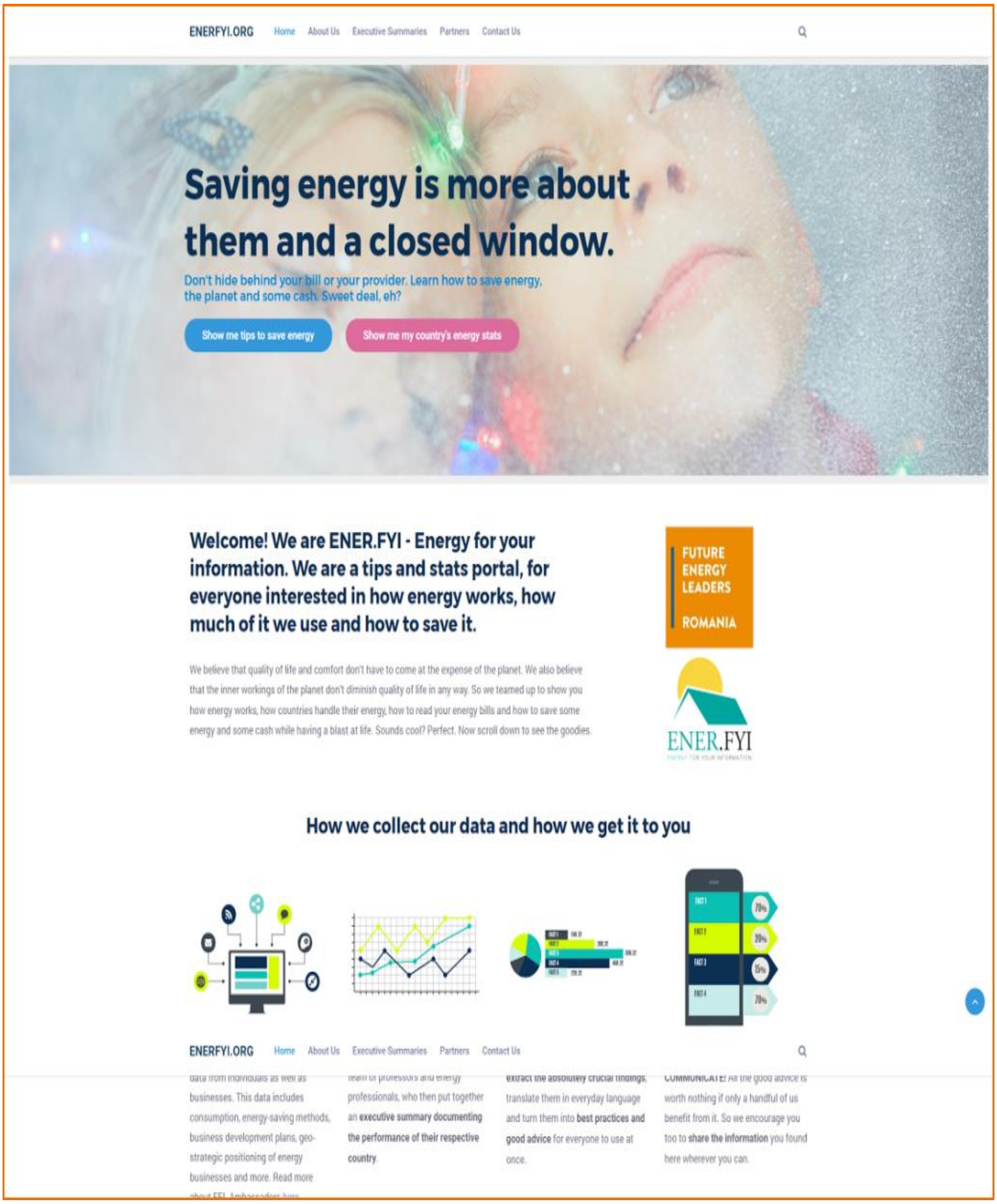


Figure 12: Example for energy saving realizable potential calculation. Retrieved from www.worldenergy.org/wp-content/uploads/2014/03/EE-Technologies-ANNEX-I-Energy-Efficiency-Potentials-and-Barriers-for-Realization.pdf

10. ANNEX II: WHAT IS ENER.FYI

Energy **F**or **Y**our **I**nformation - a tips and stats portal, for everyone interested in energy, how it works, how much of it we use and how to save it.

Our team welcomed professors, energy professionals and students, in the hope of creating a climate of understanding and an environment where innovation and respect for our world are paramount.



WHO COULD BE INTERESTED?

End users, energy professionals, entrepreneurs, political parties, communication agencies.

PROJECT MISSION

Make info easily accessible, help people save energy in all its shapes, communicate interest and get people to turn speech into action.

When you know the reason, you can fix the problem. We believe the most harm to our world comes from a lack of thorough understanding. We set out to explain how energy works and how to read your bills, so that most people can minimize any damage done to the environment unknowingly.

PROJECT VISION

Because people now have the tools to understand the issue and the numbers, energy is no longer scary or untouchable and we can help project a hands-on approach to actually save some of it.

HOW WE PLAN TO MAKE IT HAPPEN

LOAD IT WITH DATA

All Ambassadors in our taskforce are already helping to submit up-to-date data on their countries' energy stats

GET MEDIA PARTNERSHIPS

To help disseminate info about both the data and the initiative. There already is a communication agency partnering up with us. We have sparked interest already.

GET PROFESSIONAL PARTNERSHIPS

To actively involve companies in all areas join the effort - by submitting data of their own, by helping build areas of the project where our expertise is insufficient, by communicating and saving energy themselves.

TAKE AWAYS FROM ENER.FYI

WE:

1. gather up-to-date, shareable energy data;
2. translate it into plain language;
3. give tips and stats to anyone interested;
4. help people save energy the simple way;
5. teach them how to optimize energy;
6. Are international. No country is forgotten.

11. ANNEX III: WORLD ENERGY COUNCIL – FEL 100 - ENERGY EFFICIENCY TASKFORCE

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