POTENTIAL FOR THE EFFICIENCY IMPORVEMENT IN THE PRIVATE SECTOR

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ABSTRACT

According to the new allocation plan of the European Union towards efficiency improvement in the end-use sector [1], [2] the demand of electricity has to be reduced by 1% per year until the year 2020. The main sectors for efficiency improvement according to the directive are households, commercial buildings, transport and manufacturing industry. Here the energy saving potential in the private sector is investigated. Main potentials in households for savings are replacement of old appliances by newest high efficient types, reduction of number of appliances, e.g. no second refrigerator, efficient illumination, avoiding of air conditioning and reduction of stand-by losses.

INTRODUCTION

Fossil energy is a limited resource with increasing prices and environmental effects. Today in Europe the demand of electricity is still growing by 2 to 3 % per year. In the next decades there will be incentives to reduce the annual growth to below 1 % and to increase the regenerative energy to a higher portion of 20 to 30 %.
This paper investigates the potential for efficiency improvement in the private sector. In an analysis of households, the typical electrical characteristics of appliances have been determined. In the last 30 years there has been an improvement in efficiency by 50 to 60 %. Today the penetration factor has reached high degrees with appliances for cooking, cooling, washing, drying, TV, audio, information and communication.
The development of penetration and efficiency of appliances in typical households is analyzed.
Highest demand comes from cooling, washing and drying, cooking and illumination. In future communication and information will be of increasing influence.
Stand-by demand of electrical equipment forms today about 5 to 10 % of the annual private demand. Here a reduction to 4 or 6 % is possible either by new equipment with reduced stand by demand or by improved stand by management.
Main driving factor for demand is formed by old equipment. In households typically two or three refrigerators are in use, because the worn out are not disposed but still used e.g. for cooling of drinks. Inefficient illumination forms an energy demand of up to 15 %. Replacement by efficient energy saving equipment can bring a reduction by 10 %. Dryers and electrical heaters form further sinks of high demand.
In future air condition can form severe summer loadings of distribution grids. In a simulation the needs for distribution network reinforcement and for new generation is shown.
The following measures seem to be necessary:

- Reduction of number of old appliances and replacement by high efficient ones
- New passive technologies in buildings for heating and cooling and better thermal insulation
- Reduction or avoiding of air condition and wash drying
- Reduction of stand by losses

Simulations show that reductions in electricity demand of 10 to 30 % are possible without severe influence on consumer well-being.

END -USE EFFICIENCY IN THE EU

According to the EU-Directive [1] and the Allocation Plan [2] for energy efficiency in the EU about 20% of its energy is lost by inefficient use. The estimated saving potential in the different end-use sectors is in households about 27%, in commercial buildings 30%, in transport 26% and in manufacturing industry 25%.
According to the Directive in a time period of 9 years until 2015 an amount of 9% has to be saved and in the Allocation Plan 20% savings until 2020 is seen to be realistic.
A framework of directives and regulations has been established to improve energy efficiency in energy-using products as there are the Eco-Design Directive (2005), the Energy Star Regulation (2001), the Labelling Directive (1992) and the Directive on Energy End-Use Efficiency and Energy Services (2006) [1].
For 14 priority product groups the Commission will begin in the year 2007 the process of adopting minimum energy performance standards (eco-design requirements) in form of Directives. The priority product groups comprise: boilers, water heaters, computers, imaging, television sets, standby, chargers, office lightning, street lightning, room air, motors, cold commercial, cold domestic and washing.
The Action Plan is intended to mobilize governments together with market actors to encourage citizens to use energy in the most rational manner possible. There will be no legislation to prescribe individual energy consumption, but energy distributors, distribution system operators and retail energy sales companies should help to improve energy efficiency in the end-use sector by selling energy services to improve end-use efficiency.

INFLUENCE ON THE AUSTRIAN ELECTRICITY SYSTEM

The Austrian Energy System has today a high portion of regenerative energy (Tab.1). From fossil thermal power plants only 37.7 % is generated.

Type of Generation	MW	GWh	%
fossil thermal	6.061	25.015	37,7
run-of-river hydro	5.357	26.797	40,4
storage hydro	6454	12.337	18,6
wind	827	1.328	2,0
biomass	193	846	1,3
other renewable	22	18	0,0
Total Generation	18.913	66.359	100,0

Table 1 Electricity Generation in Austria 12/2005 [3]

The aim of the Austrian Energy Directive is to reach until 2010 a portion of regenerative energy of 78.1 %. Today by forced investment into wind, biomass and biogas their portion will be increased to a share of 10 % on total electricity generation. But this will not be sufficient to reach the aim.
Energy savings in the end-use sector form the most promising way to increase the regenerative generation. In Fig. 1 three scenarios are shown.

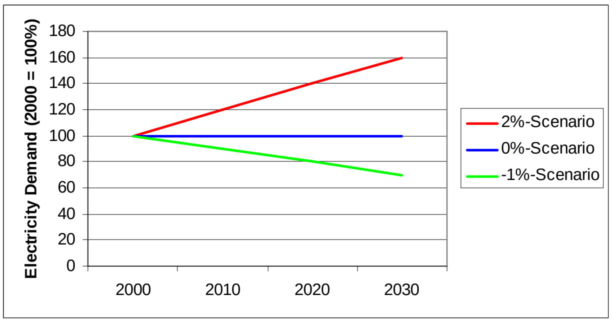

Fig. 1 Scenarios for development of Demand in Austria

If as shown in one of these scenarios electricity savings of minus 1% per year are reached until 2030, the demand will decrease by 30 % and in the year 2030 the existing hydraulic regenerative energy sources as shown in Table 1 for the year 2005 will be sufficient for electricity generation. There will be further need to use also thermal generation capacities as during wintertime the hydraulic power is reduced to about 40% of summer potential. But seen from annual electrical energy in summer is a surplus of hydraulic energy which can be exported and in winter energy can be imported.
In the 0%-scenario it is assumed, that the electricity demand will not further increase. Here by installation of new hydro power plants, wind farms, biomass power stations and photovoltaic generation with a capacity of about 30% of the electricity demand, a fully regenerative energy supply will be possible. Also in this scenario fossil power plants are needed as backup supply.
In the third scenario the behaviour in electricity consumption is unchanged and increases by about 2% per year. In the year 2030 this will cause that the portion of regenerative energy is reduced from now 62.3% to only 38%. The gap has to be closed by new fossil power plants. This will cause high dependability on fossil resources and high emissions and it will be impossible to meet the Austrian Kyoto target of minus 13% of emissions.
Minus 1% until 2030 forms a high demanding target. In the following for the private sector of households, the reason for increasing demand and the possibilities for more energy efficiency are investigated.

ELECTRICITY DEMAND OF HOUSEHOLDS

Family set-up and housing conditions

The electricity demand of households depends on a number of factors. Of main influence are:

- Size of living space an kind of building e.g. flat or a house
- Number of rooms per flat
- Condition (old or new building)
- Number of persons per flat
- Furnishing and age of the flat
- Employment and income of residents
- Age of the residents (child, adult)
- Lifestyle

The mean space per flat is today in Vienna between 40 to 90 m^2. The tendency in new buildings is towards increasing the space and the number of rooms. A further tendency is going to single-person or two-person households, which have a portion of 30 and 35 %, in total 65%.
The relative annual electricity demand related to single households is shown in fig. 2.

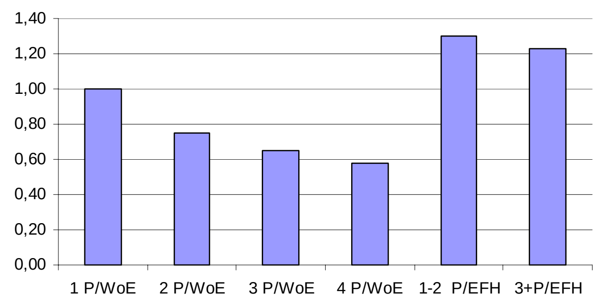

Fig. 2 Energy demand per person related to single houshoulds
(P/WoE: persons per flat, P/EFH: persons per detached house)

The trend towards single households, higher residential space and living in detached houses leads to higher specific electricity demand per person, which can be 30% or 100% higher, than the in a typical family of three or four persons.

Household Appliance Penetration

Electrical appliances in households have reached a high degree of saturation, as can be seen from Table 2.

	ownership in % of households			
type of appliance	**1980**	**1990**	**2000**	**2005**
refrigerator	95	97	99	99
freezer	49	63	69	77
electric cooker	77	81	84	84*
microwave oven	1	42	62	68
cooker hood	27	50	61	68
small kitchen appliance	82	94	95	95
dishwasher	21	39	51	57
washing machine	85	93	95	95
tumble drier	20	25	32	38
ironing equipment	98	98	98	98
vacuum cleaner	97	98	99	99
radio, tv, recorder	99	99	99	99

*) 15 % of cooking is by gas

Table 2 Ownership of appliances in households in Austria

The installed power of electrical appliances has reached 20 to 40 kW per household. As only a small portion of these is in operation the mean value of a household during peak load is only about 700 to 1.000 W.

The mean penetration rate of refrigerators is today 115%, this means that many households own more than one. For television the penetration is 146%.

The mean life time of appliances is between 10 and 20 years. Today old equipment is still in use. The efficiency improvement in the last 35 years has reduced the energy demand to values between 20 and 40% (fig. 3).

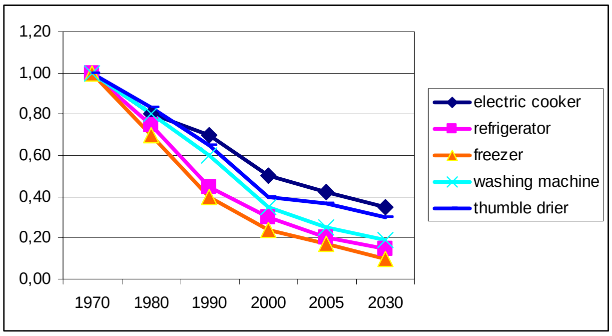

Fig. 3 efficiency improvement of appliances [Electrolux]

In future the improvement in efficiency will be lowering as the level is still high and technical and physical limits will be reached.

The main reasons for inefficient electricity use in households are:

- Usage of old appliances for 15 to 30 years. These should be replaced by newest technology (A++ according to labelling).
- If new appliances are invested the old ones are still used, e.g. a high efficient refrigerator brings a reduction of the energy demand to 30% but the old one is still used giving in total a refrigeration demand of 130% or four times the demand if only the new refrigerator is used. Refrigerators and freezers have 10 to 20% of the demand of a household.
- Reduction of stand by losses by switching off if equipment is not used. Standby represents about 8 to 15 % of the demand.
- Replacement of cathode ray television sets by flat screens. TV forms 5 % of the demand and flat screens can reduce 50 % of it.
- Reduction of the use of tumble drier and of freezers.
- Improvement of illumination by replacing filament bulbs by gas discharge lamps e.g. compact fluorescent lamps.

These measures together can reduce the demand of electricity in households by 20 to 30 % without significant change in living comfort.

SIMULATION OF HOUSEHOLDS

In a synthetic simulation model the typical penetration with appliances and their daily usage as well as standby losses are investigated. As reference a household with parents and two children is taken.

Three scenarios are compared:

Scenario conventional has typical appliances in use: washing machine, tumble drier, two refrigerators, freezer, electric cooking, dishwasher, hi-fi, three radios, two television sets, one personal computer with cathode ray monitor and printer, internet modem, cordless phone, diverse charging equipment, water heater, filament bulb illumination and some small electric equipment. The mean age of appliances is 10 years.

Scenarion maxi has the same equipment as before and additional a plasma TV-set (400 W), a second notebook computer. The washing is exclusively put into the tumble drier.

Scenario mini has only one refrigerator and no freezer. Only one efficient flat screen TV and a notebook are used. The illumination is made efficient by CFL (compact fluorescent lamp). All appliances are newest high efficient standard. A tumble drier does not exist.

In fig. 4 the three scenarios are compared.

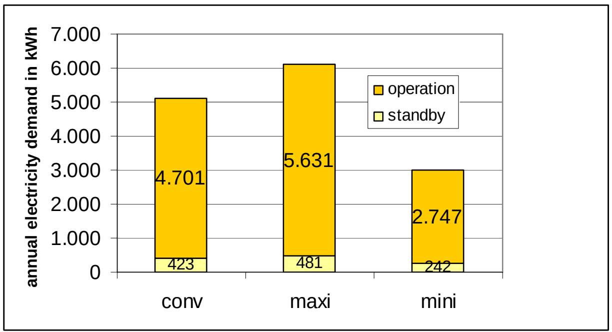

Fig. 4 Comparison of typical households by simulation

Exchanging of old equipment against new and high efficient and reduction of demand especially for refrigeration, freezing, illumination and drier can reduce the demand significantly.

Single households are compared in fig. 5.
Single luxury household is fully equipped with luxury appliances e.g. plasma TV of 500 W, special effect illumination and air condition. Drier, washing machine and dishwasher are ineffectively used at low loading.

Single mini household uses a small number of new appliances: refrigerator, flat screen TV and compact fluorescent illumination. Air condition, drier and dishwasher do not exist.

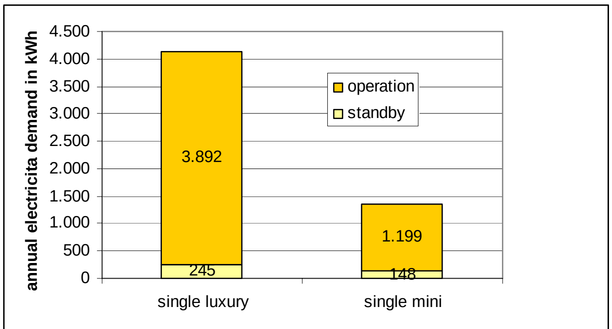

Fig. 5 Comparison of single households

A single luxury household can reach by inefficient use of appliances the electricity demand of a family. If only a small number of vital necessary high efficient equipment is used, the demand can drastically be reduced.

EFFICIENCY VARIATIONS OF APPLIANCES

As an example, the variation in efficiency of television-sets is considered. Traditional TV equipment is based on a cathode ray tube for the screen. New TV-sets with a flat screen can either be with liquid crystal display (LCD) or with plasma display.

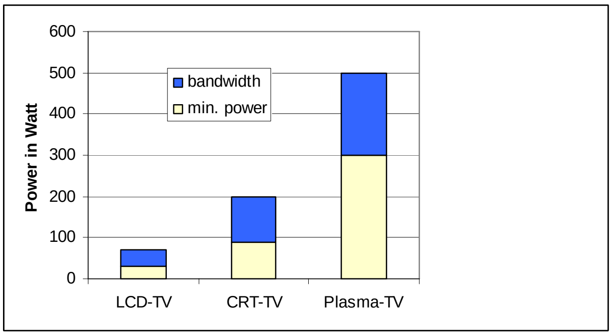

Fig. 6 Power of TV equipment of different technology

According to fig. 6 there the ratio between lowest and highest demand is 10:1. Considering the annual energy demand, the ratio including standby losses is similar.

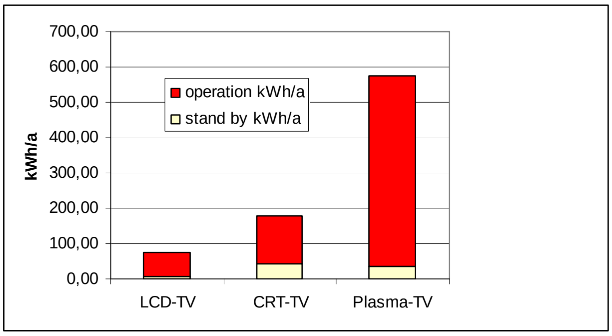

Fig. 7 Annual energy demand of different TV-technology

Also in the field of illumination, similar differences in efficiency can be found. During wintertime, waste energy of equipment can be used for heating purposes. During summertime, this is a disadvantage and can force to install air conditioning systems, which will further deteriorate the energy efficiency of households.

CONCLUSION

In households, significant energy efficiency improvement is possible without significant loss of comfort. Efficiency will in future be the most important way for conversion of energy supply from traditional to regenerative dominated generation.

REFERENCES

[1] European Commission: "Directive 2006/32/EC of the European Parliament and the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC", *http://eu-lex.europa.en/LexUriServ/en/2006/*

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