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Impacts of Energy Efficiency on Electricity Distribution Business

Methodology and Analysis

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Abstract

Energy efficiency has recently become a hot topic in Europe. Energy regulations and roadmaps for Smart Grid development for member countries are more and more built around increased energy efficiency requirements and $C0_2$ emissions awareness rather than levels of automation and other technical requirements. Electricity grid is going to become more user-friendly in the coming years and the entire black-box paradigm for end-users is going to be shifted towards energy-aware consumption.

Energy efficiency is a key solution to important issues that global community is facing nowadays. It contributes to slowing down the climate change, ensures security of supply, and provides affordable access to energy for all customers. Both European parliament and member-state governments have taken up energy efficiency on their radar as it has proved itself to be one of the most cost-effective ways to solve energy-related challenges. However, it should not be considered as a panacea or a 'go-to' solution for all grid related problems.

This research report concentrates on demand-side energy efficiency (EE) activities, rather than energy efficiency of supply-side. It covers global trends in EE and outlines the main risks, drivers, trends, targets and barriers for DSOs and electricity retailers. Additionally, potential changes in business for utilities in smart grid environment are covered.

Main techniques for energy efficiency programs implementation have been identified and reviewed: revenue decoupling, and white certificates / investment obligations. Methods of interaction with end-customers and potential domestic electric saving have been listed. A methodology, development cycle, and energy efficiency program design have been developed for a DSO company or an electricity retailer. Moreover, key components, enabling technologies, and KPIs for energy efficiency are listed in this report.

This report contains 50 pages, 24 figures, 12 tables.
Tags: *energy efficiency, energy savings, EE, DR, demand response, smart grids, smart meters, RES, business, incentives, drivers, DSO, electricity retailer*.

1 Introduction to Demand-Side Energy Efficiency

As a result of increased dependency on energy imports, concerns about climate change, and concerns about fossil fuels and nuclear power safety, European countries are facing an energy challenge. In these times, the fact that at least fifth of the energy that used in Europe goes to waste only due to inefficiency cannot be tolerated anymore. Therefore, applying energy efficiency techniques starts to look more and more attractive for all energy market players.

Energy efficiency (EE) is one of the easiest, fastest, cheapest and least risk-taking tools to address growing energy demand. Both large businesses and end-customers can harvest the benefits of energy efficiency and reduce their energy bills. The savings are available through changes in behaviour and equipment and represent sound returns on investment. Moreover, EE contributes to the environmental benefits and is widely recognized as the low-cost approach to reduce greenhouse gas emissions.

European Commission has defined Energy Efficiency as a ratio between an output of performance service, goods, or energy, and an input of energy. Increasing energy efficiency will help to achieve wider goals, such as eco-efficiency and sustainable development. This is illustrated on a figure below:

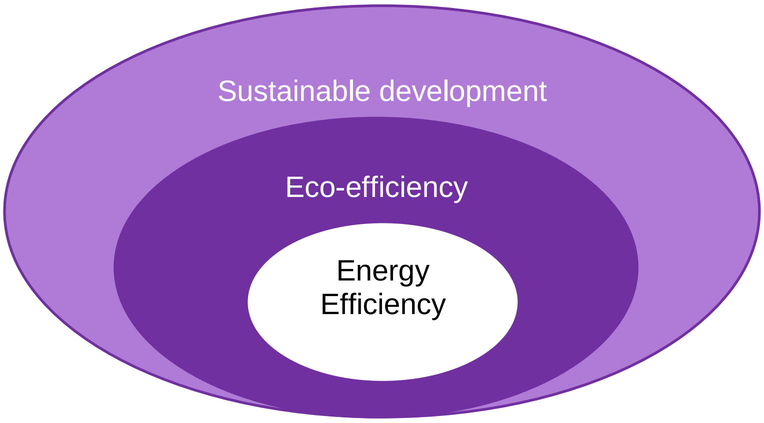


Figure 1 Energy efficiency and sustainable development [14]

More detailed definition is given in [15]:

> *Energy efficiency involves technology measures that produce the same or better levels of energy services (e.g., light, space conditioning, motor drive power, etc.) using less energy. The technologies that comprise efficiency measures are generally long-lasting and save energy across all times when the end-use equipment is in operation. Depending on the time of equipment use, energy efficiency measures can also produce significant reductions in peak demand.*

It is necessary to note, that 'energy efficiency' means using less energy inputs while maintaining an equivalent level of economic activity or service; 'energy saving' is a broader concept that also includes reduction of consumption through behavior change or decreased economic activity. However, in practice the two are quite difficult to distinguish and therefore these terms are often used interchangeably [6].

Investing in energy efficiency and technologies supporting it can contribute to sustainable development of electricity distribution business as well as increase the security of supply. Additionally, it provides an opportunity to create new jobs and increase competitiveness.

It is estimated that EU will not meet its 2050 carbon-neutrality target without implementing effective energy efficiency policies [1]. That is why it is important to study the possible ways of implementing EE measures and set targets carefully. Targets in energy sector have different natures: absolute targets, relative targets, deviation from business-as-usual, etc. It is important to carefully assess interaction between various targets in order to avoid overlapping and interfering.

Currently, there are a lot of EE policies and legal framework on the EU level. In particular, in 2006 the European Commission presented a plan for energy efficiency. This action plan outlines the framework to realize 20% savings potential over EU's annual primary energy consumption by 2020.

In order to realize the 20% saving potential, serious changes are required to change both business scenarios and customer consumption behavior. It is important to encourage European citizens to use less energy while making sure that they still enjoy the same lifestyle as they did before.

It is estimated [4] that the biggest cost-effective energy saving potential lies in residential (households) and commercial buildings sector. The full savings potential is estimated to be around 30% of their energy use. More information is given in the table below:

Table 1 Estimated energy saving potential in end-use sectors [4]

Sector	Energy consumption 2005 (Mtoe)	Energy consumption 2020 (business-as-usual) (Mtoe)	Energy saving potential 2020 (Mtoe)	Energy saving potential 2020 (%)
Households	280	338	91	27
Commercial buildings	157	211	63	30
Transport	332	405	105	26
Manufacturing industry	297	382	95	25

In future, smart grids will intelligently integrate distributed generation, RES, and EVs. This, in turn, will result in a reliable infrastructure for demand side participation by customers and higher overall system efficiency.

Energy consumption has grown significantly over the past few decades and new ways of organizing it must be developed. Even though EE programs have been introduced as early as 1970s, there remains a large potential of untapped energy savings.

According to Odyssee database, Finland tops the kWh per dwelling rating in Europe with about 7000 kWh/dwelling in 2006. The estimated saving potential of end-customers in EU-25 residential households is estimated at 27% of the total 2020 target savings. That means that promoting EE and energy saving for residential customers while keeping them well-informed about available EE programs is quite important [3].

Benefits of EE

- If energy makes up 20% of the costs for running a business, then 20% energy savings reflect a 5% increase in overall profit.
- Differentiation among rivals. In terms of marketing, proactive actions of a DSO/retailer to brand itself as a company supporting EE can give a competitive advantage.
- Less CO_2 emissions and contribution against climate change
- Decreased dependency on oil prices and oil/gas imports from non-EU countries
- Lower energy bills for households, industry, and service sectors
- New jobs from the introduction of new services that promote EE
- Improved reputation in society through environmental protection

Essentially, energy efficiency implies intelligent use of energy, which is often but not necessarily linked to energy savings.

Over time, EE can become a profitable business itself providing a marketplace for various energy services and new opportunities. In order for this to happen, both DSOs and electricity retailers must take actions to promote EE services and implementing EE practices in their business. However, the question of whether the participation in EE should be voluntary or obligatory/contract still remains open and potential benefits of both alternatives have to be evaluated.

In order for EE to really bloom into masses, easy access to all EE information is required. Energy efficiency policies should not only promote technical changes, but also changes in behaviour, consumption patterns and selection of an energy source.

It is clear that EE policies vary in different EU countries. Therefore, they must be coordinated (carbon reduction, promotion of RES and EE, etc.) on the EU level in order to achieve the best results. Integration of push-pull strategies must be assessed. A recent study by EURELECTRIC (*Power Choices*) has shown that the EU will not meet the 2050 carbon-neutrality target without implementing effective EE programs and policies.

The business of DSOs is a 'natural monopoly'. Therefore they have fewer incentives to develop EE services. However, regulations from government and obligations to invest into EE can help fix this issue. Various methods for EE regulation exist (e.g. white certificates, investment obligation, revenue decoupling, etc.). The application and analysis of these methods are described in this report.

Unlike DSOs, electricity retailers have much more incentives to introduce EE services as they have a lot of competition in their business area. Therefore, it is viable for their business to introduce new products and services to differentiate themselves from competitors and satisfy customers. However, simply introducing new EE services is not going to work for electricity retailers. They will need to incentivize their customers in order to engage them into participation in EE programs (e.g. demand response, time shift of loads, etc.). This, in turn, requires increased bill transparency and clear tariff structure for all types of customers. Additionally, new ways of informing and educating customers about available EE solutions, as well as promoting change in behavior are required.

Essentially, smart meters can help end-customers manage their electricity consumption better, allowing them to react and adjust consumption based on received information (e.g. price signals). They will also facilitate understanding of electricity bill as all the information would be transparent.
However, smart meters and home displays alone are not going to have a consistent energy saving impact and other actions of customer involvement are required. Recent studies (EURELECTRIC survey, 2011) have shown that information presented in money (euro and cents) is likely to have more impact on customer's behaviour than kWh or tones of carbon.

In terms of legislation, new rules for distributed generation (DG) billing/tariffs are required to support EE as the number of small-scale DG is only going to increase. Additionally, in order for EE schemes to take full effect, the customers should be exposed to the real price of electricity. This is not always the case due to the fact that regulators often overprotect customers by fixing price levels which do not always correspond to the real price for the electricity production.

Long-term economic benefits that come from EE are not always clear for the consumers when they are shopping for new appliances (e.g. dishwasher or boiler). Therefore, clear EE standards, labeling and performance ratings are required in order to provide more information for consumers and make sure that they take into account EE when buying household equipment.

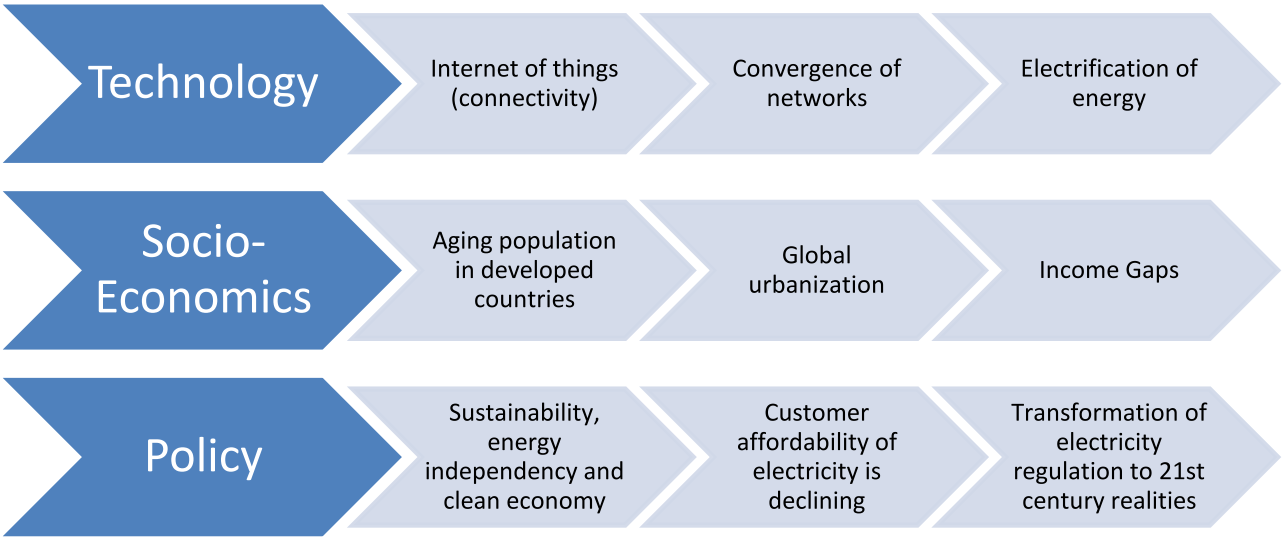
Why Energy Efficiency?

Energy Efficiency helps consumers know more about their energy consumption and allows them to make decisions based on that information. Customers can reduce their energy bills and other costs by knowing how/when/where to do it. However, there should be enough incentives for them to do so. That means that, in general, companies and consumers tend to invest in EE technologies that provide them with the same, or higher, level of functionality but with lower energy intensity.

1.1 Global Trends

The following global trends that affect energy sector and support energy efficiency can be identified:

Table 2 Global trends in energy sector [24]



1.2 Types of Energy Efficiency Programs

Possible types of EE programs are given in the table below [16]:

Table 3Types of EE programs

Type	Description
Rebates	Customers who install energy efficient appliances at home (e.g. lighting, motors, heating, ventilation, air-conditioning, building insulation, etc.)
Financing	Financing designed to offset upfront cost of energy efficiency measures.
Trade-ally incentives	These incentives are paid to businesses that sell or install energy efficiency measures.
Commissioning services	These services ensure that energy efficiency systems of buildings are operated and maintained according to standards.
Education	Educating customers and building operating staff about trades and benefits of energy efficiency.
Appliance standards	Appliance standards help to incorporate EE design and embedded demand response capabilities in household appliances.
Construction standards	Creating construction, design, and operational standards that enable EE or DR capabilities.

Proposed products for energy performance standards [4]:

- Boilers
- Water heaters
- Computers
- TVs
- Standby modes
- Chargers
- Office and street lighting
- Air conditioners
- Electric motors
- Fridges and freezers
- Washing machines

1.3 Reasons for Energy Efficiency Measures

Energy efficiency provides an opportunity for large energy savings in homes, municipal buildings and industrial sector. Improved building insulation, smart heating and cooling and energy use (e.g. efficient lighting, smart appliances, industrial process improvements, etc.).

Below is an example of potential results from energy efficiency measures:

EE Energy System

up to 20-50% savings

- Energy-efficient equipment
- Smart building design and insulation
- Efficient lighting
- Smart cooling and heating systems
- Assessment of building energy performance
- Grid-connected controls and equipment
- Information on energy use, costs of electricity and savings potential
- Low stand-by energy use

Buildings (residential and commercial)

10%+ savings

- Energy-efficient equipment
- Smart building design and insulation
- Efficient lighting
- Efficient motors
- EE-adjusted manufacturing process
- Heat waste recovery
- Improved information on energy use, costs, and energy saving tips.

Industry Energy Savings

savings

- Lower energy bills
- Fuel diversification
- Increased reliability (reduced peak loads)
- Lower GHG emissions
- Environmental benefits
- Avoided investments in new generation
- New jobs and services for EE

Overall Benefits

1.4 Energy Efficiency Drivers

Security of supply, high energy prices and EU legislation are all key drivers for energy efficiency measures and low-carbon energy services in Europe. In future, these drivers will affect energy market and gradually turn it from a commodity-driven to a service-driver model.

In future, energy efficiency market will expand from business-to-business to business-to-customer operation. For now, the business-to-customer area remains pretty much an untapped market.

It is estimated [5] that approximately 65% of all DSOs are already promoting EE in some way. The main drivers for promoting EE for DSOs and electricity retailers are commercially-related. Some of them are shown on the figure below:

Image/Brand Improvement	**Improvement of Living Standards**
Product Portfolio Expansion	**Fossil Fuels Depletion**
Customer Loyalty	**Energy Security**
Competitiveness	**EU Legislation**
Customer's 'Green' Attitudes	**$C0_2$ Emissions**

Figure 2 EE Drivers for DSOs and electricity retailers

For households that are in fuel poverty (i.e. the energy cost of a household exceeds 10% of an overall household income), some European governments introduced other ways to support customers, like social supplements that are intended to fight rising energy prices or fuel payments in cold winters. It is illustrated on an image below:

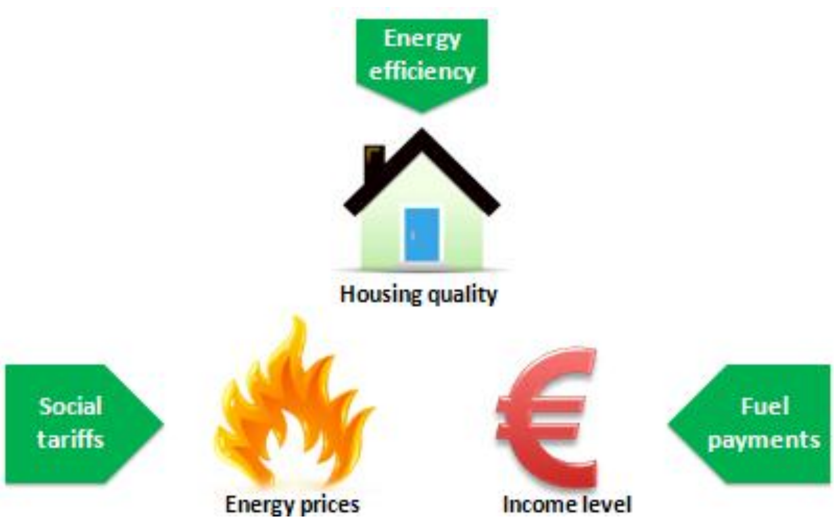


Figure 3 Drivers for fuel poverty and policy responses

On another matter, countries like China start to look seriously at energy efficiency in the energy sector and are particularly interested in software improvements for industrial applications. European companies that are consulting Chinese utilities will have to adjust their strategies and portfolios to offer this kind of software functionality. The ABB company has already announced its strategy to adjust their software and hardware offerings to support energy efficiency.

1.5 Impacts of Smart Grid and Decarbonisation

According to ERGEG position paper on smart grids [23], the decarbonisation of electricity supply may increase the price and reduce the quality and reliability of electricity supply. Some customers may accept a lower quality and reliability of electricity in return for a lower price and some may not. Therefore, a market for new products and services that help customers achieve both of these goals may appear. It is important to facilitate the transition of consumers to active customers, increasing elasticity of the demand side.

The following services can be provided by DSO in order to achieve this goal:

- Tailored electricity contracts between the customer and DSO for improved reliability and quality of electricity; for generation of electricity (feed-in tariffs)
- Financial incentives to actively manage demand (DR programs) for customers
- Dynamic pricing information and time of use energy pricing
- Legislation for 3rd party aggregator companies to provide services on behalf of customers to DSOs and electricity markets

Efficiently delivering new services to customers and generators in more cost efficient way is a challenge for network companies.

In order to ensure that all these services correspond to customers' needs, focus groups and different stakeholders must be able to participate in the definition of new functionalities.

1.6 Barriers for EE

One of the predominant factors preventing customers from participating in EE measures is lack of interest in energy services. As for the corporate sector, purchasing decisions are often based on lowest investment cost that promises fast payback time. The equipment purchased with this priority in mind often fails to comply with the latest energy efficiency requirements. All this needs to be changed by providing enough incentives for everyone.

The following barriers exist for various energy sectors and players according to the latest survey [5]:

Table 4 EE Barriers

Sector / Field / Player	Barrier
General barriers	High costs
	High risks
	High entry barriers
	Lack of skilled staff
	Insufficient commitment from other relevant stakeholders
	Lack of measurement tools: there are no widely available tools for benchmarking of building energy efficiency and there is a general lack of information of how different buildings performs relative one to another
	Lack of information about energy efficiency options

Sector / Field / Player	Barrier
	Typically, energy management is not considered a core business concern, and the cost of electricity is not regarded as large enough (when compared to other business costs) to fully commit to EE
Barriers for EE service introduction	High costs
	High risks
	High entry barriers
	Lack of skilled staff
	Insufficient commitment from other relevant stakeholders
Industry	Lack of financing due to other investment priorities (e.g. investments that increase production or reliability)
	Cost-benefit analysis: initial investments for EE technologies are quite high and saving potential payback is relatively long (most managers require the payback time of less than 3 years, which is not always possible with EE services)
Business	Diversified incentives: in case or renting, the building owner is not interested in sharing some of the costs for implementing EE because he is not paying energy bills.
	Similarly to industrial sector, requirements for high rate of return and low payback time prevent from investing into the EE services.
	Organizations think that electricity costs are fixed and incontrollable
	Dispersed responsibility between various players: those who pay the bills, equipment operators, and investors.
Regulation	Insufficient policy support and regulatory uncertainties
	Segmentation by technical standards still exists. It is important to create a harmonized global list of standards to comply with.
	Conflicting policies
	Regulations that respect consumer privacy. It is important to enable consumers' access to and control over their energy data processed by third parties. Any data exchange must also protect the sensitive business data of grid operators and other players.
End-customers	Lack of awareness
	EE is considered "a big hassle" by customers
	EE savings are not worth the hassle for the majority of customers
	Lack of interest
	Lack of confidence
	High initial investment costs
	EE programs are intrusive and require changing of usual lifestyles.
	Low payback periods
	Low energy prices
	Equipment vendors often fail to identify and implement multiple EE measures, focusing on single-purpose devices.

From the point of view of *services*, barriers such as high costs and high entry barriers are the most important. High costs of equipment combined with investment risks prevent energy service providers from large-scale EE introduction. Partial financing of EE programs to support end-customers can help resolve the barriers posted above. Moreover, PR campaigns and advertising of energy management programs can be helpful.

The following actions can help solve or at least partially reduce the barriers identified above:

- Customers / staff training
- Energy audits and estimations of EE potential
- Electricity consumption monitoring
- Electricity use optimization (e.g. time, behavior)
- Embed EE technologies in new appliances by default
- Commit to making EE easy
- Allow end-customer to control their EE commitment themselves

1.7 Risks

The following risks connected with introduction of EE measures can be identified:

- Relying the strategy and investments on technology alone without business models
- Slow adoption of EE measures by legal framework ("stop-and-go" approach with regulators)
- Execution risks
- Affordability, technical complexity
- Performance confidence and bankability

Other risks for Smart Grid sector:

- lack of standards and interfaces
- Absence of political and regulatory parameters
- Effects of Smart Meters are over-exaggerated
- Lack of economic incentives; energy savings for end-customers nowadays do not justify the initial investment (products for energy efficiency are still expensive)

1.8 EE Policies

The following EE policies targeting specific activities can be identified:

- Optimization of daily use
- Audits
- Monitoring
- Energy performance contracting
- Training

Energy Efficiency Actions in EU

The following EE action can be highlighted in EU so far:

- Energy efficiency action plan (2006)
- Urban mobility guidelines (2007)
- Buildings renovation directive
- Labeling of household appliances
- Street lighting proposals
- Eco-design directive
- Structural funds and various loans to support energy efficiency
- Roadmap 2050, Low-carbon Europe

1.9 Energy Efficiency and Demand Response

This section aims to study the relationship between demand response and energy efficiency. Possible synergies and conflicts are identified.

Few experts would argue that energy efficiency and demand response are closely related. However, there is a challenge in distinguishing these two concepts and understanding their differences for end-customers. This is something they should be educated about. And utilities and electricity retailers must take on this challenging task.

Energy efficiency corresponds to permanent changes in electricity usage through improvement or replacement with more efficient end-use devices or more effective operation of existing devices that reduce the quantity of energy needed to perform a desired function or service [19].

Demand response refers to changes in electric usage by end-customers from their normal consumption behavior in response to changes in the price of electricity over time, or incentive payments designed to stimulate the decrease in energy use at times of high wholesale market prices or system reliability threat. (DOE, 2006)

It is important to understand the differences and similarities in EE and DR as there are many potential combinations between these two activities. For example:

- Energy efficiency can reduce demand permanently (compared with peak-only times for demand response)
- Peak-demand reduction analysis can help identify inefficient or non-essential energy-consuming appliances that could potentially be reduced at other times. This would in turn result in increased overall energy efficiency
- Experience gained from DR programs can increase awareness of energy savings opportunities via EE programs.
- Customers who participate in DR programs are more likely to participate in other demand-side management programs, such as energy efficiency
- Both DR and EE can be advertised and marketed together

Program administrators do not always understand well the differences between energy efficiency and demand response. The figure below shows the logical synergy of energy efficiency in demand response and shows the potential impact on customer service levels. It is assumed that the end-customer should begin with energy efficiency improvements and later on moving towards demand response.

However, due to known barriers to EE (e.g. lack of information, long payback times, limited funding, high upfront capital investments, etc.) it is likely that a customer would enter demand response programs without completing all energy efficiency improvements. This is because DR is in general more available and economically feasible.

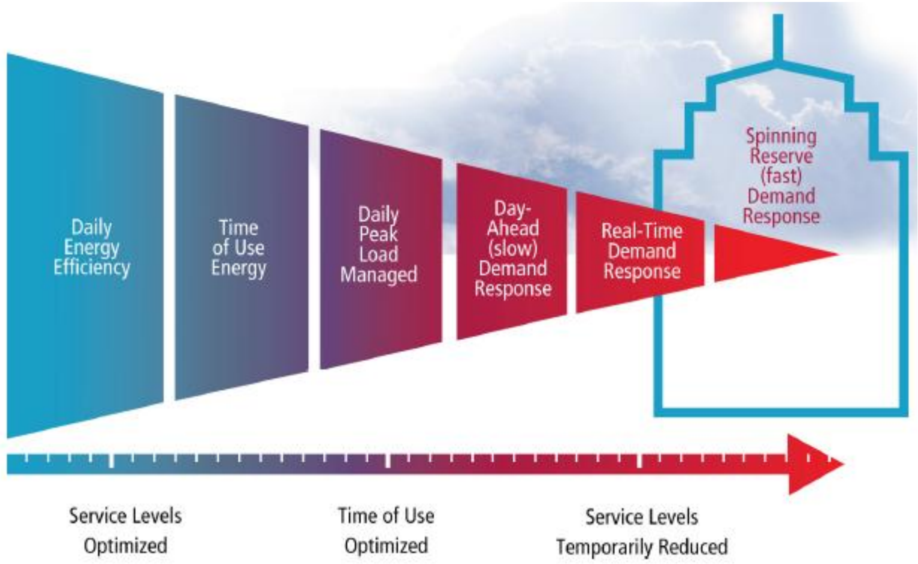


Figure 4 Energy Efficiency and Demand Response development

On the other hand, demand response can be in conflict with energy efficiency objectives. Demand response programs reduce loads during peak-hours only, when the electricity prices are high or there is a direct threat to overall system reliability. Whereas energy efficiency targets energy savings at all times during a year. This distinction can possibly create confusion with different building systems, equipment, and energy decision-making strategies.

Additionally, there can be potential conflicts between DR and EE programs for certain types of services. For example, if a customer is rewarded on the basis of the amount of load reduced (by sending a request signal) measured from a certain "baseline", he would have no incentive to invest into permanent energy efficiency measures as they might lower the baseline.

With abovementioned arguments about the relationship between DR and EE, it is clear that any effects of energy efficiency on electricity demand will tend to be in a downward direction. Therefore, it is recommended that DSOs and electricity retailers combine demand response and energy efficiency objectives into a single package offering, instead of having two distinct "demand response" and "energy efficiency" programs. This type of service bundling is already being implemented by some of the US utilities. Integrating DR and EE programs brings opportunities for cross-marketing and makes use of common marketing and sale resources. Additionally, it helps rationalize and simplify product portfolios [15].

1.10 Worldwide EE Targets

America has an Action Plan towards achieving cost-efficient energy efficiency by year 2025. Their recent studies show that energy efficiency recourse alone can possibly meet up to 50% of expected load growth over this time frame. The estimated savings from energy bills (costs avoided) is estimated to be more than $100 billion by 2025, $500 billion in net savings and reduction in $C0_2$ emissions. The action plan has 10 implementation goals:

1. Establish cost-effective energy efficiency as a high-priority resource
2. Develop processes to align utility and other program administrator incentives such that efficiency and supply resources are on a level playing field
3. Establish cost-effectiveness tests
4. Establish evaluation, measurement, and verification mechanisms
5. Establish effective energy efficiency delivery mechanisms
6. Develop state policies to ensure robust energy efficiency practices
7. Align customer pricing and incentives to encourage investment in energy efficiency
8. Establish state-of-art billing systems

9. Implement state-of-art efficiency information sharing and delivery systems
10. Implement advanced technologies

More information on the action plan can be found in [17].

2 Changes in Business of DSOs and Electricity Retailers in Smart Grid Environment

As Smart Grids are becoming reality with each day and smart technologies penetrate regular households after being demonstrated in pilot projects, the industry and public are pushing towards introduction of new services and products. Selling purely kilowatt-hours of electricity is no longer competitive and if DSOs and electricity retailers want to stay in the game, they will have to adjust their businesses to the new smart grid environment.

One of such changes in offered services can be energy efficiency programs. A utility company can involve itself into energy efficiency activities by its portfolio development and implementation of new energy efficiency projects. These projects can be performed via contractors and community-based capacity building initiatives.

The latest EU targets towards reduction of GHG emissions and increasing the share of renewable energy sources in total generation are changing the energy generation sources used in Europe. This, in turn, requires changes in operations, planning and maintenance of the electricity networks. Distribution network are becoming more sophisticated and smart. All players of electricity market will benefit from increased intelligence of the networks as it potentially promises to lower costs, improve quality of electricity and supply, introduce various tariffs and spark up with competition.

2.1 Current roles and Responsibilities for Different Market Players

The figures below provide a brief overview of current roles and responsibilities for different market players. All roles can be split into two categories: *Grid Operators* and *Grid Users*.

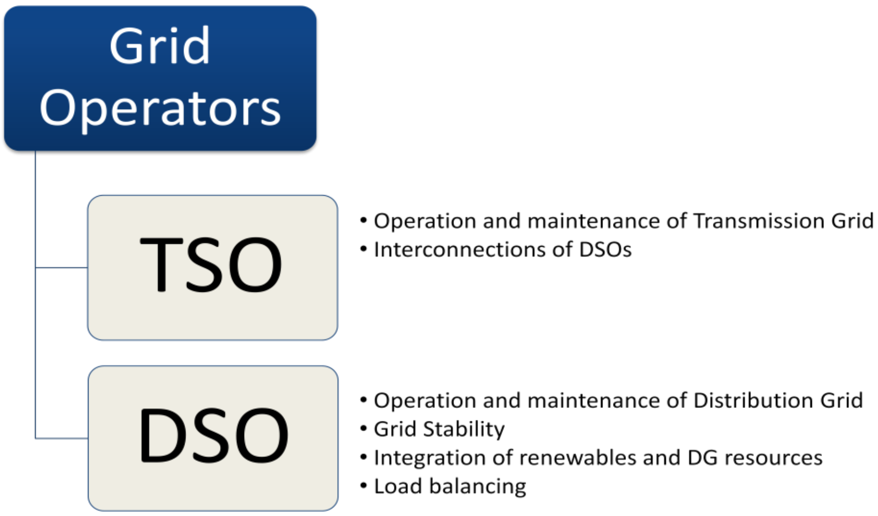


Figure 5 Responsibilities of grid operators

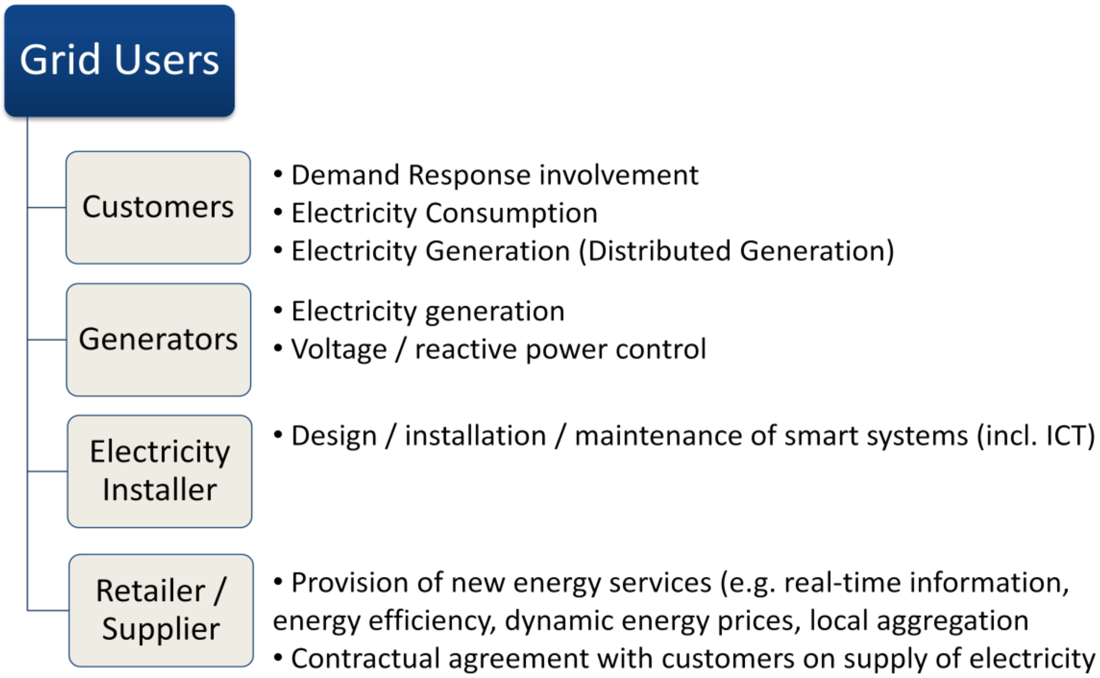


Figure 6 Responsibilities of grid users

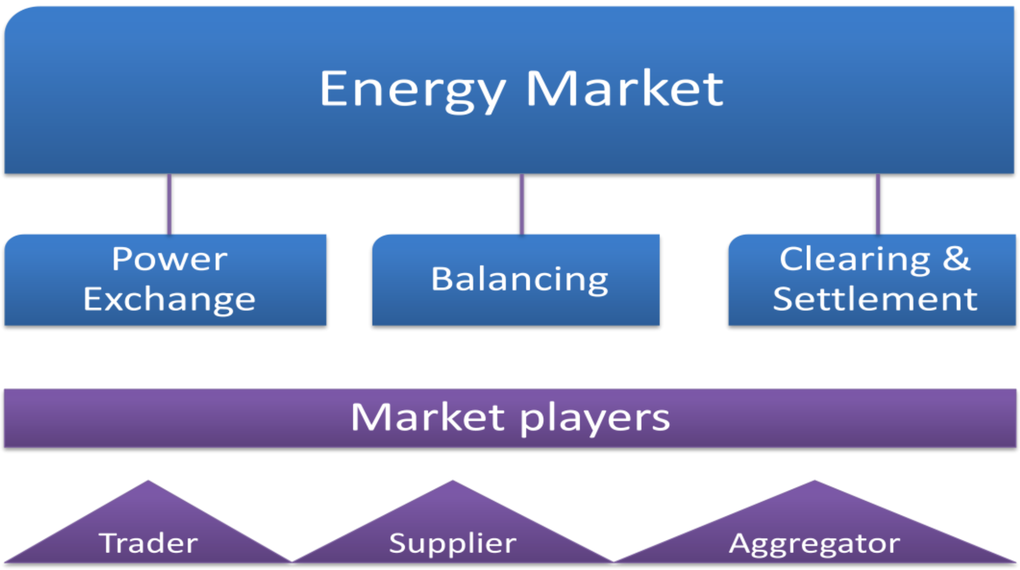


Figure 7 Energy market structure and players

2.2 Changes in Roles and Responsibilities for Different Market Players

Energy efficiency has an impact on total electricity usage, which in turn has an effect on the business.

In numerical values, the increase in energy efficiency throughout end-customers will decrease the consumption of the electricity. However, the improvement in the efficiency of the energy does not necessarily imply decrease in consumption of the electricity, but the impacts of energy efficiency actions on the demand of the electrical energy and power vary [20].

While reduction of the amount of delivered electricity have a direct impact on the revenue of a DSO in the short term, the changes in power demand will have impact on the cost of electricity distribution in the long run. This can be explained by the fact that the dimensioning of the network components is based on the peak loads and, as a result, reduction of the peak loads will delay the network capacity expansion investment needs. This will result in the decrease of capital costs of the distribution company.

The figure below illustrates the relationship between energy efficiency and electricity distribution business. Energy efficiency drivers lead to the increasing of EE supporting technologies, which in turn leads to the smarter end-user consumption of energy. This will have the impact on both short- and long-term strategy of DSO. While at the same time, the development of electricity distribution networks and wider adoption of smart grid technologies will have impacts on energy efficiency (e.g. demand response, in-home displays, smart-meters, battery storages, etc.).

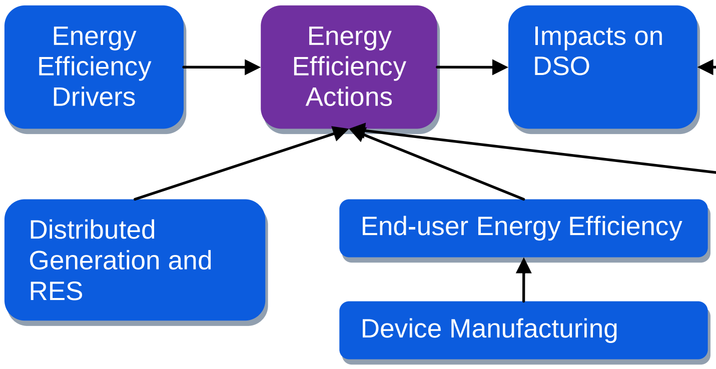


Figure 8 Relation between energy efficiency and development of electricity distribution business [20]

Refer to Figure 2 for a list of energy efficiency drivers.

End-user energy efficiency includes the following considerations:

- Heating methods
- Insulation level
- Lighting type
- Conditioning and water supply method
- EC electronics
- Home appliances
- Traffic
- Automation
- Electric drives

Impacts of Energy Efficiency on Electricity Consumption

The table below lists potential impacts of some typical energy efficiency action on total energy consumption level. The "+/-" signs indicate whether the consumption is increasing or decreasing and the number of these signs estimates the magnitude of the potential change.

Table 5 Estimated impacts of energy efficiency on the total energy, delivered energy of the distribution company, and power demand [20]

Action	Total Energy	Delivered Energy	Electrical Power
Heating method	↓↓	↓↓/↑	↓/↑
Insulation	↓↓↓	↓↓	↓
Water and air conditioning	↓↓	↓	↓
Lighting	↓↓	↓↓	↓
Home appliances	↓	↓	↓
Interactive Customer Interface	↓↓	↓	↓↓
Automation/control	↓	↓	↓
Electric drives	↓↓	↓↓	↓↓
Distributed generation	↓↓	↓↓	↓
Demand response	↓	↓	↓↓

Challenges

Here are the challenges that DSOs are facing when starting energy efficiency activities:

- Managing feeding in of electricity from DG and keeping a distribution network stable would be one of the key problems of DSO.
- Increased share of DG, demand response, energy storages (local) and EVs will impact the DSO infrastructure and business flow. Therefore, DSOs have to participate actively in such development projects along with other participants. In the long run, all elements of Smart Grid specified above will change today's mostly static distribution system into a dynamic environment with bi-directional power flows.
- With the introduction of AMR and the increasing share of information coming from ICT-enabled network devices, DSO will have to cope with the increased information flow.
- Data privacy and system security risks (including issues like owner-of-data, time-to-store data, etc.)

Due to the nature of business, DSOs operate in a regulated environment instead of a competitive market. Therefore, they have little incentive to adopt innovating techniques. The only way to stimulate innovation for DSOs is through regulations.

As the amount of data gathered from appliance usage and smart meters increases, utilities will feel a positive impacts on their business. Increased access to usage data will benefit all types of customers and will lead to improved customer-DSO relationship. Additionally, this will contribute to electricity demand reduction and energy efficiency programs.

If energy performance data (and possibly average bill and average amount of electricity consumed) is made available on a monthly basis, customers would begin to manage their energy usage more aggressively and uncover cost-effective investments in energy efficiency [18].

In [18], a utility demand management program (NSTAR Energy Star Benchmarking Initiative) has been conducted. This program demonstrated the effectiveness of benchmarking approach for end-customers. The customers were educated on their whole-building energy performance. They were informed about cost-effective energy efficiency measures on a monthly basis. Approximately 100 customers, representing over 18 million square feet of floor area have participated in the program. The results were quite staggering [18]:

- 60% of customers took actions to investigate EE upgrades
- 45% of benchmarked customers completed the implementation of one EE upgrade
- 17% of customers implemented comprehensive improvements

Trend

- Partnering with Energy Service Providers that are able to deliver EE services to domestic customers.

End customers

End customers are going to become active participants of Demand Response programs if the DSOs or electricity retailers develop easy-to-understand and transparent rules for such programs. Consumers will have more knowledge about their overall and particular consumption of energy and the way they use it. This will in turn provide the business opportunities for electricity retailers or 'aggregators' to offer new EE services. All participants would benefit from it.

Energy service providers

As DSOs and electricity retailers begin to use information collected from smart meters, new business models and energy services will appear. These services can include: customer data analysis to identify new opportunities, infrastructure management, home automation and management-enabling devices.

Energy service provider (ESP) can be an independent small or medium-sized company that offers various technical services to implement EE projects. ESPs usually offer a range of different EE technologies. In many cases they can act as subcontractors for larger companies (e.g. energy service companies).

One major issue of home automation and EE technologies is the compatibility of equipment and communication standards. Customers should be able to freely switch electricity retailer without having to change the entire home automation solution. Failing to do so will lead to inconvenience for customers and barriers for competition.

According to a survey conducted by EURELECTRIC [5], 80% of electricity supply companies operating in EU are already promoting energy efficiency. Electricity suppliers tend to adopt one-stop-shop business model for all energy services. Smart meters are regarded as gateways for EE.

Business Opportunities

The picture below shows changes in business opportunities compared to current situation:

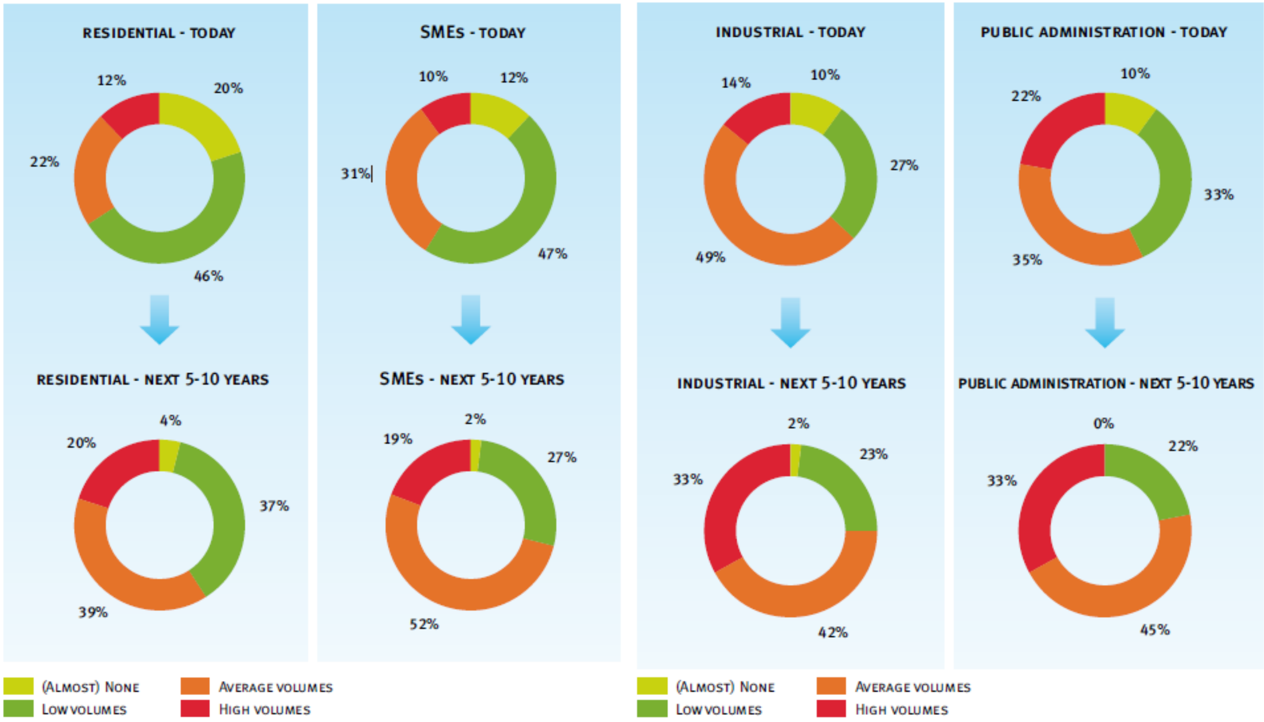


Figure 9 Changes in business opportunities for DSOs: today and in the next 5-10 years [5]

2.3 Factors Affecting Changing in Business

2.3.1 Climate Change

Without any doubt electricity generation contributes to the carbon dioxide (CO_2) emissions. In fact, it is one of the largest source of CO_2 around the world. This is due to the fact that burning of coal emits a lot of carbon dioxide. Therefore, countries around the world are looking more and more to increasing share of generation from the renewable energy resources. Especially now that nuclear power generation, which was previously regarded as another alternative to coal, raised a lot of safety concerns around the world.

DSOs

It is obvious that climate change will have a direct impact on the distribution business through increased weather-related disturbances and changes in temperatures. Mild winters make forests weaker and more vulnerable to the storms. Cold and harsh winters can create huge spike in electricity demands as people will need to heat their houses more than usual. This in turn affects the way the network companies plan and build their network and the equipment they deploy in future. Therefore, it is a good practice for DSO to follow climate change statistics and take into account climate developments when making calculations for network planning.

Electricity retailers

Climate change is going to affect electricity retailers via various regulations requiring to meet the level of low-carbon energy. This will in turn have an impact on energy bills. For example, it is estimated that the climate change policies in the UK will increase domestic energy bills on 1% by 2020 and non-domestic bills (e.g. medium-sized customers by 26% [9]. However, on the contrary, sustained increase of fossil fuel prices reduce the cost of some energy change policies, lowering the cost that is passed onto consumers. For example, if the oil price is $150 per barrel in 2020, the climate change policies would reduce the bills by around 5% compared to a bill excluding these policies.

2.3.2 Renewable Energy

Increasing concerns about security of energy supply, dependency on natural resources, and climate change mentioned in the previous subchapter are calling for use of renewable energy resources (RES) to deal with these issues. All these challenges are closely connected. For example, integration of renewable energy sources cannot be resolved without dealing with intensified focus on questions of energy security and energy efficiency. Moreover, as the society becomes more dependent on electricity supply, the requirements for power quality and reliability are being tightened. Small-scale RES when installed at customer's premises can act as a backup source of electricity during power outages.

The most important RES are bio-energy, hydro, geothermal, wind, and solar. Electricity generated by RES is delivered to the end-customers via transmission and distribution (T&D) networks. Therefore, successful integration of RES into these networks is a fundamental task.

Increased share of RES, both on the end-customer side and transmission/distribution side, would require adjusting existing business models and tariffs. Also, legislation might need to be changed in some countries. For example, feed-in tariffs for small-scale RES are not yet in place in the majority of European countries. Additionally, during the initial phases of RES introduction special policies must be introduced to provide financial support or reimbursements on purchasing of RES equipment.

Increasing share of RES and distributed generation in the distribution networks may result in decreased revenues and increased operation costs for DSOs. Therefore, DSOs have to look for new business areas to focus to keep their business viable. New business areas will create diversified revenue portfolio and at the same time make DSOs less dependent and vulnerable on their current revenue sources. External consulting companies can be hired to investigate and develop new business models by working with regulatory framework and regulators in order to develop win-win solutions for customers and shareholders.

Key challenges connected with renewable energy use for DSOs and electricity retailers:

- Availability of forecasting tools that support commercial decision-making
- Creation of commercial rewarding programmes that reward participant behaviour that is efficient to overall economic efficiency (e.g. demand response). Similarly, a system of penalties for the behavior that is harmful to overall economic efficiency is required.

Technical issues of increase distributed generation penetration for distribution networks:

- Voltage control in the vicinity of distributed generation
- Power flow management (avoiding bottlenecks)
- Fault identification in networks with distributed generation
- Ability to predict the behaviour of the network with DG via mathematical simulations

Distributed generation involves the use of small, modular electricity generation units (PV panels, wind turbines, micro-CHP). Utilities have little experience of interconnecting numerous small scale generation units into their distribution networks. And very often the possible level of penetration of renewable generation depends on the existing electrical infrastructure.

Offshore wind production is not always economically feasible and only possible where sufficient electricity grid capacity is available.

Distributed generation based on renewable energy opens a lot of opportunities for utilities. It can potentially have the following effects:

- Reduce the T&D losses and costs
- Provide customers with security of supply
- Stimulate competition in supply, adjusting prices via market trends
- Possibility to be implemented in a short time due to the modular nature of Renewable Energy Technologies

Barriers

Even though public strongly supports the adoption of renewable energy, strong barriers remain on the way of their full-scale introduction. Renewable energy projects usually require high initial capital investments due to high cost of technologies and equipment. Additionally, in many countries utilities maintain the monopoly on electricity production and T&D. High connection costs and lack of standards discourages renewable energy projects. All these issues contribute to high financial and technical risks for investing in renewable energy projects. Energy storages that are described in the next section can potentially solve the intermittency problem imposed by distributed electricity generation.

2.3.3 Energy Storage

With recent increase in renewable electricity generation and electric vehicles and their intermittent nature, it is going to be harder and harder to keep the already delicate demand/supply balance. DERs introduce a lot of uncertainties in electricity generation. And while introduction of energy storage solutions can help restore the balance in the grid, technologies that are offered on the market today face a lot of challenges. According to [10], only few energy storage technologies will find their niche in specific applications, while most others will fail. Compressed air technology can be highlighted from the energy storage technologies reviewed in [10]. It offers favorable payback to utilities; however, logistical constraints can limit the penetration of this technology. Selected battery technologies offer an acceptable business case in selected applications. However, battery costs are still too high for commercial integration into buildings. The majority of emerging energy storage technologies fail to give even a 10% internal rate of return (IRR) in any scenario [10]. Very few combinations of energy storage technologies offer an acceptable payback time, while having numerous potential pitfalls.

There are 2 main things identified in [10] that utilities need to understand when investing in energy storages:

1. Total installed energy storage capacity is less than 128 GW (~3.2% of generating capacity).
2. Substantially, all installed energy storage facilities are pumped hydro

The image below shows the installed capacity for existing energy storage technologies:

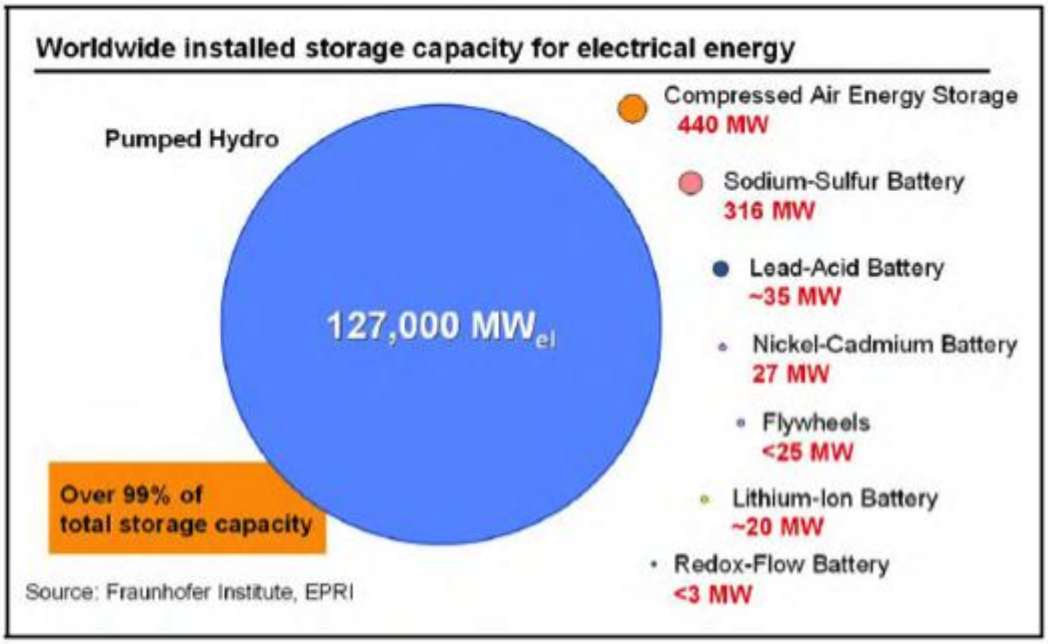


Figure 10 Worldwide installed storage capacity for electrical energy [source: EPRI]

Energy storage technologies can be applied in a number of business cases in electricity distribution business. For example, frequency regulation or deferring investment into T&D. But probably the biggest savings can come from spinning reserve area. Utilities can switch from expensive spinning reserve units, created by generators that are already synchronized with the grid but are not operating at full capacity, to electricity storage units. They have a number of advantages over regular spinning reserves: (i) they are more efficient in compensating disruptions of the power supply; (ii) near-instantaneous discharge and reserve capacity provision; (iii) advanced monitoring and control that allows disruption detection.

2.3.4 Growing Electricity Demand and Customers Participation

World population continues to grow and so is the demand for electricity. Here are a few factors that influence the increase in energy demand:

1. Emerging markets and industrialization
   New factories and production sites require a lot of energy. As less developed economies industrialize, their energy demand increases.
2. Growing economies (China and India)
   As consumers get wealthier in growing economies they start to use more cars, refrigerators, air conditioners, etc. It is expected that about half of all energy increase in the next 20 years will come from China and India. This is indicated on the image below:

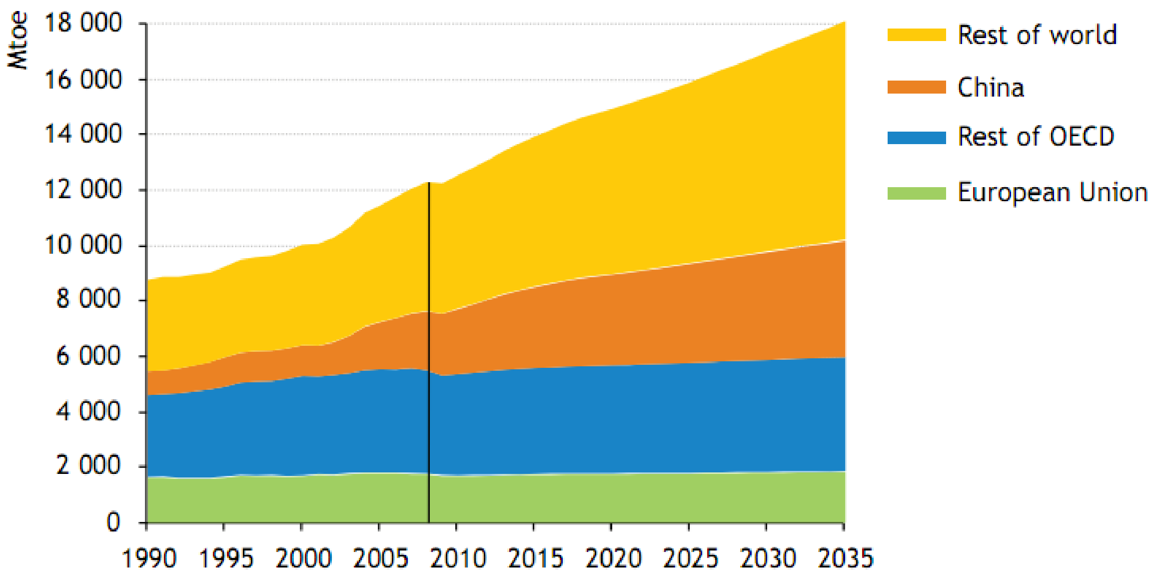


Figure 11 World energy consumption forecast [12]

3. Globalization
   Transportation is one of the largest consumers of energy in the world.

As a result of electricity demand increase, customer engagement in saving the electricity is crucial. Here are a few energy efficiency measures:

1. More efficient buildings
   Reflecting roofing, insulation, and other energy-friendly improvements can drastically reduce energy consumption of commercial and residential buildings.
2. Light bulbs
   This is one of the easiest ways to reduce an energy bill which has considerably high impact on energy saving. Replacing standard bulbs with LED or new compact fluorescent lamps allows to reduce energy consumption while providing the same level of comfort.
3. Demand-side management
   As electricity becomes more expensive, consumers and utilities will have a mutual interest in managing their demand of electricity during the day. Dedicated programs of load control promise to reduce the electricity bill for corporations and end-consumers.
4. Fuel efficiency
   Apart from investing into hybrid engines and electric vehicles, proper tire inflation and remote monitoring of pressure in tires improves fuel efficiency as well.

2.3.5 Security of Supply

With increasing energy demand and recent geopolitics, there are clear indications that oil and gas prices are going to rise and the amount of the fossil fuels are only going to decrease. Another source of energy – Nuclear power – is being questioned at the moment due to the recent disaster in Japan.

Today, the EU imports approximately 55% of its energy supply. Therefore, diversification of sources of energy generation is needed, while investing in energy efficiency and energy saving to increase security of supply. Interconnections and smartness of the transmission and distribution grids are also of great importance. EU oil and gas imports are shown on the image below:

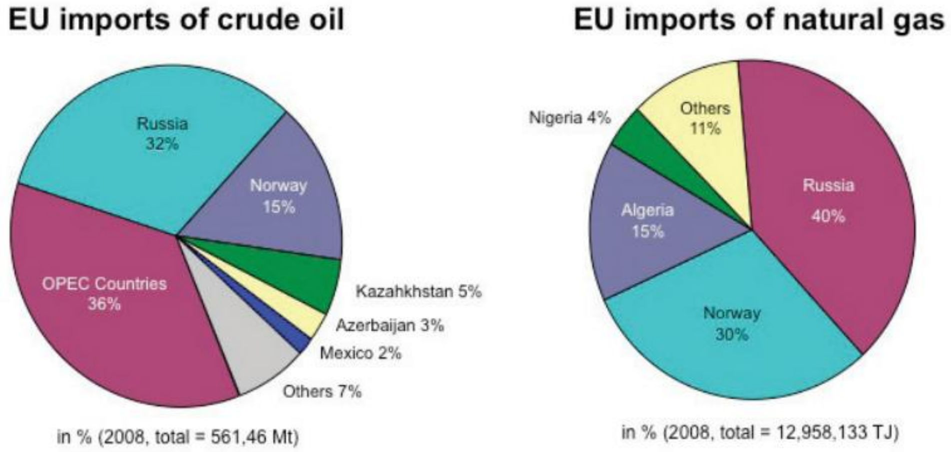


Figure 12 EU oil and gas import [source: Eurostat 2010]

In EU energy security dialogues were usually discussed between energy suppliers and an individual Member State only. As the EU market becomes more and more integrated, the security of supply is going to increase.

3 Methodology of EE for DSOs

If a DSO or electricity retailer wants to initiate energy saving and energy efficiency program, it must first assess the technical potential and the costs associated with energy savings. This needs to be performed to evaluate the profitability of an energy efficiency program.

EE programs vary in different countries. Three most widespread techniques can be distinguished among these programs:

- White certificates (Italy)
- Investment obligation (Brazil, UK, The Netherlands)
- Revenue decoupling (California)

White certificates
In order to meet rising energy saving requirements, Italian government has introduced an innovative policy framework for the promotion of energy efficiency in end-use sectors. This policy is based on mandatory energy saving targets for electricity and gas DSOs, combined with "white certificates" trading scheme. The same system is now adopted in France and Poland.

In "white certificate" scheme, the obliged DSOs have the following compliance options:

- Implement "in-house" energy efficiency projects
- Implement energy efficiency projects jointly with 3rd parties
- Buy tradable "white certificates" from 3rd parties
- Pay the non-compliance sanction

Essentially, white certificate ensures the achievement of an energy saving target. For example, KWh of energy saved, ToE saved, etc. White certificates can be traded in a specific market or "over the counter". The trading possibility ensures that savings will occur where it is more economic. That means that the parties with relatively high marginal costs of saving energy are able to purchase white certificates from parties that can realize certain savings at lower marginal costs. Therefore, the "white certificate" scheme ensures that energy saving targets are met with the economic efficiency of market-based instruments.

Revenue decoupling
In this technique, utilities are protected from revenue margin loss due to energy efficiency improvements. This is done by breaking a link between revenues and sales based on volume of distributed energy. A typical example of this technique is California's Electricity Revenue Adjustment Mechanism (ERAM). This approach eliminates the major conflict of interest for utilities for participation in energy efficiency (incentive to sell, not conserve, energy). The disadvantage of this technique is that it may be quite difficult to develop and administer. Additionally, the rates for distribution services are usually increased.

Investment obligations
In this technique, utilities are required to invest into and deliver energy efficiency. An example of such technique is UK's Carbon Emissions Reduction Target (CERT) and Brazil's 1% investment obligation. The advantages of this energy efficiency method are in flexibility, low-cost efficiency improvements and linkage to secondary markets for trading. The disadvantages are the following: expensive verification and oversight of utility delivery.

Potential Savings
An analysis of EE potential for various household electric end-uses was carried out in [2]. It is based on survey data and hourly metered AMR household power consumptions. The table below shows the potential savings by end-use type:

Table 6 Potential savings by end-use type [2]

End-use type	Action	Saving/Factor evaluated
Ground Source Heat Pump	Replacing direct electric heating with GSHPs.	Saving of 27.45% to 47.0% of heating consumption with direct electric heating.
Air Source Heat Pump	Using ASHPs with direct	Reduction in heating consumption by

	electric heaters as supportive heating.	7.8% to 25.6%.
Ventilation	Incorporating heat recovery system with Mechanical supply and exhaust ventilation.	An average 13.6% saving of the total household power consumption.
Thermostat type	Installing programmable thermostat and applying energy star recommended setting.	An average saving of 14.7% from heating energy consumption.
Thermostat setting	Lowering indoor temperature by 1 degree centigrade during heating season.	An average saving of 3.43% of total household consumption.
Standby load	N/A	An average 46.2 W per household.
Energy saving lamp	Replacing every ILBs with energy saving lamps.	Savings of 13.62% to 17.06% of total household electric power consumption other than heating.
Supportive heating	Using wood as supportive heating.	Savings of 2.32 kWh in heating for a winter day (for each m^3 of wood burned) in a year.

It is clear from the table that the biggest effect can be achieved by replacing direct electric heating with GSHP. However, this is not applicable for customers living in city apartments. Other methods, such as replacing lamps or reducing standby load can be applied for this type of customers.

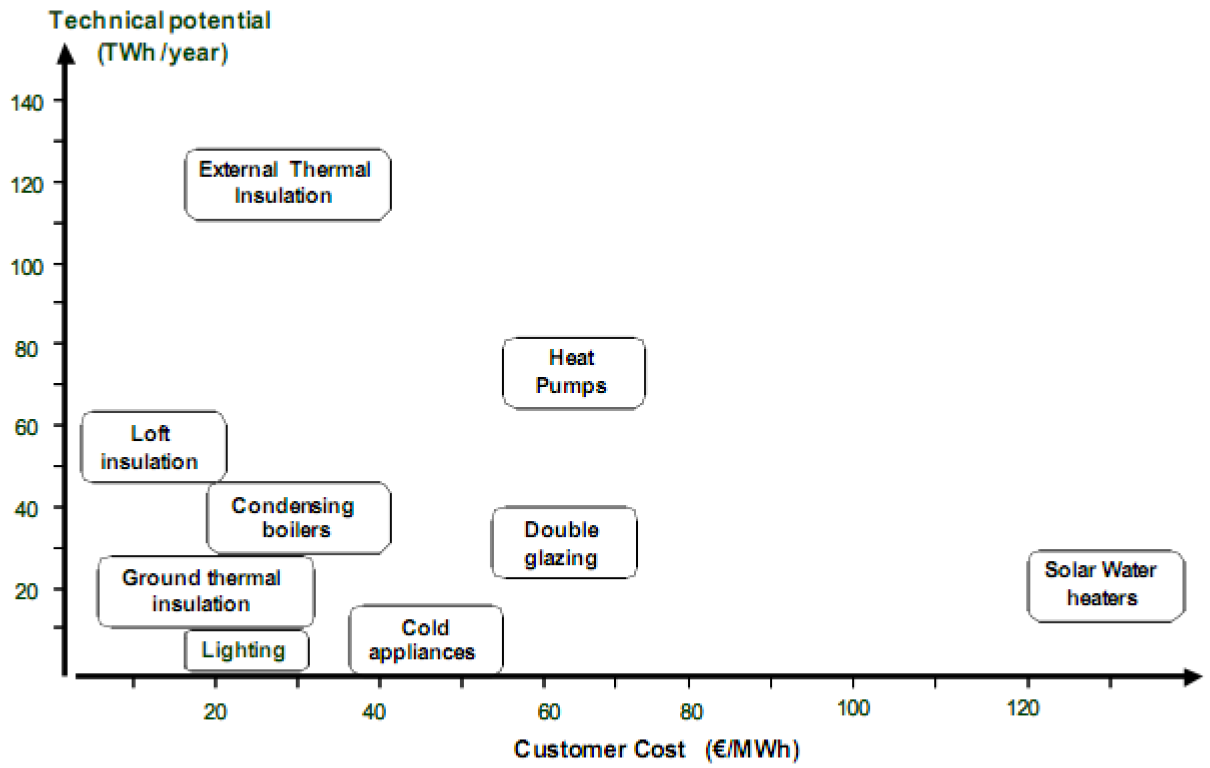


Figure 13 Technical energy savings potential for residential secor (source: EDF/R&D) customer cost corresponds to the cumulative energy saved during the lifetime of the efficient equipment, with a 4 % discount rate, the potential refers to annual final energy saving.

Selection of Baseline Technology

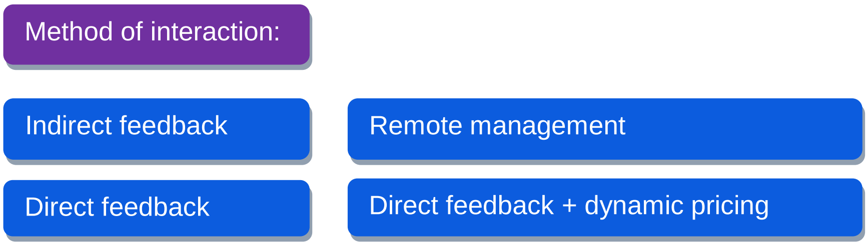
One of the main issues when evaluating the benefits of an EE program is selection of the technology for the baseline of the energy savings potential. Let us take a look at a few possible situations:

- A customer decides to invest in EE equipment before the date of natural replacement
- Natural replacement (a customer was going to invest into new equipment anyways)

If an end-user decides to invest into EE equipment driven by expected energy savings, the cost for him would be the total cost of equipment. However, if a customer is considering natural replacement, the cost is the difference between the Best Available Technology and the average market cost.

Interaction With Customers

The following methods of interaction with customers regarding EE measures can be identified:



Indirect feedback – this method implies providing improved information on customers' electricity bill.

Direct feedback – this method implies real-time information delivery using local in-home displays.

Direct feedback + dynamic pricing – this method implies real-time information delivery coupled with ToU tariffs to provide extra incentives for customers to manage their electricity consumption behaviour.

Remote management – this method implies intervention from either utility or electricity retail company to manage customers' electricity consumption directly.

The table below shows the impact from the pilot studies of various methods of interactions:

Table 7 Various methods of presenting energy consumption information [7]

Study	Date	Location	Sample Size	Description	Duration	Results (% reduction)
Arvola et al	1994	Finland	525	Frequent billing (36 days). Bills included historic feedback in the 2nd year	2 years	3-5%
Haakana et al	1995	Finland	105	Monthly comparative and weather adjusted feedback	2.5 years	7%
Wilhite and Ling	1995	Norway	611	Bi-monthly bills with usage graphic and EE tips	3 years	10%
Wilhite	1997	Norway	2000	Stavenger Energi. Customer interaction with meter display. Bills included historic feedback in the 2nd year	2 years	8%

It must be noted, that apart from providing significant reductions in consumption, the Norwegian study demonstrated persistence of the savings. It was discovered that the longer the duration of the trial, the more information is available to customer, the more persistent effects are likely to be [7].

Additionally, it has been discovered in [8] that a user-friendly in-home display is an integral part of any new smart meter specification. Such display would be most useful if they displayed instantaneous electricity consumption level, expenditure and historic feedback as a minimum. Extra functionality can include micro-generation output level indication, tariffs, and information about $C0_2$ emissions.

3.1 EE Evaluation

Before offering EE programs to the end-customers, DSOs and electricity retailers might need to evaluate the possibilities enabled by EE:

Impact evaluations reflect the amount of energy and demand savings achieved by DSM programs. These evaluations may include: engineering reviews of forecasted savings calculations, building simulation models, energy use analysis, etc.

Process evaluations identify possible ways of improving the design, promotion or implementation of DSM programs and aim at improving customer satisfaction factor. The input data for such evaluations are usually collected via surveys.

Market evaluations analyze energy market indicators and take into account temporary changes and interventions if they exist. Main market trends affecting DSM programs are taken into account for these evaluations.

3.2 EE Methodology for DSO or Electricity Retailer

The following universal energy efficiency methodology for a DSO or electricity retailer is proposed:

Figure 14 Energy Efficiency Methodology

The figure above contains possible steps towards achieving system-wide energy efficiency.

Goals

The figure below indicates strategic and operational goals of energy efficiency for a DSO:

Figure 15 Strategic and operational goals of energy efficiency for a DSO

Market development goals imply gaining new customers, deploying new technology and adding new services.
Environmental goals imply contribution to reduction of $C0_2$ and overall 'green' image of the company. **Quality and efficiency** goals imply improving quality and efficiency of the company and its business.

3.2.1 EE-related Activities

The following energy efficiency activities aimed at development of EE measures can be identified for DSOs or electricity retailers:

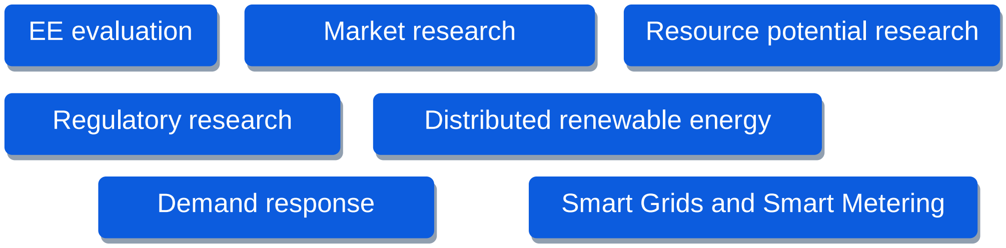


Figure 16 Energy efficiency activities for DSOs

Potential energy efficiency program development cycle can look like this:

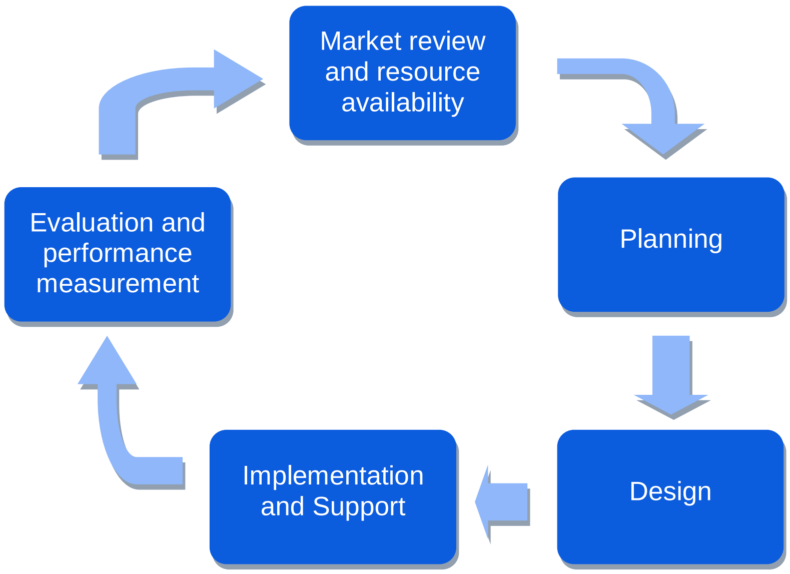


Figure 17 Energy efficiency program development cycle

3.2.2 Energy Efficiency Program Design

When designing an energy efficiency program, it is essential to determine an appropriate combination of incentives and strategies for its deployment. Key market actors involved into the program must be identified. This information is important for understanding target audience, products, services, barriers, and roll-out strategies.

Example:

Figure 18 Customer types segmentation example for an energy efficiency program

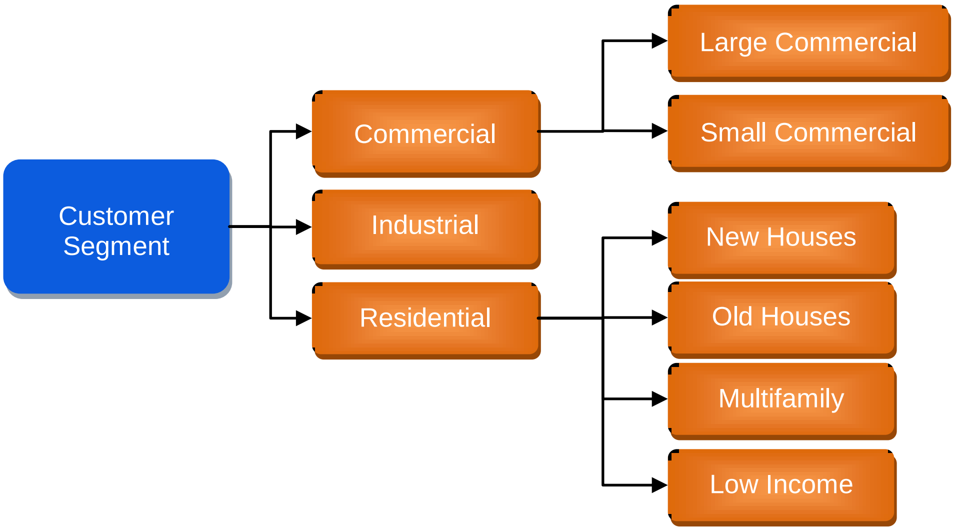


Figure 19 Stakeholder groups for an energy efficiency program

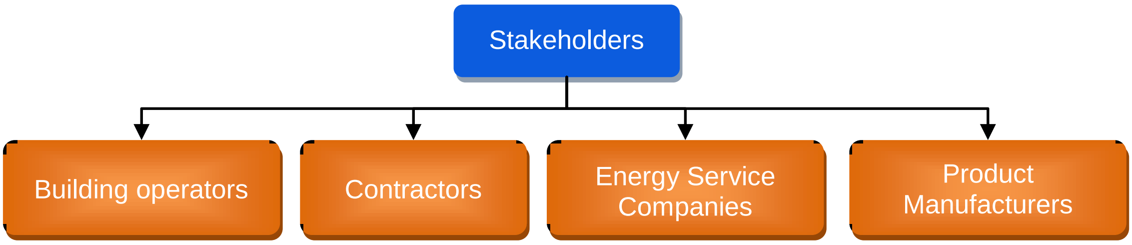


Figure 20 Possible barriers for an energy efficiency program

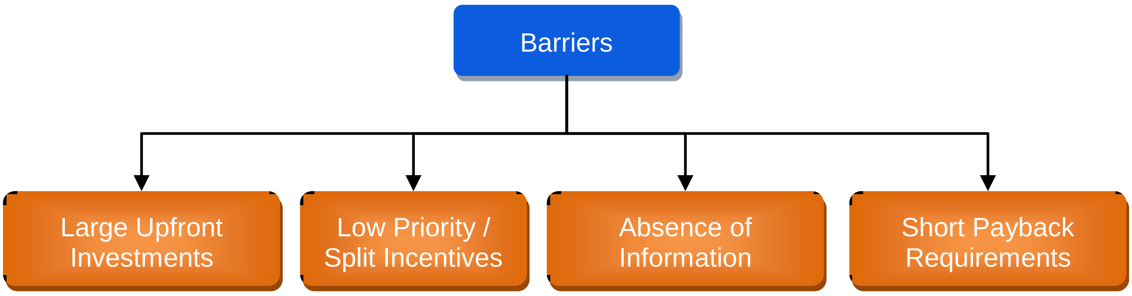
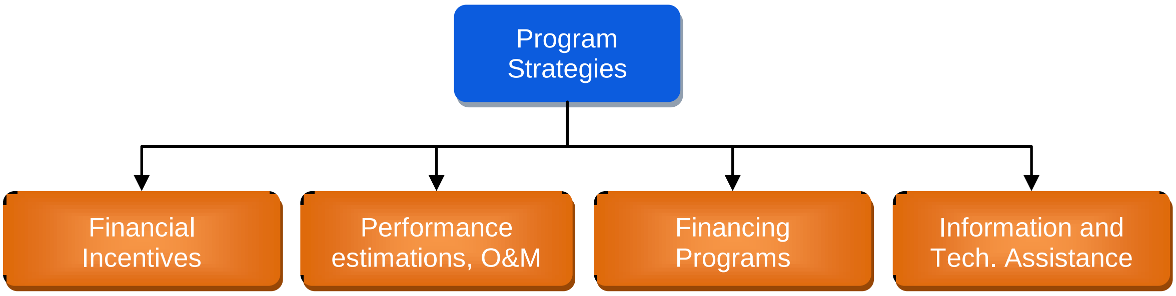


Figure 21 Possible directions for program strategies



Energy efficiency program should be designed with the main orientation towards developing a cost-effective solution that would comprise a mix of financial incentives, services, and would address the market-specific barriers. The theory described above can be condensed in the following steps:

Step 1: Identify Customer Types

One of the best ways to gasp a market is to perform customer segmentation. Once it is done, key market cycles and processes in which customers' energy efficiency investment choices can be incentivized should be outlined. Refer to Figure 18 for an example of customer segmentation.

Step 2: Identify Market Segments

Every type of customer can be matched with the most profitable efficiency opportunity and/or easiest to adopt. For example: *new construction* (for residential and office buildings), *equipment replacement*, *elective retrofit*.

Step 3: Identify Market Barriers

Steps 1 and 2 usually bring in a set of broad target markets. The next step is to outline the key players involved in these markets and the barriers that they face. Refer to Figure 20 for possible barriers. Generally, they can be split into the following categories: *structural*, *financial* and *informational*. The *structural* barriers appear when there is not enough motivation for the participants in the identified market. It may also be referred to as "split-incentive" barrier. The *financial* barriers appear when the cost of a piece of equipment with embedded energy efficiency technology costs significantly higher than the standard efficiency counterpart. The *informational* barriers appear when market players do not have enough information or expertise to determine the most energy-efficient offerings available on the market.

Step 4: Create Incentives

Incentives should be designed in a way to address the main market barriers. Financial incentives should be designed high enough to involve the desired amount of customers.

Step 5: Gathering Feedback

Energy efficiency program design process should be interactive and not purely analytical. It should engage customers and various focus groups to provide feedback. A lot of basic information (barriers, incentive types, etc.) can be gained this way. Once the program is designed, the feedback process should not stop. Continuous market observation and program updates are crucial for a decent program performance.

3.3 Impact of Smart Meters on Energy Reduction Trials

3.3.1 Energy Saving Interventions Without Smart Meter

In Energy Demand Research Project conducted by OFGEM in the UK [13], it was identified that there was no significant reduction in energy consumption when the intervention for demand response did not include a smart meter. The exceptions are: interventions using real-time-displays of electricity consumption and "benchmarking" individual customer's consumption against a typical household consumption. However, even in case of exceptions mentioned above, total savings did not exceed 1%. This fact is proved by other trials that showed that real-time-displays, energy efficiency advice or any other financial incentives to save energy have little effect without smart meters.

3.3.2 Energy Saving Interventions With Smart Meter

Energy saving interventions using smart meters were successful and the percentage of energy savings was around 3% on average [13]. This may be explained by availability of different options once the smart meter was installed (for example, more advanced real-time-displays and more frequent historic energy consumption statistics and billing). It has been found in [13] that an audible alarm for high consumption attracted negative response in the customer survey and did not cause incremental reduction in consumption. However, a "traffic lights" visual signal of electricity consumption was most positively rated feature.

Web-based interventions

In [13], web-based services were trialed to provide advice, billing information and historic consumption information. However, they did not have any effect on consumption. Literature studies indicate that there are untapped potential benefits of online services that help customers reduce their energy consumption, but also there is evidence that this potential is rarely realized. The main roadblock for realization of this potential is considered to be real-time feedback (based on real-time energy consumption, without significant delays).

3.3.3 Energy Efficiency Advice Feedback

According to EDRP project survey [13], end-customers were asked to rate the usefulness of EE advices. The table below contains the results:

Table 8 Level of usefulness of various advising aspects

Aspect of advice	Not useful	Not very useful	Quite useful	Very useful
Insulation (e.g. cavity wall and loft insulation, draught exclusion)	15.8%	18.6%	45.7%	19.9%
Heating (e.g. servicing boiler, turning thermostat down, fitting thermostatic controls)	11.2%	16.7%	51.7%	20.4%
Hot water (e.g. immersion heater, fitting cylinder jacket, advice on showers and baths)	12.8%	20.0%	48.9%	18.3%
Cooking (e.g. not overfilling kettles, putting lids on pans, using the microwave and grill)	16.5%	20.7%	44.9%	17.9%
Appliances (e.g. energy efficient ratings, filling the freezer)	11.9%	18.4%	48.6%	21.2%
Lighting (e.g. energy saving bulbs, nightlights)	10.4%	19.7%	48.1%	21.7%

The level of usefulness depends on the amount, clarity and quality of EE advices. Additionally, the household may have prior awareness of the provided information. However, advices on heating, lighting, and appliance use are the easiest place to start.

3.3.4 Energy Savings Promotion

Cycle of learning and action for end-consumers [11]:

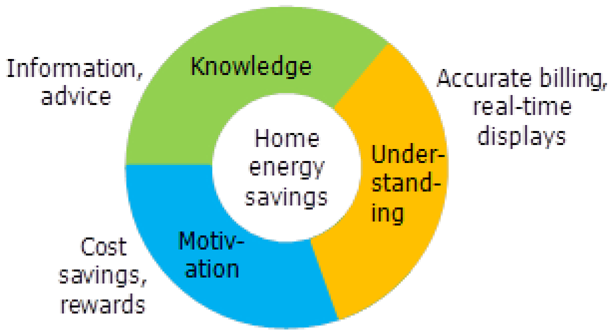


Figure 22 Cycle of learning and action for end-consumers

The following recommendations for energy saving promotion among customers can be identified for utilities:

1. *Clear energy saving targets*
   The maximum electricity savings of 20-25% can be achieved in some pilots, while the worst-case scenario can have negligible savings. A target of 3-8% of energy saving is more realistic on average.

2. *Specific information and advices*
   Average and typical energy usage statistics is less informative than information on specific groups of customers and homes. Real-time energy consumption information for individual appliances would indicate better how user's behaviour effects on total energy usage.

3. *Sustained motivation*
   The EE pilot projects have shown that even the most committed energy-saving households tend to become less effective in saving energy over time. Additionally, it has been shown that financial incentives are effective only while they last. Utilities need to find the way to sustain motivation level on the desirable level. For example, it can be done by providing custom tariffs and periodic consumption reports with highlights of usage patterns.

4. *Consumer Self-Assurance*
   Electricity retailers can give their customers an opportunity to set energy saving targets themselves. Some studies have shown that it makes households more responsive and "at ease", leaving security worries aside.

5. *Community-based initiatives*
   Sharing energy-saving experiences in communities enables learning and provides encouragement to maintain motivation. Competitive element can be a powerful motivation for electricity consumption behaviour change.

3.4 Possible Interventions for EE

The following interventions can be used for customers to provide incentive for energy efficiency:

- Smart meter
- Accurate remote billing
- Extra information about electricity consumption (e.g. graphs, historic energy consumption, comparisons, and forecasts)
- Energy efficiency advice: monthly EE recommendations sent by post and/or provided via web-portals or real-time-displays.
- Real-time-display
- Time of use tariff: provides incentive to offset demand to off-peak hours.
- Personalized consumption history available via TV
- Personalized consumption history available on a web-portal.

3.5 Changes in Consumption Behavior

It is quite challenging to take into account the behavior change when studying EE. It is highly linked with customer's psychology, income, convenience preferences and other aspects. In order to make a move towards EE programs, a customer must have the means, motive and opportunity for change of behavior. In other words, for end customers to reduce their energy demand, they must know what to do, have a reason for doing it and the resources to do it.

However, in recent years a number of start-ups have appeared that provide interactive energy saving and energy efficiency programs. For example, Simple Energy - an American startup company, offers interactive, social gaming platform for utilities to engage customers in energy-saving behaviour. Utilities can conduct energy efficiency/saving contests that will reward top savers with real-world prizes, such as gift cards, latest gadgets or direct monetary benefits.

The energy saving competitions can be conducted in local communities and covered in newspapers. During the contest, the utility's customers would compete against each other (or between districts) in making energy-efficiency changes to their home, like weatherizing doors and windows, sealing air leaks, installing programmable thermostats, changing their lightbulbs, and more. The utility will then utilize the data gathered from smart meters to measure month-over-month or year-over-year consumption of the participants. [21]

Similar initiatives are being initiated by utilities across Europe. For example, E.On energy (DSO) in the UK has introduced an "interactive house" energy saving advice website [22] that allows to estimate impact from various household energy efficiency improvements. The site is very interactive and contains both numerical and graphical information representation.

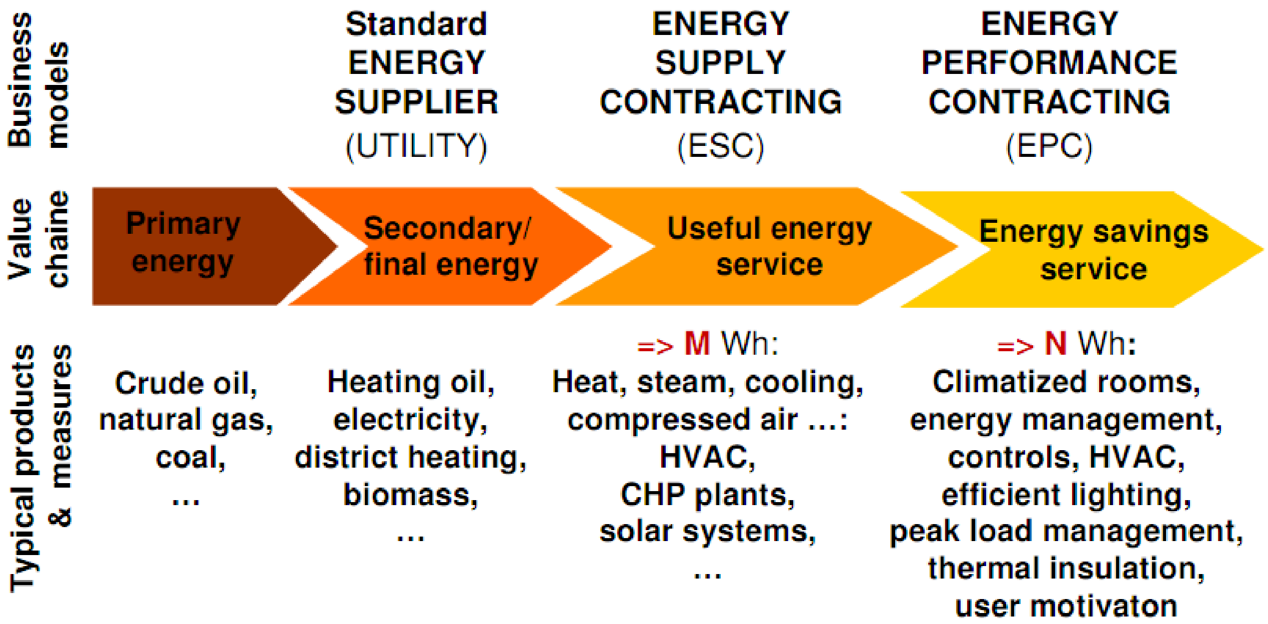
The following factors can contribute to changing of consumption behavior:

- Clustering of residential homes with smart technologies
  - shared electricity storages
  - district balancing
- Local energy markets
- Development of residential energy gateways
- Customer acceptance of smart homes
  - Customers must be familiar with smart components in their home
  - Effective interfaces for in-home devices that make customer feel "in charge"
- Creation of network-level entities
  - In-home home-automation networks (behind the gateway) of heterogeneous components (compatibility of devices)
  - Development of local cells on the distribution grid, managed by remote software agents, responsible for balancing demand in their cell.
  - Integration of the network-level entities in a smart grids reference architecture

4 Key Components of EE

4.1 Energy Contracting

Energy contracting or energy efficiency service is a comprehensive energy service product to improve energy performance and cost efficiency of building or production facilities.



4.2 Enabling Technologies for Energy Efficiency

EE Prerequisites

- *Ability to measure individual demand response or energy efficiency participation effect*

  Individual DR participation measurements are required in order to encourage customers to engage in DR and energy efficiency programs. Visual and numerical information is crucial for boosting up customer engagement and sparking up the competition among communities.

- *Integration of RES at the producer side*

  Non-discriminatory rules are required in order to facilitate the adoption of RES at customer's premises.

Enabling Technologies Overview

The following technologies can be viewed as 'enablers' of energy efficiency:

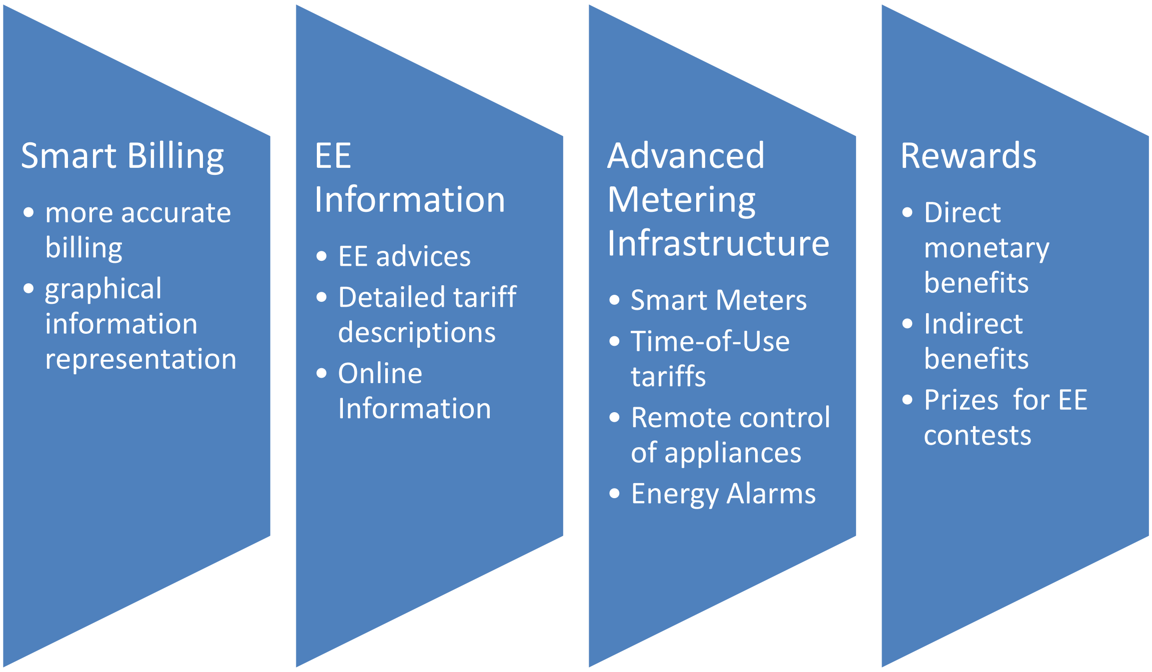


Figure 23 Enabling technologies for energy efficiency

The following energy efficiency activities can be recognized in Public Sector:

- EE in public spending
- Renovation of old buildings
- Energy performance contracting

The main enabling factors for the EE and services are smart meters and offers/tariffs that make use of actual consumption patterns of the customers. Smart meters should be capable of recording consumption on at least hourly basis. However, in order to fully exploit peak hour demand management and bring maximum benefits, a more frequent interval (e.g. 5, 10 minutes) might be needed.

Residential sector

- *Control switches*

  These devices enable direct control of air conditioners and boilers for utilities. Once installed, it allows the utility to cycle or shed a load for a short period of time if required.

- *Smart thermostats*

  These devices do not need a separate control switch for interactions with utilities. Instead, they contain all the functionality required for energy efficiency and demand response actions. The thermostats can be set up to match an occupant's schedule and make sure that cooling and heating operate only when needed. They can also maintain the desired temperature.

- *Embedded controls*

  Once home appliance manufacturers start to collaborate with utilities and electrical equipment providers, demand response functionality will be embedded in things like dryers, dishwashers, washing machines, refrigerators, etc. This will allow home appliances to automatically respond to the signals sent by a DSO or electricity retailer to participate in demand response.

Commercial sector

Automation is the key enabler of commercial sector energy efficiency. Advanced monitoring, control and communication technologies promise to contribute to demand response and energy efficiency target achievement. Energy Management Control System (EMCS) is often used in commercial facilities to control lighting and loads.

Table 9 Energy Management Control Systems functionalities [source: Kiliccote and Piette, 2005]

Energy Efficiency	Energy Efficiency + Demand Response	Demand Response
Lighting		
• Centralized on/off functions, timers.	• Central Dimming • Zone switching	• Demand limiting • Lighting sweep • Overrides
Heating, ventilating, air conditioning		
• Optimized start • Variable speed drive control • Demand-controlled ventilation • Chilled water temperature control	• Duct static pressure reduction • Global zone reset	• Equipment lockout • Pre-cooling • Thermal energy storage • Cooling reduction • Fan, pump reduction

4.3 Potential EE Household Improvements

The table below outlines the potential energy efficiency improvements that can be performed in a typical household and their impact on $C0_2$ emissions and saving potential.

Table 10 Possible Household Energy Efficiency Improvements

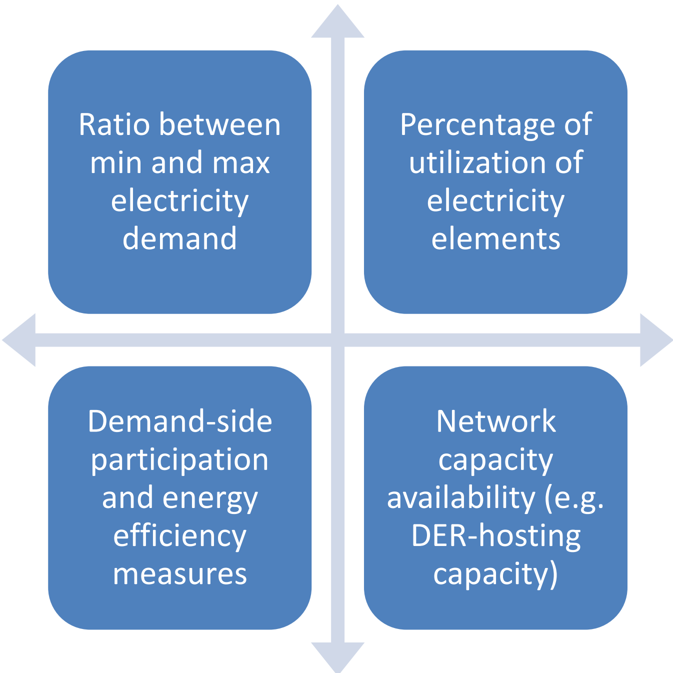
Location	Improvement	Potential*
Building exterior	*Loft insulation* – Around 25% of heat is lost through a roof of typical detached house.	Saving: 97 euro/year $C0_2$ saving: 431.1 kgs/year
	Double glazing – Single glaze windows lose up to 20% of the heat in a typical detached house.	Saving: 153 euro/year $C0_2$ saving: 680 kgs/year
	Cavity wall insulation – un-insulated walls lose up to 33% of the heat in a home.	Saving: 365.8 euro/year $C0_2$ saving: 1619 kgs/year
	Rotary clothes dryer – clothes can be dried outdoors rather than using a tumble dryer.	Saving: 13 euro/year $C0_2$ saving: 39 kgs/year
Living room	*Smart thermostat* – Turning down the thermostat by 1 degree can reduce fuel bill by up to 10%.	Saving: 58 euro/year $C0_2$ saving: 260 kgs/year
	Radiator reflectors	
	TV and home entertainment	
	Energy saving light bulbs	
	Rated fridge/freezer	Saving: 53 euro/year $C0_2$ saving: 155 kgs/year
Kitchen	*Energy saving light bulb (per unit)*	Saving: 53 euro/year $C0_2$ saving: 155 kgs/year

Location	Improvement	Potential*
	Smart meter	n/a
Utility room	Rated washing machine	Saving: 4 euro/year $C0_2$ saving: 17 kgs/year
	Rated tumble dryer	Saving: 14 euro/year $C0_2$ saving: 38 kgs/year
	Boiler	Saving: 248.4 euro/year $C0_2$ saving: 1100 kgs/year
	Radiator Thermostat (per unit)	Saving: 6 euro/year $C0_2$ saving: 29.1 kgs/year
Bedroom	Power down – a PowerDown can save energy by turning off all scanners, printers, etc. when the main desktop unit is switched off.	Saving: 19.5 euro/year $C0_2$ saving:43 kgs/year

* – the numbers are taken from E.On energy savings calculator; british pounds are converted to euros (1 GBP = 1.15 EUR) [22]

4.4 Key Performance Indicators

The following key performance indicators for energy efficiency can be identified:



5 Financial Aspects of EE

Traditional business models of energy utilities contradict society's push to energy efficiency. The revenue generation scenarios of these models are based on increase of energy supply and minimizing the cost of supplied electricity coupled with virtually unlimited growth of energy sales. However, recent European legislations have the potential to change energy markets and affect traditional business models. Should the regulatory market changes be successful in adopting energy efficiency measures, the profitability of utilities' business is going to be affected.

Utilities and electricity retailers are often exposed to wholesale power price. Thus, energy efficiency can be a significant threat to the industry. Once it fully emerges, overcapacity in the electricity markets will increase and power generation margins may get depressed. However, there are a number of potential limits to this. First, the targets set by EU are overestimated and are excessively positive. Due to this fact, these targets are very unlikely to be fully achieved. Second, energy efficiency related revenue losses might be compensated by new sources of energy demand (e.g. electric vehicles, new gadgets, etc.). Third, even if energy efficiency savings would be achieved, recent decisions by a number of European countries to phase out nuclear power and old power plants may compensate overcapacity and bring energy markets to equilibrium.

While energy efficiency is beneficial for society in general, it is unprofitable for energy providers. Therefore, utilities should develop appropriate business models to get ready to paradigm shift induced by energy efficiency. Otherwise, their profit margins are likely to suffer from a decline in energy consumption. Energy efficiency provides an excellent opportunities for both electric and gas utilities to move away from pure commodity selling and adopt energy services provision.

There is an obvious conflict of interest between customers and EU government who want to adopt energy efficiency, and utilities and retailers who strive to sell more megawatt-hours of electricity. Therefore, energy market and regulatory network need to adapt to these conflicts.

Investment in EE measures has two potential negative financial effects for utilities:

1. Potentially impossible to recover program costs on a timely basis (directly affects utility's revenue)
2. Reductions in electricity sales caused be energy efficiency can potentially reduce utility's revenue

The first effect is associated with energy efficiency program cost recovery (including administration, evaluation, implementation, and providing incentives for program participants). A failure in recovering these costs will directly affect revenue of the utility.

Regulations and policies that require utilities to undertake EE measures usually authorize utilities to seek recovery of investments on these measures. However, actual cost recovery is not guaranteed. Therefore, clarity of cost recovery is one of the most crucial factors for utilities. Otherwise, a utility may not have enough incentives to initiate an energy efficiency program if a policy does not eliminate financial disincentives. Moreover, funding mechanisms should reflect local realities. Therefore, “one-size-fits-all” approach may not be applicable for energy efficiency programs.

The objective of an energy efficiency program is to cost-effectively reduce consumption of electricity. However, a reduction in consumption directly affects (reduces) revenues of the utility. And lower revenues often lead to under-recovery of a utility’s fixed costs. This, in turn, can lead to lower net operating margins and profits and what is called the “lost margin” effect. This same effect can create an incentive in certain cases for utilities to try to increase sales and thus, revenues, between rate cases – this is known as the throughput incentive. Because fixed costs (including financial margins) are recovered through volumetric charges, an increase in sales can yield increased earnings, as long as the costs associated with the increased sales are not climbing as fast [16].

The big question is should a utility be compensated for the lost revenue margin when energy efficiency reduces sales below the level on which the current rates are based? And if yes, who's going to compensate it? One of the issues that arise with estimation of lost revenue margins is the determination of whether a loss is caused directly by an energy efficiency program or some other factors. The impacts of revenue loss due to an energy efficiency program can potentially be offset by customer growth or by reductions in costs.

Business opportunity: electricity retailers can increase their income by offering the customers other energy and non-energy related services and products (e.g. energy advisory services).

Revenue decoupling can address lost profit margins due to energy efficiency program. It also can have an impact on utilities and customer risk (e.g. it can shift risks associated with unpredictability of sales to consumers).

Business challenge: How to grow energy supply business in the environment where regulatory organs and customers are both pushing for reduction of electricity consumption. Utilities need to adjust their business models to rapidly growing energy efficiency market.

How to monetize energy efficiency?

- *Short- and medium-term period of time*: traditional heating and cooling services, low-carbon heating and micro generation.
- *Long-term period of time*: energy management services (demand response, aggregation)
- *Long-term period of time*: sophisticate portfolio approaches that offer a custom-tailored solution to a customer

Cost structure of an energy efficiency program usually consists of the following items:

- Cost of a program administrator. It includes the cost incurred by an administrator of the program and the incentives received by the customers from the administrator.
- Cost of participant. It includes the cost that a customer must pay in order to implement an EE measure: purchasing and installation cost of EE equipment.

The cost of a program administrator can be further split into the following categories:

- Promotion of EE measure/program
- Audits, subcontractors
- Resources for evaluation and registration of energy savings.

Even though some utilities may support measures aimed at promoting an effective market for energy services, the market will not necessarily stimulate the early uptake of all cost-effective energy efficiency measures, particularly those with high energy saving potential but long payback times and high upfront capital investments.

The image below shows that the investors view energy efficiency measures as a viable source of investments towards achieving European $C0_2$ emissions targets:

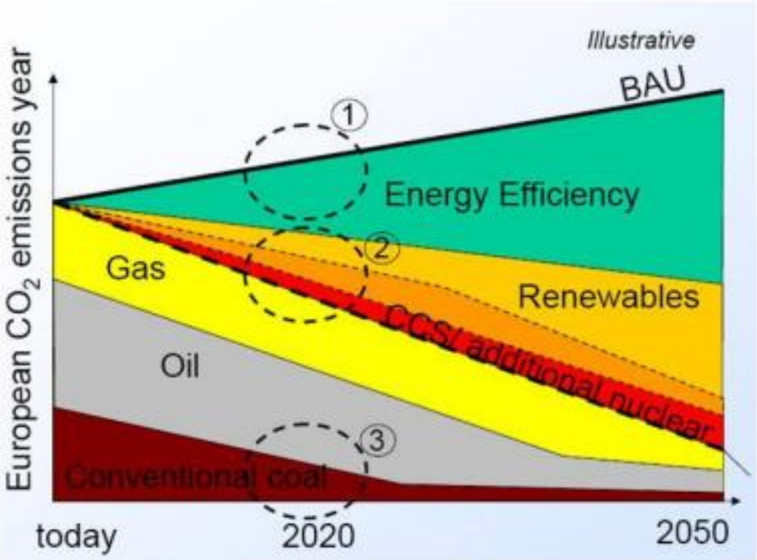


Figure 24 Investors' perspective: strategic choices to achieve European C02 targets [source: Neuhoff, 2007]

However, certain financial barriers exist on the way of implementation of energy efficiency:

- EE incentives are spread across different market players

- Short holding periods for investment properties lead to the belief that there is not enough time to gather all savings from energy investments.
- High upfront investments

5.1 Energy Efficiency Program Cost Recovery

Implementation of the energy efficiency programs by and financial implications connected with them (e.g. administration, promotion, marketing, incentives for customers, etc.) costs utilities tens of millions of euros. Therefore, the most basic requirement for elimination of disincentives to customer-funded energy efficiency is establishing processes for recovery of these costs. Inability to recover these costs directly affects utility's cash flow and revenue.

Cost recovery can be achieved via periodic tariff adjustment that should be monitored by regulatory organs. The majority of energy efficiency program costs are recovered through a so-called "expensing" mechanism. That means that for every 1€ that a utility spends on an energy efficiency program, 1€ is included to cost of service directly for customers.

5.2 Incentives for DSOs

DSOs and electricity retailers may be interested in implementing energy efficiency measures if the government provides monetary incentives (e.g. tax breaks, investment funds, etc.) for providing energy services to customers.

Additionally, all drivers mentioned in Energy Efficiency Drivers section can serve as incentives for both DSOs and retailers.

Energy retailers can play an important role in promoting energy efficiency measures among customers. Market competition between retailers creates incentives to diversify their portfolios of offerings through promotion of energy services and energy efficiency. Moreover, as more customers subscribe to energy services, the value-per-customer will increase as they are going to be paying for both energy supply and services.

However, energy efficiency programs should not be static. Electricity retailers should constantly review the effectiveness of such programs and identify drawbacks and new opportunities to enhance existing programs, while making the objectives clear and simple to comply with to end-consumers. Best practice approaches from other retailers' energy efficiency programs should be adopted.

In order to boost the incentives for energy efficiency between DSOs/ERs (electricity retailers), the government can adopt the following approaches:

- Annual awards for the most effective energy efficiency program
- Requirement for the ERs to provide average energy efficiency effect for a typical group of customers (e.g. residential, offices, industrial, etc.)
- Requirement for the ERs to audit and publish reports on the effectiveness of current energy efficiency programs.

5.3 Incentives for Customers

Energy efficiency program administrators, whether it is DSOs or electricity retailers, should encourage and motivate their customers to reduce the total amount of consumed energy for a given level of energy service provided. In addition, it is the duty of EE program organizers to facilitate the same or better level of service. Energy efficiency measures have the potential to be adopted only on the provision that it is economical for both end-users and energy providers.

Possible ways of incentivizing the customers are listed below:

- *Direct incentives*

In the form of direct payments or subsidies to individual customers reflected in purchase or installation of a specific energy efficiency measure.

- Rebates
  Payment from the program facilitator to an individual customer that is usually made after an item has been purchased and the rebate application has been submitted.
- Discounts
  Discounts can be in the form of instant reduction or upfront rebates, taken off the price of the product at the moment of purchase.
- Financing
  Providing loans to customers through an energy efficiency program can be an incentive to adopt certain energy efficiency measures.

- *Up- and mid-stream incentives*
  Financial incentives that involve payments to parties that are up the supply chain from the customer purchase transaction (e.g. manufacturers). Mid-stream incentives target retailers or installation contractors.

- *Non-financial incentives*
  - Technical services
    This incentive helps overcome the "hassle factor", steps required for implementation of energy efficiency measure (e.g. identifying, developing, installation, etc.). Program services that help customers overcome the "hassle factor" may increase the adoption rate.
  - Information services
    Information services aim at improving the ways of information delivery to end-customers. Providing information on available options and implementation processes can reduce the typical lack of information for end-customers in the industry.

The following table provides a brief overview of various incentive types and levels of market intervention [26]:

Table 11 Types of incentives and levels of market intervention

Incentive Type	**Level of Market Intervention**		
	Upstream	**Midstream**	**Downstream**
Financial • Cash rebates • Discounts • Financing • Tax credits	*Example*: Cash payment to manufacturers for making products that meet high-efficiency performance criteria	*Example*: Cash payments to retailers for promoting discount high-efficiency products	*Example*: Cash rebate to customers who purchase efficient products
Non-financial • Technical services • Information services	*Example*: Providing assistance to builders and developers to design buildings for high energy performance	*Example*: Providing point-of-purchase displays and information materials to support retailer promotions of high-efficiency products	*Example*: Helping customers develop efficiency projects, arrange installation, and ensure quality control
Bundled incentives and services • Combination of financial and non-financial incentives	*Example*: Offering builders/developers both design incentives and cash rebates for building high-efficiency buildings	*Example*: Offering retailers cash incentives and providing training for sales staff	*Example*: Providing design assistance to develop customer projects, arranging financing, and subsidizing interest rates

6 Regulatory Issues of EE

Suitable regulatory framework and market-based incentives are needed to boost energy efficiency measures adoption and overcome existing barriers. One possible solution for this (issued by a regulator) can be shifting the rewarding paradigm from providing monetary benefits and rewards for energy efficiency rather than for the amount of energy supplied. Moreover, once the energy efficiency market emerges, binding requirements need to be created. Regulatory organs are in a tough position. They have to find the right balance between the reward-and-punishment incentives for both utilities and end-customers.

Energy efficiency regulations are formed by a variety of constraints and considerations of ownership and financial structures of the utilities. Here are a few considerations for policies:

- EE policy should balance an appropriate amount of risk and rewards between utilities and consumers
- EE policy should contribute to stabilization of rates, tariffs and customer bills
- EE policy should stabilize utility revenues
- EE policy should contribute to transparency and simplicity of the EE programs

Guidelines for Public Funding

The following guidelines can be used when designing energy efficiency public funding programs:

- Coordination between public funding sources is needed to ensure that resources are used effectively.
- Public funding should be used along with, and not in competition to, the market for energy efficiency measures conducted by private companies, with the aim of promoting positive spin-off effects for society.
- Transparency and accountability should be ensured when designing mechanisms for raising and distributing public funds for energy efficiency.
- Public funding needs to be non-discriminatory, i.e. open to all market players, including energy companies.

6.1 Energy Efficiency Policies and Objectives

Energy efficiency policies should not only bind DSOs and electricity retailers with obligations to introduce energy efficiency, but also provide financial incentives for DSOs to participate in it. Aligning financial incentives of DSOs with the delivery of cost-effective EE programs ensures the key role that DSOs can play in capturing energy savings. That implies committing to a consistent way of cost recovery in a timely manner.

The table below enlists the main European legislation on energy efficiency [27]:

Table 12 Main European legislation on energy efficiency

Year	Regulation / Directive	Scope
1992	Directive on labeling of consumption of electrical appliance	Fridges, freezers, washing machines, etc. must indicate energy efficiency level
1992	Directive on the efficiency of heaters fed with gas or liquid	Certification introduced, with the «CE» label for those reaching the minimum standards.
2000	Climate Change programme	European states start discussing ways to reduce CO2 emissions, and energy savings are stressed as a promising route.
2002	Directive on the energy performance of buildings	Minimum of energy efficiency targets for old and new buildings imposed in all states.
2003	Directive on Emissions Trading Scheme	Emphasis placed on CO2 emissions reduction: incentives provided to improve the efficiency of

		power generation.
2005	Directive establishing a framework for the setting of eco-design requirements for energy-using products (or framework "eco-design directive")	Objective: increase the energy efficiency of all products throughout their lifecycle (I.e., products that consume energy themselves - not windows, for instance). In principle, the Directive applies to all energy-using products except vehicles for transport.
2005	Green paper of the European Commission on energy efficiency	Prepared the 2007-13 action plan: 20% energy efficiency improvement target by 2020 proposed.
2006	Action plan on Energy Efficiency over 2007-1	Objective: reduce energy consumption by 20% by 2020.
2006	Directive on end-use efficiency and energy services	Objective: energy savings representing 9% of total final consumption by 2016 (vs. the 2000-2005 average). All states required to draw up an Energy Efficiency Action Plan to reach the objective
2007	European energy policy	The objective of 20% energy savings by 2020 reaffirmed and presented as one axis of energy policy, alongside security of supply, and renewables development: 20% savings must be obtained by 2020 (based on a standard project of energy consumption); 20% of energy must come from renewables; greenhouse gas emissions must be reduced by 20%. This 20/20/20 package was approved by the European Council on 12 December 2008 and by The European Parliament five days late
2009	Extension of scope of the 2005 Eco-design directive approved by the European Parliament	Increases the scope in order to cover other energy-using products that help reduce consumption indirectly (windows, construction products, shower heads, etc.)

Among non-binding EU targets, two can be highlighted in particular: (1) End-Use Energy Efficiency and Energy Services Directive (2006) which projects 9% energy savings from overall consumption by 2016; (2) National Energy Efficiency Action Plan that was prepared by all member states. These targets will be hard to meet. Recent estimates expect savings of only 11% [29].

7 Conclusions

Key findings of the report

- The majority of the identified barriers for energy efficiency are going to be overcome in future. With clear environmental goal and proper justification, evaluation, and measuring, there are no major roadblocks on the way of its wide adoption.
- Energy efficiency measures may help end-customers overcome rising energy prices, whereas carbon taxes might not be accepted by the general public.
- There is a great potential for energy efficiency in Finland, as it tops the kWh per dwelling rating in Europe with about 7000 kWh/dwelling per year.
- Effective and clear coordination between energy efficiency and demand response is needed with participation of all electricity market players, including regulator, DSO, and electricity retailer. Demand response measures, when adopted, will contribute to the reduction of peak generation power plants, and at the same time will allow for accommodation of small-scale renewable generation through real-time monitoring, more accurate load estimations, and controls.
- Europe is not going to meet 2050 carbon-neutrality target without contributing to energy efficiency program implementation.
- For DSOs, there is a lack of incentives for energy efficiency. Therefore, regulators should stimulate them with binding investment obligations for energy efficiency. For electricity retailers, energy efficiency can be a viable business as new products and services for energy efficiency support can help differentiate themselves from competitors and satisfy customers.
- Energy saving competitions can be adopted in local communities as a tool for boosting the awareness and initiatives for energy efficiency.
- Investment in energy efficiency has two potential negative financial effects for DSOs: (a) difficulties in recovering program costs on a timely basis (directly affects utility's revenue); (b) reductions in the amount of distributed electricity caused by energy efficiency can potentially reduce revenue margin of a DSO. However, program cost recover can be achieved via periodic tariff adjustment that monitored by a regulator (e.g. "expensing mechanism": for every 1€ that a utility spends on an energy efficiency program, 1€ is included to the cost of service billed to customers).
- Electricity retailers can increase their income by offering customers other energy and non-energy related services and products (e.g. energy advice services)
- Energy efficiency measures have the potential to be adopted only on the provision that it is economical for both end-users and energy providers.

General considerations

Energy efficiency is getting more and more attention nowadays. This comes on the agenda after tsunami catastrophe in Japan. European countries have reviewed their roadmaps and some of them decided to gradually phase out nuclear generation. Using energy efficiency instead of increasing generation is going to gain more and more attention. Germany has recently announced its plans to decommission all nuclear power plants by 2022. Consequently, government policy emphasizes energy conservation and use of renewable energy resources.

New energy services are likely to be introduced by utilities in near future. A portfolio of energy services can include the following items:

- Energy efficiency measures and energy advising/auditing
- Energy management
- Financial services
- Smart metering
- Hourly-based pricing
- Smart heating

Energy efficiency can only be successful if customer convenience stays on the same level or are enhanced, while at the same time reducing the amount of energy consumed and/or reduce the impact on environment. Without a clear perceived personal benefit of energy efficiency, there might be not enough incentives for it to become a wide-spread service or adopted general practice.

Energy efficiency is a cheap form of new energy and an effective way to reduce emissions. Some estimates suggest that by 2030 the amount of energy saved through improved energy efficiency will exceed the amount of energy consumed from any single supply source [25].

As the capacity of electricity networks in urban areas is approaching its limit and fossil resources are close to depletion, energy efficiency can pay an increasingly valuable role in ensuring preserving the environment and supporting our usual way of life.

It is obvious that the shift towards decentralized electricity generation will not happen overnight. It is a long process. And surely, it will require a lot of investments. Therefore, energy costs are highly likely to rise and create cost additional pressure for end-customers. This factor is one of the most significant drivers for investments in energy efficiency. Various innovative technologies will help people recognize, analyze, and control their energy consumption and, as a result, reduce their monthly electricity bill.

The latest European directive on energy efficiency includes rules designed to remove barriers and overcome some of the market failures that impede efficiency in Europe's supply and use of energy, including, but not limited to the following measures:

- *Building upgrades*. Bring up to minimum energy standards at least 3% of the floor space of each public building, beginning in 2014.
- *Energy efficiency targets*. Require all energy retailers to increase efficiency by 1.5% per year.
- *Audits*. Promote home and business energy audits.
- *Smart meters*. Require smart meter rollouts in accordance with earlier directives — calling for 80% deployment by 2020, and 100% by 2022.
- *No estimated bills*. Require electricity billing to be based on actual consumption. Today, virtually all European consumer power bills (except in Scandinavia and Italy) are based on estimated meter readings. Actual readings are taken only once a year or so. This is another important driver for smart meters.
- *Energy information*. Consumers must receive detailed energy information free of charge, and have the right to have their data sent to energy service providers of their choice.

The inevitable increase in adoption of energy efficiency measures is going to have an impact on the amount of delivered electricity in T&D grids, and potentially – on power demand. Whether DSOs and electricity retailers want it or not, their revenues are going to be affected by these measures. Delivered energy will have impact on the revenues of the electricity distribution in the short-term, while its impacts in the long-term can be compensated by adjusting the tariff structures.

Decrease in demand of electricity may affect the dimensioning of network components and help avoid planned investments in them. This may potentially decrease capital investments of a DSO in the long-term. However, it should be mentioned that the effects of energy efficiency may vary and does not necessarily imply the decrease in power demand. For example, electric vehicles will decrease oil consumption, but increase electricity consumption. Additionally, the estimates show that the use of heat pumps in Finland will decrease the annual delivered electrical energy by 11% by year 2020. This will decrease the annual revenue by 5% with the current tariff structure.

While the abovementioned decrease in delivered electricity may sound as bad news for the business of DSOs, smart metering and interactive customer gateways hold the opportunity for introduction of new energy services and as a result – revenue increase. AMR services will allow for more precise load forecasting, which will in turn improve the operation of electricity retailers and DSOs, decreasing the need for expensive regulating power.

How to monetize energy efficiency?

- *Short- and medium-term period of time*: traditional heating and cooling services, low-carbon heating and micro generation.
- *Long-term period of time*: energy management services (demand response, aggregation)
- *Long-term period of time*: sophisticate portfolio approaches that offer a custom-tailored solution to a customer

Benefits of EE

- If energy makes up 20% of the costs for running a business, then 20% energy savings reflect a 5% increase in overall profit.
- Differentiation among rivals. In terms of marketing, proactive actions of a DSO/retailer to brand itself as a company supporting EE can give a competitive advantage.
- Less CO_2 emissions and contribution against climate change
- Decreased dependency on oil prices and oil/gas imports from non-EU countries
- Lower energy bills for households, industry, and service sectors
- New jobs from the introduction of new services that promote EE
- Improved reputation in society through environmental protection

Energy efficiency for buildings and public sector

Energy efficiency in the building sector has one of the highest savings potentials, with approximately 40% of produced energy being consumed in residential and commercial buildings. Exploiting this potential depends on different stakeholders (e.g. inhabitants, owner, regulator, etc.).

Investment in energy efficiency programs for buildings is a very cost-effective way to reduce energy consumption. It is estimated that by 2020, energy efficiency programs for buildings would allow energy savings of 10-25% compared to business-as-usual scenario. By 2050 this figure is estimated to be about 50%.

Energy efficiency for residential sector

In residential sector, to keep customer base growing and secure their loyalty, electricity retailers will need to focus on providing new energy services (including, but not limited to energy efficiency), while DSOs would probably increase their revenue margins from energy efficiency programs to recover lost revenues from selling less energy.

End-customer consumption behavior should be assessed more thoroughly. In general, it is quite challenging to take into account the behavior change when studying energy efficiency as it is highly linked with customer's psychology, income, convenience preferences and other aspects. In order to make a move towards energy efficiency programs, a customer must have the means, motive and opportunity for change of behavior. In other words, for end customers to reduce their energy demand, they must know what to do, have a reason for doing it and the resources to do it.

7.1 Key Recommendations

The main recommendation for Fortum is that energy efficiency should be taken into account in a concrete way, not just on the general level (i.e. as a policy). Proper and realistic evaluations of its impact must be made. However, it is probably not realistic to expect too much of it. Energy efficiency should be integrated into other strategies, such as carbon emission reductions, rather than being a simple add-on.

Further on, testing of various energy efficiency policies is required. This can only be achieved through a dialog with regulator and experience sharing. Selecting the right incentives, quantifying rewards, and defining the responsible partner for investments into energy efficiency is no easy task. It can only be solved with test driving the policies.

Recovering costs and lost margins from investing in energy efficiency programs will, without any doubt, involve discussions from a variety of stakeholders. The most challenging task is to determine who should pay and how much.

The following recommendations can be given on Energy Efficiency measures:

1. Recognize energy efficiency as energy resource
2. Commit to long-term plans on implementation of cost-effective energy efficiency
3. Promote, educate and advertise the benefits of energy efficiency opportunities
4. Coordinate financial funding programs to support energy efficiency
5. Work closely with regulatory organs to provide enough incentives for both utilities and end-customers to deliver cost-effective energy efficiency
6. Combine demand response and energy efficiency objectives into a single package offering to reduce program costs and harvest mutual benefits.

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