Demand Side Management for residential and commercial end-users

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This paper focusses on demand side management in the residential and commercial sector, i.e. for small end-users. Demand side management provides a range of technical, organisational and behavioural solutions to cut or decrease electricity consumption and demand. In this article, special attention is given to proposals for cost-effective actions, which are classified from no-cost to investments with long payback time. We conclude that there are lots of solutions to save electricity and reduce greenhouse gas emissions.

Contents

1 Introduction

Demand Side Management (DSM) is the implementation of policies and measures which serve to control, influence and generally reduce electricity demand. DSM aims to improve final electricity-using systems, reduce consumption, while preserving the same level of service and comfort.

DSM is recognized as a major solution in the fight against climate change since energy consumption and peak demand are reduced, installed capacity and distribution network extension can be avoided (or postponed), and less primary energy is required, reducing greenhouse gas emissions.

DSM has been first used in California to avoid construction of new electricity power plants and grid strengthening.

Demand side management relies on a combination of using high efficiency equipment and efficient use of electricity through good operating practice.

DSM is usually a task for utilities. In this paper, a different approach is presented for commercial and residential end-users. As shown on the pie chart below, the share of the residential and commercial sectors in electricity consumption are more important compared to the industry and transport sectors.

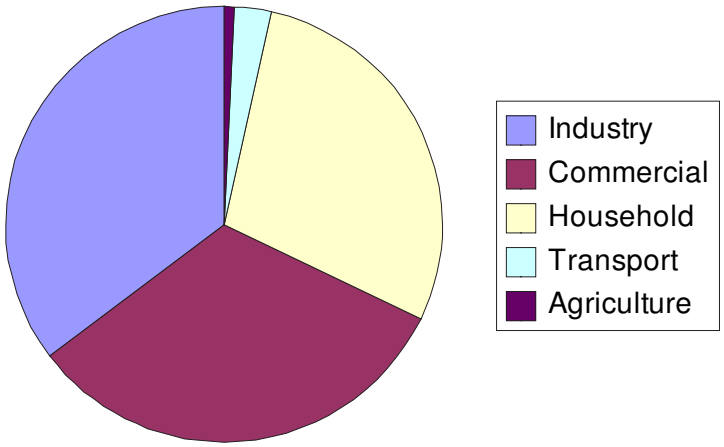

Figure 1: Breakdown of electricity consumption in France, 1999 - Data source: DGEMP 2001

With the recent trend of larger buildings and the penetration of new energy uses (air conditioning, computers, modems, ...), electricity consumption for the residential and the commercial sector has significantly increased over the last years. In France for instance, the electricity consumption has increased by 50% since 1990. [ADEME, 2004]

Given the few actions implemented so far to improve energy efficiency in these sectors, a large energy saving potential remains. In this paper, we present an overview of concrete DSM actions.

2 Ongoing programmes and initiatives

With the 1997 Kyoto Protocol for the reduction of greenhouse gas emissions, the European Union committed for 2010 to a reduction by 8% of its emissions compared to the 1990 level and a development of renewable electricity which should reach 21% for the EU-25.

Initiatives and programmes have been started on different levels (local, national, European) to accelerate the promotion of energy efficiency: the current green paper on Energy Efficiency, the eco-design directive, the energy services directive, the standby initiative, a variety of SAVE actions (Greenlight, Cold II, ...). Actions can be of various nature:

- a legal framework, such as the European Directives,
- a voluntary agreement, such as the Nicolas Hulot Campaign [DEFI] addressed to general public, or to commercial end-users, such as the Greenlight action
- a technical solution to a concrete problem of transmission and distribution, such as the DSM programme at Boutre-Carros in South of France.

More recently, national campaigns such as 'Faisons vite, ca chauffe' in France target directly a large public with TV-spots, press articles and websites developing awareness of climate change issues.

3 Residential and commercial DSM issues

3.1 Residential

In order to implement the most efficient and cost effective DSM actions, it is necessary to identify the largest energy consumers: studies have shown the importance of cold appliances (refrigerator and freezers) or air conditioning (for instance in the summer crisis in California 2000).

The energy consumed depends on the equipment's power, but also on the number of operating hours. That's why high power equipment such as irons or microwaves, which are on average used only during short periods of time, consume much less energy than refrigerators. On the other hand, stand-by consumption can be significant despite small power consumption. On average, the sum of all the standby power devices in electronic

equipment can reach around 80 W in a house, which represents an annual electricity consumption of approximatively 650 kWh [DG JRC].

The pie chart below shows the breakdown of electricity consumed by type of appliance for a Belgian house.

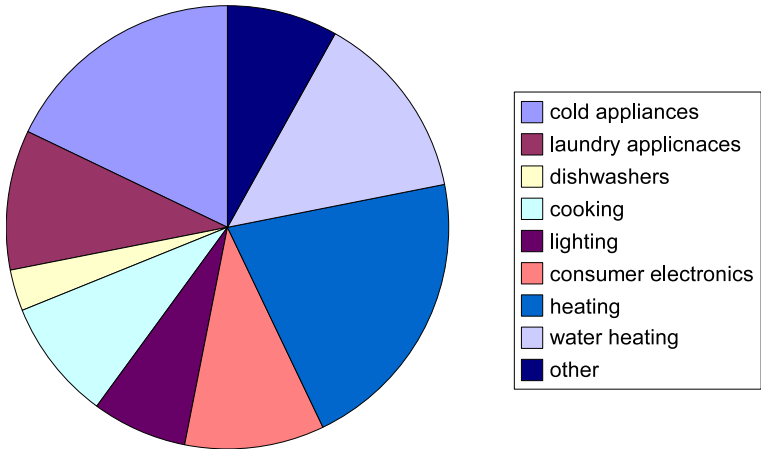

Figure 2: Breakdown of electricity consumption in belgium households 1999 - Data source: BFE

As mentioned, cold appliances and heating represent a significant share of the total electricity consumption.

3.2 Commercial

Depending on the type of activity, the energy consumption pattern can vary widely. As shown on the diagram below, electricity use for air-conditioning is highest for stores, while offices have increasing electricity consumption due to the use of computer equipment, and hotels or restaurants have the highest demand for space and water heating.

- Electrical appliances such as computers, printers, fax machines, copy machines, ... have relatively small power – and therefore, electricity demand – per unit of equipment. But as their number is significantly growing, their electricity consumption can be as high as 25% of the total consumption of a typical office building [ALPHEO, 2005].
- Standby consumption of electrical appliances has recently caught the attention since a European study found out that it represents up to two thirds of appliances' electricity consumption: only one third of the consumption of equipment is related to operating in the active mode [ALPHEO, 2005].

- The consumption of lifts is not well known, estimated to vary between 5 000 and 8 000 kWh/year/lift. A large energy savings potential exists for lifts through design measures and use of efficient equipment [ALPHEO, 2005].
- Lighting represents typically between 20 and 40% of the electricity bill for offices. Lighting is directly associated with comfort, security and atmosphere.
- Finally, electric motors are widely used in the commercial sector mainly as auxiliary equipment for HVAC. Such small motors (under 1 kW) have very low efficiency (around 60%). In France, their consumption represents 17% of the commercial energy consumption [ALPHEO, 2005].

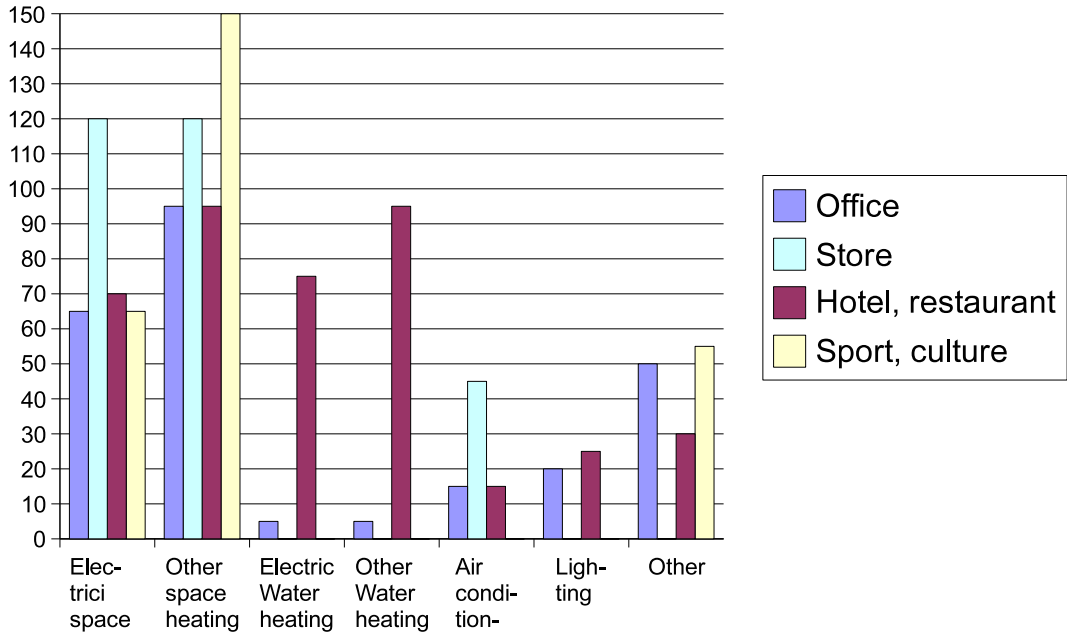

Figure 3: Breakdown of energy consumption (kWh/m^2) by type of activity and usage for the French commercial sector - Data source : AERE

Finally, even if DSM actions undertaken differ depending on the ownership status of the building (the owner is using the building or is renting it out), there are DSM actions that apply to both owner-occupied and rented buildings.

3.3 General interests of DSM

In addition to the benefits of DSM action such as reducing the electricity consumption issue or preventing the construction of new power plants and transmission lines, there are other significant benefits which should be mentioned.

- DSM actions are cost-efficient and bring substantial financial savings. DSM is one of the rare type of investments which generates its own economy,
- DSM actions can improve the welbeing and comfort of end-users,
- DSM actions are win/win solutions with positive impacts for all actors involved : local authorities (reduction of public electricity bill, emphasizing local resources, concrete contribution within the national and European commitments, ...), end-users (reduction of electricity bill, improvement of service and comfort, concrete contribution to the national and European commitments, corporate citizenship, ...), producers and suppliers (reduction of required investments for extension of power and transmission capacity, better public image, customer retention, concrete contribution to the national and European commitments, ...).

4 Energy savings actions and money savings

Considering the largest energy consumers, we present the possible energy saving actions, classified by their payback time for the residential and the commercial sectors. Many of the actions can be implemented in both sectors, while others are sector-specific.

4.1 No-cost actions

The no-cost measures are above all related to consumer behaviour. These actions are regularly mentioned during information campaigns (ADEME's campaigns in France for instance):

Common actions to residential and commercial end-users

- The first action, to save money if not energy, is to check the adequacy between the need and the electrical standing charge,
- All unnecessary light bulbs and appliances should be turned off,
- All standby powered equipment should be turned off (TV sets, microwave oven, ... at home, computer, fax machines, printers, copy machines at the office).

Specific actions to the residential sector

- Reduce temperature of hot water ($60°C$ instead of $80°C$), consume less water (shower instead of baths),
- Lids should be kept on when cooking,

- Fridges door should not be left open for longer than necessary (cold air escape). Hot or warm food should not be put straight into the fridge (need to cool down first). The freezer should be regularly defrosted to keep it running efficiently. If it tends to frost up quickly, the door seal should be checked. And if the fridge is next to a cooker or boiler, a good gap should be left between them,
- Washing machines and tumble dryers should always be used at full load or with the economy programme. The low temperature programme should always be used: washing powders are just as effective at lower temperatures,
- Closed curtains at dusk will reduce heat transfer through windows,
- Reduced thermostat temperature by $1°C$ can cut heating bills by 7%.

Specific actions to the commercial sectors

- As no energy label exists for professional cooking appliances, the design study should be sufficiently detailed, preventing oversizing,
- Office equipment (computers, printers and copy machines) should be turned off during long idle periods, such as lunch breaks,
- Setting up and activating the saving mode for computers reduces the electricity demand. It needs to be done for each individual computer.

4.2 Short payback time actions

The following short payback time actions depend on everyone, on daily habits, on comfort and wellbeing and on lifestyle – they are above all a matter of culture. Their implementation relies therefore directly on people's goodwill and willingness to change. Typically, these actions are simple technical solutions, with a straightforward implementation process, low investments and immediate energy savings. Above all, they are decision and management aid tools which allow to regulate heat and cold production to match specific needs:

Common actions to residential and commercial end-users

- The electricity consumption for light can be reduced through an optimal use of daylight both on vertical and horizontal planes,
- Programming the control of light, air conditioning, heating (timeswitch thermostats, radiator valves, circulating pumps, ...) allows to match needs with particular comfort expectations,
- Insulating hot water tanks and pipes: fitting a jacket (at least 75 mm thick) to a hot water cylinder will reduce heat loss by around 75% [EST],

- Energy audits are proposed by utilities to optimize tariff selection.

Specific actions to the commercial sector

- Regular maintenance and cleaning allow to identify ageing bulbs, which consume 10 to 15% more electricity while emitting less light. Hence, the replacement of ageing bulbs before failures is cost-efficient,
- Double doors reduce air losses for heating or air conditioning,
- Lighting control with presence detectors, programming, and sensor controls based on outside light intensity can save 25 to 50% of electricity consumption for lighting [ALPHEO, 2005],
- The operation of electrical motors needs to be adjusted to the need: circulation pumps for heating systems have no need to operate when the building is not occupied for instance. When variable needs are involved, the use of a variable speed drive for motors optimizes their efficiency and hence reduces energy consumption by 30 to 60% (with an average payback time of 3 years). A regular maintenance programme can reduce the energy bill by 30% with simple actions such as cleaning, or detecting main characteristics, in order to prevent motors from an accelerating ageing,

  Example: the replacement of manual interruptors by timers on 20 vacuum cleaners resulted in 280 MWh/yr of energy saved, which represents savings of €12 800 per year. This action had an indirect positive impact on the heating consumption with a reduction of 350 MWh/yr and further savings of € 10 500 euros per year. The initial investment of €9 600 was therefore earned back in only a few months [ADEME, 2004].
- Reactive power should be compensated to avoid surcharges from the electricity supplier.

4.3 Medium payback time measures

Medium payback time actions presented below allow to reach further energy savings, but require more investment.

Common actions to residential and commercial end-users

- Replace old light bulbs with efficient light bulbs CFL (average payback time: 6 months [EST]). The installed power for lighting can be significantly reduced (typically from 1000 W to 250 W for 5 bulbs replaced) to create an equivalent amount of light,
- Shifting non-priority equipment for particular usages allows to reduce peak electricity demand, with a lower standing charge for power in the electricity contract as a

result.

Specific actions for the residential sector

- Replace old appliances with new high efficiency units. For example, a typical old fridge consumes around 600 kWh/yr while a high efficient fridge (A++) will consume only 160 kWh/yr. Light bulbs, light fittings, refrigeration products, laundry and dishwashing appliances, gas boilers and oil boilers are typical appliances for which efficiency can be improved: over a thousand household products carry now an energy label or logo. People can use the EU Energy label or specific labels and programmes such as the Topten or Energy Saving Trust websites.

  Example: a typical household with inefficient appliances (C and D-class) would have to subscribe a 9 kVA contract, with a 4 MWh/yr electricity consumption. On the other hand, a household with efficient appliances would only need to subscribe a 6 kVA contract with a consumption of 2.2 MWh/yr, which represents a saving of around €160 per year.

- Window design and orientation: 0.15 up to 0.25 m^2 of window surface per m^2 for a temperature between 18 and 21°C in a climate with moderate winters. Strengthen the insulation of opening mechanisms for windows oriented North.

Specific actions for the commercial sector

- Efficient office equipment is labelled with the Energy Star Label. This label certifies among others that the appliance has an adjustable automatic standby mode and reduced electromagnetic emissions,

- Lift consumption can be significantly reduced with an appropriate system (replace hydraulics system with a counterweight system – gain 40%, implementation of variation speed drive – gain 20%, avoid oversizing and reduce the speed from 1 m/s to 0.63 m/s, automatic light interruption) [ALPHEO, 2005],

- An energy management system monitors and collects data for a building, improving knowledge of the consumption by usage, time and season. It eases the implementation of demand side management, but also metering and billing for a company.

4.4 Long payback time measures

Long payback actions are above all action at design stage, or major refurbishments replacing a whole system. In the case of a new building, these actions should be taken into account at an early stage of the design process.

- A heating system that uses a high efficiency condensing boiler with the correct heating controls can save you as much as 40% on the heating bill,

- Outside house insulation: this is the most efficient house insulation measure since it lowers the thermal bridges losses. It is also the most expensive, and changes the outlook of the wall (it may not be applied for historical or architectural reasons),
- Inside house insulation: if outside house insulation is not affordable,
- Replace single-glazing and poorly insulated window frames with efficient window (double- or even triple-glazing, low emissions). It brings not only an improvement in thermal comfort, but also reduces noises and condensation. Double-glazing reduces heat loss through windows by 50%,
- Veranda for south facing side of a house. Passive gains are roughly 35 kWh per square meter. To prevent summer overheating, curtains must be installed on the outside of the veranda.

Example : the Cité Adminsitrative of Evry (France). Energy audits have been performed to identify the most relevant energy saving actions. The first insulating actions reduced the bill of HVAC systems from €1.02 millions to 0.84 millions. The set up of seasonal controls saved a further 5% on the heating bill. Renegotiating the electricity contracts saved €15 300 with the same level of consumption.

5 Conclusion

As presented in this paper, demand side management relies basically on two aspects: technology and behaviour. Continuous information and education programmes are necessary for the development of efficient systems. Both of these aspects need to be maintained, stimulated and improved. Finally, DSM is not only good practice for reducing energy consumption – it has also side-benefits such as improved wellbeing and comfort of end-users.

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