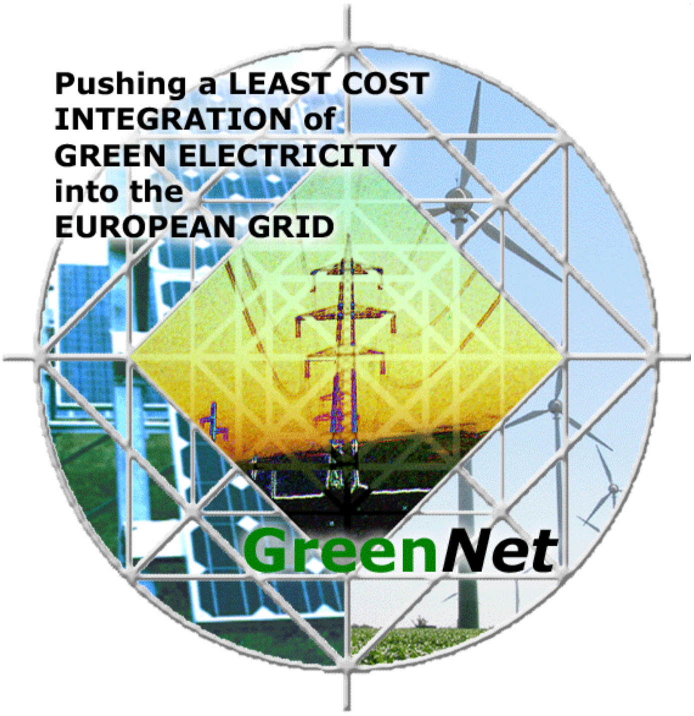
Report of the project

PUSHING A LEAST COST INTEGRATION OF GREEN ELECTRICITY INTO THE EUROPEAN GRID

Green*Net*



Determination of the Potentials and Cost of Energy Efficiency Measures on the Demand Side in the EU15 Member States

Work Package 5

within the 5th framework programme of the European Commission supported by DG TREN

Contract N°: NNE5-2001-660

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Summary

This report describes the output of Work Package 5 of the project **Green*Net***. The objective of WP 5 is to assess the potential, costs and economics of demand side management (DSM) measures and energy efficiency.

The method includes:

- Assessment of the potential, costs and economic consequences of implementing DSM applications and energy efficiency to influence demand (based on field studies in the past and on new communication technologies)
- Derivation of a comprehensive data base for the costs and net effects of several DSM measures in different consumer groups

Duration: 12 months; according to the schedule Project Month 4 – 15
Leader**:** Heat&Power, Lund University, Sweden (9 person-months)
Partners**:** eERG (8 person-months), IT Power (4 p-m), EEG (1 p-m), Risoe (1 p-m), IER-Stutt (1 p-m), Enviros (0.5 p-m), NECA (0.5 p-m)

Two following deliverables were planned within WP5:
D8 Internet-based database
D9 Final Report

The WP5 final report consists of four main parts: Chapter 2 describes the methodology of implementation of the demand-side measures in the GreenNet model, Chapter 3 describes data sources for our analysis, and Chapter 4 gives details about assumptions and choices when analysing DSM-measure. Chapter 5 presents the results and Chapter 6 gives different examples of successful DSM-actions in European countries.

Energy Efficiency DSM are the energy efficiency activities for achieving an overall reduction of primary energy supply for end-use energy demand, e.g. load management and/or fuel-switching. The aim is to reduce the total cost of energy services and to reduce primary energy consumption.

EEG has proposed a main structure of the DSM database. The DSM database was developed for each investigated country and will represent a "dynamic matrix" i.e. how much of the 2020’s achievable end-use energy saving potential (100%) can be reached and implemented for every year, i.e. for 2002, 2003 … 2019.

The following categories and abbreviations are used in bands for DSM:

'Country '-'energy product category'-'energy source category'-‘existing/new’-'energy source - short name'-'band number (i.e. 1, 2, 3 etc.)'

The database was created for EU-15 countries plus four new EU countries (Czech Republic, Hungary, Poland, Slovakia) and two other European countries (Norway and Switzerland). The main tool used for data is the MURE II database (homepage: www.isis-it.com/mure/).

The participants agreed (Brussels, January 2004) that Heat&Power and eERG would be responsible for input (via MURE II tool) from the following countries:

Heat&Power	SE, FI, DK, NO, DE, HU*, PL*, BE, LU, NL
eERG	IT, FR, ES, PT, GR, AT, CH*, UK, IE, CZ*, SK*

* Countries not included in MURE II Database

Enviros, NECA and Energia Klub helped with data collecting from their respective countries that were not included in MURE II database. eERG developed an excel questionnaire for this purpose.

In the MURE II database, there are no costs indicated for different DSM measures in the industry and tertiary sector. In this case, the partners agreed during the Milan-meeting (October 2003) that eERG and Heat&Power would prepare the numbers based on literature surveys as follows:

	Industry subsectors	Tertiary subsectors*
eERG	L, M, R	L, E, R, M, I
Heat&Power	H, C, A P	H, C, W

* Differences between public sector PB and commercial sector CO

Bands for the GreenNet database were obtained in different ways depending on access to data and information.

Each field within the database could be:

- Derived directly from MURE
- Derived from data already existing in MURE (or derivable from MURE) with some calculations
- As assumptions made by the WP5 group justified by data sources and references
- Calculated from the other fields

Each band could be:

- Totally derived from MURE – for example all bands for the residential sector for EU15-countries.
- Totally derived from calculations – for example all bands for the residential sector for EU+10 countries, with input data from our partners.
- Partially derived from calculation - only data in the C to G columns, the most of industrial and tertiary bands.

Preparing this final report WP5 on DSM measures, the participants suggested presenting a selection of good practice examples from successful EE-DSM projects in the European countries. Heat&Power and eERG have made this selection with the help of Risoe, IT Power, Energia Klub, IER-Stutt and Enviros.

The methodology developed during this study seems to be quite solid. More effort should be put on quality of data, continuous update of statistics from different EU countries is of great importance. New EU countries, beside the four already incorporated in the GreenNet model, should be included. Potential for new end-uses (technologies) not possible to be included within the time frames of this project should be considered. There is also a possibility to introduce dynamic costs (learning curves) and discussion on effect on the peak load demand.

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1 Introduction

1.1 Motivation

This report describes the output of Work Package 5 of the project **Green*Net***. The objective of WP 5 is to assess the potential, costs and economics of demand side management (DSM) measures and energy efficiency.

1.2 Overview of Green*Net*

1.2.1 Objectives and problems to be considered

The core objective of GreenNet is to consider how to enhance the proportion of electricity from renewable energy sources (RES-E) within the EU. By applying a least-cost approach, the costs and interactions to all important supply-side and demand-side options were analysed.

The factors considered include technical constraints and opportunities for:

- updating and/or extending the grid for RES-E connection and integration,
- integrating advanced electricity storage technology,
- demand side management for sympathetic load-matching and reduction, thereby conserving energy and optimising renewable energy generation.

The analyses were conducted in a dynamic framework for predicting future scenarios. By considering a structured and wide range of possibilities, the best option(s) for RES-E could be chosen with the lowest costs for society.

1.2.2 The major product

The major product of the whole project is the simulation software **Green*Net*.** This contains the following major features:

- A comprehensive database describing potentials and costs of:
  - different RES-E technologies in different EU countries,
  - the grid with RES-E integration (as well as potential and costs of necessary upgrades and extensions),
  - storage technology integration to support intermittent RES-E generation,
  - DSM (demand side management) measures for suitable load reduction and energy conservation,
  - management of sympathetic loads to optimise the performance of RES-E.
- Definition of different policy instruments for supply and demand within the EU, both as a whole and for single countries, and for all or single technologies.
- Simulation of scenarios for supply-side and demand-side options using a dynamic approach, i.e. allowing changes of strategies and scenarios over time.
- Depending on the features and policy instruments chosen, to meet specific objectives, derivation of a least-cost priority list for the deployment of RES-E by technology and country.

Finally, based on the results of the simulation software **Green*Net***, comprehensive models were derived for financial burden sharing of costs caused by different players in the electricity market.

1.2.3 Results and application

The major result is a least-cost time-path for a continuous and significant increase of RES-E to meet specific targets of installed capacity and electricity generated. This includes a year by year recommendation for different measures (development of RES-E technologies, grid upgrade and extension, storage technology integration, and different DSM measures) for the EU as a whole and for single countries.

To underpin recommendations and to strengthen the decision making process for stakeholders, the simulation software **Green*Net*** will be available via the internet.

1.2.4 Project Structure

As there can be seen in Figure 1.1, the working programme of GreenNet was divided into 13 different Work Packages (WPs).

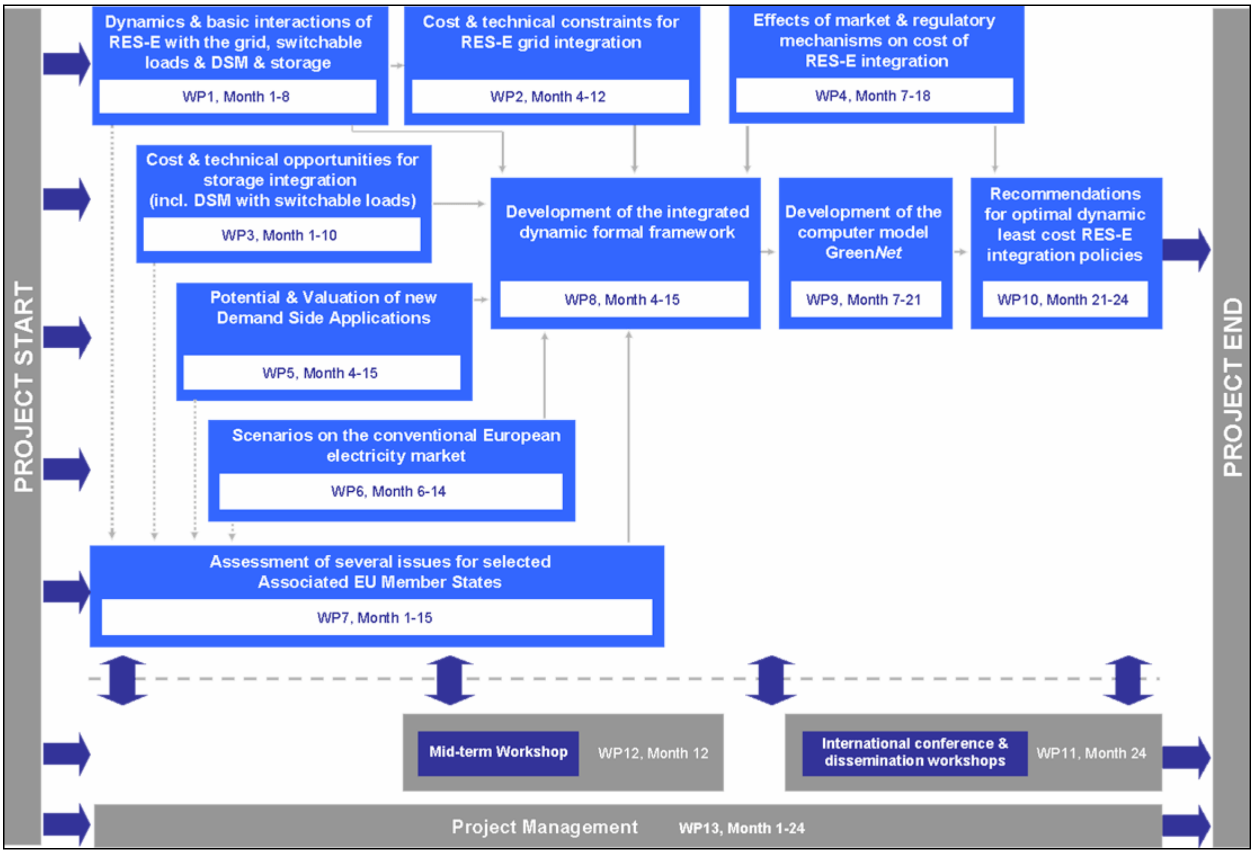

Figure 1.1 Structure of the project **Green*Net***

The major objectives of each Work Package are briefly summarised below:

WP 1: Dynamics & basic interactions of RES-E with the grid, sympathetic loads & storage

The objective of WP 1 is to (a) analyse the dynamics and basic interactions of RES-E plant with the grid, (b) consider how loads may be switched to optimise RES-E generation (sympathetic loads), (c) the use of storage technologies linked to intermittent RES-E generation. These analyses are initially for individual EU countries and then for the EU as a whole. The aim is to provide a database of cost curves for several RES-E technologies and different RES-E/grid arrangements.

WP 2: Cost & technical constraints for RES-E grid integration

WP 2 derives the cost, the technical constraints and the additional measures necessary for integration of RES-E technologies into the Western European transmission and distribution grid.

WP 3: Cost & technical opportunities for storage integration (including sympathetic loads)

The objective of WP 3 is to derive the cost, the technical opportunities and the additional measures necessary for integrating storage technologies and related techniques to support intermittent RES-E.

WP 4: Effects of market and regulatory mechanisms on the cost of RES-E integration

WP 4 assesses the costs of intermittent RES-E in various electricity balancing and settlement systems in the EU and to recommend policy, regulation and market design for balancing and settlement mechanisms, priority dispatch and interconnection of RES-E to the grid.

WP 5: Potential and costs of Demand Side Management measures

WP 5 deduces the potential, costs and economics of demand side management (DSM) measures and energy efficiency.

WP 6: Scenarios on the conventional European electricity market

WP 6 produces different scenarios for the development of conventional European electricity market (mainly wholesale prices) that are mainly responsible for the market penetration and competitiveness of RES-E integration, storage technologies and demand side applications.

WP 7: Assessment of several issues for selected Associated EU Member States

WP 7 considers several issues in WP 1, 2, 3, 5, 6 (RES-E potentials and cost; conditions and cost for grid access, storage and load management technology support as well as demand side applications; wholesale electricity price scenarios) for selected Associated EU Member States, namely the Czech Republic, Poland, Slovakia and Hungary.

WP 8: Development of the integrated dynamic formal framework

WP 8 establishes an integrated dynamic formal framework. It combines the dynamic interaction of RES-E generation and integration into the grid, as supported by storage technologies, load management and other measures for demand side management and energy efficiency.

WP 9: Development of the Computer model Green*Net*

WP 9 develops the computer model **Green*Net*** based on the dynamic analytical framework. This includes (a) comprehensive testing, (b) evaluation of the model results by simulating typical empirical case studies, and (c) conducting comprehensive quantitative analysis.

WP 10: Recommendations for optimal dynamic least-cost RES-E integration policies

WP 10 extracts recommendations for policy makers and stakeholders. The considerations are for a European-wide implementation of least-cost strategies for the integration of RES-E technologies into the grid. This includes the application of storage technologies and demand side applications.

WP 11: International conference and dissemination workshops

WP 11 will organize the final international conference of GreenNet and a series of international dissemination workshops. The latter will be at an EU and also Associated EU Member States level, to promulgate the final product: GreenNet toolbox software.

WP 12: Mid-term feedback workshop

WP 12 co-ordinates the discussion of the WP's 1, 2, 3, 5, 7. This includes presenting the preliminary results to key stakeholders for feed-back for further modelling and derivation of policy recommendations.

WP 13: Project Management

WP 13 manages GreenNet- e.g. communication between the project partners, organisation of meetings, development of the project web-site and preparation of documents and reports.

1.3 Work Package 5

Objective

Main objective is to derive the potential for and costs of Demand Side Management (DSM) measures for efficient electricity supply in different European countries for the year 2020. The method includes:

- Assessment of the potential, costs and economic consequences of implementing DSM applications and energy efficiency to influence demand (based on field studies in the past and on new communication technologies)
- Derivation of a comprehensive data base for the costs and net effects of several DSM measures in different consumer groups

Duration

12 months; according to the schedule Project Month 4 – 15 (April 2003-March 2004)

Leader

Heat&Power, Lund University, Sweden (9 person-months)

Partners

eERG (8 person-months), IT Power (4 p-m), EEG (1 p-m), Risoe (1 p-m), IER-Stutt (1 p-m), Enviros (0,5 p-m), NECA (0,5 p-m)

1.3.1 Tasks

According to the ***GreenNet*** proposal, five tasks were planned to be carried out within WP5:

Task 5.1. Summarize the economics of energy conservation and energy efficiency
Leader: Heat&Power

Task 5.2. Comparison of major features (e.g. technical, economic) of different Information and Communication Technologies ICT (internet-commerce, DLC, PLC, GSM, etc.) with special focus on DSM applications in electricity markets
Leader: IT Power

Task 5.3 & 5.4. Empirical results of field studies: Comprehensive evaluation of results of different types of field studies (past and ongoing) in different EU countries for different consumer groups. The different field studies consider dynamic tariffs, application of new ICT with special focus on DSM, etc. Included are the clustering of results and derivation of corresponding indicators, etc.
Leader: eERG

Task 5.5. Estimation of future potential and cost of different types of DSM measures and of DSM and ICT technologies for large-scale implementation in different consumer segments in the EU15
Leader: Heat&Power

During the discussions on methodology and according to the decisions taken within other work packages, the contents of Task 5.2 was changed to focusing on EE-DSM measures in different sectors.

All tasks were carried out simultaneously and co-operatively by all the WP5 partners.

1.3.2 Deliverables

The following deliverables were planned within WP5:

D8 Internet-based database
D9 Final Report

1.4 Outline of this report

The WP5 final report consists of four main parts: Chapter 2 describes the methodology of implementation of the demand-side measures in the ***GreenNet*** model, Chapter 3 describes data sources for our analysis, and Chapter 4 gives details about assumptions and choices when analysing DSM-measure. Chapter 5 presents the results and Chapter 6 gives different examples of successful DSM-actions in European countries.

2 Implementation of DSM-measures in *GREENNET*: Methodology

In this section, we explain the steps taken for producing the dynamic electricity demand curves. Step 1: Strategic review. Step 2: information required for the demand database. Step 3: Criteria for setting the cost level for using energy saving technologies. Step 4: the development of the electricity demand curve.

2.1 Overview

In contrast to capacities and costs of power supply (for details see Resch et al. 2003), demand is not fully specified from data within the ***GreenNet*** toolbox. Consequently, specific details of the total electricity demand have to be entered exogenously.[1] This allows flexibility, so users of the software can change the suggested demand forecast (i.e. default value) for their own simulation runs. Nevertheless, electricity demand can be influenced within the toolbox due to the consideration of demand-side activities.

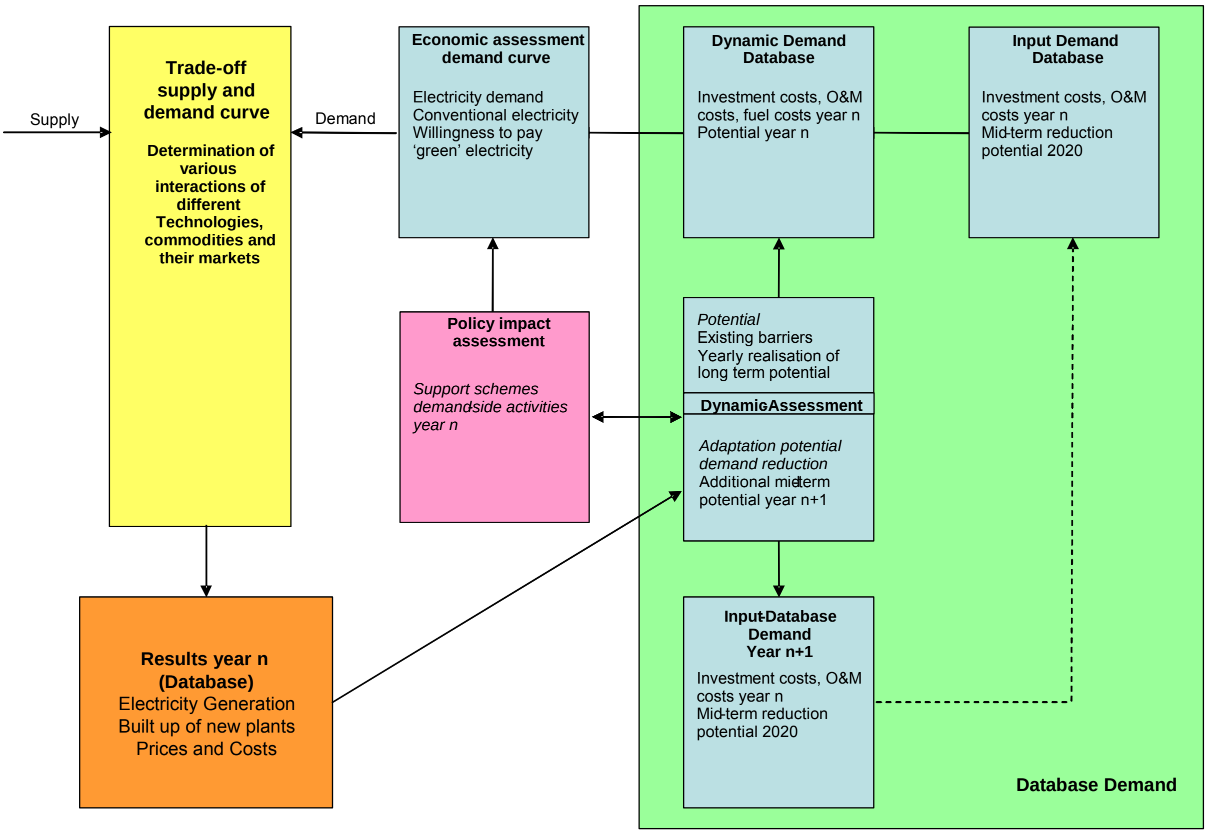

Figure 2.1 Overview of creating dynamic demand curves for electricity generation

The determination of the dynamic database for electricity demand is summarised in Figure 2.1. Dynamic demand curves for different groups of technology in each country are developed within the ***GreenNet*** toolbox. They are characterised so (a) the price level at which

[1] The default electricity demand forecast in the GreenNet toolbox is based on "European Energy and Transport Trends to 2030" (DG TREN, 2003)

it is rational to use energy saving technologies and (b) the potential for electricity saving, can both change year by year. In contrast with the supply side, the magnitude of these changes is given exogenously (as costs) and endogenously in the model (as potential), i.e. the differences in the values compared with the previous year depend on the outcome of the simulated year. The procedure for deriving the dynamic cost curve takes place on four levels, Figure 2.1.

(i) Determination and calculation of the "input demand database"
For simulating the first year (i.e. year 2004), the ***GreenNet*** program goes back to the "input demand database". This database contains information according to technology group within the different sectors (e.g. households, industry and tertiary) and the different countries. This information includes potential electricity savings when using standard technology. Key information includes

- investment costs,
- O&M costs,
- electrical efficiency,
- full-load-hours, and
- additional potential of electricity saving to year 2020.

For years beyond 2020, the "input demand database" becomes the "adapted input demand database". This database considers the simulation results with respect to the available long-term potential; see step (iv) below.

(ii) Derivation of "dynamic demand database" for the simulation year
The dynamic database for the simulation year is derived by combining the "input demand database" with dynamic parameters, which can be varied or adapted within the model for each year.[2] The assessment for the demand-side is less complex than for the supply side, because the existing barriers and obstacles are given exogenously in the ***GreenNet*** toolbox and are not derived within the simulation process. This dynamic database contains technology-specific information about the electricity price at which (a) it is cost effective to use electricity saving technologies and (b) the possible potential for electricity demand reduction for the simulated year. The detailed procedure deriving the cost-resource curve is described in a following sub-section2.4.

(iii) Consideration of policy support and economic assessment
Before the analysis of the interaction of different promotion schemes and market conditions, a further adaptation of the ‘dynamic’ demand curve is necessary, namely an economic assessment of the demand curve. Within this step, a possible technology and country-specific policy support mechanism will be considered. In general, such a mechanism reduces the electricity price at which it becomes economic to use the electricity saving technology as compared with the standard technology.

(iv) Adaptation of the "input demand database"
At the end of the simulation run for the year n, the "input demand database" for the following year (n+1) is created by adapting the "input demand database" for the year n. Changes are necessary with respect to the remaining additional electricity saving potential. It must be reduced if part of this potential has already been achieved in the simulated year n

[2] These values are available as time-series in a country and technology specific database.

As already mentioned, this adapted "input demand database" serves as a starting point for the subsequent year, see step (i).
Based on the total electricity demand, a division into sub-demands might be necessary if market separations take place in the simulation with the ***GreenNet*** toolbox. More precisely, for RES-E[3] and combined-heat and power (CHP) strategies[4] sub-markets can occur. If this is the case, the conventional electricity demand serves as the residuum.

Before explaining the single steps in more detail, the data requirements for the demand side will be described.

2.2 Necessary Data

The database for calculating the cost curve for electricity-saving of demand is less complex than for supply. On the demand-side, only information for the electricity-saving potential and its costs needs to be available at two levels, namely:

1. by country
2. by technological or economic band.

The data requirements for each of these levels will be outlined below.

2.2.1 Country level

Country-specific data are characterised by being, valid for all the technologies considered, but varying between different countries and over time. For the derivation of the demand curve, only few data on country level are necessary, see Table 2.1.

Table 2.1 Summary of demand side country-specific data

Parameter	Aim: to determine
Total electricity demand (scenario 1)	Electricity demand for baseline scenario
Total electricity demand (scenario 2)	Electricity demand for CO_2 stabilisation scenario
Total electricity demand (scenario 3)	Electricity demand for Kyoto scenario
Price elasticity	Electricity demand for one country
Investor behaviour / interest rate	Electricity demand for one country
Total heat demand from CHP	CHP demand / capacity

2.2.2 Technology band level

Due to the wide variety of applicable energy saving technologies, most parameters are determined for the particular technology band (see sub-section 3.1). In contrast to the supply-side, DSM activities that have already been implemented are not considered, except implicitly through the sector-specific electricity demand. This means that only the energy

[3] E.g. if it is assumed in the simulation run that a RES-E quota is implemented.

[4] In the model a certain heat demand must be covered by CHP plants. Therefore, also a certain electricity supply from CHP – following the heat to power ratio of individual plants – is available.

saving potential and the price at which its implementation is economic, will be derived for new measures.[5]

Table 2.2 Summary of band-specific data

Band Parameters	Input (In) / output (Out) data	Aim: to calculate
Technology parameter		
Lifespan of energy saving technology	In	Capital recovery factor for energy saving technology[6]
Lifespan of alternative technology	In	Capital recovery factor for energy saving technology
Cost parameter		
Investment costs energy saving technology per output	In	Electricity price at which DSM measure is economically efficient
Investment costs alternative technology per output	In	Electricity price at which DSM measure is economically efficient
Operation and maintenance costs independent of electricity consumption energy saving technology per output	In	Electricity price at which DSM measure is economically efficient
Operation and maintenance costs independent of electricity consumption alternative option per output	In	Electricity price at which DSM measure is economically efficient
Payback time energy saving technology	In	Electricity price at which DSM measure is economically efficient
Payback time alternative technology	In	Electricity price at which DSM measure is economically efficient
Interest rate	In	Electricity price at which DSM measure is economically efficient
Level of electricity price at which DSM measure is economically efficient (willingness to invest)	Out	Electricity price at which DSM measure is economically efficient
Potential parameter		
Energy consumption per unit output	In	The mid-term energy saving potential
Energy consumption per unit output of alternative technology	In	The mid-term energy saving potential
Energy saving potential per unit output	In	The mid-term energy saving potential
Dynamic restriction of yearly implementation	In	Link with dynamic restriction calculation tool
Mid-term energy saving potential compared to BAU scenario	Out	The annual energy saving potential
Energy saving potential year n:	Out	The maximal energy saving potential of the band for the simulation year n

[5] If all or part of the band will be achieved in the simulation year, total additional potential of electricity demand reduction will be reduced in the following year. Similarly, if this whole or part of the achieved band (technology) is at the end its lifetime (e.g. a bulb after 3 years) the newly free potential for electricity demand reduction is again available in the next year. However, the cost structure and the potential may differ compared to the initial band due to technological progress, i.e. different / lower investment costs and higher efficiency.

[6] In the model the minimum level of the lifespan and the payback time will be used.

2.2.3 Summary

Figure 2.2 summarises the demand side data-structure. In contrast to the supply side, only country- and band-specific data are required.

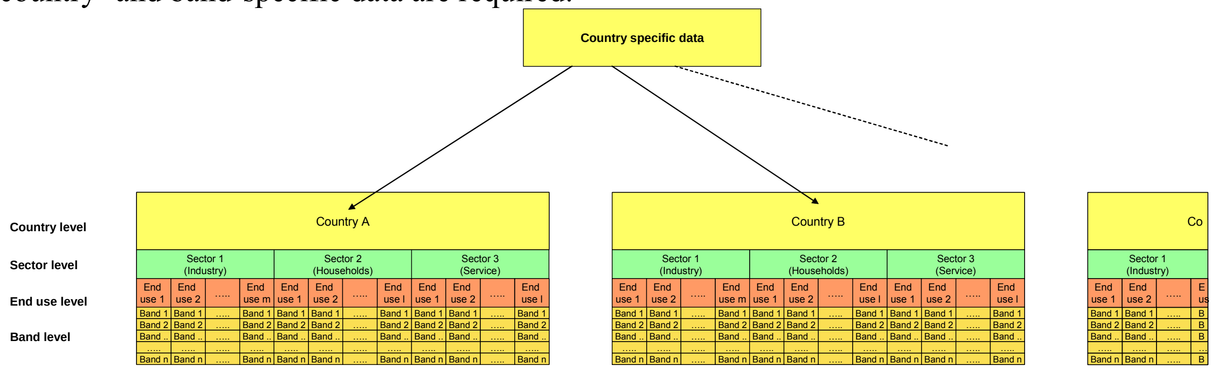

Figure 2.2 Overview of demand-side data classification

2.3 Willingness to invest in demand-side activities

In the ***GreenNet*** toolbox, consumers are assumed to invest in energy saving technologies if these investments are cost effective for them. Consequently, per unit of output[7], the total life-cycle cost of the energy-saving technology must be less than, or at least equal to, the total life cycle cost of the equivalent energy demand scenario. In general, accepting the energy saving option as the most cost effective depends on the electricity price. In general, if electricity prices become cheaper, then energy saving technology becomes less economic. The willingness to invest is characterised by the electricity price at which both energy saving by DSM and the status quo are equally 'economic'.

To analyse this for a commercial 'product', let:

- *WIT* .... Willingness to invest energy saving equipments / technologies
- p_e........................ Minimum electricity price at which DSM measure is economic, i.e. the switch price [€/MWh]
- q_{el} .... Electricity consumption per unit product output [MWh/output]
- I.......................... Investment costs of energy saving technology per unit product output [€/output]
- CRF.................... Capital recovery factor: $CRF = \frac{z * (1+z)^{PT}}{\left[(1+z)^{PT} - 1\right]}$
- z .... Interest rate per year
- PT .... Life time of energy saving technology [y]
- $C_{O\&M\ Nel}$............... O&M costs independent of electricity consumption per unit output energy saving technology [€/output]

[7] Output may be, for example, per tonne of steel, or per luminous intensity, per GJ mechanical energy

q_{Ael} .... Electricity consumption of status quo or of alternative technology, per unit output [MWh/output]

I_A .... Investment costs of alternative energy saving technology per unit output [€/output]

CRF_A .... Capital recovery factor of alternative: $CRF_A = \frac{z*(1+z)^{PT_A}}{\left[(1+z)^{PT_A} - 1\right]}$

PT_A .... Life time of the alternative technology [a]

$C_{A\ O\&M\ Nel}$ .... alternative technology O&M costs, independent of electricity consumption, per unit output [€/output]

The criteria at which both technologies – the energy saving and the alternative option are equally economic, is given by:

$$p_e * q_{el} + I * CRF + C_{O\&M\ Nel} = p_e * q_{A\ el} + I_A * CRF_A + C_{A\ O\&M\ Nel} \tag{1}$$

Hence, the electricity price at which the investment will be initiated can be derived by re-arranging the above equation.

$$WTI = p_e = \frac{(I * CRF - I_A * CRF_A) + (C_{O\&M\ Nel} - C_{A\ O\&M\ Nel})}{q_{Ael} - q_{el}} \tag{2}$$

Note, unlike the calculation of the electricity generation costs, important parameters, such as the investment costs or the O&M costs, are normalised per unit of output produced.

- Investment Costs

  The additional DSM capital investment costs differ by technology and sub-sector. In addition, since most DSM technologies are still not mature, the unit investment costs can be expected to decrease over time. However determinating the investment costs is crucial. Moreover, for DSM measures, the number of potential technologies is very large. Therefore it is reasonable to attempt a 'learning curve approach' for each DSM technology option. Therefore the present published investment costs of most DSM technologies will used, unless there are credible cost development forecasts in the literature. The investment costs for the year n are calculated by forecasts made in other studies (e.g. MURE or IKARUS), otherwise they are assumed constant.

- Capital recovery factor

  As the lifespan may vary between the energy saving technologies, the payback time against the status quo may vary too.[8] This difference also influences the economic cost assessment of the investment costs.

[8] E.g. while the lifespan of a standard light bulb is one year, an energy saving lamp lasts - on average - 5 years.

2.4 Development of the demand-curve for electricity

In contrast to power supply data, information about demand is usually less reliable. In principle, demand depends on the unit price of electricity, the portfolio of technologies generating the electricity, the country (region) and the time (i.e. demand changes over time). For the time t_1, the only certain information is the present demand. The marginal unit price is given by the intersection of market price p_M and the quantity of electricity demand q_{el}, see Figure 2.3.

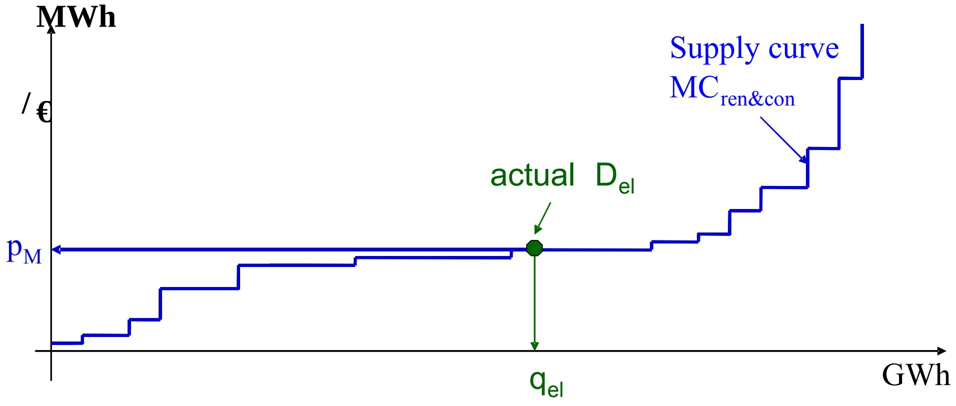

Figure 2.3 Knowledge about supply and demand

Analysing electricity prices over time and between different countries, the following can be concluded:

- demand decreases if power prices increase, i.e. all consumers try to control expenditure. The reason for the reduction in the electricity demand can be threefold:
  - inefficient and careless use is reduced, e.g. lights are switched off when rooms are empty, machines are not left on needlessly. In practice there are many opportunities for this, but our analysis assumes such practices already occur.
  - Hence, for our study, decrease in service: in the short term; this is the only immediate reaction for efficient consumers to counteract price increases,
  - demand-side activities: in the long run, consumers take measures to save electricity by replacing all or part of their applications and technologies by systems consuming less electricity. In practice, only a few of the existing demand-side reduction options will be used, especially if price increases are temporary. This is because there are many obstacles which impede change in consumer equipment and behaviour, namely:
    - consumer complacency and carelessness
    - incomplete information
    - low transparency of the DSM market
    - high uncertainty about the electricity price development in the future.
- The price elasticity decreases over time and with higher incomes.
- The value of price elasticity depends on whether electricity prices increase or decrease. Normally elasticity is less if prices decrease. The reason is that it is not sensible to reverse already-implemented demand-side benefits, e.g. if the consumer replaced an inefficient refrigerator by purchasing an efficient one and then the electricity unit price

reduces, the consumer will still use the new, efficient refrigerator since there will always be a cost benefit.

- Price elasticity changes with the absolute price level.

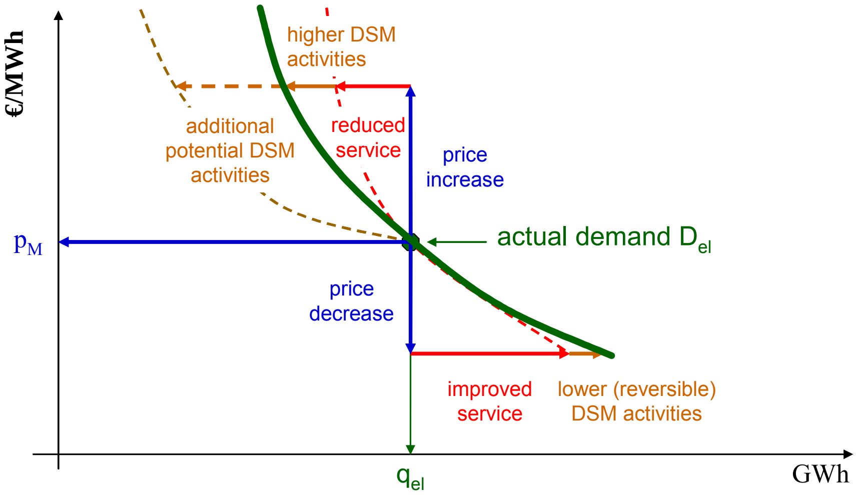

Figure 2.4 Interpretation of the demand curve

Figure 2.4 depicts the character of a demand curve. The total demand consists of both service and demand side measurement. In practice, only some parts of the demand side activities can be implemented; compare arrows indicating 'additional potential DSM' and 'implemented DSM activities'. In addition, due to irreversible DSM measures, the demand increase is less than the demand reduction, assuming the same increment of price change. Also experience shows that national demand increases with time for a growth economy, as most consumers purchase more appliances and power consuming services. This means the whole demand curve shifts to the right with increase in time.

In the ***GreenNet*** toolbox, three effects are considered:

(i) electricity demand changes (increase) with time,
(ii) demand reaction to short-term electricity price changes (service demand),
(iii) demand changes due to demand-side measures.

Similar to the supply curve, the demand curve is modelled as a stepped function.

On the left-hand side of Figure 2.5 a realistic continuous static demand curve is depicted as a response to common tariff structures. The stepped function on the right-hand side of Figure 2.5 represents a practical function for modelling.[9] Thereby, sites with "similar conditions" are described by one band.

In the model, bands are characterised by a single energy saving option / technology (e.g. low energy lighting) in a certain area (e.g. household, industry or tertiary sector).

[9] In addition, considering the uncertainty of the demand forecast in the future (total demand), the accuracy applying a stepped demand function instead of a continuous curve can be neglected.

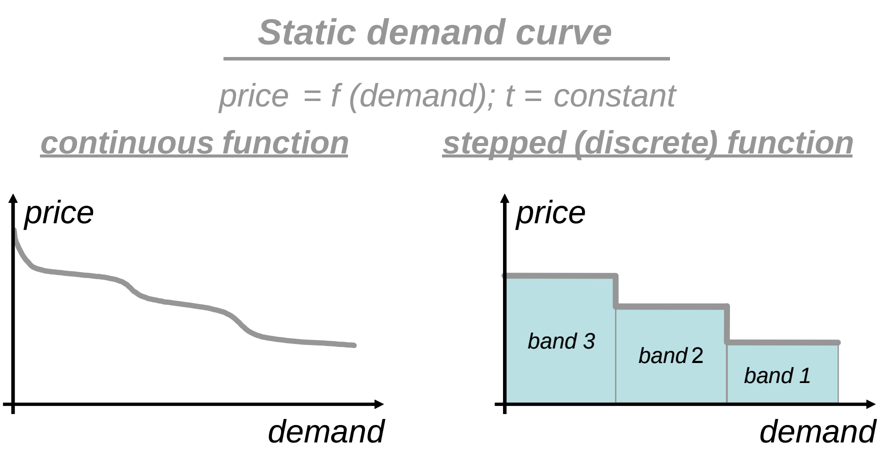

Figure 2.5 Characteristic run of a static demand curve: Continuous (left-hand side) and stepped function (right-hand side). Note: 'Price' is the tariff 'unit price' at the margin, e.g. euro/kWh.

2.4.1 Modelling electricity demand increase

The most important factor is that demand changes with time. Also, different demand scenarios are considered because electricity demand is dependent on the general economic, political and social conditions, Business as usual (BAU) is the baseline, with the scenario given by the EC (DG TREN, 2003); this reflects current policies and trends, but without the inclusion of additional policies to reduce CO_2.[10]

The data for the electricity demand forecast will not be considered in absolute terms in the toolbox. The model is able to consider DSM activities using relative changes. The calculation of the reference point of electricity demand for a certain year n is given by:

$$D_n = D_{n-1}\left(1+\frac{D_n^* - D_{n-1}^*}{D_{n-1}^*}\right) \quad (3)$$

where:

D_n .... Assumed electricity demand in year n [GWh] - input value for the simulation year n

D_{n-1} .... Actual electricity demand in year n-1 [GWh] - result from the simulation year n-1

D^*_n .... Forecast of the electricity demand year n [GWh] – value from database

D^*_{n-1} .... Forecast of the electricity demand year n-1 [GWh] – value from database

[10] Other scenarios, which can be used as default scenarios for the model runs – if data are available – are: . Other scenarios modelled are:

- CO_2 emissions remain at their 1990 level throughout the projected period, compared to the baseline this means approximately a 12% reduction in 2020.
- CO_2 emissions drop by 6% compared to their 1990 level until 2010 and remain at this level until 2020, compared to the baseline this means an approx. 18% reduction in 2020.

The assumed electricity demand for the year n (D_n) depends on two factors:

1. the actual electricity demand for the year n-1. This value directly results from the ***GreenNet*** toolbox calculation for the year n-1.
2. the growth rate of the electricity demand. The growth rate is determined by demand forecasts for the year n-1 and the year n.

These values are given exogenously in the ***GreenNet*** toolbox by an external demand scenario.
However, by considering the simulation results, the assumed demand forecasts, as given by different demand scenarios, are adapted. Hence, despite the exogenous nature of the demand forecast, an "internalisation" takes place.

2.4.2 Modelling service demand changes

The service demand D_{ser} only reacts to changes in the service level, i.e. actual demand-side measurements by changing the infrastructure are not relevant[11]. Figure 2.6 shows a characteristic demand curve. In the ***GreenNet*** toolbox, it is assumed that (i) changes in the service are characterised by the electricity price elasticity, and (ii) this elasticity does not vary with unit price. However, both the elasticity and the unit price can vary by time and country.

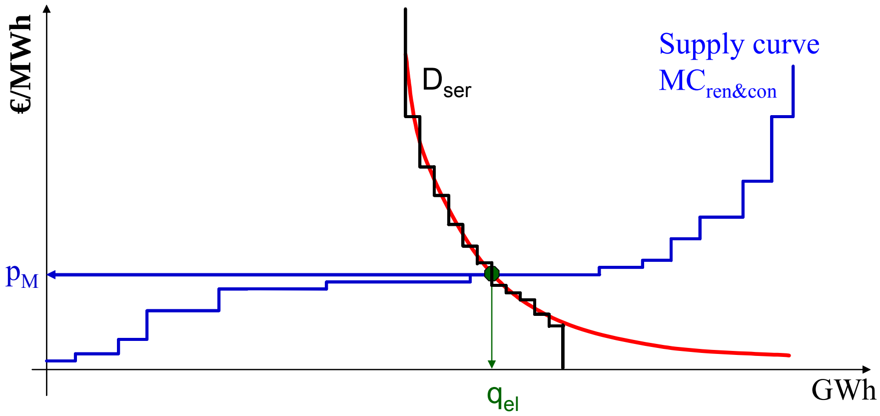

Figure 2.6 Modelling the response of demand to changes in the unit price of electricity in the ***GreenNet*** toolbox

2.4.3 Modelling demand-side activities

The methodology for deriving the third component of a demand curve, the change due to demand side measures, is explained below.

In the ***GreenNet*** toolbox, it is assumed that reductions in electricity demand will be made within the modelled time interval they become economically justified, e.g. within one year. However, in practice, this is seldom the case, since old equipment and practices remain in use because of consumer lethargy and incompetence. Nevertheless, we assume perfection in this respect as a 'base case' study. As already explained in the previous section for the derivation

[11] This means in the short-term it is not feasible to applying less energy consuming equipments.

of the demand curve, neither generation costs nor energy saving costs are important by themselves. The criterion that is of importance is the electricity unit *price* at which the application of an energy saving technology becomes economic.
The demand-side activity curve represents the relationship between energy saving potential (= potential of reduced demand) and the price at which this potential will be used. Similar to the supply curve, the measures can be ordered according to the electricity price, starting with low prices, see Figure 2.7.

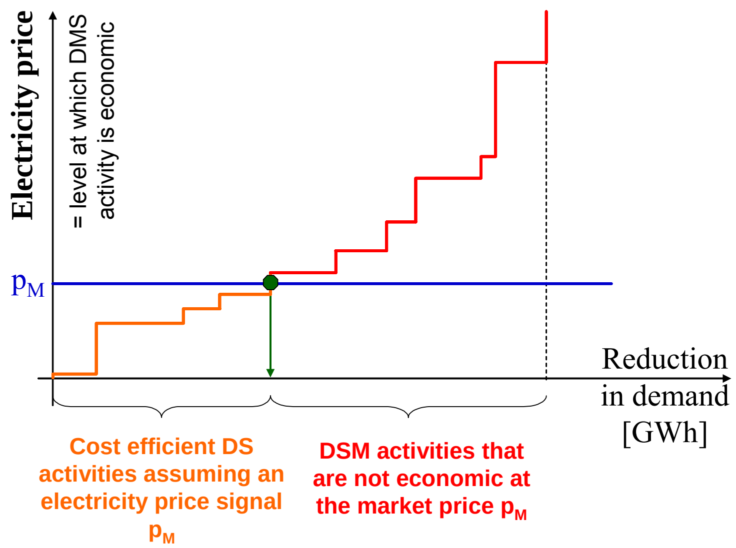

Figure 2.7 Development of the demand curve due to demand-side activities, as a function of electricity unit price.

In the ***GreenNet*** toolbox, it is assumed that all activities giving benefits at less than the actual electricity price are already implemented; see left part of the reduction demand curve in Figure 2.7. It can be seen that the "costs" of implementing some parts of the electricity saving potential are less than the current unit electricity price (p_M). Under static conditions, this potential should have already been achieved in the past. Assuming, however, a dynamic environment, "cheap" electricity saving potential still exists. The reasons are:

1. due to existing barriers, only part of the potential savings can be achieved within the year,
2. some aspects of the energy saving potential will involve new techniques not previously available. Hence, that particular potential saving was not available in the past and so would not have been implemented.

An increase of the electricity demand due to previously implemented demand-side measures becoming uneconomic is neglected in the ***GreenNet*** toolbox. The reasons are (i) the available potential for this is very small, and, (ii) it can be assumed, at least for almost all the simulation runs, that future electricity unit price will not decrease significantly. [12]

However, the ***GreenNet*** model requires the actual electricity demand as input, not the potential savings. Hence, the curve of Figure 2.7 must be turned around the ordinate (y) axis, see Figure 2.8, to appear as a function of actual demand (i.e. savings are a negative demand).

[12] In general, it can be assumed that these measures lead to an increase in electricity price.

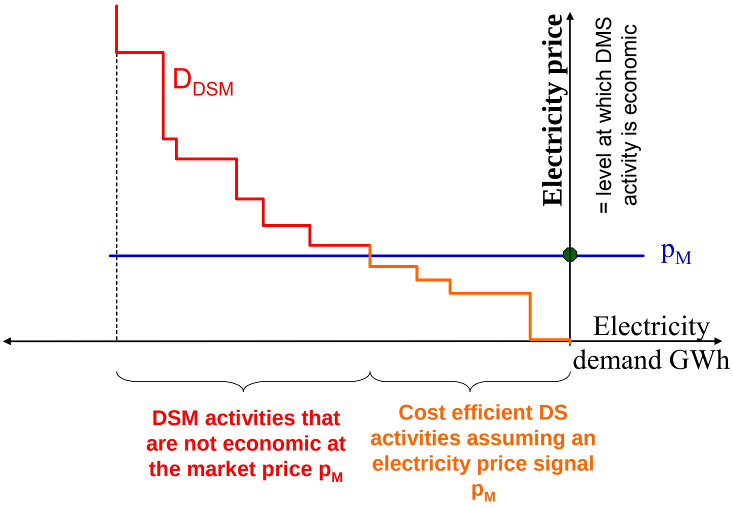

Figure 2.8 Development of the demand curve due to demand-side activities

Note: cost curve of DS activities in the form used in the GreenNet toolbox - left hand side: reduction of demand, right-hand-side increase of demand

Similar to the supply-side, in practice only part of the energy saving potential for demand-side measures can be implemented within a year. Hence, dynamic assessments must again be taken into account. Figure 2.9 depicts this schematically; the red lines represent the mid-term energy saving potential, the green lines the additional potential, which can be used in the next year (year n) for each band. Of course, the actual availability may vary between the single bands.

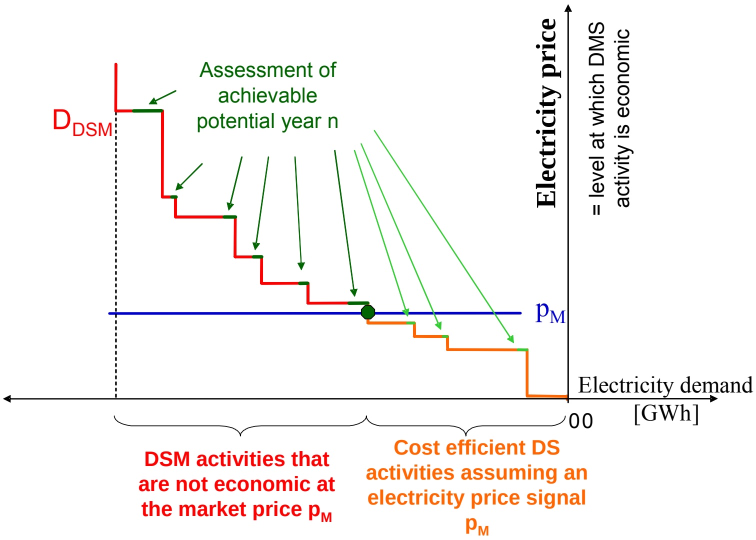

Figure 2.9 Cost curve assessment for additional energy saving potential year n

In contrast to the dynamic assessment for the supply-side, the evaluation of the existing barriers is modelled in a less complex manner for the demand-side. Firstly, the barriers are given exogenously, that is the actual saving potential for the next year are not determined by the toolbox, and, secondly, just one parameter per band is specified. Of course, this parameter can change over time. Figure 2.10 shows the dynamic demand curve due to demand side measures for the year n, by adding the green lines in Figure 2.9

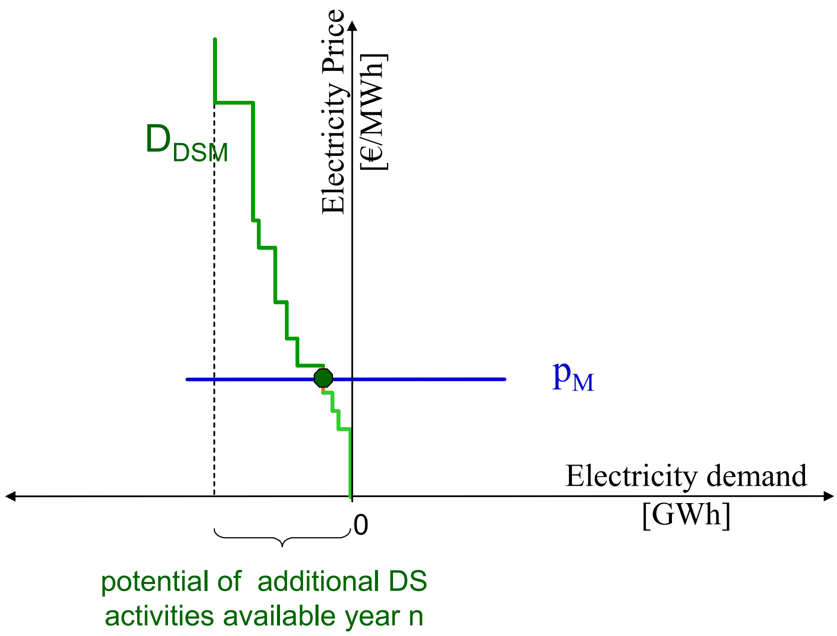

Figure 2.10 Dynamic demand curve due to demand side measures for the year n

One use of the DSM curves in the ***GreenNet*** toolbox is to analyse the effects of DS policies on both electricity supply and demand. Therefore, it is necessary to include DSM policy options in the model.

2.4.4 DSM policy and promotion strategies considered in the *GreenNet* toolbox

One aim of considering DSM curves in the ***GreenNet*** toolbox is to analyse the effects of DSM policies on both the electricity supply and the demand structure. Therefore, it is necessary to include DSM policy options in the model.
The following price and demand driven promotion schemes are considered in the ***GreenNet*** toolbox:

- Tax incentives
- Investment subsidies
- Granted tariffs
- Demand Quota
- Standards

Price driven instruments – design options

Investment subsidies:

The ***GreenNet*** toolbox simulates the effects of investment subsidies in percent of the total investment costs for electricity saving systems. In reality, investment subsidies are restricted to a specific budget allocation. This fact is also considered in the toolbox. The implementation of investment subsidies is expressed analytically in equations (4) and (5).

$$\widetilde{p}_e * q_{el} + I * CRF + C_{O\&M\ Nel} - \beta * I * CRF = \widetilde{p}_e * q_{A\ el} + I_A * CRF_A + C_{A\,O\&M\ Nel} \quad (4)$$

$$\widetilde{p}_e = \frac{\left((1-\beta) * I * CRF - I_A * CRF_A\right) + \left(C_{O\&M\ Nel} - C_{A\,O\&M\ Nel}\right)}{q_{A\ el} - q_{el}} \quad (5)$$

subject to: $\sum_{i=1}^{n} \beta * I < Budget$ [13]

where

$\widetilde{p}_e$ .... (Minimum) electricity unit price for DSM measure to be economic, considering possible tariffs, grants, benefits etc: [€/MWh]

q_{el} .... Electricity consumption per unit product output [MWh/output]

I .... Investment costs of DSM technology per unit product output [€/output]

CRF.................... Capital recovery factor: $CRF = \frac{z*(1+z)^{PT}}{\left[(1+z)^{PT} - 1\right]}$

z .... Interest rate per year

PT .... Life time of energy saving technology [a]

$C_{O\&M\ Nel}$............... O&M annual costs of the DSM technology, per unit output energy saving technology [€/output]

q_{Ael}...................... Electricity consumption of alternative DSM technology per unit output [MWh/output]

I_A .... Annual investment costs of alternative DSM technology, per unit output [€/output]

CRF_A.................. Capital recovery factor of alternative DSM technolgy:

$$CRF_A = \frac{z*(1+z)^{PT_A}}{\left[(1+z)^{PT_A} - 1\right]}$$

PT_A .... Life time of the alternative technology [a]

$C_{A\ O\&M\ Nel}$............ O&M annual costs of alternative DSM technology per unit output for alternative technology [€/(output, a)]

n .... *number of different technologies receiving investment subsidy*

Budget .... max amount of the total grant for the year n for all different technologies [Million Euro/a]

With an investment subsidy, the electricity unit price at which it is economic to apply the efficient technology (the switch price) will be reduced, i.e.

$\widetilde{p}_e < p_e$

[13] The budget restriction is only feasible for investment subsidy in a whole sector, i.e. for common policy in the residential, industry or tertiary sector.

Tax incentives:

Tax incentives can also be implemented in the ***GreenNet*** toolbox**.** For simplification, it is assumed that tax benefits are granted on the investments spent on electricity saving systems. In contrast to investment subsides, however, it is assumed that the budget for the tax incentives scheme is not restricted.[14]
Analytically this means:

$$\tilde{p}_e * q_{el} + I * CRF + C_{O\&M\ Nel} - \beta * I * CRF = \tilde{p}_e * q_{A\ el} + I_A * CRF_A + C_{A\,O\&M\ Nel} \quad (6)$$

$$\tilde{p}_e = \frac{((1-\beta) * I * CRF - I_A * CRF_A) + (C_{O\&M\ Nel} - C_{A\,O\&M\ Nel})}{q_{A\ el} - q_{el}} \quad (7)$$

where

$\tilde{p}_e$ .... (Minimum) electricity unit price for the DSM measure to be economic, considering for example tariffs, grants, switch price: [€/MWh]

q_{el} .... Electricity consumption per unit product output [MWh/output]

I .... Investment costs of energy saving technology per unit product output [€/output]

CRF.................... Capital recovery factor: $CRF = \frac{z * (1+z)^{PT}}{[(1+z)^{PT} - 1]}$

z .... Interest rate per year

PT .... Life time of energy saving technology [a]

$C_{O\&M\ Nel}$............... O&M costs of DSM technology per unit output with energy saving technology [€/output]

q_{Ael}...................... Electricity consumption of alternative DSM technology per unit output [MWh/output]

I_A .... Investment costs of alternative energy saving technology per unit output [€/output]

CRF_A.................. Capital recovery factor alternative: $CRF_A = \frac{z * (1+z)^{PT_A}}{[(1+z)^{PT_A} - 1]}$

PT_A .... Life time of the alternative technology [a]

$C_{A\ O\&M\ Nel}$............ O&M costs per unit output for alternative technology [€/output]

Note: To calculate the electricity switch price for both the investment subsidy and the tax incentives, the necessary investments into both the electricity saving and the "standard" technologies should be known. However, in practice for this project, it was not always possible to collect these data in sufficient detail.[15] Therefore, an additional method was

[14] In the real world this fact is expressed by the „uniformity" principle, i.e. no one can be excluded from the scheme. Therefore, in the model the instrument "investment subsidy" and "tax incentives" differs in the model implementation just in one point, the restriction of the available budget.

[15] Investment costs for the electricity saving and the standard technology has been collected for the household sector only. For the tertiary and industry sector is was only possible to gain information about the investment costs of electricity saving technologies but not for the standard system (to complex).

included in the toolbox to be able to simulate the effects of such DSM; this method requires less information than otherwise.

Granted tariffs:

A simple approach, but not frequently used, is the so called "granted tariff". With this support scheme, the investor receives a grant if certain energy saving systems are installed or if a "standard" technology is replaced, i.e. every kWh saved will be granted by a payment. To avoid high transaction costs, it is assumed that the electricity saved refers to average savings expected from using a standard technology (i.e. savings against a baseline). Trying to measure actual savings would become extremely complicated. .
In addition, to simulate realistic cases, a budget restriction is considered in the ***GreenNet*** toolbox. This approach is analytically determined by

$$\tilde{p}_e * q_{el} + I * CRF + C_{O\&M\ Nel} - p_G * (q_{A\,el} - q_{el}) = \tilde{p}_e * q_{A\,el} + I_A * CRF_A + C_{A\,O\&M\ Nel} \qquad (8)$$

Converted and compared with equation (1) for the electricity switch price without any support mechanism

$$\tilde{p}_e + p_G = \frac{(I * CRF - I_A * CRF_A) + (C_{O\&M\ Nel} - C_{A\,O\&M\ Nel})}{q_{A\,el} - q_{el}} = p_e \qquad (9)$$

$$\tilde{p}_e = p_e - p_G \qquad \text{subject to} \sum_{i=1}^{n} p_{Gi} * (q_{A\,el\,i} - q_{el\,i}) < Budget \qquad (10)$$

where

p_e .... (Minimum) electricity unit price for which the DSM measure is economic without any support, i.e. the switch price without any support [€/MWh]

$\tilde{p}_e$ .... (Minimum) electricity price level for which the DSM measure is economic considering the granted tariff, i.e. the switch price with granted tariff [€/MWh]

p_G .... Granted tariff for each MWh electricity saved compared to a standard system [€/MWh]

q_{el} .... Quantity of electricity consumption per unit product output [MWh/output]

I .... Investment costs of energy saving technology per unit product output [€/output]

CRF.................... Capital recovery factor: $CRF = \frac{z * (1+z)^{PT}}{[(1+z)^{PT} - 1]}$

z .... Interest rate per year [1/a]

PT .... Life time of energy saving technology [a]

$C_{O\&M\ Nel}$............... O&M costs independent of electricity consumption per unit output energy saving technology [€/output]

q_{Ael}...................... Electricity consumption with alternative technology, per unit output [MWh/output]

I_A .... Investment costs of alternative energy saving technology per unit output [€/output]

CRF_A .... Capital recovery factor alternative: $CRF_A = \frac{z*(1+z)^{PT_A}}{\left[(1+z)^{PT_A}-1\right]}$

PT_A .... Life time of the alternative technology [a]

$C_{A\ O\&M\ Nel}$ .... O&M costs of alternative DSM technology per unit output [€/output]

n .... *number of different grant tariffs*

Budget .... max amount of the total grant for all different technologies [Mill Euro/a]

Promotional tariffs:

An alternative approach will be the direct promotion of special electricity price tariffs for specific applications. For each kWh consumed by this application, a guaranteed (reduced) electricity price will be charged instead of the standard electricity price.[16, 17]
This approach has the advantage that the actual consumption and not the estimated "average" saving will be charged. The disadvantage is that separate electric meter must be installed for each connection to energy saving equipment.

Equation (11) determines the switch price when different electricity prices can be expected e.g. a lower tariff for implementing a more efficient technology.

$$p_{pr} * q_{el} + I * CRF + C_{O\&MNel} = p_e * q_{A\ el} + I_A * CRF_A + C_{A\,O\&MNel} \qquad \text{with } p_{pr} < p_e \tag{11}$$

$$WTI = p_e = \frac{(I*CRF - I_A*CRF_A) + (C_{O\&MNel} - C_{A\,O\&MNel})}{q_{A\ el}} + p_{pr} * \frac{q_{el}}{q_{A\ el}} \tag{12}$$

$$p_e = \frac{(I*CRF - I_A*CRF_A) + (C_{O\&MNel} - C_{A\,O\&MNel})}{q_{A\ el}} + p_{pr} * \frac{q_{el}}{q_{A\ el}} \tag{13}$$

where:

p_e........................ (Minimum) electricity unit price at which the DSM measure is economic; this is the switch price [€/MWh]

p_{pr}....................... guaranteed electricity price (promotion tariff) using energy saving technology [€/MWh]

q_{el} .... Quantity of electricity consumption per unit output [MWh/output]

I .... Investment costs energy saving technology per unit output [€/output]

CRF.................... Capital recovery factor: $CRF = \frac{z*(1+z)^{PT}}{\left[(1+z)^{PT}-1\right]}$

z .... Interest rate

[16] Obviously, the promotion tariff must be lower than the „standard" electricity price, otherwise no incentive is given to use this tariff.

[17] This approach is implemented e.g. for heat pumps in the Czech Republic.

PT .... Life time of energy saving technology [a]

$C_{O\&M\ Nel}$ .... O&M costs independent of electricity consumption per unit output energy saving technology [€/output]

q_{Ael} .... Quantity of electricity consumption alternative technology per unit output [MWh/output]

I_A .... Investment costs alternative less energy saving technology per unit output [€/output]

CRF_A .... Capital recovery factor alternative: $CRF_A = \frac{z*(1+z)^{PT_A}}{\left[(1+z)^{PT_A}-1\right]}$

PT_A .... Life time of the alternative technology [a]

$C_{A\ O\&M\ Nel}$ .... O&M costs independent of electricity consumption per unit output for alternative technology [€/output]

Currently the installation of different meters is not a realistic option, therefore, this approach in neglected so far in the ***GreenNet*** toolbox.[18]

Figure 2.11 illustrates the method for determining the net DSM curve, assuming a price driven strategy (e.g. investment subsidy, tax incentive or promotion tariff for two bands). First, the net financial support for the different technology bands and sectors must be identified, see left hand side in Figure 2.11. In this example two bands receive government support. [19] The net "electricity switch level" depends on the chosen price driven strategy. Then the demand reduction curve due to DSM must be ordered according to the "electricity switch level", starting from the right to the left, and with the lowest costs, see right hand side of Figure 2.11.

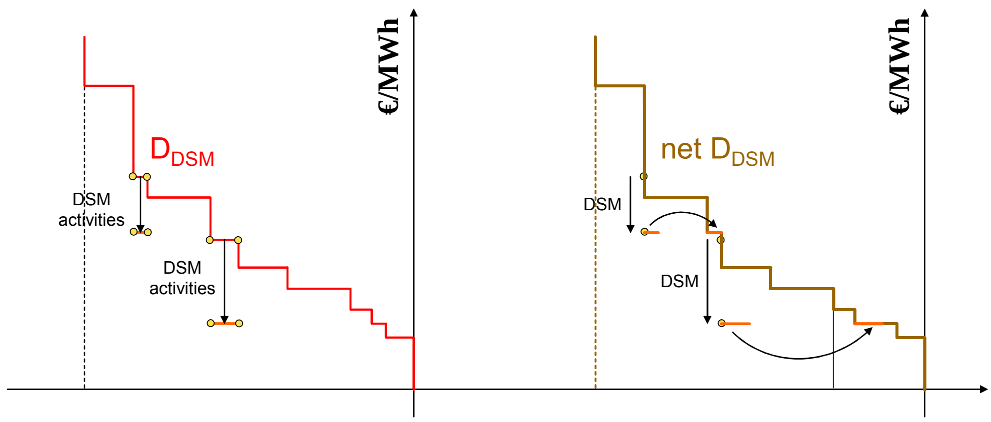

Figure 2.11 Determination of the net demand curve for DSM assuming that two band are promoted

[18] An extension of the toolbox, however, is feasible in the future.

[19] E.g. these two band characterise the promotion of low energy lightings for single households and multi family housed, respectively. In this case, the orange lines replace the red ones.

Demand driven instruments– design options

Demand quota:

One option to promote DSM is to restrict the demand (growth) to a certain level, i.e. a fine (penalty) has to be paid for consumption above a stated electricity demand. Such a policy does not by itself relate to the promotion of RES-E supply, but only restricts the demand-side. A ‘demand side quota system’ can be implemented either as non-tradable absolute targets (for different sectors) or as a tradable system. In the latter option, trade of "electricity consumption certificates" is feasible among and within the sectors. Note both options represent a huge intervention into the economic system and are unlikely to be implement in a free economy.[20]

The demand restriction imposed by the demand-quota is expressed by equation (14)

$$D_{Quota\,n} = \left(1 + \frac{\alpha}{100}\right) \cdot D_{el\,n-1} \qquad (14)$$

Note: the demand-quota obligation may not be binding in all cases, e.g. if an increase of the electricity demand is allowed for a new manufacturing development (α high). In general, the actual demand is given by

$$\widetilde{D}_{el\,n} = Min\left[D_{Quota\,n}, D_{el\,n}\right] = Min\left[\left(1 + \frac{\alpha}{100}\right) \cdot D_{el\,n-1}, D_{el\,n}\right] \qquad (15)$$

This situation is illustrated in Figure 2.12. As long as the electricity unit price does not increase dramatically, the quota system restricts the total demand. With a large electricity unit price[21], the demand decreases due to the economic efficiency of reduction of electricity demand beyond the quota level. This means that under this assumption, the "naturally responding" electricity demand is less than the quota obligation $D_{Quota\ n}$. The actual total demand curve for the year n is depicted by the full lines in Figure 2.12 – the red line relates to binding quotas and the green line to demand decreased under the necessary level imposed by the quota.[22]

where:

α .... quota restriction, maximum increase of the total demand in year n compared to year n-1 [%]; α can be positive (increase of demand) or negative (reduction of the electricity demand)

$D_{el\,n-1}$ .... total electricity demand year n-1 [MWh/a]

$D_{el\,n}$..................... total electricity demand year n without demand quota [MWh/a]

$D_{Quotal\,n}$ .... maximum total electricity demand year n impose by the quota [MWh/a]

$\widetilde{D}_{el\,n}$ .... actual total demand curve year n [MWh/a]

---

[20] In reality it is only feasible to implemented such a scheme as voluntary agreement but not mandatory for all sectors.

[21] E.g. due to the introduction of a low CO_2 target or shortages in the supply.

[22] In the case that the quota is very restrict the situation can occur that it is impossible to reduce the demand to this level, also if all feasible DSM are implemented.

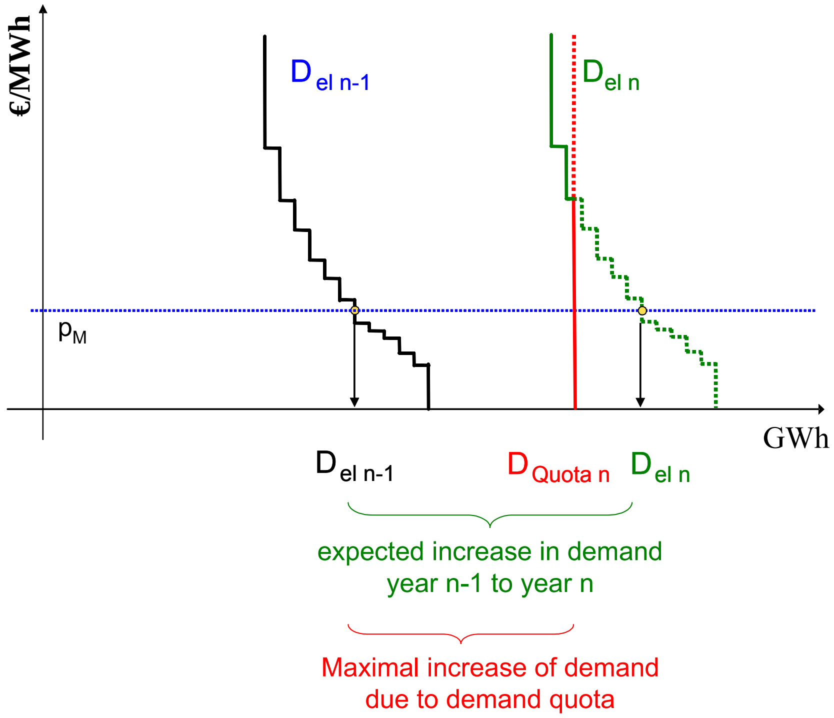

Figure 2.12 Determination of the demand curve

Standards

Standards are a strong instrument for implementing energy saving systems for a specific end-use technology or sector. With an obligation to use efficient devices, a demand reduction is guaranteed.[23] As a 'command-and-control' instrument, no direct costs occur for the government, neglecting administration costs imposing the standard. Nevertheless, costs may occur for society, since the users must pay all additional costs themselves. However, this has the advantage that costs accord to the "polluter-pays" principle.

It is assumed that, by introducing a standard, the energy saving option will be fully implemented. This means that the full demand reducing potential will be used.[24] The switch price is set to zero for those technologies within their end-use technology group for which a standard is imposed, see Figure 2.13.[25] Of course, if all end-use options within a technology group are imposed by a standard, the switch price of the total DSM curve is set to zero.[26] This, however, does not mean that the DSM curve for this technology group can be deleted. Rather the opposite is true; the full energy saving potential is available with zero costs.[27]

[23] Neglecting the rebound effect due to higher service level.

[24] Note: In the database it is already considered that only a certain share of the available potential can actually realised, both by setting a dynamic restriction of the yearly available potential and by restricting the mid-term potential for 2020. This means with respect to the second term that the technical mid-term potential is higher than the realisable mid-term potential used in the database.

[25] For example an energy efficiency standard for the technology "refrigerators" with in the end-use technology group "household - electricity appliances" is introduced.

[26] For example for the end-use technology sector "household - lighting" only energy saving bulbs can be installed.

[27] Of course, costs for society exist, as the individual user has to invest into the energy saving technologies.

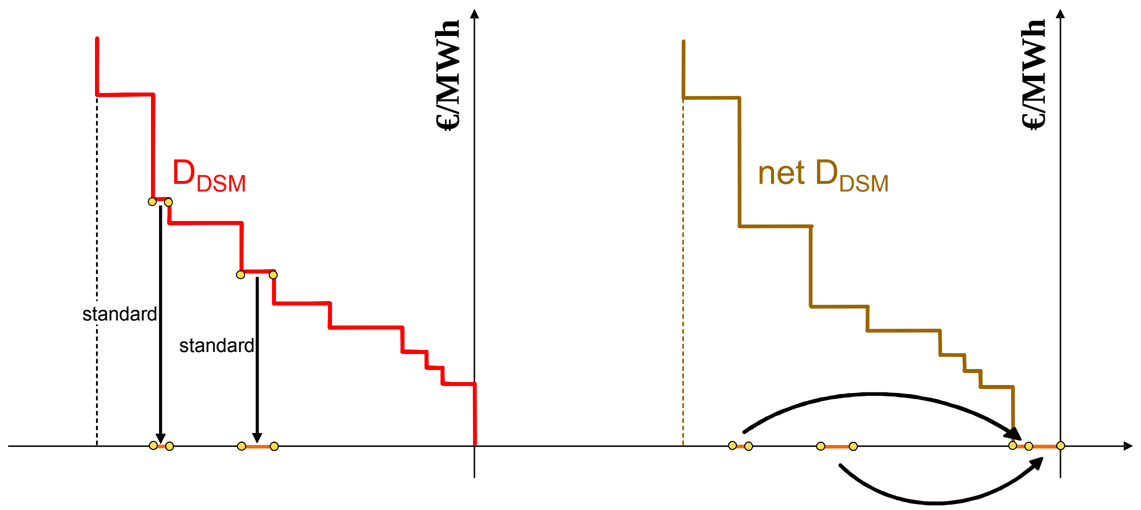

Figure 2.13 Determination of the net demand curve for DSM assuming that for two bands a standard in introduced

2.4.5 Modelling total demand

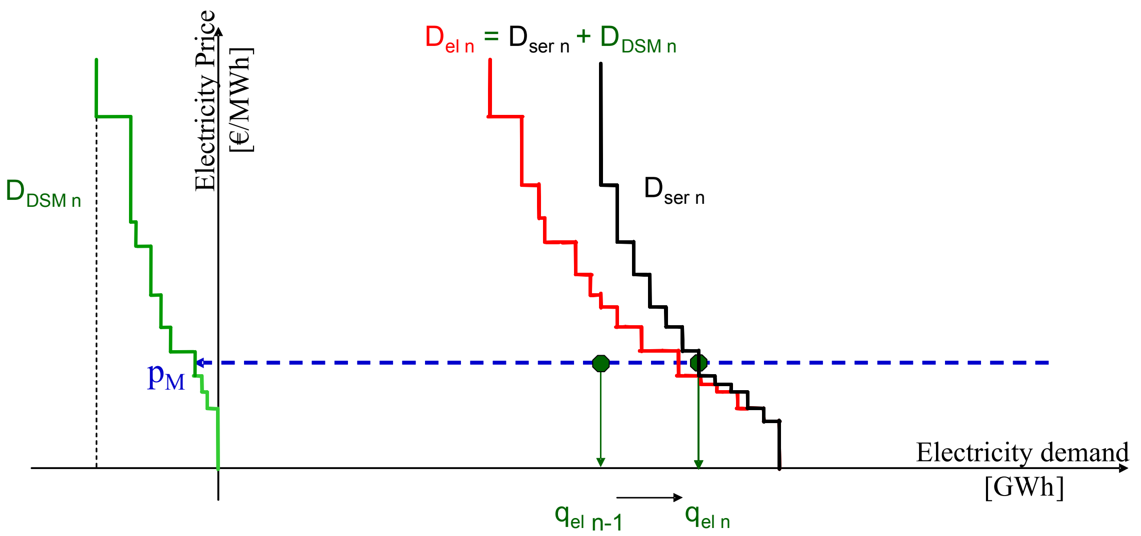

Figure 2.14 Construction of the total dynamic demand curve for the year n

The total demand curve for year n can be derived by adapting the demand for the previous year n-1. Mathematically, $q_{el\ n-1} \Rightarrow q_{el\ n}$[28]. Here, $q_{el\ n}$ represents the expected demand, assuming that the electricity price remains unchanged in year n from year n-1.

Based on $q_{el\ n}$, the service demand curve can be created according to the assumed price elasticity for the year n ($D_{ser\ n}$). In addition, the total dynamic demand can be derived by 'horizontal' addition of, (1) the service demand curve and, (2) the demand curve for demand-side activities. Analytically,

[28] Note: The change in the electricity price in the demand forecast has to be considered by adapting the demand for the year n. In the case that in the demand forecast for the year n a higher electricity price is assumed, the additional demand for the year n compared to the year n-1 must be adjusted appropriately.

$$D_{el\,n} = D_{ser\,n} + D_{DSM\,n} \qquad (16)$$

The construction of the total demand curve, for the case with no policy support, is depicted in Figure 2.14.

The situation assuming a constant[29] promotion of measures for reducing electricity demand is depicted in Figure 2.15. As with the argument for equation (16), but not explicitly mentioned there is a so called "economic rebound effect". This effect can be modelled within the ***GreenNet*** toolbox using the split of the total demand into 'service demand' and into 'demand reduction based on DSM'. More precisely, the total "theoretical" demand reduction resulting from the mechanisms for DSM (Δq_{el} in Figure 2.15) cannot be fully used, because, at the same time, the service level (Δq_{ser}) rises due to the reduced electricity price. Hence, the actual demand reduction is given by the difference between the 'demand reduction DSM' and the 'demand increase due to improving the service', see Figure 2.15. Analytically,

$$\Delta q_{el} = \Delta q_{el\,DSM} - \Delta q_{ser} \qquad (17)$$

The net effect depends on the slope of the total demand curve. With a flat curve, the "economic rebound" is very large.

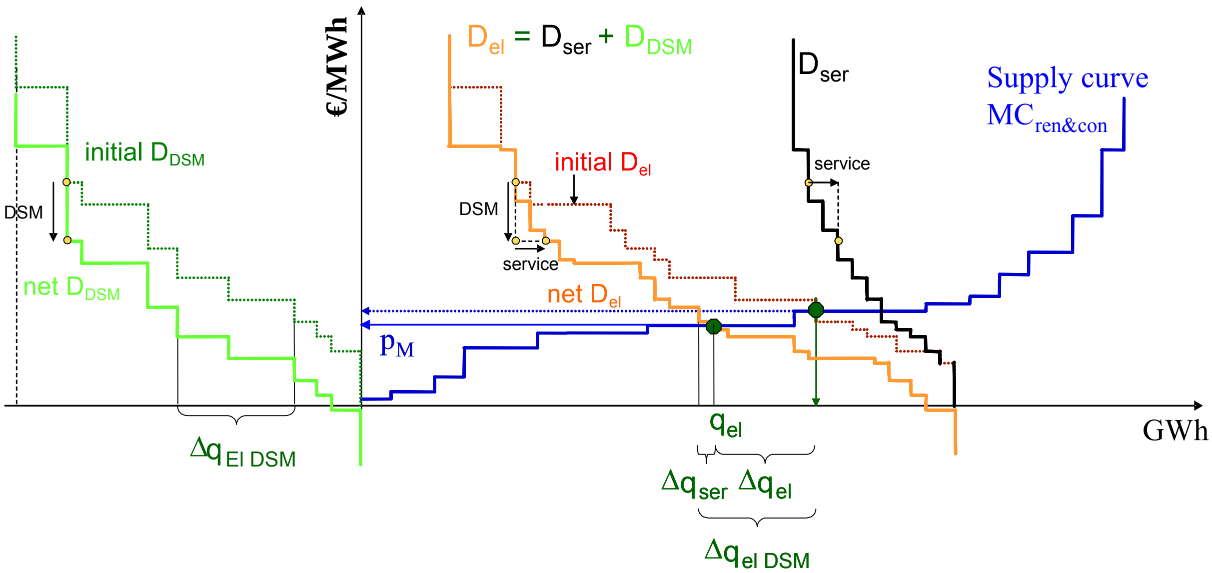

Figure 2.15 Construction of the total dynamic demand curve for the year n, assuming a constant financial incentive for demand-side measures

In addition, a similar effect occurs if the demand-side measures are promoted, e.g. by financial and/or political) mechanisms. As a result of reduced DSM costs (indicated by the "DSM"-arrow), consumers react with an additional demand (increase of the service level, as indicated by the "service"-arrow). Consequently, parts of the demand reduction due to demand-side measures will be compensated by increased demand, due to reduced electricity price, see also Figure 2.15.

[29] This means that each technology in each sector receive the same financial support – constant reduction independent from the band (technology) in the magnitude of "DSM".

3 Data sources

3.1 DSM measures - definitions

Definition: Energy Efficiency DSMs are the energy efficiency activities for achieving an overall reduction of primary energy supply for end-use energy demand, e.g. load management and/or fuel-switching. The aim is to reduce the total cost of energy services and to reduce primary energy consumption.

3.2 DSM Database structure

EEG has proposed a main structure of the DSM database. The DSM database will be developed for each investigated country and will represent a "dynamic matrix" i.e. how much of the 2020's achievable end-use energy saving potential (100%) can be reached and implemented for every year, i.e. for 2002, 2003 … 2019.

3.3 DSM activities – categories and band names

The following categories and abbreviations will be used in bands for DSM:

'Country '-'energy product category'-'energy source category'-'existing/new'-'energy source - short name'-'band number (i.e. 1, 2, 3 etc.)'

Band name example: SE-E-DSM-N-IN-C-1 means:

Sweden – Electricity - DSM measure - New measure – Industry – Air conditioning – Measure 1.

3.3.1 Categories and abbreviations

Country:

European Union 15		EU
	Austria	AT
	Belgium	BE
	Denmark	DK
	Finland	FI
	France	FR
	Germany	DE
	Greece	GR
	Ireland	IE
	Italy	IT
	Luxembourg	LU
	Netherlands	NL
	Portugal	PT
	Spain	ES

Sweden	SE
United Kingdom	UK
European Union 10+	E+
Czech Republic	CZ
Hungary	HU
Poland	PL
Slovakia	SK
Other countries	
Norway	NO
Switzerland	CH

Energy product category:

Electricity	E
CHP	C

Energy source category:

DSM	DSM

New vs. existing measures:

I. New measure	N
II. Existing measure	X

Sectors:

1. Industry (IN)
   - i. Space and water heating — H
   - ii. Air conditioning — C
   - iii. Lighting — L
   - iv. Compressed air — A
   - v. Motors / drives — M
   - vi. Refrigeration — R
   - vii. Processes — P

2. Residential (RE)
   - a. Single family houses (SH)
     - i. Space heating — H
     - ii. Ventilation – air conditioning — C
     - iii. Sanitary (potable) hot water — W
     - iv. Lighting — L
     - v. Electrical appliances — E
     - vi. Refrigeration — R
     - vii. Stand by — S
   - b. Multi-family houses (MH)
     - i. Space heating — H
     - ii. Ventilation – air conditioning — C
     - iii. Sanitary (potable) hot water — W
     - iv. Lighting — L
     - v. Electrical appliances — E
     - vi. Refrigeration — R
     - vii. Stand by — S

3. Tertiary sector (TS)
    a. Commercial service (CS)
        i. Space heating H
        ii. Ventilation – air conditioning C
        iii. Potable hot water W
        iv. Lighting L
        v. Electrical appliances E
        vi. Refrigeration R
        vii. Motors/drives M
        viii. ICT/office machinery I

    b. Public service (PS)
        i. Space heating H
        ii. Ventilation – air conditioning C
        iii. Potable hot water W
        iv. Lighting L
        v. Electrical appliances E
        vi. Refrigeration R
        vii. Motors/drives M
        viii. ICT/office machinery I

Electrical transport and agriculture are not taken into consideration now, because of the insignificant number and impact of present and future DSM-measures compared to the other sectors (according to decision during GreenNet WP5 Milan-meeting in October 2003).

3.4 MURE II (Mesures d'Utilisation Rationnelle de l'Energie)

The main tool used for data is the MURE II database. The description of MURE II is based on MURE (homepage: www.isis-it.com/mure/):

MURE provides information on energy conservation measures that have been carried out in the EU 15 Member States and Norway. It was designed and developed, within the framework of the DGXVII SAVE programme, by a team of European experts from INESTENE (F), ISI-Fraunhofer (D) and March Consulting Group (UK), led and co-ordinated by ISIS (Institute of System Integration Studies), Rome, Italy. The programme enables simulations and comparisons of the potential impact of energy efficiency and DSM measures at a national level for each EU15 country and Norway.

The MURE II database consists of four separate blocks:

- Industry,
- Households,
- Tertiary,
- Transport.

Each block contains the appropriate energy conservation measures, statistical data and simulation tool.

Three main classes of data are provided, for each of the EU15 countries and Norway:

- Measures (accessed through the Query function),
- Statistical data relevant to the energy consumption of the sector (accessed through the Data Management function and the graphs function),
- Technical and cost data are also included for the residential sector to enable the calculation of the energy saving potential and cost of measures (accessed through the Technical Parameters function).

The simulation tool calculates the impact of applying different DSM methods to different end-uses. It is therefore based on two assumptions:

- Each measure is associated with one or more end-uses
- The impact of each measure is therefore the result of the energy performance of the corresponding end-use equipment and their penetration rate into the market.

Each measure may involve one or more technologies and a given technology may be implemented as a result of more than one measure.

The simulation is built in such a way that the cumulative effect of different technologies can be accounted for [MURE, 2003].
The simulation process is fully interactive with default values available at all stages. This means that it is possible to create new additional parts for those 5 countries that do not exist in the standard MURE II Database.

According to the experience from running the MURE Database, the following methodology is proposed for the potential and costs of DSM measures for different European countries:

1. For EU15 countries and Norway, the MURE programme can be used after updating the relationship parameters for each country in 2001, i.e.:
   - Thermal energy price EUR/toe
   - Electricity end-use energy price EUR/kWh
   - Annual interest rate %
   - Annual inflation rate %
   - Energy price annual growth rate %.

   Then the results giving the potential and costs of DSM measures can be entered directly into ***GreenNet*** DSM Database.

2. For 5 remaining countries that are not included in MURE II Database (CH and PL, CZ, SK, HU), the data should be collected and delivered by responsible GreenNet participants (see next section). Then the data will be entered into ***GreenNet*** bands by H&P and eERG.

3.5 Data collecting

The list of investigated countries was discussed at the WP5 meetings in Vienna (in April and July 2003). The WP5 participants agreed that the model should include 21 European countries: EU-15, NO, CH and PL, CZ, SK, HU.

The participants agreed (Brussels, January 2004) that Heat&Power and eERG would be responsible for input (via MURE II tool) from the following countries:

Heat&Power	SE, FI, DK, NO, DE, HU*, PL*, BE, LU, NL
eERG	IT, FR, ES, PT, GR, AT, CH*, UK, IE, CZ*, SK*

* Countries not included in MURE II Database

Enviros, NECA and Energia Klub helped with data collecting from their respective countries that were not included in MURE II database. eERG developed an excel questionnaire for this purpose.

In the MURE II database, there are no costs indicated for different DSM measures in the industry and tertiary sector. In this case, the partners agreed during the Milan-meeting (October 2003) that eERG and Heat&Power would prepare the numbers based on literature surveys as follows:

	Industry subsectors	Tertiary subsectors*
eERG	L, M, R	L, E, R, M, I
Heat&Power	H, C, A P	H, C, W

* Differences between public sector PB and commercial sector CO

3.6 Quality of input data

The quality of input data was discussed at the WP5 meetings. Quality of data should be labelled in the database. The following marking is proposed:

Data	**Quality**	**Colour**
Official data, statistics	excellent	white
Other valid sources	good	green
Our own and others assumptions on well known base	acceptable	yellow
Assumptions without clear reference or known base	uncertain	red

4 Choices and Assumptions

4.1 Explanatory notes

4.1.1 Bands

Bands for the GreenNet database were obtained in different ways depending on access to data and information.

Each field within the database could be:
- Derived directly from MURE
- Derived from data already existing in MURE (or derivable from MURE) with some calculations
- As assumptions made by the WP5 group justified by data sources and references
- Calculated from the other fields

Each band could be:
- Totally derived from MURE – for example all bands for the residential sector for EU15-countries.
- Totally derived from calculations – for example all bands for the residential sector for EU+10 countries, with input data from our partners.
- Partially derived from calculation - only data in the C to G columns, the most of industrial and tertiary bands.

4.1.2 Cost and potential per sector

Some data differ from country to country: these are shown divided in different cells per country. Some data differ from technology to technology and, generally not from country to country: these are shown with "unified cells"

Residential sector

- **Potential savings**: derive from MURE (or partners), differ from country to country
- **Share in % of potential reachable per year**: Assumption from the WP5 group, differ from technology to technology
- **Cost of kWh saved**: Original Data from MURE plus calculation to fill the bands, differ from country to country
- **Interest rate**: Assumption (10% for residential sector)

Industrial and Tertiary sector

- **Potential savings** are calculated as:

  (Total consumption for final use) * (% saving from specific technology) * (maximum possible penetration rate - actual penetration rate)

- **Consumption per sector / final use**: derive from MURE (or partners), differ from country to country
- **Saving from specific technology; maximum possible penetration rate; actual penetration rate:** derive from MURE (or partners), depending on technology, generally not on country
- **% of potential reachable per year**: Assumptions from the GreenNet WP5 group, differ from technology to technology
- **Cost of kWh saved**: International literature - assumption or calculation from the GreenNet WP5 group - average values depending on the technologies (generally not depending on country)
- **Interest rate**: Assumption (8% for industry and commercial tertiary, 5% for public service tertiary)

4.1.3 Costs per kWh saved

As already stated in previous documents, the costs per kWh saved for Tertiary and Industry sector are not included in MURE. Thus it is responsibility of Politecnico di Milano and Lund University to derive them from international literature.

From MURE we have listed different possible technologies for saving electricity (and for each of them MURE suggests data on saving from specific technology; maximum possible penetration rate; actual penetration rate.

5 Results

5.1 Energy saving potentials in residential sector - assumptions and methodology

5.1.1 Data sources

EU-15 countries and Norway

Calculations, according to the methodologies detailed in this chapter, have been performed using the following inputs, contained in the MURE database, which refers to year 1995:

- Yearly average final energy consumption of electrical appliances,
- Price of electrical and thermal energy,
- Final energy saving potential in year 2020,
- Investment cost of average and efficient technologies.

Switzerland

The data source, for the calculation of energy saving potentials in Switzerland, is the report "CO2-Reduktionspotential Erdgas", edited in April 2002, by CEPE, Centre for Energy Policies and Economics of the Swiss Federal (www.cepe.ch).

EU+10 countries

Input data from these four countries (HU, PL, CZ, SK) was prepared and delivered by our respective ***GreenNet*** partners.

5.1.2 Overall assumptions

Final energy saving potential is expressed in tonnes of oil equivalent (1 TOE equals 11880 kWh).

The share of realisable energy saving potential compared to long-term potential of implemented measure is 1 divided by the lifetime span of a given technology. Among the available measures, the least-cost measures have been chosen.

5.1.3 Long-term saving potentials and costs calculation for the ***GreenNet*** bands

1. Insulation and control devices, band code: Country-E-DSM-N-RE-MH-H-1, 2, 3, 4, 5
   Long term potential energy saving is given by the product of the stock of houses with electric heating in year 2020, and energy saving of a single house due to insulation of ground, roof, walls and windows or to the installation of control devices.

   Both the stock of dwellings with electrical heating system and the energy saved due to insulation technologies in year 2020, are derived from MURE database simulation tool.

2. Heating fuel substitution, band code: Country-E-DSM-N-RE-MH-H-6
   Long term energy saving potential due to heating fuel substitution is given by the product of the stock of houses with electric heating in year 2020, and the entire energy consumption of an electrical heating system, taken into account operating and maintenance costs of the new system, which in most of the countries is a gas heating system. Only in Greece, an oil system has been chosen.

   The stock of dwellings with electrical heating system in year 2020 is derived from MURE database simulation tool.

3. Water heating fuel substitution, band code: Country-E-DSM-N-RE-MH-W
   Long term energy saving potential is the whole consumption of electrical boiler, since the existing electric boiler is substituted with solar panels.

   The stock of dwellings with electrical boilers in year 2020 is derived from MURE database simulation tool.

4. Household appliances and lighting, band code: Country-E-DSM-N-RE-MH-E, Country-E-DSM-N-RE-MH-L, Country-E-DSM-N-RE-MH-R.
   Long term energy saving potential is given by the product of the stock of household appliances or lighting systems, in year 2020, and the saving due to the installation of the best technologies available on the market instead of the average ones.

   The stock of household appliances and lighting systems in year 2020 is derived from MURE database simulation tool.

5.1.4 Country specific issues

For some of the countries, due to lack of data in MURE database, special assumptions or investigations have been carried out. A brief description is given below.

Austria

The source of data related to electrical heating is Austria Statistik, because the data contained in the MURE database is incorrect.

Czech Republic

There is no distinction between fridge-freezers and freezer: the energy saving potential is calculated for cold appliances as a whole.

Ireland

Unitary space heating consumption of Irish houses, by different fuels and type of housing, has been assumed equal to that of United Kingdom.
United Kingdom data have been used to determine also the proportion of individual family and multi-occupied dwellings in Ireland, since there were only available total and individual houses data.

Portugal

Since data is not available in MURE database for Portugal, unitary space heating consumption, by different fuels and type of housing, is assumed equal to that of Spain.
The same assumption (analogy with Spain) has been made with regard to investment cost of a gas heating system.

5.1.5 Interactions between heating related measures

If the fuel substitution measure is implemented there're no more available measures related to electrical heating, since the energy consumption becomes equal to zero.

If the control devices measure is implemented, the energy saving potential related to the other available measures must be reduced by 7%, which is the gain of this measure both for single and multiple houses.

5.1.6 General comments from Heat&Power

Heat&Power Research Group was responsible for cost indicators for different DSM measures in the industrial and tertiary sector. Based on literature surveys, input data were prepared for several end-uses.

All the costs of electricity savings due to different measures are assumed to be equal for all the GreenNet database countries and expressed in EUR per saved MWh (EUR value 2001). Lifetime and annual shares of realisable electricity saving potential compared to long-term potential are assumed based on facts available in the references. Electricity consumption for a specific sector in each country was directly collected from MURE or calculated as a share for the end-use purpose.

5.2 Refrigeration in industrial and tertiary sector

The cost of the electricity saving option in the 'Refrigeration in the Industrial and Tertiary Sector' are assumed to be equal in the different countries included in the ***GreenNet*** Database. The potential of each electricity-saving option is calculated as a percentage of the consumption for that for refrigeration in the two sectors. This percentage is assumed to be equal in the different countries included in the ***GreenNet*** Database.

Costs are expressed in Euro/MWh. Figures are different for the Public and the Commercial Sector[30] because the interest rate is assumed to be 5% per year for the Public Sector and 8% per year for the Commercial Sector.

All the data on costs and the data on percentage potential savings included in the following tables, are derived from "Energy Savings Potential for Commercial Refrigeration Equipment" prepared by Arthur D. Little, Inc. for Building Equipment Division Office of Building Technologies U.S. Department of Energy June 1996

[30] Intended as Industry and Tertiary Commercial subsector.

Even though this research was prepared for the USA market, we consider it the most comprehensive and coherent source of data publicly available. The figures in that report were given in US 1996 Dollars. In the following the data is expressed in 2003 Euro.

In the refrigeration end-use, considerable savings are possible by the introduction of high efficiency motor drives. The analysis of the energy efficiency potential and costs for such motors is not included in this paragraph. It is included in the specific paragraph dedicated to electric motors.

Average lifetime of refrigeration technologies is 10 years. Annual share of realisable energy saving potential compared to long-term potential is considered to be 15% for all the technologies.

5.2.1 Insulation

Little, 1996, classifies two different types of solution for improving insulation: (1) thicker insulation and (2) improved insulation.

Thicker Insulation	**Savings**	**Costs (Eur/MWh)**	
	%	**Commercial Sector**	**Public Sector**
Beverage merchandiser	3.0%	72.7	64.3
Ice Machines	3.0%	40.2	35.5
Reach-in Freezers	3.8%	61.7	54.2
Reach-in Refrigerators	2.2%	149.2	131.1
Refrigerated Vending Machines	5.4%	54.2	47.9
Walk in coolers	0.4%	303.5	263.7
Walk in freezers	3.6%	27.6	24.0

Improved Insulation	**Savings**	**Costs (Eur/MWh)**	
	%	**Commercial Sector**	**Public Sector**
Beverage merchandiser	0.9%	846.8	748.5
Reach-in Freezers	1.6%	1116.6	981.4
Reach-in Refrigerators	0.9%	1505.0	1322.7
Supermarkets	0.3%	282.0	245.1

Furthermore, the MURE database estimates a 2.25% potential saving for generic insulation improvements.
We propose two different options: thicker and improved insulation, the figures of savings and potential are calculated as averages of the values given for the different end-uses:

	Savings	**Costs (Eur/MWh)**	
	%	**Commercial Sector**	**Public Sector**
Thicker Insulation	3.1%	101.3	88.7
Improved Insulation	0.9%	937.6	824.4

5.2.2 Floating Head Pressure Controls

Floating head pressure controls are proposed only for supermarkets and walk-in coolers.

Floating Head Pressure	Savings	Costs (Eur/MWh)	
	%	Commercial Sector	Public Sector
Supermarkets	3.1%	22.0	19.1
Walk-in coolers	17.6%	3.0	2.6

MURE estimates a 2.5% potential saving for floating head pressure controls. As a conservative estimate, we will adopt the values given for supermarkets.

5.2.3 Antisweat Heat Controls

MURE does not consider antisweat controls. The figures of savings and potential that we propose are calculated as averages of the values given for the different end-uses.

Antisweat Heat Controls	Savings	Costs (Eur/MWh)	
	%	Commercial Sector	Public Sector
Walk-in coolers	2.3%	67.1	58.3
Walk-in freezers	6.4%	66.8	58.1
Supermarkets	5.7%	11.2	9.7

5.2.4 Defrost Controls

MURE does not consider defrost controls. The figures of savings and potential that we propose are calculated as averages of the values given for the different end-uses.

Defrost Controls	Savings	Costs (Eur/MWh)	
	%	Commercial Sector	Public Sector
Reach-in Freezers	2.8%	48.9	43.0
Supermarkets (electric defrost)	1.3%	21.3	18.5
Supermarkets (hot gas defrost)	0.5%	52.2	45.3
Walk-in freezers	2.3%	36.6	31.8

5.2.5 High-Efficiency Fan Blades

MURE does not consider high-efficiency fan blades. The figures of savings and potential that we propose are calculated as averages of the values given for the different end-uses.

High-Efficiency Fan Blades	Savings	Costs (Eur/MWh)	
	%	Commercial Sector	Public Sector
Refrigerated Vending Machines	3%	3.3	2.9
Beverage merchandiser	6%	1.8	1.6
Walk in coolers	6%	6.1	5.3
Walk in freezers	5%	5.7	5.0
Supermarkets	3%	0.4	0.3
Ice Machines	1%	2.5	2.2
Reach-in Freezers	2%	2.5	2.2
Reach-in Refrigerators	4%	2.5	2.2

5.2.6 Conclusions

In the following compilation we present the cost and potential for the different energy saving option that we propose for the refrigeration in the Industrial and Tertiary Sector.

	Savings	Costs (Eur/MWh)	
	%	Commercial Sector	Public Sector
Thicker Insulation	3.1%	101.3	88.7
Improved Insulation	0.9%	937.6	824.4
Floating Head Pressure	3.1%	22.0	19.1
Antisweat Heat Controls	4.8%	48.4	42.0
Defrost Controls	1.7%	39.8	34.7
High-Efficiency Fan Blades	3.9%	3.1	2.7

5.3 Lighting in industrial and tertiary sector

5.3.1 General Comment

The data are derived from a study for Denmark. However, for the reasons explained below, it is reasonable to apply the data to Europe in general, so giving an optimistic estimate of saving potentials and costs.

5.3.2 Source of data

Nearly all data come from the Energy Piano (2001). This report itself makes reference to other studies.

5.3.3 Saving potential and cost data for individual technologies

Principle data source is DEA (1995). The current penetration rates, saving potentials and costs relate to Denmark. How correct are we in applying figures for Denmark to the rest of Europe?
The Energy Piano (2001) report covers six countries in relative detail: Belgium, Denmark, Greece, Spain, Italy, UK.

In each country, an audit of 50 buildings was undertaken in the following sectors:
- Private office
- Public offices
- Retail
- Education
- Health

which allowed the most common light sources, ballasts and luminaires to be identified.

From this work, it appears that energy efficiency of lighting plant installed in Denmark equates generally with the average efficiency of partners countries considered in the study.

On a number of points, the efficiency of plant in Denmark may be greater than the European average.

Indeed Denmark has operated a number of policies for improving energy efficiency of indoor lighting plant in recent years. For example:

1. The Danish Energy Agency and Danish Electrical Utilities published best practice guidelines in 1996 on good and energy efficient lighting in offices, schools and shops, including recommended power densities

2. The guidelines emphasise the need to use the correct maintenance factor when designing plant in order to avoid over sizing.

3. It is possible to obtain subsidies from the Danish Energy Agency to improve lighting system efficiency.

Thus, for example, from the Energy Piano, (2002):

- penetration of energy efficient triphosphor tubes
  - in Denmark: 63%
  - other partner countries: 50.13%

- penetration of HF ballasts
  - in Denmark: 12%
  - other partner countries: 10%

Thus by applying penetration rates for energy efficient technologies for Denmark to the rest of Europe, it is reasonable to assume that we offer a realistic estimate of energy savings potentials.

The DEA (1996) study presents data for

- 1996 : the actual situation then
- 2005 : a projection of penetration rates supposing soft and hard policy drivers
- 2020 : a projection of penetration rates supposing soft and hard policy drivers

We apply the situation in 2004, using the data presented by DEA, (1996) for the year 1996. We do this for two reasons:

1. The 2005 projections, even if the soft policy drive had been followed, have not authenticated. The actual penetration rate of electronic ballasts is still only 12% (from Energy Piano, 2002) compared to the 56% penetration rate supposed for the 2005 scenario.

2. As stated above, the penetration rates of energy efficient technologies for 1996 in Denmark appear to be if anything more than the European average. Therefore even if the soft policy scenario had held true, this would not reflect the wider European situation.

The **product cost data** reported for ***GreenNet*** are as provided by DEA, 1996 for 1996. No attempt has been made to update the cost data. Again, supposing that a natural reduction in costs of energy efficient technologies occurred in the period from 1996 to 2004, the figures applied provide a realistic estimate of costs.

5.3.4 Product lifetimes

- Lifetimes are simply estimated on the basis of the following rational:
- **Fluorescent tubes** last 10,000 hours when operated with electromagnetic ballasts and 18,000 with electronic ballasts. Supposing an average use of 3,000 hours per year (above average if we consider data from Energy Piano, 2002) the lifetime is from 3 to 6 years, or on average 4.5 years.
- **Electronic ballasts** have a lifetime (supposing ideal operating conditions of 150,000 hours and supposing 3,000 hours a year average use) of 50 years. We suppose an economic lifetime of lighting plant to be 25 years.
- **Luminaires** have no working parts and their lifetime is generally defined by the ballasts (50 years).We suppose an economic lifetime of lighting plant to be 25 years.
- **Occupancy and daylight sensors** maybe more susceptible to changes in office working procedures which occur on shorter time scales, relative to complete building restructuring.

5.3.5 Data elaboration

It has proved necessary to slightly elaborate the data provided by Energy Piano, 2002 and DEA, 1995 to develop the result required for Green Net.

However, other than the data identified in the previous section of this elaboration is based entirely on the data provided by the two reports. The elaboration simply extrapolates the DEA data to the form required of ***GreenNet***.

5.3.6 Total lighting energy use and saving potential

Proportion of Light on Total Commercial Sector Energy Use 1994 (Energy Piano, 2002)

Country	Proportion of Light on Total Commercial Sector Energy Use
France	20%
Germany	20%
Denmark	30%
Italy	30%
UK	30%
Netherlands	52%
EU average	25%

Total saving potential for tertiary sector according to source:
- Caddett: 50%
- Greenlight: 45%
- Energy Piano: 40 - 45%

Analysing the DEA data detailed in the previous sections, the adoption of best technologies would bring average energy ***GreenNet*** down from 22 kWh/m^2 and year to 15.78 kWh/m^2 and year, a saving of 30%. Thus again, the adoption of DEA data generally underestimates the overall saving potential for Europe.

5.4 ICT Technologies - Tertiary Sector

The energy saving potential for ICT Technologies in the Tertiary Sector can be technical savings potentials or behavioural driven potentials. Cremer (2003) lists the following options:

OPTIONS AND POTENTIALS IN OFF-MODE

- use of switchable multiple socket outlets, with which appliances can be switched off completely;
- manufacturers equipping their products with switches that disconnect completely from the grid.

OPTIONS AND POTENTIALS IN STANDBY MODE

- If fitted with a separate circuit for standby operation, the power draw of appliances can be reduced to less than 0.5 W, as long as only simple functions like an internal clock or the preservation of an internal memory have to be fulfilled. If more complex functions have to be fulfilled in standby mode, the energy consumption cannot be reduced as much solely by adjusting the power supplies.

OPTIONS AND POTENTIALS IN NORMAL OPERATION

- quicker substitution of cathode ray tube monitors by LCD monitors;
- switching off server computers overnight in small and medium enterprises;
- savings options exist in the reduction of the energy demand for cooling and aeration in the base stations and in limiting the number of base stations;
- Personal computers: energy efficient design comparable to the design of notebook computers including the use of mobile CPUs, which are however significantly more costly than the desktop models.

Almost all of these options are cost-zero options, as well as a wider introduction of Energy Star products.

These options cannot be included in the ***GreenNet*** Database. The only possible option that can be included in ***GreenNet*** is the substitution of cathode ray tube monitors by LCD monitors.

5.4.1 Substitution of CRT Monitors with LCD Monitors saving potential and costs

Roth (2002) estimates that Monitors represent 23% of total ICT consumption in the tertiary sector (Kawamoto, 2001 suggest a 22% for commercial sector).

Almost 50% of the installed monitors are 17 inches models, so we will consider only this size to calculate cost, assuming that they will be average values that we can use for all the monitors.

First of all we calculate the annual consumption of the two technologies.

		Active	*Stand-by*	*Off*	*Source*
Time in operational mode	hours	3280	2980	2500	Roth 2002

Power Draw		*Active*	*Stand-by*	*Off*	*Source*
CRT 17"	Watt	76	7	1	Robeson 2002
LCD 17"	Watt	30	2	2	Robeson 2002

We can thus estimate

Annual Consumption		
CRT 17"	kWh/year	273
LCD 17"	kWh/year	109
Consumption reduction		60%

Current market analysis shows that average cost for a CRT 17" Monitors is around 150 Euro, while for LCD Monitors is about 450 Euro and decreases continually.
Lifetime of the technology is on average 30,000 active hours. We suppose 6 years lifetime.

5.5 Electrical appliances – Tertiary sector

In this part no data are available in MURE, probably because the stock of electrical appliances is included in the figures for the domestic sector and it is not possible to divide between, for example, washing machines in the domestic sector and washing machine in the tertiary sector.

5.6 Electric motors driven system in Industrial and Tertiary Sector

The consumption for electric motors, as intended in the following, includes all the consumption due to motor system, i. e. regulation system, transmission, operating machine. We therefore should always intend "Motors driven systems" when we write "Motors".

The cost of the electricity saving option for electric motors in the Industrial and Tertiary Sector are assumed to be equal in the different countries included in the ***GreenNet*** Database. The potential of each electricity saving option is calculated as a percentage of the consumption for electric motors in the two sectors. This percentage is assumed to be equal in the different countries included in the ***GreenNet*** Database.

In the Tertiary sector, consumption for electric motors includes Ventilation/Air conditioning and Other motors consumption. In the Industrial sector, consumption for electric motors includes Ventilation/Air conditioning, Compressed Air and Other motors consumption.

In the international literature costs are expressed in Euro/MW, knowing the average annual consumption of the alternative technologies (kWh/kW installed), we calculated the cost per saved kWh. Figures are different for the Public and the Commercial Sector[31] because the interest rate is assumed to be 5% for the Public Sector and 8% the Commercial Sector.
Average Lifetime of Electric Motors is 15 years. Annual share of realisable energy saving potential compared to long-term potential is considered to be 6.7% for all the interventions assuming that it is possible to intervene only on those final users that have already decided to buy or substitute electric motors.

5.6.1 High Efficiency Motors (HEM)

High efficiency motors interventions include new motors with higher efficiency as well as rewinding of existing motors. In both cases the savings are calculated as the consumption reduction obtained comparing the efficient technologies to the average on the market. In our hypothesis HEMs can substitute all installed motors.
The identification of extra-costs for HEMs is rather complicated: they are mostly due to marketing strategies, rather than to real costs issues. Transaction costs due to project and procurement are still not negligible, although they will probably diminish considerably when HEMs will be introduced on large scale (as assumed in ***GreenNet***).
We choose a realistic estimation assuming that costs for new motors would be 78.70 EUR/MW for HEMs, compared to 63.70 Eur/MW standard motors (24% extra costs).

Electronic variable speed drives can substitute among 25% and 55% of motors, depending on the size and on the final use. We assumed an average of 40% as maximum penetration potential. Costs are significantly higher then those for standard motors (145 Eur/MW instead of 63.70 Eur/MW) but the high saving potentials make them quite profitable.

5.6.2 All system redesign

In some cases, where high consumption is mainly due to high inefficiency, it is advisable an overall intervention by an ESCO. This possibility can interest only 10% of final consumption for electric motors, and has high costs (284 Eur/MW instead of 63.70 Eur/MW for standard motors) but yearly consumption can decrease from 715 to 362 kWh per kW installed.

The following table shows the main results of our analysis.

	Savings	Maximum Penetration	Costs (Eur/Saved MWh)	
	%	%	Commercial Sector	Public Sector
High Efficiency motors	5%	100%	45.3	37.3
Variable speed drives	20%	40%	69.4	57.3
Whole system redesign	50%	10%	72.8	60.0

[31] Intended as Industry and Tertiary Commercial subsector.

5.7 Space heating and hot water - Industrial sector

For this end-use, two measures are considered according to the MURE database:

1. Auto-Manual control
Lifetime of this measure is assumed to be 15 years. Energy savings potential is 12% and the annual cost 13.33 EUR per saved MWh – these facts are obtained or estimated from Vattenfall's STIL-study U1991/70 (Göransson et al, 1992).

2. Insulation
Lifetime of this measure is also assumed to be 15 years. We assume that the insulation is increased by 50 mm. This means energy savings potential of about 20% at the annual cost of 86.70 EUR/MWh saved, according to an analysis carried out by Adamson (2001) at the Lund University.

	Lifetime of implemented technology	Share of realisable energy saving potential compared to long-term potential	Savings	Annual costs of saving
	years	% per year	%	(Eur/MWh)
Auto-Manual control	15	6.7	12	13.33
Insulation	15	6.7	20	86.70

If electricity consumption data are not available in MURE, the energy quantity for this specific end-use can be calculated as following:

Total electricity use for industry can be obtained from Eurostat (2001) or IEA (2001). According to the study published by Xenergy Inc. (Rufo & Coito, 2002), we assume that HVAC end-use amounts to 12% of this total electricity use. Heating and hot water fraction constitutes 42% of this 12%, i.e. 5% of the total electricity use.

5.8 Air conditioning (cooling and ventilation) - Industrial sector

Two measures are considered in this case, according to the MURE database:

1. Insulation
Lifetime of this measure is assumed to be 15 years. In average, insulation is increased by 50 mm. Energy savings potential is the same as in "heating and hot water" case above, of about 20%, at the same annual cost of 86,70 EUR per saved MWh, according to Adamson (2001).

2. Auto-Manual control
Lifetime of this measure is assumed to be 15 years. Energy savings potential is 12% according to Vattenfall's STIL-study U1991/70 (Göransson et al, 1992). The annual cost is 29.07 EUR/MWh saved. This cost is obtained from the report "California's Secret Energy Surplus - The potential for energy efficiency". Auto-manual control costs are equal to a sum of cooling and ventilating measures. Statistics for cooling (costs) are

available for industrial sector. Ventilation share is taken from commercial sector with an assumption that the cost is the same as for industry.

	Lifetime of implemented technology	Share of realisable energy saving potential compared to long-term potential	Savings	Annual costs of saving
	years	% per year	%	(Eur/MWh)
Auto-Manual control	15	6.7	12	29.07
Insulation	15	6.7	20	86.70

If electricity consumption data are not available in MURE, the energy share for this specific end-use can be calculated in the similar way as for "industrial heating and hot water":

Total electricity use for industry can be obtained from Eurostat (2001) or IEA (2001). According to the study published by Xenergy Inc. (Rufo & Coito, 2002), we assume that HVAC end-use amounts to 12% of this total electricity use. Air conditioning fraction constitutes 58% of this 12%, i.e. 7% of the total industrial electricity use.

5.9 Compressed air - Industrial sector

Six different DSM measures are considered for this end use:

1. Upgrading compressors

2. Recovering waste heat

3. Overall system design

4. Reducing pressure losses

5. Reducing air leaks

6. Frequent filter replacement

Lifetime, energy savings and costs of the DSM measures are based on two publications about compressed air in Europe (Radgen & Blaustein, 2003; Agricola & Radgen, 2003). As it can be seen in the table below, "air leaks reductions" have the highest saving potential within this end-use, about 16%, at relatively low cost of 1.87 EUR per saved MWh. Lifetime for "frequent filter replacement" is assumed to be 1 year and the cost are relatively high, 84.00 EUR/MWh saved, probably because of labour costs.

If electricity consumption data are not available in MURE, the energy amount for this specific end-use can be calculated as following:

Total electricity use for industry can be obtained from IEA (2001) or Eurostat (2001). According to the ECEEE publication (Agricola & Radgen, 2003), we assume that compressed air end-use amounts to 7% of this total electricity.

	Lifetime of implemented technology	Share of realisable energy saving potential compared to long-term potential	Savings	Annual costs of saving
	years	% per year	%	(Eur/MWh)
Upgrading of compressor	15	6.7	2.1	5.67
Recovering waste heat	15	6.7	4.0	1.87
Overall system design	15	6.7	4.5	5.67
Reducing pressure losses	15	6.7	1.5	3.80
Reducing air leaks	15	6.7	16.0	1.87
Frequent filter replacement	1	100.0	0.8	84.00

5.10 Processes - Industrial sector

The adoption of best practice DSM measures in process measurement and control technologies can create energy savings of 2 to6% on a typical industrial site. A large process site can provide unique opportunities to realise energy savings of between 5 and 15%, depending on the quality of existing control systems and the nature of the process. On larger industrial sites, improved process control is usually the third most important potential energy saving measure after CHP and energy efficient motors and drives. Data from projects worldwide show that the correct application of control improvement technology realises benefits that include energy savings of 5-15%.

Different cost-effective energy-efficiency measures can be applied to industrial processes. They are very industry-specific and not easy to generalise on the industrial sectors in different countries. Due to high variability and sometimes very limited applicability it is not possible to quantify and generalise their saving potential, achievable impact on total energy use, and their costs. Of these reasons, we are not able to deliver methodologies of developing bands for this specific industrial end-use.

5.11 Space heating and hot water - Tertiary sector

General comment: In this case, the bands are calculated for the whole tertiary sector, as it is not possible to find enough facts to derive the input data for both commercial and public sub-sectors.

For these end-uses, two measures are considered according to the MURE database:

1. Auto-Manual control

Lifetime of this measure is assumed to be 15 years. Energy savings potential is 12% and the annual cost 13.33 EUR per saved MWh – these figures are derived from Vattenfall's STIL-study U1991/70 (Göransson et al, 1992).

2. Insulation

Lifetime of this measure is also assumed to be 15 years. We assume in this case that a mixture of different measures is performed to improve the building envelope. This means energy savings potential of about 15% at the annual cost of 66EUR per saved MWh, according to Vattenfall’s STIL-study U1991/70 (Göransson et al, 1992).

	Lifetime of implemented technology	Share of realisable energy saving potential compared to long-term potential	Savings	Annual costs of saving
	years	% per year	%	(Eur/MWh)
Auto/manual control	15	6.7	12	13.33
Insulation	15	6.7	15	66.00

If electricity consumption data is not available in MURE, the energy amount for this specific end-use can be calculated as following:

Total electricity use for industry can be obtained from IEA statistics (2001). According to the study published by Vattenfall (Göransson et al, 1992), we assume that this end-use amounts to 22% (heating 17% and hot water 5%) of this total electricity use.

5.12 Ventilation and air conditioning - Tertiary sector

General comment: As before, this end-use cannot be divided into commercial and public sub-sectors.

For this end-use two measures are considered according to the MURE database:

1. Auto-Manual control

Lifetime of this measure is assumed to be 15 years. Energy savings potential is 5% and the annual cost 121 EUR per saved MWh – these figures are calculated based on Vattenfall’s STIL-study U1991/70 (Göransson et al, 1992).

2. Insulation

Lifetime of this measure is also assumed to be 15 years. Energy savings potential is assumed to be of about 22.5% at the annual cost of 66.00 EUR/MWh saved, according to Vattenfall’s STIL-study U1991/70 (Göransson et al, 1992).

	Lifetime of implemented technology	Share of realisable energy saving potential compared to long-term potential	Savings	Annual costs of saving
	years	% per year	%	(Eur/MWh)
Auto/manual control	15	6.7	5	1.21
Insulation	15	6.7	22,5	66.00

If electricity consumption data are not available in MURE, the energy share for this specific end-use can be calculated as following:

Total electricity use for industry can be obtained from IEA (2001). According to the studies published by Vattenfall (Göransson et al, 1992) and Xenergy Inc. (Rufo & Coito, 2002), we assume that "ventilation and air conditioning" end-use amounts to 18% of this total electricity use.

6 DSM activities – successful actions

Preparing this final report WP5 on DSM measures, the participants suggested presenting a selection of good practice examples from successful EE-DSM projects in the European countries. Heat&Power and eERG have made this selection with the help of Risoe, IT Power, Energia Klub, IER-Stutt and Enviros.

6.1 Industrial sector

Country: Czech Republic

Industrial sector	*Title*: Implementation of electronic speed control of electric drives *Start date*:
	Summary: Installed input of electrical drives in the Czech Republic is about 190 MW in electrical motors with 1 kW. These drives are used for the following purposes: • Pumping and transport of liquids - 120 MW • Ventilation funs - 30 MW • Other drives - 40 MW In many of these cases there is a need for variable speed of operation or efficient start-up and braking of such drives. In most of the cases the control of such drives is done on the output of the pumps and ventilation funs though throttle governing which results in throttling loss and also energy losses. To minimise such losses the electronic speed control.
	Technical data: Most of the drives can been equipped with the electronic speed control.
	Energy data: The following ranges of capacity of drives can be equipped with electronic speed control: • Pumping and transport of liquids - 70 MW of which 20 MW have already been equipped with electronic speed control • Ventilation funs - 7 MW of which 2 MW have already been equipped with electronic speed control • Other drives - 3 MW of which 1 MW have already been equipped with electronic speed control. In total about 57 MW of drives could be equipped with electronic speed control which can save 80 000 MWh per year of electricity and 96 330 t/a of fuel for its generation.
	Economic data: Average unit investment costs are Euro 10,000/MW and total a costs are Euro 570,000 for the whole Czech Republic..
	Information source (reference): Catalogue of Energy Saving Measures, ENVIROS.

Country: Denmark

<table>
<tr><td rowspan="6">Industrial sector</td><td>Title: Electricity consumption of compressed air reduced by 60%

Start date: 1998</td></tr>
<tr><td>Summary:
Compressed air is an expensive source of energy, as only a fraction of the energy consumed is actually converted to mechanical work. In 1995, around 10% of Danish industry’s total electricity consumption could be attributed to the production of compressed air. More attention must be paid to compressed air installations if energy consumption in industry is to be further reduced. As part of a planned compressor renovation, ABB Motors in Denmark analysed the plant’s compressed air installation. The results showed that energy consumption could be more than halved by replacing the old single central compressor with a number of smaller ones more suited to the varying need for compressed air.</td></tr>
<tr><td>Technical data:
The new compressor unit consists of:
• two compressors, each with a capacity of 5.7 m3/min, type BS51;
• two compressors, each with a capacity of 3.4 m3/min, type AS31;
• two cooler units for drying compressor intake air, type TE91;
• controller Mac 41; • flow meter (Vortex); • electricity meter; • fan with integral motor.
The advantage of using four smaller compressors instead of a single large one is that they consume less electricity during periods of idle operation.</td></tr>
<tr><td>Energy data:
Prior to the renovation, the plant’s compressed air unit was based on a central 17.7 m^3/min compressor with an annual energy consumption of around 570 MWh. A subsequent analysis of the plant’s compressed air installation showed that using only one compressor unit to supply air to the entire plant made it very difficult to cope with the fluctuations in compressed air needs over a typical working day. The constant need for air was around 5.5-7.7 m^3/min, with peak loads of around 14 m^3/min. Calculations showed that energy consumption could be reduced by more than half by replacing the old 17.7 m3/min compressor with a number of smaller compressors, which were more suited to the plant’s varying need for compressed air. Calculations also revealed that the payback period would be around 3.5 years. Several other energy-saving measures have also been added, e.g.:
• the installation has been fitted with both electricity and air meters, allowing energy efficiency to be monitored;
• the two air dryers have been fitted with hygrometers, eliminating any unnecessary refrigeration for drying intake air;
• the ventilation system’s integral motor automatically reduces ventilation speed when the outdoor air temperature allows.
With the smaller compressors and the additional energy-saving measures mentioned above, the annual power consumption has now been reduced to around 210 MWh. An additional compressed air tank was subsequently installed because of problems that arose due to intervals of pressure fluctuation during the working day. This additional tank significantly stabilised the air supply, and enabled air pressure to be reduced by 0.3 bar. This gave a further 3% saving on power consumption for air compression.</td></tr>
<tr><td>Economic data:
The installation costs for the new compressor system totalled DKK 760,000. Of this, the compressors cost DKK 451,000. The energy savings achieved have been measured at around 360 MWh/year. Assuming an electricity price of DKK 0.40 kWh, the annual saving is DKK 144,000. The payback period is therefore 5.3 years for the project as a whole, or only 3.1 years based solely on the cost of the compressors. This calculation does not include a 30% grant from the Danish Energy Agency, which left a total cost to the company of only DKK 532,000. The payback for the project as a whole including the grant is thereby 3.7 years. In 1995 around 10% of the total electricity consumption in Danish industry could be attributed to the production of compressed air. It is therefore essential that more attention is paid to compressed air installations if energy consumption in industry is to be greatly reduced.</td></tr>
<tr><td>Information source (reference): CADDET database
http://www.caddet.co.uk/public/uploads/pdfs/newsletter/993_07.pdf</td></tr>
</table>

Country: Germany

Industrial sector	*Title*: Use of variable speed drives (VSD) and energy-efficient motors (EEM) in industry *Start date*: ~ 1998
	Summary: The use of variable speed drives and efficient motors in industry has been subject of several studies and also some promotion programmes. The studies generally conclude that the use of energy-efficient motors is in most usages also economically efficient. Also variable speed drives contribute to both cost and energy savings in many applications. However in general varying loads and a sufficient number of operating hours per year are required. This has led to a voluntary agreement between the European motor and drive manufacturers and the European Commission on the reduction of the share of inefficient motors in total motor sales.
	Technical data: Electric motors of a broad power range are used in industry. Power input ranges between less than 0.4 kW and more than 500 kW. Larger motors are in general more efficient and relative efficiency gains are usually lower. But still more than 50 % of the total saving potential is with motors of 30 kW and more (ISR et al. 2000). VSD are not applicable in all uses, but when applied can provide energy savings of 15 % to 35 %.
	Energy data: Potential cost-efficient energy savings are estimated for the German Industry to be 18.7 TWh/a. This corresponds to 9.4 % of total industrial electricity consumption in 1997 (ZVEI 2001).
	Economic data: The cost reductions corresponding to the above mentioned savings sum up to 1.5 bill. €/a (ZVEI 2001).
	Information source (reference): ZVEI, Fachverband Automation: Elektrische Antriebe; Energieeinsparmotoren: „Kosteneinsparung statt Regulierung". 2. geänderte Neuauflage. Frankfurt/Main As cited in: LfU Bayern: Klima schützen – Kosten senken. Leitfaden für effiziente Energienutzung in Industrie und Gewerbe ISR et al.: Improving the Penetration of Energy-Efficient Motors and Drives. Brussels 2000

Country: Great Britain

Industrial sector	*Title*: Introduction of variable-speed air compressors in glass bottle production. *Start date*:
	Summary: .A reliable source of compressed air is essential to the bottle blowing process and the company (Lewis and Towers, of Edenbridge, Kent, UK) made improvements to their compressed air system. The objectives were to obtain precise pressure control to reduce the energy cost of providing compressed air.
	Technical data: The company uses compressors for distributed air supply around the factory. However, the previous compressors were obsolete and unreliable, leading to unstable, inadequate and expensive pressurised air supply. The improved arrangement had one Variable Speed Drive Compressor (VSD) in parallel with three fixed speed compressors, of which one was on standby. Previously, control of air pressure was inaccurate. The methods used were to switch compressors on and off manually and to use a motorised valve to restrict the air flow. The techniques were inefficient, with up to 65% of full load power being consumed even when no air was being produced. The changed system ran one or two fixed speed compressors at full load as base supply and used the VSD for marginal changes. The use of the VSD compressor improved energy efficiency, because the relationship between air delivered and power consumed was nearly linear. In addition, the VSD enabled improved control of output pressure and this gave operability benefits. Although the VSD compressor consumed slightly more power than a fixed speed machine at full load, its use at part loads was significantly more efficient.
	Energy data: The electricity energy saving for the whole process was between 2 and 4%. Saving was 83,100 kWh/year
	Economic data: The price of the VSD compressor was more expensive than a fixed speed compressor, but the extra cost was recouped through reduced electricity consumption, worth approximately £3,530/y. This gave a payback period of 1.7 years on extra the capital investment of £ 6,000.
	Information source (reference): <www.caddet-ee.org> * IEA: International Energy Agency OECD:

Country: Spain

<table>
<tr><td rowspan="7">Industrial sector</td><td><u>Title</u>: Pyme-Energia

<u>Start date</u>: 1998</td></tr>
<tr><td><u>Summary</u>:
In 1998, undergoing the obligation set by Law 54/1997, all major Spanish electricity distribution companies have carried out the Pyme-Energia Programme.
Pyme-Energia was aimed at reducing electricity consumption in small and medium enterprises. It was addressed to electronic engine regulation and efficient lighting. The customers had three months to ask for the contribution and three months to implement the investments. The rebates were 30 % of the total investment costs.</td></tr>
<tr><td><u>Technical data</u>:
The energy companies received full recovery of the incentives given to the customers, plus a lump sum per watt covering management, promotion and diffusion costs. It was for electric motors and drives:
- 5 pesetas (3 Cent) per speed-controlled Watt for Control system introduction
- 5 pesetas (3 Cent) per substituted Watt for substitution of motors by high-efficiency motors
For lighting, the implementation cost refund was 25 pesetas (15 Cent) per saved Watt for any intervention that reduces installed power.
All the cost recovery was assigned ex-post after a deep evaluation carried out by the National Energy Commission.</td></tr>
<tr><td><u>Energy data</u>:
We focus here on the results obtained by Endesa and Iberdrola, which performed about 88% of the total results (CNE 2001). Iberdrola supported 27 538 lighting units (25 185 were foreseen) and 40 346 kW of regulated engines (34 000 were foreseen). ENDESA supported 55 163 lighting units (53 935 were foreseen) and 29 516 kW of regulated engines (31 260 were foreseen). The estimated annual savings were 64 MWh/year for Iberdrola and 19 for Endesa.</td></tr>
<tr><td><u>Economic data</u>:
The total costs were 3.38 MEuro for Iberdrola and 2.66 for Endesa: both were close to what was foreseen. Given the energy saving results above, the actual levelised costs of conserved energy was 7.8 Euro/MWh for Iberdrola and 20.2 Euro/MWh for Endesa.</td></tr>
<tr><td><u>Information source (reference)</u>:
Comision Nacional de Energia - Informe resumen de los resultados de los programas de gestion de la demanda de 1998 asignados a las grandes empresas distribuidoras, April 2001</td></tr>
</table>

Country: Sweden

Industrial sector	*Title*: Speed control of pumps saves energy at a pulp mill *Start date*: 1993
	Summary: Frequency-controlled, medium-consistency pumps have been installed on the new fibre line at Iggesunds Bruk in Sweden to optimise the use of electricity. The actual electricity consumption for pumping fibre suspension has dropped by 26-27% compared to when using alternative control valves. The achieved energy savings amount to 20kWh per ton of pulp to which must be added savings generated by increased capacity and reduced maintenance costs. Operational availability has improved and the average rotation speed dropped by as much as 20%, which is estimated to double the life of bearings. Maintenance costs are expected to be lower than if alternative control valves had been used. Noise levels recorded 1 m from the pumps have fallen by more than 5 dB(A).
	Technical data: The aim of this project was to reduce electricity consumption for pumping of fibre suspension by 25%, thus cutting costs and improving the operational availability. Another purpose was to reduce noise and maintenance costs by improving the performance of the plant.
	Energy data: Accumulated energy consumption for all pumps is reduced by 26…27% in terms of kWh per ton. Experiences indicate that maintenance costs can be reduced by approximately the same amont as electricity costs. The noise level (audible noise) is halved from 91 dB(A) before to 83…86 dB(A) after the installation.
	Economic data: The cost of the project, including additional costs for MC pumps and related equipment, as well as the cost of evaluation, is estimated at SEK 3.5 million. Annual energy savings of 6,500 MWh, give a simple payback period of about 2 years, calculated at an energy price of SEK 0.25 per kWh.
	Information source (reference): www.caddet.org/public/uploads/pdfs/Brochure/r163.pdf

6.2 Residential sector

Country: Czech Republic

Residential sector	*Title*: Ripple Control *Start date*:
	Summary: Ripple control is one of the means for the control in the electricity supply networks i.e. control of the electricity consumption using an existing electricity network as a signal transmission path. This system enables remote on or off switching of different loads. Ripple control represents a modern and economical means of control in electricity supply networks, with the wide range of applicability. Main purpose of the ripple control is control of different loads. Ripple control gives electricity supply companies a means of making optimum use of existing plant and thereby of continuing to supply electricity under favourable economic conditions, in spite of rising costs caused by higher prices for oil and other sources of primary energy. Since the electricity supply system must be designed for the highest peak loads likely to occur, a supply company can operate all the more economically the more even its load curve is.
	Technical data: Ripple control system makes use of control signals transmitted over an existing electricity supply network. As in radio broadcasting the flow of information is in one direction only that is from one or more transmitters to thousands of receivers. An audio frequency signal is superimposed on the supply waveform as a short sequence of impulses, forming a code format for the transmitted control orders. A typical structure of one ripple control system consists of a control programming unit, remote control facilities between control centre and substations and many receivers in the low - voltage distribution network. The central programming unit stores the programs and transmits them at predetermined times or in response to the external inputs to the various injection points.
	Energy data: N/A
	Economic data: The daily load curve may be influenced in two ways: indirectly and directly. An indirect influence is the switchover of electricity meters by ripple control receivers at contractually agreed high and low rate periods. Direct influence on the load curve is achieved by switching on or off loads having energy storage characteristics or flexible hours of operation (space heaters, water storage heaters, washing machines etc.). Example, use of the ripple control in direct control of the load is at its very beginning. Existing ripple control installations are used mainly to switchover electricity meters. In some large cities in Germany, (Munich, Hamburg) by the help of ripple control, nearly even load curve has been achieved. Calculations have shown that if the ripple control is used in such a way up to 30% of the capital investment in the chain generation - transmission - distribution can be saved since the electricity consumption rises and the peak demand remains at certain level over a long period of time. Taking into consideration all facts (prices, operating life, maintenance, checking and the like) benefits can be gained by using ripple control if the number of electricity meters to be controlled exceeds 500 for low voltage RCS and 2000 for medium voltage RCS. Furthermore, the transmission of ripple control signals over the electricity network allows some other uses, such as control of street lighting, alerting members of fire - fighting, police, use of different tariffs and the like.
	Information source (reference): http://www.tel.hr/hdc-itd/Engleski/RCS.htm

Country: Denmark

<table>
<tr><td rowspan="6">Residential sector</td><td><u>Title</u>: Residential electricity savings through coordinated district heating promotion

<u>Start date</u>: 1998</td></tr>
<tr><td><u>Summary</u>:
Despite Denmark's strong drive towards renewable energy, electricity is still one of the most environmentally detrimental energy sources for heating. This is due to Denmark's traditional dependency on fossil fuels for electricity production, still predominately based on coal-fired power plants. In connection with the Danish Government's Action Plan for Energy (1996) it is an objective to reduce the residential sector's total electricity consumption by 15% (1,500 million kWh) by the year 2005. 1998 was the first year in which a reduction was recorded. Households are responsible for around 30% (10,200 million kWh) of the total electricity consumption in Denmark, with electric heating currently the single biggest consumer, accounting for 23% of this. On average, an electrically heated building in Denmark is responsible for the same amount of CO_2 emission as four similar buildings using district heating. Electric heating is also the most expensive heating source – both for individual households and for society as a whole.</td></tr>
<tr><td><u>Technical data</u>:
In order to achieve the reduction goal of 15%, a national electricity conservation scheme was launched in 1996 to support local electricity conservation initiatives in residences and public buildings. The scheme is administered by the Danish Energy Agency's body for electricity conservation, called Elsparefonden, which is financed by a newly launched green tax of DKK 0.006 per kWh used. Elsparefonden has put special focus on the conversion from electrical to district heating and natural gas supply, and around 70% of the DKK 90 million available annually is used for this purpose. They have a three-step approach that makes it easy for homeowners to switch from electric heating, i.e.: • ensuring free connection to the district heating network and financial support for installation costs; • negotiating favourable terms for district heating installations with plumbers and installers; • providing grants.
Currently around 6% of the total of 2.4 million Danish households is still heated by electricity. In 1998, 4,000 homes were converted from electricity, and projects are currently underway in 60 towns.</td></tr>
<tr><td><u>Energy data</u>:
One good example can be found in the town of Rødbyhavn (population 2,000), located in the south of the Danish island of Lolland. In 1998 the local district heating company (Rødbyhavn Fjernvarme) was able to increase the number of households using district heating by 83 (with a total heated area of 8,071 m2), equivalent to 59% of the electrically heated homes in areas already covered by the district heating network. All 83 homes had previously been electrically heated. Today only 4.5% of homes in district heating areas in Rødbyhavn are still heated electrically. The company now supplies district heating to around 580 homes (with a total heated area of 154,644 m2). This expansion was made possible by combining a very favourable discount for new customers with a professional marketing campaign. The discount was the outcome of an efficient cooperation between local parties and Elsparefonden.</td></tr>
<tr><td><u>Economic data</u>:
Calculations show that an average household (130 m^2) with an electricity consumption of 15 MWh per year can save around DKK 6,000 in annual heating costs by converting from electricity to district heating. As a result of Elsparefonden's three-step approach installing district heating has typically cost each of the 83 households only around DKK 30,000, after financial support from Elsparefonden (usually DKK 12,000-14,000), and DKK 23,000 from the district heating company (including the waived connection charge). This gives an average simple payback period of around five years, making conversion a good alternative.

The district heating company has invested DKK 1,839,700 in connecting the 83 homes to the district heating grid. They have calculated the marginal return from the households to be around DKK 390,000 annually, thereby also giving a simple payback period of five years.</td></tr>
<tr><td><u>Information source (reference)</u>:
CADDET database: http://www.caddet.co.uk/public/uploads/pdfs/newsletter/994_04.pdf</td></tr>
</table>

Country: Germany

<table>
<tr><td rowspan="7">Residential sector</td><td><u>Title:</u> Förderprogramm Gas-Brennwertgeräte Stadtwerke Tübingen

<u>Start date: 1992</u></td></tr>
<tr><td><u>Summary:</u> The purchase of gas condensing boilers has been subsidised by the municipal utility of Tübingen (86,000 inhabitants)</td></tr>
<tr><td><u>Technical data:</u>
In the period 1992 to 1997, a total number of 792 boilers have been subsidised. The share of participants (compared to total boilers installed in the target group) is estimated at 34 %. This largely exceeds the participant shares in similar programmes run by other utilities and organisms (cf. Haug et al. 1998, Weber et al. 2001). As major success factors, the continuity in the programme and the strong involvement of stakeholders has been identified. The Free-rider percentage was estimated from survey data to be 58 %.</td></tr>
<tr><td><u>Energy data:</u>
Energy savings are estimated to be 18 000,MWh over the lifetime of the boilers.</td></tr>
<tr><td><u>Economic data:</u>
The subsidy provided was 750 DM (390 €) per boiler for central heating and 250 DM (130 €) per boiler for storey heating.

The costs per unit of energy saved are estimated to be 1.8 ct/kWh (rebate, marketing and administration cost)</td></tr>
<tr><td><u>Information source (reference):</u>
J. Haug et al.: Evaluation and Comparison of Utility's and Governmental DSM-Programmes for the Promotion of Condensing Boilers. Forschungsbericht des IER, Band 52. Stuttgart 1998
C. Weber et al.: Market Transformation for Energy Efficient Technologies – Success Factors and Empirical Evidence for Gas Condensing Boilers. In: Energy 27 (2002), S. 287 - 315</td></tr>
</table>

Country: Great Britain

Residential sector	*Title*: Holyhead Power Save Project: demand side management. *Start date*: 1993
	Summary: The Project was to reduce demand for electricity in the town of Holyhead on the small island of Anglesey in North Wales, so that the transformers between the transmission and distribution grids need not be upgraded because of otherwise increased demand. The project was part of a regional economic development project, also supported financially by the European Community "SAVE" program and the utility.
	Technical data: Features were: (1) To offer compact fluorescent lamps installed directly in the homes of residential customers, who accounted for 51% of the total electricity consumption in the target area. Each customer was offered two electronic compact fluorescent lights (CFLs), with a choice of power consumption, installed directly by utility-nominated staff at a cost of 70p (ca. $ 1) per lamp to the customer, a reduction by more than 90% compared with the then normal retail price of £ 10 (ca. Euro 15). (2) Free insulation of electric water heaters. (3) Substantial cash rebates for efficient appliances. (4) Other specific actions, e.g. energy-efficient refrigeration, fluorescent lighting retrofits, free energy audits.
	Energy data: In the target area of the project, the utility served about 3,500 customers, and peak demand was a little less than 10 MW. The sustainable DSM project was said to have reduced demand by 1 MW (10%).
	Economic data: With the £ 0.5-million program (ca. Euro 750,000), the utility achieved a sustainable peak demand reduction of 1 MW (10% of the demand).
	Information sources (reference): IAEEL 1/93; University of Newcastle studies by Guy and Marvin,

Country: The Netherlands

Residential sector	*Title*: Energiepremieregeling - Netherlands Energy Efficiency Rebate Scheme *Start date*: January 2000
	Summary: The Energiepremieregeling (EPR) provides a grant for residential customers that buy energy-efficient appliances or perform energy savings adaptation to their dwellings. The Ministry of Finance allocated a total sum of approximately 100 MEuro per year that was collected within the increase to the Energy Tax decided in 1999. The Energy Companies were chosen by the Ministry as the actor who pay the rewards because they "constitute a recognisable authority" to the customers. When customers buy an efficient appliance they obtain a coupon that they can send to the energy company that supply electricity or natural gas to them, to obtain the contribution. The Energy Companies can deduct the energy credits they pay to householders from the regulating energy tax for which they are liable. The Energy Companies are also reimbursed for the costs incurred in the implementation of the Programme. The Energiepremieregeling has been supported by a wide scale information campaign including national campaigns on television and national newspapers, advertisement in shops, actions on installers and websites (such as www.energielabel.nl).
	Technical data: The list of the technologies addressed contains for example cold appliances, dishwashers, washing and drying machines (50 Euro for each appliance, 100 Euro for super efficient appliances , 160 to 205 Euro for tumbler dryers); LCD monitors and TV; floor ground or wall insulation (from 2.5 to 12 Euro per square meter); heat reflecting glasses (from 20 to 30 Euro per square meter); high efficiency combined boilers; low temperature heating systems; lighting systems control. The energy premium is applicable to the most energy efficient equipments such as Class A appliances or similar certification for other technologies. Also a grant for energy performance audits is given when at least one of the measures recommended in the audit is carried out.
	Energy data: In November 2001, almost two years after the start of the EPR, one third of Dutch households had applied for the EPR rebates. Of this, around two thirds concerns domestic appliances. The introduction of the EPR has led to an enormous growth of the supply of A-labelled appliances. The market share of A-labelled washing machines has grown from 40 to 88% over the 1999-2001 period. For refrigerators this is from 26 to 67%. This increase is most likely due to the EPR and has led to a situation where retailers very often advice their customers to buy an A-labelled appliance as the best on offer. The 1999-2000 sales of A-labelled refrigerators, freezers, washing machines and dishwashers have increased by respectively 116%, 95%, 95% and 117%. In the second year (2000-2001) sales increases of a then already larger number were 22%, 35%, 28% and 32%. The increase in sales has also produced a decrease in the prices of white goods. It has been estimate an annual saving of 37 kWh/year for each washing machine, of ca. 50 GWh/year for all the Netherlands. Direct measurements show that the potential annual savings for the substitution of cold appliances are at least twice those obtained by the substitution of washing machine. We estimate that annual savings for the Energiepremieregeling scheme should be around 150 GWh/year only for the white goods sector. The total savings in the heat sector have been estimated as ca. 250 GWh/year.
	Economic data: The amount of funds available to the citizens for 2000 and 2001 were 158 MEuro, of which 97 % was actually spent. The implementation costs by the utilities were 41MEuro. The implementation costs were thereby 20% of the total expenditure. The largest part of the subsidies was obtained for the purchase of refrigerators/freezers and washing machines (42%).
	Information source (reference): "Evaluation EPR Costs and Benefits" Van Holsteijn en Kemna BV (VHK) Delft/Brussels, October 2002

Country: Sweden

Residential sector	*Title*: Local Weather Forecasts control the HVAC System in Buildings Start date: 1st December 1995
	Summary: Local weather forecasts combined with new information technology saves more energy compared to conventional control systems. Honeywell INUcontrol AB in Sweden has together with SMHI, the Swedish Meteorological and Hydrological Institute, launched a new type of energy and management control system - weather forecast control system - which saves energy and increases the indoor comfort. The system has been developed and tested on several buildings in Sweden with good results.
	Technical data: Through a weather forecast the datacentral knows how the weather and the energy demand will be hour to hour up to 3-5 days ahead of time. The temperature used to control the system is a so called "equivalent temperature" (ET), which regards how the indoor temperature is effected by air temperature, solarradiation and wind in cogestion with the buildings orientation, performance, usage and earlier weather situations. The weather forecasts are adjusted to local geografical effects on used weather variables. If the weather forecast proves to be wrong, which is very rare, an outdoor temperature meter controls the indoor climate.
	Energy data: The system has been evaluated under a period of two years on two identical residential buildings in the Hestra area in Borås, Sweden. The first building was controlled in the traditional way and the other with weather forecast control system. The building with weather forecast system has had 10% or 20 kWh/m^2 less heat costs. In the buildings no cooling systems are installed. For control of cooling system even higher potential savings is estimated. The evaluator's means that further energy savings can be made with weather forecast control on 10 to 20% in comparison to traditional control systems.
	Economic data: The weather forecasts are bought on an annual subscription basis. The fee is 0.32 EUR/m^2 floor area. The forecasts will be send through the Internet to a computer in the building. The investment for the system is approximately the same as installing a conventional energy management control system. The saving due to the forecast control system is at least 20 kWh/m^2 in Sweden. Each kWh costs 0.043 EUR excl. VAT. This means that the energy saving is 0.86 EUR/m^2. The system saves energy of 0.54 EUR/m^2 and costs 0.32 EUR/m^2. The profit is 0.54 EUR/m^2.
	Information source (reference): CADDET database http://www.caddet.org/infostore/display.php?id=4043

6.3 Tertiary sector

Country: Belgium

Tertiary sector	*Title*: Relighting *Start date*: 1998
	Summary: FINES N.V., an independent and privately owned Belgian ESCO created in 1997, offers energy-efficient lighting system retrofit ("relighting") services to high lighting density sites on a turn-key basis. Most of their customers are local authorities (swimming-pool, sports centre, etc.), but FINES also works for the industry or office buildings. The turn-key scheme is essential to the realisation of the energy savings because it is the best way to overcome the lack of time, knowledge and financing on the customer side.
	Technical data: The ESCO invests with priority in ballasts (25% of the savings), lamps (T8 and T5) and in luminaires (with reflectors). The comparison with the pre-existing situation is very easy in this case (metering of consumption in operation mode). Additional savings can be obtained using lighting management devices (occupancy sensors, dimming systems, etc.). These extra savings depend on other factors such as occupant behaviour or daylight intensity and are therefore more difficult to monitor but monitoring is still possible. Although FINES is in charge of the audit, studies and the financing, the retrofit is implemented by sub-contractors under project responsibility of FINES. Independent of any manufacturer, FINES guarantees savings for a minimal investment. As an ESCO, the company bears the technical risk because the contract includes an obligation of performance but also the financial risk. There are two main ways to pay for this service: either the customers have the capital avail-able to pay directly or they need a financing plan (Third Party Financing – TPF - contract). A third alternative would be to sell the new equipment to a financial company, which would rent it to the customer (leasing). In the case of a TPF contract, payments are fixed and based on engineering estimates and on-site verifications. Actually, before and after the relighting, the consumption of sample rooms is measured during a few weeks. Savings are assessed, and this assessment is the basis for the monthly payments. In most cases, the length of the payback period is about four to seven years.
	Energy data: In around 50 projects to date, electricity savings in lighting between 30 and 70 percent were achieved.
	Economic data: In a free pre-feasibility study, FINES proves the project can save enough energy to save money with a reasonable payback period. If the customer agrees to continue, he can define his needs exactly in order to make a full feasibility study. When this study is positive the client is expected to continue to execution. In most cases payback time is three to five years, while the lifetime of the implemented technologies are up to 15 years.
	Information source (reference): www.fines.be, www.electrabel.be

Country: Denmark

Tertiary sector	*Title*: New HFC-Free Bottle Cooler Cuts 40% of Electricity Consumption *Start date*: 1998
	Summary: In a development project supported by the Danish Energy Agency, it has been possible for the companies Vestfrost, Danfoss, Coca-Cola and the Danish Technological Institute to develop a new bottle cooler that uses approximately 40% less electricity than traditional bottle coolers. At the same time, the new bottle cooler, unlike conventional ones does not use chemical substances, which contribute to climate changes. The company Vestfrost produces the new bottle cooler. Energy savings are gained by, amongst other things, the use of a new and more energy efficient variable speed compressor from Danfoss, more efficient ventilators and glass doors with reduced energy loss.
	Technical data: The new bottle cooler uses a new type of compressor that can run at variable speeds (Danfoss NLV11K). When many warm bottles are placed in the cooler, the compressor runs at full speed and ensures quick refrigeration of the products. Also new condensers with greater area of heat transmission have been fitted in the cooler. Efficient direct current ventilators are used in the cooler. Using 12.8 W instead of 24 W has ensured evaporator ventilation with lower energy consumption. Of the 12.8 W only 9.2W are used inside the cooler's cabinet whilst the remaining 3.6 W are used outside (for power supply) Hence only the 9.2 W strain the cooling system. Improved glass doors showing better insulation characteristics than the normal doors are used. The U value is 1,28 instead of the normal 2,64 W/m^2 K. The lighting in the cooler cabinet has been placed in such a way that the source of light is outside the cabinet. This reduces the cabinet being affected by heat and thereby reduces energy consumption for cooling. In the coolers "top hat" over the door an 11 W low energy bulb has been fitted instead of the conventional 15W neon strip + choke coil with normal loss of effect of 10 W.
	Energy data: For initial laboratory testing of the prototype 270 soft drink cans were cooled from 32°C to 3°C in 19 hours. This corresponds with standard testing procedures from The Coca-Cola Company. The laboratory results showed that the new energy efficient bottle cooler used approx. 3.24 kWh/per 24 hours corresponding to a 34% reduction compared to conventional coolers. The subsequent field tests show that the energy consumption for the conventional coolers is approx. 4,8 kWh/per 24 hours whilst consumption for the new coolers is approx. 2,9 kWh/per 24 hours. This represents a saving of 40%.
	Economic data: The total budget for the project has been DKK 4.7 million. The Danish Energy Agency has contributed DKK 2.8 million from the Agency's subsidy scheme for the promotion of energy savings in Danish trade. For each individual cooler the pay back time will be around two years.
	Information source (reference): CADDET database: http://www.caddet.co.uk/infostore/display.php?section=1&id=4108

Country: Czech Republic

Tertiary sector	*Title*: IFC/GEF Efficient Lighting Initiative (ELI) *Start date*: May 2000
	Summary: • The Czech lighting sector consumes approximately 10 percent of the national electricity production. While new office and public buildings are equipped with high-tech lighting systems, most of older buildings, such as schools, have inefficient lighting systems. Incandescent lamps were in late nineties still the most common source of light in households. It is evident, that there was a lot of opportunities to improve energy efficiency by changing people's lighting purchase habits and change the market. • Several methods have been used to market energy savings in the lighting sector in the Czech Republic. For households, a traditional TV and newspaper advertising campaign was launched (in two Phases), combined with public relations and cooperation with producers and sellers of ELI-certified CFLs. Cooperation was initiated with electricity distributors to help them improve the services they provide to their customers on the liberalized market. Reconstruction of street lighting systems is being promoted chiefly by conducting feasibility studies for municipal councils and by initiating contacts between them and suppliers of high quality lighting equipment. The activities of ESCos (Energy Services Companies) in the lighting sector constitute an effort to help create and expand the market for these services among their potential customers.
	Technical data: **Criteria for products marked with the ELI logo are as follows:** • Guaranteed service life – a minimum of 6,000 hours; • Longer guarantee – for a minimum of one year; • Non-decreasing specific capacity depending on the duration of operation – after 2,000 hours of operation the luminous flux must not decline below 80 % of the original value; • Fast rise – rise to a minimum of 75% of output within 100 seconds from switching on; • Good colour performance – the colour performance index must be at least 80 (at least 70 for energy-saving fluorescent light bulbs with a tube diameter larger than 2 cm) on a scale of 0-100 ; • Safety – adherence to all national regulations; • Reliable data – the quality of certified products is continuously checked at random in independent laboratories.
	Energy data: Electricity savings in case of replacement of incandescent lamp with fluorescent lamp are up to 80%. Expected annual electricity savings are 450 MWh.
	Economic data: - Evaluation of the ELI Residential Campaign (Phase I) resulted in the following figures: - Sales of CFLs rose (for 2001 in comparison with 2000) depending on data source from 15 to 79%. - Consumer awareness of CFLs benefits increased 4.6 times in comparison with pre-campaign surveys. - The total GRP number of the ELI Residential Campaign reached 2150 (The GRP (Gross Rating Point) unit reflects the hit ratio with the target group of readers, listeners or viewers. One GRP point means addressing 1% of the population. This parameter originates from media monitoring.). - The ELI social campaign had with 8 mil CZK invested the same impact as commercial 20 mil CZK campaign (thanks to social nature given to the campaign by ELI team and advertisement company REMMARK).
	Information source (reference): www.efficientlighting.net/

Country: Germany

Tertiary sector	*Title*: Efficient non-residential lighting project Stadtwerke Hannover *Start date*: 1996
	Summary: A first project was carried out by the Stadtwerke Hannover during their so-called LCP test phase. It addressed specifically medium-sized commercial and industrial customers. A follow up program ran during the LCP implementation phase 1998/99 for small commercial customers.
	Technical data: In the main program, 50 % rebates for CFLs were given and about 38.4 € rebate for HF ballast fixtures. A total of 334 customers participated in the programs (27 in the test phase, 305 in the implementation phase).
	Energy data: Total energy savings are indicated as 1683 MWh/a with higher savings per participant in the first phase (29 MWh/a) than in the second (3 MWh/a)
	Economic data: Total program costs summed up to 655 T€. In the second program, the share of the costs for rebates is estimated to be about 35 % of total costs.
	Information source (reference): Stadtwerke Hannover: Unsere Energie-Einsparideen rechnen sich. Die LCP-Testphase im Überblick. Hannover 1998 As cited in: Wuppertal Institut (ed.): Energy Efficiency Programmes and Services in the Liberalised EU Energy Markets. Wuppertal 2003

Country: Great Britain

Tertiary sector	*Title*: Energy Efficiency in Petrol Station Lighting *Start date*: Project Start date: 1st July 2001, completed Feb 2004
	Summary TotalFinaElf upgraded one of its petrol stations in the UK, replacing external light fittings with a modern, energy-efficient alternative to reduce electricity consumption for lighting by 67%. The project payback period was 2.25 years. The new fittings improved the quality of the forecourt's lighting and security, a significant factor in customers' choice of stop, and significantly reduced the cost and inconvenience of lighting maintenance.
	Technical data: 18 fittings were installed, and immediately achieved a 45% reduction in lighting load, from 4.95 kW to 2.7 kW. The existing traditional 250 W lamps were replaced with modern 150 W lamps. In addition, the installation of a lighting management system, based on ambient light levels and programmed time control, ensured that lighting is switched on only when required. The lighting system uses a combination of Endurance and Autolux products. The Endurance is an induction lamp first introduced in the late 1990s, which uses only 150 W, but can replace traditional 250 W lighting. The lamp lasts for 13 years if used for 15 hours/day, in comparison to a life expectancy of two years for a traditional lamp. The reduced electricity consumption and low maintenance costs of the Endurance lamp result in a significant lifetime cost reduction. Autolux is an automatic lighting control system that responds to natural daylight and a programmed time control. The light management system can deliver up to 50% savings on electricity consumption. It can also extend useful lamp life and reduce maintenance costs. The lamps supplied by Chalmor are fitted in a sealed unit, which protects them from dirt and insects that normally affect performance. The lamps are weatherproof and can be cleaned by jet washer without requiring access equipment, thereby saving the cost of equipment provision. Sites with traditional lighting, on the other hand, have to be cleaned annually. The cleaning and maintenance tasks involve a partial closure of the forecourt to allow safe access. This essential precaution discourages customers and disrupts trade. Consequently, a lighting scheme with much reduced maintenance requirements has less adverse impact on sales.
	Energy data: The system also records the running time of the lighting: a reduction of 39% in running hours was forecast for the year ending July 2002. With the previous light fittings, 8,760 running hours were recorded, compared with a forecast of 5,309 running hours with the new fittings. Total savings were 29,028 kWh/year, meeting the forecast load saving of 67%. Savings of 12.48 tonnes/year of CO_2 emissions
	Economic data: Lifetime cost reduction of 53% (in energy consumption, lamp replacement and maintenance) Improved quality of lighting gives greater security and safety for staff and customers, and enhanced trade. The total cost of the lighting improvements was £9,175 (Euro 13,100), including the lighting control system, representing an outlay greater than for traditional lamps and fittings. However, taking into account energy consumption, lamp replacement and maintenance reductions, overall long-term savings are 53% per year. The payback period for installing this energy-efficient system instead of traditional lighting is just 2.25 years.
	Information source (reference): <www.caddet-ee.org> * IEA: International Energy Agency OECD

Country: Sweden

Tertiary sector	*Title*: Electricity-efficient programme for supermarkets *Start date*: 1994
	Summary: A Swedish utilities company, Stockholm Energi. has identified some key, profitable, energy-saving measures which will be marketed as a package for application in all types of supermarkets. It is possible to achieve an energy saving of at least 10% in a supermarket, with a payback period of approximately one year by making a few simple changes. More expensive measures should be considered during retrofitting and construction of new supermarkets. At an early stage the additional cost of installing energy -efficient equipment is often negligible.
	Technical and energy data: Energy efficiency measures performed at 10 supermarkets show the following results (based on 11 opening hours per day):
	Economic data: This project showed that an average-sized supermarket can annually save 27 MWh, equivalent to saving of SEK 18,000 (calculated with an energy price of SEK 0.60/kWh. The average capital investment required was SEK 20,000, which gives a simple payback period of 13 months.
	Information source (reference): www.caddet.org/public/uploads/pdfs/Brochure/r194.pdf

Measure:	Cost [SEK]	Energy saving [MWh/a]	Payback [a]
Night-time freezers cover	2000	2.8	1.2
Night-time cabinet curtains	7000	8.4	1.4
Optimisation of lighting	2000	3.3	1.0
Door sealing	2000	2.1	1.6
Defroster timer	250	---	0.1
Timer and daylight sensor for signs	4000	8.8	0.8
Lighting control for chest freezers	1000	0.6	2.7
Space heating controller	2000	1.0	3.5

7 Conclusions

Energy saving potential in Residential Sector in year 2020 compared to year 2003 consumption is estimated to about 60% divided into:

- space heating: 27 %
- hot water: 62 %
- lighting: 3 %
- appliances: 4 %
- refrigeration: 4 %

Costs of DSM measures can be estimated as following:

Residential sector

39 % of potential under 100 euro/MWh (mostly lighting and hot sanitary water)
43 % of potential between 100 and 200 euro/MWh (mostly dish, washers and insulation)
18 % of potential above 200 euro/MWh

Industrial and Tertiary sector

Most intervention under 100 Euro/MWh

Intervention above 100 Euro/MWh: occupancy sensors and daylight control (lighting), LCD monitors (costs are rapidly decreasing), improved insulation (refrigeration)

The methodology developed during this study seems to be quite solid. More effort should be put on quality of data, continuous update of statistics from different EU countries is of great importance. New EU countries, beside the four already incorporated in the ***GreenNet*** model, should be included. Potential for new end-uses (technologies) not possible to be included within the time frames of this project should be considered. There is also a possibility to introduce dynamic costs (learning curves) and discussion on effect on the peak load demand.

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