E F F L O C O M

Energy efficiency and load curve impacts of commercial development in competitive markets

EU/SAVE 132/2001

Policies and tools for Demand Response

EFFLOCOM results and recommendations

Date:	**2004-08-27**
Report ID	**EU/SAVE 132/01 EFFLOCOM report no. 8**
Class:	**Deliverable**
Reported by:	**EFFLOCOM group**
Contact person:	**Ove S. Grande** (email: ove.s.grande@sintef.no)
Distribution:	**EC Restricted**

EFFLOCOM Partners:

SINTEF	Partner 1 / Coordinator	Norway
(Electricity Association (EA) *)	Partner 2	England)
VTT	Partner 3	Finland
Energy piano	Partner 4	Denmark
EDF	Partner 5	France
E-CO Tech	Partner 6	Norway

*) Withdrawn from the project by 31 July 2003

Contributors to this report:

Ove S. Grande, SINTEF Energy Research
Seppo Kärkkäinen, VTT
Casper Kofod, Energy piano
Denise Giraud, EDF
Håvard Nordvik, ECO-Tech

The EFFLOCOM documentation:

EU/SAVE 132/01 EFFLOCOM report no. /date	Title	Responsible
1 / 2003-11-07	**Phase 1 - Basis for Demand Response**	Electricity Association/ SINTEF
2 / 2003-11-07	**Influence of Competition**	Electricity Association/ SINTEF
3 / 2004-02-19	**Description of technology for Direct Communication (revised)**	SINTEF
4 / 2003-11-07	**Description of the EFFLOCOM Pilots**	VTT
5 / 2003-09-05	**Interim Progress Report**	SINTEF
6 / 2004-06-30	**Incentives for Demand Response and for Investments in Infrastructure and Technology**	SINTEF
7 / 2004-06-30	**Results from the EFFLOCOM Pilots**	VTT
8 / 2004-08-27	**Policies and tools for Demand Response EFFLOCOM results and recommendations**	SINTEF
9 / 2004-08-27	**Summary report**	SINTEF

Table of Contents

1 Introduction

The EU/SAVE project EFFLOCOM started July 2002 and was completed June 2004. Project partners from five countries, Norway, Denmark, Finland, France and England have been working in the project. The results are based on specific studies and altogether six national projects that were defined as EFFLOCOM pilots. Additional information from Sweden has been provided via a Swedish subcontractor.

The project has been seeking to remove barriers to energy efficiency through the determination of customer response to different market based customer services of deregulated markets.

During the project period the focus has turned from energy efficiency or Demand Side Management[1] (DSM) issues to potential and incentives for Demand Response[2] (DR) in periods with shortage of production capacity.

The project has been divided into four phases previous to this final reporting:

- **Phase 1** forms the basis for the subsequent phases by studies of load profiles and evaluation of the potential of load reduction in peak hours.

- **Phase 2** analyses the impacts of deregulation on the load profiles for different customer categories and on national or regional level.

- **Phase 3** analyses the impacts of technology for direct communication for automatic meter reading and remote load control, and gives an overview and an evaluation of the incentives for load reduction and investments in needed technology.

- **Phase 4** summarizes the experiences and results from the 6 EFFLOCOM pilots.

This final technical report of the project gives an overview of the relevant framework for energy efficiency and demand side participation in the electricity markets in the involved countries and EU, and summarizes the results from the project with reference to the documentation from phase 1-4 [1-5]. On this background the main conclusions and recommendation from the project are given in the concluding chapter.

---

1 Demand Side Management: Permanent Energy reduction as a result of energy efficiency efforts

2 Demand Response: Response by load reduction of limited duration (from one to a few hours) in case of production and/or transmission capacity shortage

2 Framework from the authorities

2.1 Denmark

Energy efficiency activities in Denmark date back to 1976. A wide portfolio of initiatives has been developed, and is still in force. This strong effort brought to a substantial decrease in energy consumption in most sectors [6].

The electricity sector underwent major changes with the passing of the Electricity Supply Act in 1999. After the unbundling of vertically integrated electric companies, non-commercial network companies have been created. Since April 2001, large electricity customers are allowed to switch suppliers, and by January 2003, all electricity consumers are able to do so. Since August 2000, 30% of the natural gas market has been open to competition.

A supportive framework for the development of EE-DSM in a competitive market was put into effect trough different mechanisms; the most important are the obligation to the electricity network companies and the establishment of the Electricity Saving Trust in 1996.

2.1.1 Electricity saving trust

The Electricity Saving Trust is funded by a volume-based levy of 0,08 Eurocent/kWh, collected by network companies. Private companies, consults and/or electricity companies are invited to tender to design and implement projects. The projects with the highest reduction of CO_2 emissions at the lowest cost are selected. In 2001, the activity of the Trust to promote conversion from electric heating to district heating or natural gas focuses in particular on the large cities with coal-based CHP. In 2002, the Fund has initiated local campaigns for changing from electric heating to natural gas at the same time as “come again” campaigns are implemented in the district-heating areas in which the plants conducted conversion campaigns in 1998. The last years the Trust has been conducting campaigns in co-operation with manufacturers, retailers, the association of the electricity network companies ELFOR and the Danish Energy Agency (DEA) on low-energy light bulbs (CFLs), white goods and standby consumption in TVs and videos. In relation to the public sector, the Electricity Saving Trust is working to spread the A agreements where municipalities, counties and state institutions commit themselves to purchasing only low-electricity-consuming equipment.

2.1.2 EE-DSM obligations for the network companies

The framework of the energy saving activities of the electricity network companies is laid down in the Energy Saving Bill, which aims to ensure up to date, resource-conscious efforts to promote energy saving; and secondly, the need to co-ordinate the various activities, including also creating a solid framework for energy-saving activities in a time of increasing liberalisation in the electricity supply undertakings.

The target for the DSM activities of the network companies is 121 GWh additional yearly. Costs recovery is carried out trough a Public Service Obligation levy 0,08 Eurocent/kWh on the grid tariffs constituting a no-profit no-losses scheme.

The network companies collect the levy via the electricity bills. At present the companies spend approximately 20 million Euro annually on energy saving activities. The Electricity utility association ELFOR is taking care of national planning and evaluation/documentation of the DSM activities.

The Executive Order which implements the Energy-Saving Act provisions in the field of public electricity-supply sets that the grid companies are obliged to place the following categories of energy-saving activities at the disposal of the consumers in the supply area:

1. General information for consumers on energy savings (e.g. distribution of information material, information campaigns, teaching and other information activity).

2. Individual energy consultancy for households (e.g. consultant services, communication of information on energy consumption in appliances).

3. Energy consultancy for commercial companies and public institutions, in order to advise the recipients concerning efficient energy utilisation and to identify the energy-saving potential.

The above services are free of charge for the final customers (the third service often lead to more detailed service paid by the customer).

In spring 2001 the Ministry issued an Executive Order on the future energy saving activities of the natural gas distribution companies. The framework of the activities corresponds to that of the electricity companies.

On 29 May 2001 a new parliamentary agreement was reached on Natural Gas Supply and Energy Savings. Obligations to electricity network and supply companies, to natural gas and district companies and to the Electricity Saving Trust were reinforced. Specific agreements were signed on enhanced energy saving efforts in the municipal sector and in state institutions, as well as on the promotion of energy efficient products.

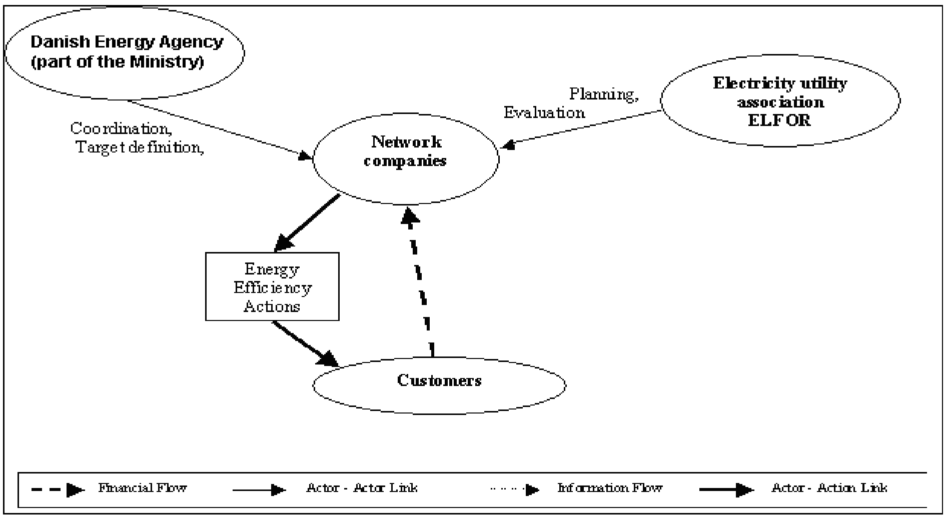

Figure 1 Actors involved in energy efficiency

2.2 FINLAND

2.2.1 Energy conservation agreements

Energy conservation agreements constitute a procedure based on voluntariness, within which the Ministry of Trade and Industry and trade associations have agreed on promotion of improved efficiency of energy use and the use of renewable energy sources. This contractual procedure, which was initiated in 1997, covers nearly 60% of Finland's energy consumption. Of the contractual sectors, the Ministry of Trade and Industry has the main responsibility for the energy, real estate and construction sectors, municipalities and joint municipal authorities, and industry. The Ministry of the Environment bears the main responsibility for an agreement on the residential building sector concluded in the autumn of 2002. The Ministry of Transport and Communications has overall responsibility for the conservation agreements of the transport sector.

The companies and corporations that have signed energy conservation agreements have bound themselves to reporting on their energy consumption and to improving its efficiency, as well as to increasing energy conservation awareness in their own organisations. One concrete measure is performing energy audits and analyses of buildings and production processes. The Ministry of Trade and Industry has, for its part, committed to supporting e.g. energy auditing and energy conservation investments. The effectiveness of the conservation agreements is assessed annually on the basis of the information reported by companies and corporations.

The conservation agreements that are the Ministry of Trade and Industry's responsibility will be in force until the end of 2005. The preparations for their prolongation and adaptation to the operating environment that will prevail after 2005 will be started in 2004 at the latest.

Motiva Oy, an Information Centre for Energy Efficiency, answers for the administration of activities related to the energy conservation agreements. Motiva's website includes information on the companies and corporations that are parties to the agreements, as well as the annual ESS reports, which present in more detail the activities and results by contractual sector.

2.2.2 Energy auditing

The Ministry of Trade and Industry has supported the energy audits and analyses of buildings and production processes since 1992. Energy audits are comprehensive surveys of the possibilities of energy use and energy conservation, which are drafted according to separate instructions. At the end of 2002 the auditing activities encompassed over 5,000 service or production buildings. It has been estimated that the energy saving effect of auditing exceeds 1 TWh annually. Energy audits are performed, supported by the Ministry, in the service sectors, industry and in the energy sectors. Energy auditing of residential blocks-of-flats, which will be on the Ministry of the Environment's responsibility, will be initiated during 2003.

In energy auditing, Finland is an internationally esteemed forerunner. Finland's experiences and know-how have often been made avail of, when auditing schemes have been built in various countries. Finland has also coordinated two large projects belonging to the SAVE II Programme of the European Commission, which were to map out the auditing situation in

Europe and design the organisation of systematic auditing.

Motiva Oy is responsible for the administration of energy auditing, which is supported by the Ministry of Trade and Industry. Its tasks include promotion and follow-up of auditing, training of auditors and quality assurance of auditing. Applications for aid to energy audits are handled regionally at the Employment and Economic Development Centres. The website of Motiva Oy contains more detailed information on energy auditing.

2.2.3 Energy conservation programme 2000

The Energy Conservation Programme of the Finnish Government was revised in 2000 as part of the drafting of the energy-sector programme of the National Climate Strategy. The programme has been integrated into the National Climate Strategy.

Development and commercialisation of energy-efficient technology, financial steering instruments and improvement of the efficiency of regulation by norms are central actions in the Energy Conservation Programme. In addition, concluding energy conservation agreements and developing energy audits and energy analyses are important measures. Efficient implementation of all of these requires supporting information dissemination, training and motivation. The energy-saving activities of the European Union and other international organisations should be supported and also utilised in the implementation of national measures. Each administrative sector is responsible for carrying out the measures. As part of the follow-up to and reporting on the National Climate Strategy, the Ministry of Trade and Industry monitors the implementation of the programme and reports on its advancement.

Cost-effective reduction of greenhouse gas emissions was set as the primary goal for the Energy Conservation Programme. Increasing energy efficiency should lead to achieving at least one quarter of the total reduction target for the year 2010. This would mean that carbon dioxide emissions should be cut by 3-4 million tons.

The programme measures are mainly focused on the end use of energy. Still, improvement of the coefficients of efficiency in energy production as well as the transfer and distribution of energy has also been included in the actions. The fuel choices of energy production plants have been excluded from the conservation programme, whereas utilisation of passive solar energy and other renewable energy sources is part of the programme promoting renewable energy sources.

Good energy-saving results have already been attained in some sectors. For instance, the annual reports of the energy conservation agreements show that the measures taken during 1998 - 2001 saved annually approximately 0.6 TWh of electricity and 2.5 TWh of heating energy.

2.2.4 Update on the Energy Conservation Programme in 2002

The update on the Energy Conservation Programme is connected with the need to make energy savings more efficient. The need was also brought up in the parliamentary statements given to the Government in connection with the handling of the National Climate Strategy and the nuclear power decision. The working group that prepared the update examined the implementation and effects of the previous energy conservation programme and looked for new saving methods.

The report “Energy Conservation Programme 2003–2006” by the working group states that the appropriations for the energy aid to companies and corporations should be increased and new modes of financing energy-saving investments should be examined. The report further suggests that the aid granted for subsidies for renovation of buildings to be increased. Additional inputs in disseminating information on energy conservation would also be needed. It is required that, to develop technology, the financing by the National Technology Authority Tekes for energy conservation is maintained at least on the 1999 level. Within the next few years, implementing the measures proposed would call for around EUR 80 million per year of State financing, on the average.

It is proposed in the report that the energy conservation agreement system should be extended and developed. The agreements could also cover better research and product development processes and processes of acquiring services and products. Setting binding objectives and sanctions should also be considered.

Moreover, the working group suggests that energy taxation should be developed into a direction that would promote energy conservation and co-generation of heat and power. The impacts of the forthcoming emissions trading directive should also be considered while developing energy taxation. It is further proposed that new study and development projects could be launched to allow higher energy savings in transport and a more energy-efficient community structure. The working group also suggests that tightening of the building code should be looked into and that a communication plan for the programming period would be drafted in order to improve information dissemination on energy conservation.

The programme proposed by the working group is expected to cut the carbon dioxide emissions by 4-6 million tonnes compared to the situation presented in the Business-as-Usual scenario for the year 2010. The amount of the reductions will depend on the fuels replaced. It is estimated that the programme would bring around a 4-6% savings in primary energy in 2010 compared to a situation in which no new measures would be undertaken.

2.3 ***FRANCE***

Following a wide national energy debate, in which associations, elected representatives and citizens participated, proposals were made in a White Paper which was submitted for discussion at the end of 2003 and which will allow the French Government to draft a framework bill which will be submitted to Parliament in the spring of 2004.

This document gives extracts of the third part of this “White Paper” (called the Government’s energy proposals).

2.3.1 Proposed measures

Foreword

The French energy policy has four main objectives:

1- *To guarantee the right of access of all citizens to a quality energy supply throughout the French territory;*

2- *To help strengthen the economic competitiveness of our country and its companies;*

3- *To guarantee security of supply in France;*

4- *To help protect the environment and particularly the reduction of greenhouse gases to which the energy sector contributes in a major way both directly and indirectly.*

Section I: Demand Side Management

Chapter 1 General principles

I.1.1 The demand side management policy aims to reduce end energy intensity by 2015, -2% per year on average over the last five years. The end energy intensity is defined as the ratio between the end energy consumption and the gross national product.

I.1.2 *In order to make energy savings, the State will encourage voluntary energy saving actions. It will adopt legislative, fiscal or regulatory measures and will issue its own standards to encourage the development of equipment or to encourage sensible behaviour while remaining aware of the need for European coherence.*

Chapter 2 – Energy savings certificates

I.2.2. Awarding energy saving certificates

Above a minimum energy saving threshold in kWh defined by decree of the Minister of Energy, legal persons who have carried out actions with the objective of realising energy savings can obtain energy saving certificates.

The energy saving certificates are awarded depending on the type of action carried out, the volume and characteristics (for example, carried out over a day or a year) of the planned energy savings and, where relevant, the geographical area concerned. They last for 10 years and can be traded between economic players.

The first certificates will be awarded in 2005.

A non-exhaustive list of actions leading to the awarding of certificates will be published by the Minister of Energy.

The ADEME will keep a database up to date which includes the characteristics of all the requests for certificates, the subsequent action taken and the planned energy savings.

I.2.3 Obligations imposed by the State

A Council of State decree defines the list of legal persons on whom the Minister of Energy can impose by decree energy saving obligations over a given period. The list includes people who sell energy or energy consuming products to end-users.

Chapter 3 –Energy efficiency in buildings

I.3.0 *The current primary energy consumption of buildings is around 500 kWh/m^2. In 2050,………… it can be hoped that all new buildings will have a consumption of less than 40 kWh/ m^2. In parallel, a gain of a factor of 3 should be obtained by the renovation of existing buildings. In this way, in 2050, an average consumption saving of primary energy stock of around 125 kWh/m^2 should have been made, which corresponds to the current amount being globally divided by 4.*

I.3.1 *In the third section of volume 1 of the building and habitat code, a chapter V will be created as below:*

"Chapter V Energy Performance Certificate"

Art L. 135-1 *The energy performance certificate of a building or a part of a building is a document which includes in particular the quantity of energy estimated for a standard use of the building and reference values so that the consumers can compare and evaluate the building's energy performance. It is accompanied by recommendations intended to improve the profitability of the energy performance. It includes in the long term an estimate of CO2 emissions.*

Chapter 4 – Other means of saving energy

1.4.1 *Teaching establishments, whether public or private, will award a larger place in their programmes to the need to save energy and to the concrete means of obtaining this.*

.

1.4.2 Any company in the energy sector advertising in any form in France, will pay each year an amount equal to 10% of its advertising expenses the previous year. Companies with an annual advertising expenditure of less than 1,000,000 Euro are exempt from this contribution.

1.4.4 Energy impact study

For any development project subject to an impact study, the study must include a section on the rational use of energy with the objective:

- *of making an evaluation of the planned operation on the updated consumption of the various energies and on the greenhouse gas emissions…*
- *of exploring the various means possible to reduce the impact of energy in the hypothesis that the impact study would reveal an increase in energy needs.*

<u>Section II: Regironal and social solidarity</u>

Chapter 1- Non replaceable electricity

II.1.1 *Electricity must be supplied throughout the national territory at an equal supply tariff wherever the supply takes place.*

II.1.2 *The public transmission system operator and the public distribution system operators will design and operate their networks in such a way that a regular quality electricity supply is ensured compatible with the standard uses of electricity.*

II.1.3 *In order to guarantee electricity to those with the lowest revenues:*

- *access to electricity for households with the lowest revenues is ensured by a special electricity tariff as "an essential product" incorporated into article 4 of the law of 10th February 2000,*
- *an aid to temporarily maintain an electricity supply is offered to people in a vulnerable situation who have difficulties in paying their electricity bills. An electricity supply to ensure non replaceable electricity uses, as defined in II.2.2 below, when this is covered by electricity, must be temporarily maintained in this way.*

<u>Section III- Security of supply</u>

Chapter 1 – Security of supply

III.1.1. Security of supply is a major objective of any energy policy.

The State must therefore promote:

- *the diversification of the energies themselves,*
- *energy savings and the use of decentralised generation with renewable energies,*

- *the variety or durability of sources which can be used for a single energy,*

- *the development of storage capacities available for security reasons where energy storage is possible,*

- *the existence of interconnections between countries for network energies and the means of managing these interconnections,*

- *the mix of equipment with the final consumer. This permits him in normal time to arbitrate between two energies for questions of cost and in crisis moments to keep his facilities operating should one of the energies used momentarily disappear.*

III.1.2. In application of the principles recalled in III.1.1. above, a decree will define the main indicators to be considered for France, as well as the values that these must attain so that the energy policy respects the security of supply objective.

Chapter 2 – Electricity security of supply and its consequences on the electricity system

III.2.1. The Minister of Energy guarantees security of supply by ensuring:

- the capacity and availability at all times of the French generating facilities and their structure (fuels used, share of renewable energies)

- the capacity and use of lines of interconnection between France and the surrounding countries. These lines, initially designed to improve the security of the European electricity network, optimise the number of facilities in Europe, notably in peak time, and offers an additional guarantee of the efforts for productivity of the operators taking into account the competition permitted by the border exchanges.

- the capacity of the transmission and distribution networks to provide, at all times and at any place in the territory, the power required by the end user. The public transmission system development plan approved by the Minister of Energy in application of article 14 of the law of 10^{th} February 2000 ensures security of supply both nationally and regionally.

The electricity transmission system operator warns the Minister of Energy when French generating facilities are no longer liable to ensure a minimum level of security of supply. He specifies at this moment the remaining level of security.

In order to assess this minimum level, the electricity transmission system operator simulates several supply and demand scenarios with a 5-year time range, taking into account the long term import and export contracts, the climatic hazards, the electricity demand and the availability of generation, transmission and distribution facilities. The minimum level is attained when the probability of failure becomes greater than one year out of ten.

There is failure when the balance between supply and demand at a national level is no longer attained in at least one of the scenarios studied.

This imbalance, if it occurred, would lead the electricity transmission network to have rotating electricity cuts of around one to two hours which could concern a significant part of the population in order to avoid a collapse of the network leading to total cuts until it is restored.

2.4 NORWAY

The Norwegian Water Resources and Energy Directorate (NVE) was from 1991 to 2002 responsible for the public policy concerning energy efficiency and introduction of new renewable resources. NVE was performing this work on behalf of the Ministry of Petroleum and Energy.

In 1995 five groups was chosen for a triennial period to operate the subjects industry, buildings, Business specific introduction, campaigns, information and education. The groups were responsible for arranging the energy economising activity on a national level. In addition regional centres for energy efficiency was established. These regional centres should ensure the electricity utilities requirements work for energy efficiency and communicate the publicly offer to the whole country.

All electricity utilities in Norway are obliged to offer energy efficiency services to their end-use customers. This work was finances through a mark-up on the network tariff of 0,00025 €/kWh (0,002 NOK/kWh). The authorities requested the electricity utilities to cooperate and establish regional centres working for energy efficiency. This would result in more multidisciplinary and neutral centres of competence concerning energy efficiency in the different counties/regions in the country.

The mark-up on the network tariff (0,00025 €/kWh) was transferred to the centres for energy efficiency for financing the work. The regional centres for energy efficiency represented a nationwide network of companies performing consultation for energy efficiency to residential- and industrial customers, on behalf on the State.

From 1.1.2002 all the instruments concerning energy efficiency were collected and transferred to the state enterprise Enova. Most of the centres working for energy efficiency continued their work on a commercial basis.

2.4.1 The Norwegian Energy fund

The regulation concerning The Norwegian Energy fund was approved in December 2001. The basis for this regulation was that the Norwegian Parliament in March 2001 approved a new model for financing the work for reorganising the consumption and production of energy. The government also decided to establish a new energy organisation – Enova SF.

A mark-up of 0,000375 €/kWh (0,003 NOK/kWh) on the network tariff was made mandatory and transmitted to the Energy fund. In addition the fund gets allocations from the state budget.

Enova SF will manage the resources in the fund.

2.4.2 Enova SF

Enova SF was established in 2001 to contribute to the work for an environmentally friendly change of consumption and production of energy in Norway. Enova is a state-owned enterprise, owned by Ministry of Petroleum and Energy. Enova started its work 1.1.2002.

Enova will work for increased energy production from alternative energy sources, and for less increase in energy consumption (compared to a situation with no motivation for reduced increase in consumption).

Enova SF shall contribute to a new environmentally friendly production of energy and energy efficiency of total 10 TWh/year within 2010. 4,5 TWh/year should be realised within 2005.

Different initiatives that Enova is working with:

- Enova is supporting development of water-borne heat (district heating) based on new renewable energy resources, waste heat and heat pumps. The Norwegian Parliament's target is 4 TWh/year water-borne heat within 2010.

- 5 TWh/year of new heat production, such as firewood (1,5 TWh/year) and waste (3,5 TWh/year).

- 3 TWh/year of wind power within 2010.

2.4.3 Regulations concerning metering

General

The network operator is responsible for *all* the metering data connected to metering points in his concession area according to the regulation for metering, settlement and coordinated behaviour for power trading and invoicing of network services [7]. The network operator is also responsible for the metering to be performed.

A customer that uses electricity is connected to the distribution network operated by the Network operator (also called Distribution System Operator). The point where the customer is connected to the distribution network is in this document mentioned as *metering point*. The metered data is associated to this metering point.

Periodically metering

All metering points should be metered at least once a year, referring to Monday. With higher frequency of metering, all metering should be referred to a Monday.

Household customers with a yearly consumption higher than 8.000 kWh should be periodically metered. The metering should be performed every third, second or every month and the metering should be referred to a Monday.

Hourly metering

From 1. January 2005 all metering points with a yearly consumption larger than 100.000 kWh should be hourly metered. Today the regulations require hourly metering of metering points with a yearly consumption larger than 400.000 kWh. The network operator shall in this situation cover the costs for the installation of technology.

The network operator can also perform hourly metering of additional metering points, if this is in his interest. The end-use customer cannot deny the installation. The network operator shall cover the costs related to the installation.

The end-use customers can require hourly metering of the electricity consumption. In this situation the network operator can require that the end-user should cover the costs for installation of technology.

The power supplier cannot require hourly metering of the electricity consumption of an end-use customer.

2.4.4 White papers concerning energy efficiency and hourly metering of electricity consumption

The topic concerning hourly metering of electricity consumption is also discussed in two white papers from the Norwegian Ministry of Petroleum and Energy, [8] and [9]. A summary of the main points is presented in this chapter.

The EFFLOCOM pilot 6 “End User flexibility by efficient use of ICT” is mentioned as a reference for the parliamentary discussion concerning two-way communication that will take place in the summer 2004.

White paper 41 (2002-2003)

This white paper is dealing with tariffs for distribution of power and technology for two-way communication (direct communication) for metering of electricity consumption. The document is discussing two-way communication in general and different models for financing of the technology.

The installation of technology for two-way communication is limited due to high costs, rapid technology development and a large uncertainty concerning costs and benefits with the technology.

In the different models for financing the technology it is emphasized that the actors that benefit from two-way communication also should cover the costs, and it should also be this/these actor(s) that should take the decision for investments.

The today’s revenue cap regulation of the network operators gives incentives for investments in technology for two-way communication if this is profitable for the network operator. The revenue cap regulation opens up for evaluating two-way communication in addition to other initiatives as for example investing in the distribution network. The network operator should invest in two-way communication if this is profitable. The costs should therefore be in accordance to the benefits of the technology.

The end-users’ flexibility in electricity consumption is an important part when discussing technology for direct communication and load control. Customers with large flexibility will have largest benefits from installation of this technology. The technology can make contracts for remote disconnection of loads possible, and the customer can offer power reserves to the market.

The Ministry’s evaluation can be summarised as follows:

- One actor should have the main responsibility for the installation, management and financing of the technology for two-way communication. This will in practice be the network operator.

- The network operator can enter into a contract with other actors that also benefits from the technology, for contribution to the financing.

- From 1. January 2005 60% of the electricity consumption in Norway is hourly metered. Probably it is these customers that can contribute most in a period with scarcity of power. The potential of this consumption should be better utilised before additional requirements concerning development of two-way communication are performed. The potential implies among others development of incentives for energy efficiency for these large customers.

- The technology for two-way communication is still developing, and a requirement for full installation of two-way communication is therefore not suitable at the moment.

White paper 18 (2003-2004)

This white paper is dealing with different subjects concerning security of electricity supply in Norway. Two-way communication and hourly metering is also included in this document. The evaluation of the white paper is not finished per March 2004.

Based on this white paper, the government want to improve the handling of periods with scarcity of energy and power with i.a. to adjust for increased efficiency in energy and power consumption through new contracts, direct communication and more frequently meter reading and settlement in tight periods.

Two-way communication can make hourly metering and load control possible at the site of the customer. This will again increase the flexibility in electricity consumption based on running information about electricity costs and consumption and load control.

Hourly metering can motivate the customers to reduce the electricity consumption and save energy, since the customer will be settled based on his own electricity consumption for each hour.

The white paper treats different initiatives for increased flexibility in energy and power consumption;

- The Norwegian option-market where customers get paid for power reserves is a genuine way to reduce the consumption for a shorter period. Disconnection of loads would make the situation better in periods with scarcity of energy and/or power.

- Power contracts with prices that are following the market situation will motivate the customers to reduce the consumption in peak load periods with high prices.

- Two-way communication and technology for load control opens up for hourly metering and load control at the end-use customers. The flexibility in consumption will probably increase when the customers get updated information about prices in the power market and electricity consumption, and when the customer can get agreements for load disconnection after a compensation for a possible reduction in comfort.

2.5 EU

The following chapters summarize a “Proposal for a Directive of the European Parliament and of the Council on energy end-use efficiency and energy services” /* COM/2003/0739 final - COD 2003/0300 */ 10 December 2003 [10].

Only the relevant Commission Directives is selected. The complete text can be found on: http://europa.eu.int/comm/energy/demand/legislation/end_use_en.htm.

2.5.1 CHAPTER I Subject matter and scope

Article 1 Purpose

The purpose of this Directive is to enhance the cost-effective and efficient end-use of energy in the Member States by:

- Providing the necessary targets, mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections for the efficient end use of energy;
- Developing a market for energy services and for the delivery of energy efficiency programmes and other energy efficiency measures to end users.

Article 2 Scope

1. This Directive shall apply to the distribution and retail sales to final customers of energy.
2. Member States can exclude small distributors or retail energy sales companies from the application of this Directive.

Article 3 Definitions (partial)

Assumed known; but we recall the most important.

(a) "Energy": energy in the form of electricity, natural gas, district heating and cooling, heating fuel, coal and lignite, transport fuels, and forestry and agricultural energy products and waste.

(b) "Energy efficiency measures": all actions, such as energy services, energy efficiency programmes and mechanisms or similar activities, initiated by any market player, including governments and authorities, that lead to verifiable and measurable improvements in end-use energy efficiency, and thus to energy end-use savings, during the period of measurement.

(c) "Energy Service": the physical amenity for energy end users derived from a combination of energy and energy using technology and, in certain cases, the operations and maintenance necessary to deliver the service meeting quality performance requirements and improving energy efficiency, contracted for a fixed period of time and paid for directly by the customer or agent who benefits from them.

(d) "Energy efficiency programmes": measures (e.g. energy audits, financial rebates for energy-efficient equipment and information and other measures of the kind mentioned in Annex III) targeting energy end users or market agents and designed to help them undertake energy-efficiency measures, normally paid for collectively and offered by national agencies, energy retail suppliers, distributors and other market players.

(e) "Energy efficiency mechanisms": specific measures, such as certification, regulated tariffs, taxes, subsidy schemes, funds, etc., undertaken by governments or government bodies to create a supportive framework or incentives for energy companies, energy service companies, installers or other market players to provide energy services and energy efficiency programmes, not addressing end users directly.

(f) "Energy audits": a systematic procedure that obtains adequate knowledge of the existing energy consumption profile of the building site, industrial operation, etc.; identifies and quantifies cost-effective energy savings opportunities; and reports the findings.

(g) "White certificates": certificates issued by independent certifying bodies confirming the claims of market actors for savings of energy, as a consequence of energy end-use efficiency measures.

2.5.2 CHAPTER II Energy savings targets

Article 4 General target (partial)

1. Member States shall adopt and meet a mandatory target for cumulative annual energy savings attributable to energy services, energy efficiency programmes and other energy efficiency measures such as those listed in Annex III.

2. The target shall consist of an annual amount of energy to be saved that is equal to 1% of the amount of energy distributed and/or sold to final customers, as calculated for the base year according to Annex I. The costs of the measures adopted to achieve this target should not exceed their benefits.

3. The first savings in the distribution and/or retail sales to final customers, according to this target, will be applied to the first calendar year after the year this Directive is transposed into national legislation. This savings will increase by the cumulative application of the targets of the following years, until and including the year 2012, for a maximum of 6 years.

4. The base year energy consumption and other conditions, such as taking into account the effects of measures implemented in previous years, shall be calculated in accordance with the methodology set out in Annex I and savings, measured and verified in accordance with the guidelines in Annex IV. For purposes of comparison and for conversion to a comparable unit, the conversion factors provided for in Annex II shall apply.

Article 5 Procurement of energy end-use efficiency by the public sector (partial)

1. Member States shall adopt and meet a mandatory target of an annual energy savings in the public sector through the procurement of energy services, energy efficiency programmes and other energy end-use efficiency measures. This target may be a sub-target of the overall target set out in Article 4(1), meaning that fulfilment of the public sector target will contribute to fulfilling the overall target.

2. The public sector target shall consist of an annual savings of at least 1.5% of energy distributed and/or sold to this sector, allocated and calculated in accordance with Article 4.3 and the methodology in Annex I. For purposes of comparison and for conversion to primary energy, the conversion factors set out in Annex II *(not in this report)* shall be applied.

3. To achieve the target adopted pursuant to paragraph 1, Member States can in particular use public purchasing guidelines to enable public administrations to integrate energy efficiency considerations into their investment and operating budgets and activities through the use of energy services, energy efficiency programmes and other energy efficiency measures. While respecting the procedures enshrined in national and Community public procurement legislation, the guidelines may cover the following:

    (a) requirements for the use of financial instruments for energy savings, such as third-party financing and energy performance contracting, that stipulate the delivery of measurable and pre-determined energy savings (including whenever public administrations have outsourced responsibilities) when purchasing energy services and energy efficiency measures;

    (b) requirements to purchase equipment and vehicles from energy-efficient products of each category of equipment and vehicles, using, where applicable, minimised life cycle cost analysis or comparable methods to ensure cost effectiveness;

    (c) requirements to purchase products that have low standby power consuming mode using, where applicable, minimised life cycle cost analysis or comparable methods to ensure cost effectiveness.

4. Upon expiration of the period during which the target is applied, the Commission will review the target mentioned in paragraph (2) and examine whether it shall present a proposal for prolongation or amendment of this target.

2.5.3 CHAPTER III Promotion of energy end-use efficiency and energy services

Article 6 Energy distribution and retail energy sales companies

Member States shall remove barriers to the demand for energy services and ensure that energy distributors and/or retail energy sales companies selling electricity, gas, district heat and/or heating oil:

(a) offer and actively promote energy services as an integral part of the distribution and/or sales of energy to customers, either directly or through other energy service providers. Energy audits shall be provided for free to their customers as long as 5% of them are not covered by energy services.

(b) refrain from any activities that might impede the delivery of energy services, energy efficiency programmes and other energy efficiency measures or hinder the development of the market for energy services and energy efficiency measures in general. The authorities or agencies designated in Article 4(5) shall take the necessary measures to bring such activities to an end where they occur;

(c) provide the information on their end-use customers necessary for the appointed authorities or agencies designated in Article 4(4) to properly design and implement energy efficiency programmes, and to promote energy services and energy efficiency measures. This information should include historical and current information on end-user consumption, load profiles, customer segmentation, and geographical location of customers, where applicable, while preserving the integrity and confidentiality of commercially sensitive information.

Article 10 Tariffs and other regulations for net-bound energy

Member States shall ensure that:

(a) incentives to increase the volume of transmitted energy or sales of energy embedded in tariff regulation schemes in monopoly segments of the distribution of net-bound energy are removed. This may be done by the introduction of transmission and distribution tariff structures that take into account, in addition to the volume of sales, such factors as the number of customers served, by the use of revenue caps or by any other measures that can be deemed to have the same effect;

(b) costs for investments made on the energy end-use side by distribution companies can be recovered by including them in their distribution tariffs, where appropriate, having due regard for the need to ensure equal competition and a level playing field for other providers of energy services. Cost recovery may be allowed for costs incurred in fulfilling energy service obligations pursuant to Article 6(a), provided that such costs are deemed reasonable and competitive by the responsible authority.

Article 13 Metering and informative billing of energy consumption

1. Member States shall ensure that: all end-use customers of net-bound energy distribution and/or retail supply companies are provided with competitively priced individual meters that accurately reflect the customer's actual energy consumption and actual time of use.

2. Member States shall ensure that: billing reflects actual consumption in understandable terms, and is carried out frequently enough to enable customers to regulate their own energy consumption. For net-bound energy, and where appropriate, distribution charges and energy charges shall be displayed in the same bill.

3. Member States shall ensure that: in or with bills, contracts, transactions, receipts at distribution stations and in promotional material, all energy distributors and/or retailers make the following information available to final customers:

   (a) current actual prices and, where appropriate, actual consumption;

(b) where appropriate, comparisons of the consumer's current energy consumption with consumption for the same period in the previous year, in graphical form;

(c) comparisons with an average normalised or benchmarked user of energy of the same category;

(d) environmental impact, such as CO_2, of energy distributed or sold for consumption;

(e) contact information, including websites, where information on available energy services, energy efficiency programmes and other energy efficiency measures, as well as technical specifications for energy-using equipment, may be obtained.

2.5.4 ANNEX I Methodology for calculating targets for end-use efficiency

The methodology used for calculating the national targets set out in Articles 4 and 5 shall be the following:

1. Member States shall calculate the arithmetic average of total final domestic energy consumption for the most recent five calendar-year period, previous to the implementation of this Directive for which official data are available, using this as the base period for the total duration of this Directive. This data shall be the amount of energy distributed or sold to final customers during the period, not adjusted for degree days, structural changes or for production changes.

2. The annual energy savings targets shall be calculated on the base period and expressed in absolute terms in GWh, or equivalent, using the conversion factors in Annex II.

3. Energy savings in a particular year that result from energy efficiency measures initiated in a previous year not earlier than 1991 may be taken into account in the calculation of the annual savings. These energy savings should be measurable and verifiable, in accordance with the guidelines in Annex IV of this Directive.

2.5.5 ANNEX III

Eligible energy efficiency programmes and other energy efficiency measures

This annex provides examples of where energy efficiency programmes and other energy efficiency measures may be developed and implemented. To be taken into account for meeting the energy savings targets set out in Articles 4 and 5, energy services, energy efficiency programmes and other energy efficiency measures must contain activities that result in verifiable and measurable savings that reduce energy use, without increasing the environmental impact. The energy services, energy efficiency programmes and other energy efficiency measures shall be cost-effective and their delivery and implementation open to all certified, qualified and/or accredited providers of energy services, energy efficiency programmes and other energy efficiency measures. This list is not exhaustive but is intended to provide guidance.

1. Eligible areas where energy efficiency programmes and other energy efficiency measures may be identified and implemented:

a) Heating and cooling (e.g. new efficient boilers, installation/efficient update of district heating/cooling systems, etc.);

b) Insulation and ventilation (e.g. wall cavity and roof insulation, double/triple glazing of windows, etc.);

c) Hot water (e.g. installation of new devices, direct and efficient use in space heating, washing machines, etc.);

d) Lighting (e.g. new efficient bulbs and ballasts, digital control systems, etc.);

e) Cooking and refrigeration (e.g. new efficient devices, heat recovery systems, etc.);

f) Other equipment and appliances (e.g. new efficient devices, time control for optimised energy use, stand-by loss control, etc.);

g) Product manufacturing processes (e.g. more efficient use of compressed air, condensate and switches and valves, use of automatic and integrated systems, efficient stand-by modes, etc.);

h) Motors and drives (e.g. increase in the use of electronic controls, variable speed drives, integrated application programming, frequency conversion, etc.);

i) Fans, variable speed drives and ventilation (e.g. new devices/systems, use of natural ventilation, etc.);

j) Demand response management (e.g. load management, peak shaving control systems, etc.);

k) Mode of travel used, e.g.

l) Modal shifts of travel, programmes that provide, e.g.

2. Eligible horizontal measures

Focused horizontal measures may be considered eligible if energy savings can be clearly measured and verified according to the guidelines in Annex IV of this Directive. This includes the following (non-exhaustive):

- Regulations, taxes, etc. that aim primarily at reducing energy end-use consumption;
- Standards and norms that aim primarily at increasing the energy efficiency of products and services;
- Campaigns that promote energy efficiency and energy efficiency measures.

2.5.6 ANNEX IV Guidelines for Measurement and Verification of Energy Savings

1. How Energy Savings should be measured

Energy savings shall be determined by estimating and/or measuring before and comparing to the use after the implementation of the measure, while ensuring adjustment and normalisation for extrinsic conditions commonly affecting energy use. Conditions commonly affecting energy use may also differ over time. Such conditions may be the likely impact of one or several plausible factors (not exhaustive) : weather conditions, such as degree days; occupancy levels; opening hours for non-domestic buildings; installed equipment intensity (plant throughput), using schedule for installation and vehicles, relationship with other units.

In measuring the energy savings set out in Article 4, a bottom-up model shall be used. This means that energy savings obtained through a specific energy service, or in a specific energy efficiency programme, measure or project, shall be measured in kilowatt-hours (kWh), in Joules (J) or in kilogram oil equivalent (kgoe) and added together with energy savings results from other specific services, programmes, measures or projects. The assigned public authorities or agencies set out in Article 4(5) will ensure that double counting of energy saving, which results from a combination of energy efficiency measures, are avoided.

The achieved energy result to be reported in accordance with Article 14 *(not in this report)* in the Directive shall be based on the following:

(1) If the service or programme/project is finalised and sufficient data are available at the time of reporting, the results shall be measured according to point 2.1 in this Annex.

(2) If the service or programme/project is not finalised or sufficient data are not available at the time of reporting, the results shall be measured according to point 2.2 in this Annex.

2. Data and Methods that may be used (Measurability)

Several methods for collecting data to measure and estimate energy savings exist. At the time of the evaluation of an energy service, energy efficiency programme, measure or project, it will not always be possible to rely strictly on measurements. A distinction is therefore made between methods measuring energy savings and methods estimating energy savings.

2.1 Data and Methods based on Measurements

<u>Bills from Distribution Companies or Retailers</u> : metered utility bills may form the basis for measurement for a suitable and sufficiently long period before the introduction of the energy service, energy efficiency measure, service or programme. These may then be compared to metered bills for the period after the introduction and use of the measure, also for a suitable and adequately long period of time.

<u>Energy Product Sales Data</u> : the consumption of different energy products (e.g. petroleum, coal, wood, etc.) may be measured by comparing the sales data from the retailer or distributor obtained before the introduction of the energy services,

programmes or other energy efficiency measures with the sales data from the time after the measure. A control group shall be used.

Equipment and Appliance Sales Data : performance of equipment and appliances may be calculated on the basis of information obtained directly from the manufacturer.

End-Use Load Data : energy use of a building or facility can be fully monitored to record energy demand before and after the introduction of an energy service, programme or other energy efficiency measure. Important relevant factors (e.g. production process, special equipment, heating installations, etc.) can be metered more closely.

2.2 Data and Methods based on Estimates

Enhanced Engineering Estimated Data: Inspection : energy data may be calculated on the basis of information obtained by an external expert during an audit of, or other type of visit to, one or several targeted sites. On this basis, more sophisticated algorithms/simulation models could be developed and be applied to a larger population of sites (e.g. buildings, facilities, vehicles, etc.). This method will only confirm energy savings, not verify them.

Simple Engineering Estimated Data: Non-inspection : data may be estimated using engineering principles, without using on-site data, but with assumptions based on equipment specifications, performance characteristics, operation profiles of measures installed and stipulations based on statistics.

3. How to Deal with Uncertainty

All the methods listed in Chapter 2 of this Annex may contain some degree of uncertainty. Uncertainty may derive from :

- instrumentation errors;
- modelling errors,
- sampling error:

Uncertainty may also derive from planned and unplanned assumptions; these are typically associated with estimates, stipulations and/or the use of engineering data. The occurrence of errors is related to the chosen system of data collection that is outlined in Chapter 2 of this Annex. A further specification of uncertainty is advised.

4. How to Verify the Energy Savings

As far as economically feasible, the energy savings obtained through a specific energy service, energy efficiency programme or measure shall be verified by a third party.

3 Summary of EFFLOCOM results

3.1 Load curve studies (Phase 1 and 2)

3.1.1 Country specific characteristics of load profiles

Load analysis related to demand response (load management) planning purposes has been performed [1 and 2]. The analyses include total system as well as customer category hourly load profiles from six countries: Denmark, Finland, France, Norway, Sweden and UK (which throughout this report refers to England and Wales). For France and UK, customer category load profiles were unavailable.

Similarities and differences in the total load patterns are explained. Customer category load profiles have been used to produce hourly customer segmentations of the total load for most countries during the year 2001 (when most countries had deregulated the electricity market).

Mean day temperatures for each country have been used to perform temperature sensitivity analysis. The database that holds all collected data is available at the project web site: www.efflocom.com (password protected).

Load drivers as climate, season, day types (weekend/workday), price signals, hourly variation and building type (by customer) have been mapped to better quantify country specific potentials for load management and energy efficiency.

Investigation of the loads shows the following broad relationships:

- Temperature sensitivity

  All countries have quite high temperature sensitivities during spring and autumn, being the result of electric space heating. Some countries show positive temperature sensitivities during summer – a result of cooling and air conditioning.

- Seasonal characteristics

  For all countries the consumption is higher during winter than the other seasons. This can be explained by use of electric space heating and use of lighting during cold and dark seasons. France and UK that have moderate temperatures during winter also show a much higher demand during colder seasons due to less restricted building codes, and fewer requirements for insulation standards of buildings.

- Day types

  All countries show a big difference in the day profiles for working days compared to weekends. This is natural since industry is partly shutting down activity during weekends.

- Hourly patterns during day

  All countries show reduction in the load during nights. All countries have two high activity periods during working days, one in the morning and one during evening. UK is special where the evening peak is much higher than the morning peak, the evening peak must be the result of domestic activity in this country - the use of ToU tariffs could be a reason for the high evening peak.

A large potential for demand response/load management is found for all countries:

- Reduction of peak load is possible for most countries due to the high activity of the domestic sector during the winter peaks. Automatic switching off of loads as water heaters and space heating would yield a more even peak load profile, and a lower peak.

- The load from the Industry sector represents the most interesting objects for demand response and power reserves

- The load duration curves for all countries show that 5 % peak load reduction could be achieved by concentrated demand response efforts in 20-75 hours.

- Estimates of the sector vice potential is available only from the Nordic countries where about 10-20 % of the peak load is reducible on hourly basis provided that the needed technology and economical incentives are in place.

- Countries that allow and promote space heating have low load factors – these countries could reduce the peak loads if the utilities and public authorities opposed space heating by promoting other sources for heating, and by promoting better insulation of buildings. (Building standards).

- Countries that make use of special tariffs as ToU tariffs show peak load profiles that are more even. Finland is a good example having the highest load factors of all countries investigated. In Finland customers mostly use central heating, and can accumulate heat during night at low prices. Denmark shows the greatest difference between night and day consumption during winter - Denmark has heavily promoted district heating and use of natural gas the later years, and customers can easier close down their electric consumption during nights.

Peak load reduction in one Nordic country gains the whole region.

- A study of the peak demand in the Nordic countries (Denmark, Finland, Norway and Sweden) shows a high degree of coincidence between the annual peaks of the individual countries. This means that the potential for demand response found by segmentation of the load curve for each country can be added in order to estimate the potential of load reduction in the whole region.

3.1.2 Influence of competition on load curves

The system loads from six countries: Denmark, Finland, France, Norway, Sweden and UK have been investigated to find possible similarities and differences in load patterns before and after deregulation [2]. Typical load patterns and load profiles of different customer categories are also assembled. The customer load patterns are investigated and combined with system load to make hourly customer segmentations of the total load for each country during the year 2001, and also for earlier years dependent on country describing the typical consumption before deregulation. The database that holds all collected data is available through a web site: www.efflocom.com (password protected).

The main aspects of deregulation are:

- Unbundling of services into monopoly and competitive businesses
- Opening of the electricity market
- New structures of network tariffs
- Change of supplier options
- Change of ownerships

It is difficult to relate the registered minor changes to any of these main aspects.

There have been no basic changes in tariffs and other products since deregulation. However, investigation of the total system hourly loads before and after deregulation shows the following broad relationships:

Temperature sensitivity

No radical change has happened since deregulation of the markets in the investigated countries. Generally, Finland, Denmark and UK have the lowest temperature sensitivities; and Norway, Sweden and France have the highest. Sweden is the only country that has higher average sensitivities after deregulation compared to before.

All Norwegian and Swedish temperature sensitivities are more negative than the average. The deregulation of Norway seems to have lead to higher temperature sensitivity for all seasons and day-types, except summer and winter workdays. This can be explained by a growth of demand of the domestic sector.

Sweden seems to have another development – less temperature sensitivity in the cold season since deregulation, and higher sensitivities during summer. No clear explanation is found to account for this.

UK has a dramatic reduction of sensitivity of the winter season since deregulation, no clear explanation is found.

Regarding France, in 2001 the customers sensitive to weather conditions were not yet eligible to the market. In 2001, France has the highest temperature sensitivity in winter season. This can be explained by the fact that el. prices are relative low in France and by the development of electricity space heating since 1973 in response to the oil crisis. However EDF on the one hand has promoted a better insulation and the use of energy controllers and on the other hand has launched real-time tariff options (EJP, Tempo). These new options have disturbed the correlation between daily electricity consumption and temperature. Concerning summer the results are not significant and nothing can be concluded except that the influence of air conditioning is not yet visible.

For Finland we miss temperature data for a year before deregulation, so no sensitivity has been calculated for this reason. The sensitivities after deregulation are quite low, even though Finland is a cold country. This indicates use of non-electric space heating.

In 2001, Denmark has reduced sensitivities compared to year 1998. This might be explained by other reasons than deregulation since only 33% of the Danish consumption participated in the free market in 2001 (where 16% started 1. April 2000) – one of the reasons might be that the authorities of Denmark has taken measures to move away from using electric space heating the later years.

Development of Customer demand

No radical changes in peak load profiles and utilisation factors are found since deregulation. No radical changes are found in the distribution of annual energy consumption and maximum demand of different customer segments.

Peak load comparison before and after deregulation:

- Norway: Reductions of process Industry (after deregulation), higher share from public service. This can be explained by the state of the industrial market leading to lower activity in 2001.
- Sweden: Reduction of Industry activity at peak, but a higher share of domestic customers.
- Denmark: Nearly no changes in the peak load and energy shares before and after deregulation of 33% of the market.
- Finland: Greater share from Industry and the business sector after deregulation while the domestic customers has a lower share.
- It has not been possible to make a segmentation of the UK peak day, (lack of customer type profiles) but the peak day profiles before and after deregulation are

not very different, indicating no radical changes in the consumption of customer types.

- No segmentation of the peak into customer groups has been made for France, due to lack of customer type profiles. The peak profiles show a growth of 10.5% during 1996 to 2001, and the growth seems to be equal for all hours. This indicates no radical changes in customer load patterns.

3.2 Impact of ICT and economical incentives (Phase 3)

The aim of Phase 3 has been to analyse the impacts of new communication infrastructure on energy consumption. The work has been divided into two parts: Description of technology and Incentives for load reduction and investments in technology.

3.2.1 Technology for Direct Communication

The technology for direct communication (also called two-way communication) is described in a separate report [3] as a part of the phase 3 work. The exchanged information via direct communication is typically metered values of different kinds and signals for load control, alarms etc.

Direct communication is in most cases established for automatic meter reading (AMR) as a result of authority requirements regarding more frequent meter reading, e.g. hourly metering of large customers. Except from Italy and to some extent Sweden, there are few examples of establishment of direct communication to smaller customers in Europe. Several major Danish network utilities has in spring 2004 announced that they will establish direct communication to all their customers within the next 2-3 years.

A system for direct communication consists of three main parts:

- *Equipment at the customer (energy consumption point)*. In most cases it will be a terminal connected to the electronic pulse meter.

- *Communication system*. The communication system consists of communication “lines” and in several cases also a communication concentrator. The communication lines may be physical or virtual lines. There will often be different types of communication between the customer and the communication concentrator (communication 2) and between the communication concentrator and the data collection central (communication 1). The communication between the energy consumption point and the data collection point may also be directly (communication 3).

- *Central collection system, also called front-end system*. The system will typically be installed at the utility. It will be the interface between the system for direct communication and other software programs like Customer Information System (CIS), Meter Value Server (MVS) and Network Information System (NIS).

At the energy consumption point the most important functionality are collection of meter values, registration of consumption according to different tariffs, registration of peak power consumption, performing load management, registration of interrupts and alarms and storage of information.

Technology for load management may be a part of the system for direct communication or may be a separate system. If it is a part of the system for direct communication it may be included in the terminal or it may be installed in the contact close to the load. In the last alternative, it is necessary to have some communication between the terminal and the technology in the contact close to the load.

The technology in the communication concentrator point is often made such that it is possible for the concentrator to collect meter values from the connected terminals without an initiative from the front-end system. The meter values are stored in the concentrator until they are requested from the front-end system. In this way the operation time and communication costs for collection of meter values are reduced.

The following types of communication are described in the report: power line communication (PLC), Public Switched Telephone Network (PSTN), Integrated Services Digital Network (ISDN), Global System Mobile (GSM), General Packet Radio Service (GPRS), radio communication and broadband.

The report describes strategic consequences for the utility by selection of technology for direct communication. It also describes experiences from establishment of the technology. Important experiences are: immature technology, lack of integration with other IT-systems, vendors without large-scale delivery experience and utilities without experiences with large scale establishment.

In Norway the costs for establishment of direct communication will be in the range 133-533 Euro (1000-4000 NOK). These are average costs for all types of systems. Both investments in technology and installation costs are included in the estimates. The costs for establishment of direct communication will vary with different factors.

Recommendations regarding technology for direct communication in the report are:

- Contribute to more cost effective solutions for direct communication.
- Evaluate experiences with load management.
- Contribute to share of information and experiences between utilities.
- Work for standardization of interfaces for information exchange in systems for direct communication.
- Work for standardization between systems for direct communication and other IT-systems like CIS and MVS.

3.2.2 Incentives for Demand Response and for Investments in Infrastructure and Technology

The main focuses of the second phase 3 report [4] are the incentives the customers are facing with regard to load reduction, and the incentives different parties have to invest in needed technology. The final cost-benefit analyses for the specific investment/effort are decisive for the realism of the projects in question. A general discussion of the principles and main aspects of the costs and benefits and potential ways of co funding of the infrastructure is included in the report.

A lot of customers in the electricity markets pay a retail price that is average over time, despite the fact that the electricity markets refer to a spot market, which is traded on an hourly basis. These customers have no incentive to respond by load reduction on high prices in the shortage periods, e.g. in the morning and the afternoon hours. This lack of price sensitivity on the demand side leads to market inefficiency and in the long run significant advantages for the producers who can decide the price in the peaking hours.

The goal is to improve the demand side price elasticity on general basis, and the demand response in case of shortage. It is assumed that the most important incentives for load reduction are related to money and profit. The network tariffs and the energy price are of this reason important factors for the response. An overview of the different price signals the customer is facing in the participating countries is presented and discussed on a more general basis.

In a deregulated environment the electricity price paid by the customers consists of the following elements:

- Network tariff (from network owner)
- Energy price (from the supplier)
- Taxes (from the authorities)

France has just started its deregulation process while the Nordic countries have several years of experience. The electricity price to customer has of this reason not reached the same level of "unbundling" in France as in the other countries participating in the project. The main difference is that the energy price is confidential in France while it is public in the other countries.

The main customer incentives for load reduction are related to the price signals given by the network tariff and the energy price. Experiences from the EFFLOCOM project and previous studies indicates that the following tariffs and energy products gives the best motivation for load reduction:

<u>Network tariffs</u>:

- Time of Use (ToU)-tariffs with enter day variations in price
- Dynamic tariffs that are amplified in periods with shortage

<u>Energy price:</u>

- Hourly spot price
- Hourly spot price combined with automatic load reduction when spot is high
- ToU-price e.g. with day/night variation

The taxes represent in most cases a major share of the electricity bill and will, if the tax is a fixed price independent of the consumption, represent a limitation of the potential price variations provided by the network tariffs and energy prices mentioned above.

A bilateral contract for load reduction is an alternative to price elasticity efforts. Most of the schemes implemented relate to system operator products for reserves and reliability purposes. The Nordic TSOs have all utilized interruptible or reducible loads as capacity reserves. Mainly larger industrial loads are used, but aggregated smaller loads are also an option.

Common for the price signals mentioned above is the need for reliable documentation and to some extent controllability of the loads in question. This means that more frequent metering and facilitation of load control (LC) are required for the consumption in question.

In most cases these requirements lead to the conclusion that investments in technology for automated meter reading (AMR) are needed.

The most common way of executing AMR is to replace the conventional meters with electronic devices and to establish Direct Communication (also called Two Way Communication) between customer and the company responsible for the metering. This technology, which is described in a separate EFFLOCOM report [2], includes the option of remote control of reducible loads.

However, the whole meter value chain has to be improved to secure that the quality of the metered values are good enough for the power market. This means that supplementary investments in Customer Information Systems (CIS) and/or Meter Value DataBase (MVDB) have to be expected. Utilization of the Internet and investments in web-based services is another object of interest.

There are several motivations for investments in the technology mentioned. Some of the motives are based on the interest of the whole society to the benefit for all, and some are related to the benefits of each actor involved. Basically the benefits could be categorized in the following groups:

- Improved end user response to shortage in production and/or transmission capacity
- Efficiency improvements with regard to metering and data management procedures
- Improved quality and precision of metered data
- Profit and cost savings

The benefits of the stakeholders are mixed together and full benefit is in many cases dependent of investments by several parties. The different aspects with regard to investments in needed technology is discussed, referred to the stakeholders: Society, Transmission System Operator, Market Operator, Network Owner, Supplier, Customer and other energy service providers.

One important aspect when considering introducing some kind of varying electricity prices is the outcome of the cost-benefit analysis of the experiment.

The analyses of the experiments have usually showed a lack of welfare justification because the costs of the equipment needed for hourly metering of the energy consumption exceeds the benefits. However, with new technology, the costs might become lower than the benefits. Regulations and/or dedicated subsidies from the authorities might be needed if the net corporate benefit remains negative, provided a positive socio-economic outcome of the investment.

The cost/benefit aspects for investments in different technologies are discussed separately based on the methodology described in the “Guidebook for B/C Evaluation of DSM and

Energy Efficiency Service Programs" prepared for the European Commission in 1996, and of the description of the different actors interest for investments.

So far investments in technology have been limited of economical reasons because the different actors does not find profitability alone. More cooperation between the stakeholders and regulatory arrangement are needed to secure that projects that are proven socio-economic beneficial will be accomplished.

In general stable regulations and tax policies from the authorities are needed to reduce the regulatory risk of investments.

3.3 Lessons learned from the pilot tests

3.3.1 Demand Response offered by households with direct electric heating (Danish Pilot)

Overview and objective

The peak power balance in the Nordic power system is gradually turning to be very tight. Hardly any investments in new production are carried out. For this reason focus has turned towards emphasis to encourage manual or automatic demand response, which implies need for hourly metering for documentation, and controllability in order to meet the response requirements.

The Danish demand response pilot project was established in 2003 including 25 domestic homes with direct electrical heating. Enabling technologies include extra customer installations including control and remote quarter of an hourly meter reading by GPRS communication and customer services provided by the Internet.

The objectives of the Danish pilot project is to increase the end-user flexibility in periods with scarcity of electrical energy and power by:

- Establishing a decision basis and suggest external conditions for a prioritised building of an infrastructure based on IT-solutions for direct communication, demand response and more customer services.
- Develop, test and evaluate incentives, which stimulates flexibility in consumption, with basis in an economical bonus (to be a part of a power price tariff) and implementation of IT in order to facilitate the customers acting and knowledge on their consumption.

The implementation of the direct communication and control system started spring 2003 and was completed by October 2003. Automatic meter reading and the demand response were tested in the period 1 November 03 – 30 April 04.

Achieved results and key figures

Technology

The technology included:

1. A standard small electronic meter recording and storing the heating electricity consumption every quarter of an hour. The meters were working with no problems.

2. An Amplight control unit including individual control of five zones/appliances. Two way communication including control and daily meter reading is performed by GPRS. For most houses the GPRS communication has been working good except for three houses in one geographic area who did not receive all calls for interruption in the first month of the experiment. The problem was for the GPRS provider resulting in an improvement. During the next years GPRS is expected to cover all parts of Denmark since the new mobile phones are using GPRS. Due to the GPRS problems for a few houses, extra security was build into the software managing the Amplight system including:

   - Start and stop of an interruption is communicated in the same message to all the controllable units.

   - Repetition of sending messages.

   - Automatic control every night that all controllable units are switch on.

   - Ensuring that the time of interruption and recording 15 min consumption is synchronized.

3. Customer interface to the system by Internet including access to set the limits for the control of the five different control zones, access to stop an actual interruption in case of inconvenience and a daily updated report on use of electricity and the saved bonus by demand response control. The Web interface has been working perfect all the time. We are having perfect time series of consumption per quarter of an hour and hour for all 25 houses!

Demand response

The demand response system is designed for activation when the Nord Pool hourly Elspot prices exceed the price level set by the utilities and the TSO. Actually, a year contains around 10 hours with very high spot prices. In the pilot project is simulated a future situation within the coming years including 100 hours per year. The highest 100 spot prices appear on working days and in the two time periods: 06-11 and 16-19 hours. This is thus the time when the interruptions have been made in the pilot project. The bonus for demand response varied between 0.13, 0.27 and 0.40 Euro/kWh for the electricity consumption interrupted.

October - December 2003 were relatively warm with no real winter temperatures with a Nord Pool spot-market being very calm with stable low prices. From beginning of January 2004 the winter started with some limited price variation at the market. Due to mild winter, the control strategy was in January 2004 changed to systematic testing of interruptions at different time of day and of duration.

The customers were selected due to a yearly consumption above 16,000 kWh/year. At the days of interruption, the average daily temperature has been from –8 C up to 11 C with a respective interrupted heating load from 5.3 to 2.5 kW/house.

10 (40%) of the customers have used the option to stop an interruption in case of inconvenience. 7 customers have only used the facility 1-2 times only used the facility one time.

The maximum duration an interruption was defined to be three hours. 6 (24%) of the 25 houses have used the facility to limit the duration of interruption for some zones, time of day and/or depending on level of bonus.

Customer received in average a demand response bonus of 80 Euro/customer. Before start of the pilot project it was calculated that the bonus might be up to 130 Euro/customer. With a mild winter the bonus was in according to expectations.

Only 45% of the interrupted consumption was used afterwards to bring the temperature back to the required level. Assuming that the interrupted load is in average 3,3 kW (equal to an average temperature of 0^0C) this gives a saving of 3,3 kW * 100 hours * 55% = 180 KWh equal to 40 Euro/customer.

The economical benefit for the customer were thus in total 80+40 = 120 Euro/year.

Cost/benefit and recommendations

The Danish pilot doesn't include a full cost/benefit analysis including cost and benefits for Customer, network owner, supplier, system operator and society.

The pilot includes a comparison of the flexible load to investment in further production to be used in the few hours where is difficult to meet the demand.

Based on actual costs in the pilot and evaluation with the manufactures of hardware and software as well the installers, the cost of equipment, software and installation is evaluated to be 800 Euro per house in case the installation includes 1000 houses. The pilot shows that 5 kW/house can be interrupted at cold days. Assuming that the 5 kW/house also counts for the 1000 houses, the investment is equal to 160 Euro/kW or 31 Euro/kW per year (10 years, 7%).

As a comparison, the investment for gas turbines is around 80 Euro/kW per year (10 years, 7%). This analysis thus indicates that investment in flexible load is a good investment.

The customers in the pilot have during the winter 2003/2004 in average saved 80 Euro by offering flexible loads for electric heating and they have in average obtained 40 Euro in energy savings. In case the control system also comes to include customer facilities for lowering (interrupting) the heating in periods during the day and/or night, the benefits for the customer are estimated to be much higher. The customer may thus be willing to pay a part of the investment in equipment, software and installation.

The households with electric heating have shown to be very flexible, happy with the demand response participation, they have followed the development in their consumption per week or month and they offer to continue with demand response. Some customers suggest to include the dishwasher, the washing machine and the tumbling machine in the demand response management. Recommendations for further development of demand response are:

- A Nordic coordination of authority regulations is necessary since all the Nordic countries benefit from flexibility in electricity consumption.
- Subsidies from the authorities should be considered.
- The success in the pilot project forms the way for a future large scale testing of equipment, data flow and load reduction in close cooperation with suppliers and network companies.
- Practical methods for pooling the benefits of the different actors in order to overcome the investments in common have to be developed. The role role of the TSO, the supplier, the network company, the installer and maybe a performance contractor representing the customer has to be defined. Hourly metering and the potential of load control in peak hours e.g. give opportunity for new supplier products reducing the risk of the supplier connected to periods with huge fluctuations in spot price.
- Further investigation on the potential for demand response and limitations for load control for all kind of customers/end uses. 125,000 houses are heated by direct electric heating in Denmark. In case 50,000 of these customers are offering demand response with an average demand of at least 4 kW/house on cold days, this gives a demand response potential of 200 MW.
- Further deveopment of the technology enabling more flexible individual management of the single appliances and end-use
- What kind of tariff of agreement gives different end-users the best incentive.

3.3.2 Effect of web-based feedback on the electricity consumption and load curves (Finnish Pilot)

Overview and objective

In Finland the electricity meters of residential customers living in blocks of flats are usually read once a year. The real estate electricity consumption, of which no single resident is directly responsible of (such as outdoor lighting and ventilation), is often measured once a month and the results are provided on paper. However,

- the consumption reports have been prepared only several times a year,
- there has not necessarily been any person assigned to follow the consumption,
- only monthly values have been available, not daily or hourly consumption,
- the historical data has not been readily available and
- it has not been possible to readily compare the consumption of the real estate to that of other real estates.

For these reasons there has been a lack of information about the true consumption. In this pilot 31 real estates in the town of Tampere were chosen to be the target of better consumption information. The purpose was to measure the real estates' electricity consumption more accurately and frequently than usual and give the measurements as feedback to the residents. The main objective was to study whether the consumption feedback would cause changes in consumption.

The main responsibility of monitoring electricity consumption among residents belonged to so-called energy experts, who are voluntary laymen. Each of the 31 real estates had one energy expert. The experts are residents in the real estates and change from time to time.

Achieved results and key figures

Real-time consumption measurement was installed into the real estates. The measurements are remote-read through public telephone network once a week. The measurement accuracy is one kilowatt-hour per hour, which has suggested to be improved.

The engineering office Suomen Talokeskus maintains the *Kulunet* website (http://www.kulunet.com), from which the consumption measurements can be accessed. The service requires username and password which were provided to all energy experts during the study. Some experts had the username from the beginning.

During the study the Kulunet service underwent updates due to which consumption feedback was delayed. Hourly and daily consumption was available to experts since September 2003. All experts received the Kulunet username as late as February 2004. Another setback was that the experts' involvement in the feedback process was not too intense. The following reasons may have caused this:

- Experts have little incentive to study the feedback since they get little monetary benefit (the cost saving is divided among all residents)
- Especially the hourly curves are difficult to study and should be accompanied with more information
- Training of experts has been too infrequent
- Not all experts have access to the Internet, which is required for the use of Kulunet

A common notion was that the hourly consumption data as such is too complicated for the energy experts to analyze. It should be divided into components so that the experts can see what portion of the power each appliance draws. To some extent this is possible non-intrusively by monitoring currents and voltages in the lines that supply the whole building. Unfortunately, this cannot be fully automatic. The base load, which is always present, cannot be analyzed in this fashion but each appliance must be measured separately.

Consequently expert activity in the Kulunet feedback system remained low throughout the study period. Only three out of 31 experts visited Kulunet more than a few times (these will be called active experts). Creating Kulunet usernames for everyone in February '04 caused a considerable rise in the use of Kulunet although mainly one real estate is responsible for this. How much of this initial activity erodes away with time remains to be seen. So far a typical pattern with the experts seems to be that they get unexcited with Kulunet and their visits become more infrequent.

Table 1: Comparison of real estate electricity consumption of real estates, which had active and inactive experts.

Quantity	Active experts	Inactive experts
Average consumption change Feb-Apr 2004 vs. Feb-Apr 2000–2002	-0.6 %	+2.3 %
Average consumption change Feb-Apr 2004 vs. Feb-Apr 2001–2002	-0.4 %	+2.1 %
R2 between hourly values in Feb-Apr 2004 and Feb-Apr 2001–2003	0.92	0.83

With so little participation in studying the web-based feedback it is not possible to draw any conclusion about what way having better consumption feedback about real estate electricity affects consumption. Of course, the feedback was available to about half of the experts (those who have access to the Internet) but only three used it.

In Table 1 one can see that the consumption change in spring 2004 relative to previous springs was lower in the real estates, which had active experts, but the difference is small. The table also shows that on the average the load curve shapes in spring 2004 resemble those of previous springs a bit more in real estates with active experts. This is purely coincidental.

All experts were polled by mail questionnaire and the three active experts were interviewed by phone. According to interview the active experts had not noticed any abnormalities in consumption and had not taken action to reduce consumption. Therefore it is safe to say that feedback did not cause changes in consumption in this case.

The active experts had not taken advantage of the hourly consumption feedback. Although monthly values are easier to study, there's so little information in them that it is difficult to see other than very large changes in average level of consumption. The use of hourly values can be made easier by producing a forecast of probable hourly consumption based on historical data. This is readily accomplished for example with EME Forecast software developed by VTT. The software can also be used to produce an automatic warning when consumption deviates too much from past pattern.

Recommendations

A common notion was that the hourly consumption data as such is too complicated for the energy experts to analyze. The results also suggest that the current system does not serve its purpose and some radical changes must take place if feedback is really meant to be exploited.

- The feedback should be provided to all residents instead of just energy experts.
- The residents should be given an incentive to study the curves. If a resident makes a report of abnormal consumption, he should reap most part of the resultant saving.

- The consumption should be further analyzed into consumption from different appliances as far as possible. The above-mentioned forecast procedure should be used to produce reference values for hourly consumption.
- Of course, it should be made certain that the feedback is utilized to full extent by paid personnel at service companies which take care of maintence of the real estates.

3.3.3 Tempo tariff feedback at EDF (French Pilot)

Overview

Since the 1960's, little by little, EDF has been moving towards real time tariff linked to the marginal costs. As a consequence, its customers have been incited to reduce their consumption when the generation costs are high.

tempo tariff was the most sophisticated tariff for mass-market customers in the previous French monopoly context. It allows to smooth both annual and daily load curves.

Brief recall of *tempo*

Tempo is an annual tariff (from 1 September to 31 August) that depends on the day of the year : each hour of a year is characterized by one of the 3 colours with different prices :

- blue : 300 days a year, night (8 hours) & day (16 hours), all the Sunday are blue.
- white : 43 days a year, night (8 hours) & day (16 hours) including Saturday but with low probability.
- red : 22 days a year, night (6 hours) & day (18 hours), all day from 1 November to 31 March except Saturday, Sunday and Special days

Special equipments are required to profit by this tariff : an electronic meter that pilots electrical equipments (heating, boiler etc.) and a monitoring box that informs the customers from 20 hours for the next day colour.

Table 2 Energy Cost by category in c€/kWh, all taxes included

(August 2004 from http://particuliers.edf.fr/rubrique112.html)

Blue night	4.46
Blue day	5.53
White night	9.07
White day	10.75
Red night	16.82
Red day	47.02

Table 3 Annual subscription in €/year

(August 2004 from http://particuliers.edf.fr/rubrique112.html)

9kVA	162.42
12-15-18 kVA	222.36
24-30 kVA	409.06
36 kVA	549.72

The four steps of *tempo* story

Step 1 : experimentation (1989-1992)

The objectives were to evaluate customers' reaction to the price and their satisfaction level and to test new technologies (electronic meter, notification device, energy controller, ripple control). The experimentation has been made on 800 customers in 6 French regions, with load curve measurement in 70 homes.

Step 2 : the launch (1993-1995)

Tempo is considered as a commercial product with 4 different versions:

- standard *tempo* (only electronic meter),
- dual energy *tempo* (boiler can be switched from one energy to another)
- thermostat *tempo (able to manage space heating, and water heating according to the electricity price)*
- comfort *tempo* (with a sophisticated energy controller)

Linked with a new range of services:

- Are you a *tempo* customer ?
- Right price Advisory (using the software tool GUITARES)
- Electric heating and domestic hot water diagnostic

Step 3 : generalisation (after1995)
Tempo has been offered to all mass-market EDF customers. Gradually 300,000 residential customers and more than 100,000 small business customers have chosen *tempo.*
Step 4 : evolution of the context (2004)
On the one hand, because of technological progress, the range of the generation costs has been reduced and, on the other hand, because of the opening of the market (July 2004 for small business and 2007 ? for residential customers), the network prices and supply prices must be separated and market prices are more volatile.

Feedback

For the first step, the daily consumption has been reduced on average

- by 15 % on white days compared to blue days
- and by 45% on red days compared to blue days

Concerning customer satisfaction level :

- 84% were quite or very satisfied with *tempo*
- 59% told us that they had made savings
- 53% considered the option as slightly unrestrictive or entirely unrestrictive
- 87% have understood the tariff principle very well

For the second step, customers were satisfied or very satisfied (90%), mainly because their bill has been reduced by 10%. So EDF decided to introduce *tempo* in the EDF tariff and to keep on studying *tempo* customers : for example : satisfaction barometer (2 telephone surveys, the first 3 months after the installation of tempo, the second, one year later). For the third step, the main result is that *Tempo* was chosen in order to reduce electricity end-user bills and globally the customers are happy with this tariff. The main negative point is the fact of having *consecutive* red days without the possibility of knowing in advance.

Conclusion

In the previous monopolistic situation, tempo has been successful.

Today, in a deregulated market, tempo might become less suited to this new context and maybe less attractive for customers. In an open market, if EDF needs to manage its global load curve, it will probably have to define other types of dynamic prices for mass-market customers. Until now nothing has been announced. Nevertheless the *tempo* feedback will be very useful for the definition of new contracts including supply and services.

3.3.4 Implementation of Demand Side management in Oslo (Norwegian Pilot 1)

Overview and objective

The main objective was to postpone grid reinforcement with use of DSM (energy efficiency actions). To postpone two planned grid reinforcements, the pilot project was to achieve 10-15% peak load reduction in two different grid-areas. The second objective was to increase knowledge about electricity customers behaviour and compose a motivation model that can be used by the grid-owner and his coadjutant partner for energy economising. This motivation model should prepare for establishing appropriate routines for DSM within the grid-owner organisation.

Main task for removing barriers:

- For the customers: Through dialogue with different kind of commercial and household customers feasible barriers, which can effect implementation of energy efficiency actions, were mapped. Motivation analyses and model tools were made. The analysis deal with barriers connected to owner structure/organisation, type of customer, type of actions, cost-benefit from the actions and different ways (besides tariff) of affecting customers energy consumption.

- For the grid owner: Through a continuous dialogue between the project group and the staff working with grid reinforcement, there is made a recommendation for how to make use of the project results within the grid owner's organisation.

Project methodology

DSM action as an alternative to grid reinforcements is solely based on cost-benefit:

$$\Sigma\, C_{DSM} \leq \Sigma\, C_{Grid\ reinforcement}$$

Where:

$\Sigma\, C_{DSM}$ – the utility's total cost concerning implementing DSM actions

$\Sigma\, C_{Grid-\ reinforcement}$ – the utility's total cost concerning grid reinforcement actions

In its simplest way, the philosophy is based on the fact that every shortage of electric capacity can be approached by either reinforcing the already existing distribution network to meet the future demand, or on the other side try to adjust the consumption to the capacity that already exist. The latter means implementing DSM actions. The way to go, are simply decided from a cost-benefit analysis, where all costs concerning the alternatives are taken into account and the cheapest alternatives are chosen.

In several cases, DSM actions are profitable compared to conventional grid reinforcements. However, for the utility, one has to make sure that the actual DSM actions serve as remedial actions concerning capacity problems in the distribution systems

This meaning that the utility has to make sure that all suggested actions are followed up and actually implemented with the customers. All experience shows that customers have to be strongly motivated to implement energy efficient actions, in spite of the fact that the customers will reduce their own costs.

Planning and design for conventional grid reinforcement actions are well described tasks with predictable parameters. However, DSM actions represent an approach where the methodology and parameters included are not so well defined.

The results gained throughout the project have given valuable experience concerning procedures, methodology, possibilities and barriers for carrying out energy efficient actions.

Based on project experiences, a working process for the network planning considering DSM was established.

Two different smart house concepts (DSM-actions) for residential customers were tested for respectively 156 blocks of flats and 17 semi detached houses. The achieved reduction of peak power consumption was up to 15% of historical maximum metered peak load (kW). Energy savings (kWh/year) were metered from +9% (increase) to -18% (reduction). The variation in the results was dependent on how the customers adjusted the smart house equipment as well as changes in the households' electrical equipment.

Within a certain city area of Oslo, energy efficiency actions (DSM actions) were tried initiated among 40 commercial customers. Typical energy efficiency actions which were included in the project were replacement of electrical energy carriers, building automation systems, renovation and maintenance of buildings, installation of new and more energy efficient equipment. Before ending the project in 2001, 13 out of 40 customers started or were finished with implementation of the recommended energy efficiency actions. These implemented or planned implemented actions involved a total peak load reduction, which was divided in two different grid areas. For the two transformer substations supplying the actual customers it was estimated a peak load reduction of 3.7 MW (11%) from the existing 34.2 MW (substation 1) and 0.8 MW (3%) from existing 25.0MW (substation 2). The 13 customers have an estimated peak load at 15.7 MW. This implies an aggregated peak load reduction of 28.4% (4.46 MW) expected achieved within the end of year 2003. For the 13 customers, it is also estimated an expected energy saving at 25%, equivalent to 14.7 GWh/year.

Conclusions and recommendations

In several cases, DSM actions can be proved to be profitable compared to conventional grid reinforcements. But to be profitable to the network company it must be ensured that the actual DSM actions serve as remedial actions concerning capacity problems in the distribution systems. To achieve this, the means which are used have to comply with the incentives and goals among both the Network Company and the customer. All experience shows that customers have to be strongly motivated to implement energy efficient actions, in spite of the fact that the customers can save money for themselves.

Through comprehensive studies in Oslo a methodology for implementing DSM actions as an alternative to grid reinforcements has been developed. A pilot study in a random grid area in Oslo, shows a general potential for energy saving and peak load reduction of 10-15%. This potential is related to a wide type of measures, among them installation of new equipment, replacement of electrical energy carriers, renovation of buildings and installation of smart house solution. There is a similar potential in Oslo among residential customers related to electrical heating and electric boilers. The time horizon for realizing DSM actions is empirically 3-4 years for commercial customers and 1-2 years for residential customers.

Implementation of DSM actions depends on several motivation key factors, such as “ownership vs. rent of premises”, “cost allocation”, “contact persons and decision-making process”, as well as financing solution for the DSM actions. All energy efficiency actions which were implemented in the pilot studies were profitable to the customer. However, the cost-benefit incentive was not always the most vital incentive for the customer to accomplishing DSM actions. The network tariff which makes about 20-40% of the total electricity cost, affects the majority of the motivation key factors. Even if the customer received additional subsidies of energy auditing and energy efficiency actions, the network tariff in most cases seems to be the strongest incentive for accomplishing DSM actions.

To what extent DSM actions is accomplished in certain grid area, as well as the time horizon for implementation, depends on key motivation factors and how these are being exploited.

3.3.5 New technology for Controlling of Power load in Oslo (Norwegian Pilot 2)

Overview and objective

The main objective of this pilot is to initiate remote control of minimum 2 MW power load among various categories of commercial customers. The power load is to be controlled in limited time period and shall not be ordinary interruptible power loads such as electric boiler with back up systems. The power load that is to be controlled shall be defined as uninterruptible consumption according to the existing Network tariff or in other words defined as design load of the grid capacity. The grid owner in the project will initiate implementation of necessary actions among the commercial customers through offering new network tariffs. Necessary actions will be implementation of new technology for smart house and building automation or other solutions for remote control of single power loads. The project will also gain knowledge concerning “what makes the customer carry out the necessary actions?”

Project methodology

Compared to the methodology used in pilot 1, “Implementation of DSM in Oslo”, this pilot only focuses on technical solution for load control and the means needed to make the customer allow the Network Company to remote control different loads. The project has selected a random group of commercial customers with historical peak load above 800kW each and with location in the eastern part of Oslo. The focus in this project is to find solutions of remote control of power load, which do not interfere with the customers' activity. There are several challenges to face because the activities among the customers vary from furniture sale, copper melting, and water supply, engineering work to operating an outdoor skating rink. When finding smart-house solutions to control different power loads which hardly ever have been controlled or interrupted before, the methodology for convincing the customer is vitally important. In most occasions it is the customer himself who knows best the vulnerability of the power loads and most customers will be more or less sceptical of any changes of the normal activity. Therefore, the project has focused on the methodology of presentation of the new network tariff, as well as designing a tariff that makes the customers invest in the necessary smart-house solutions for load control themselves.

Conclusions and recommendations

A considerable potential for controllable power load is documented among 7 out of 14 customers. These 7 customers have a total maximum peak load of 18.1MW and are offered a new pilot tariff from the Network Company. The potential for controllable load among the 7 customers is estimated at 8.8 MW or 49% referred to maximum peak load. The new pilot tariff shall give the customers cost-benefit incentive for investing in load control solutions, as well as giving incentive for letting the Network Company remote control the particular loads in limited time periods. Preliminary results in 2004 show that two of the 7 potential pilot customers will enter a new pilot tariff agreement.

Some of the main objectives in this pilot study have been to examine the barriers related to convince the customer to permit remote load control by the Network Company and the barriers related to make the customer himself invest in load control solutions (smart house solution). The loads that the project seek to acheive controlled are vulnerable loads, mostly without any back-up system. These loads have hardly ever been remotely controlled before. To acheive this, the project have tried to give the customer the necessary incentive through a new pilot network tariff. The following main barriers have been discovered in this study of different customers (enterprises) with very different kinds of loads:

- <u>Duration of load control</u>
  One of the most important barriers is related to the duration interruption or downward adjustment of loads

- <u>Time of rest between each load control</u>
  The time of rest between interruption is a critical barrier in all of the 7 cases of load control studied in this pilot.

- <u>Number of interruptions</u>
  The number of interruptions or downward adjustments of loads during each day, week, month or each year is critical for some of the customers.

- <u>Alert before load control</u>
  Through dialogue with the customers the project has experienced that for some customers it is difficult to decide whether an alert before load control is needed or not. It is often difficult to distinguish between a psychological barrier for cutting loose from the way of operation to day and the actual possibilities or limitations of the controllable load.

- Technical solution for load control

  In some cases, finding the technical solution for load control can be the most difficult barrier of them all.

- Consequense of a possible failure of re-connection after load control

  Another important barrier to most of the customers are consequences from any signal failure that might occur when the particular loads are beeing connected after the interruption have taken place.

- Extraordinary operational situations

  For some customers extraordinary operational situations might be a big barrier to realize any kind of remote load control, this, even if the probability for such a situation is very small.

- Organizational, ownership, business management og psycological barriers

  Barriers related to company organization, ownership, business management and psychology obviously have been cardinal for the customers decision. These issues have not been deeply studied in this pilot.

- Sufficient cost-benefit through the Network tariff

  Vital for all of the customers are the cost-benefit of the necessary investments for load control reflected from the network tariff. This barrier has been the main discussion subject during all meetings with the customers.

Designing the optimal network tariff that complies with the above-mentioned barriers, as well as presenting the network tariff in an educational way to customers with very different activities seems to be the main challenge. Knowledge about the customers' activities and decision making processes, as well as focus on the financial benefit in an alternative tariff appears to be the best way to meet this challenge.

3.3.6 Consumer flexibility by efficient use of ICT (Norwegian Pilot 3)

Overview and objective

Due to very tight peak power balance in the Nordic power system, and with hardly any investments in new production, focus has turned towards emphasis to encourage manual or automatic demand response, which implies need for hourly metering for documentation, and controllability in order to meet the response requirements. The Norwegian pilot 3 involves establishment of Direct Communication (two-way communication), including hourly metering and separate channel for remote control, to altogether 10 894 customers in two different network areas.

The objective is to increase the end-user flexibility in periods with scarcity of electrical energy and power by:

- Establishing a decision basis and suggest external conditions for a prioritised building of an infrastructure based on ICT-solutions for direct communication and load control.
- Develop, test and evaluate different incentives, which stimulates to flexibility in consumption, with basis in network tariff, power products and other market solutions.

The implementation of direct communication started spring 2002 and was completed by October 2004. Automatic meter reading, remote load reduction and the demand response to ToU network tariffs and hourly spot price energy products from the suppliers were tested in the main test period 1 November 03 – 30 April 04.

Achieved results and key figures

<u>Technology</u>

Technology and communication from six different vendors are used in the pilot. There were experienced more problems than expected from all the vendors, both the large international concerns as well as the smaller Norwegian companies. Previously, Direct Communication had been established to relatively few large customers. This project has shown that establishment of technology to many smaller customers is more complex.

In general, errors occurred in all the systems and in all parts of the systems. Examples of problems or deficiency with the technology were:

- GSM modems that frequently went into a blocked mode.
- Different versions of a system that did not work together.
- Insufficient communication from radio antennas that were mounted inside the fuse box.
- Systems that were programmed from factory with wrong parameters
- Too long response time for remote load control for some customers.

However, the lessons learned in the project indicate that there is a potential of improvements. The technology will probably be improved as a consequence of the project.

Demand response

Table 4 shows the registered response of the involved customers in the two network areas.

Table 4 Average load reduction in the peak hour

Test description	Network Operator I	Network Operator II
Remote control (Disconnection of water heaters)	~0,5 kWh/h	~0,57 kWh/h
Tou energy tariff (price difference high/low load: ~0,125 €/kWh)	~0,18 kWh/h	~0,18 kWh/h
Hourly spot price	~0,6 kWh/h	~0,4 kWh/h
ToU + Hourly spot price	~1 kWh/h	~0,3 kWh/h

Cost/benefit and recommendations

As expected the cost/benefit analysis performed for the network owners involved gives negative corporate profitability of investments in direct communication. The costs (C) includes both investment and operational costs and the benefits (B) are related to more efficient meter handling, postponed network investments and more accurate accounting. The average figures were:

C= ~94 €

B= ~24 €

Net present value (NPV) = B – C = ~-70 €

It is important to note that these figures also include extra ordinary costs due to problems with technology. These costs will probably be reduced when the technology is better tested. Research and development can also contribute to more well-working technology, i.e. standardization of interfaces between Direct Communication systems and other IT-systems like Customer information systems etc. Also the operational costs can be reduced considerably. Additionally, improved utilisation of the technology will make it possible for the network owner to raise the benefit figures.

Consequently, the potential of improvement of the network owner cost/benefit is significant. However, financial contribution from the authorities and/or other stakeholders (suppliers, customers) seams to be needed to secure the project economy.

The following additional benefits are identified in this project:

- Society: Environmental benefit due to reduced need for new production and power lines
- Supplier: Reduced risk in the power market and improved customer relations

- Customer: Potential of electricity cost reduction

This implies that the society via regulations should promote establishment of the investments in Direct Communication that are proven socio economic beneficial. Additionally arrangements for payment from other actors to the network operator should be developed.

Recommendations for further development of Direct Communication to smaller customers (<100.000 kWh/year), based on experiences from the pilot test:

- The technology should be prepared for hourly metering and remote load control.
- The quality requirement of automatic metered data should be defined.
- Market based solutions for load control should be further developed.
- ToU tariffs and hourly spot price products should be offered to all hourly-metered customers.
- Implementation of technology for remote load control should be implemented stepwise, based on target figures from the authorities (for example referred to the yearly increase in peak load).
- Subsidies from the authorities should be considered. The subsidies should be limited to the cost of alternative investments in power (in Norway equivalent to the cost of an extra kW in an existing hydro power station ≈ 25 €/kW/Year).
- Tender procedure is recommended to promote cost effective solutions.
- Further development of technology for Direct Communication should focus on:
  - Standardisation of interfaces
  - Quality assurance of meter values in customer information systems and meter value databases.
- A Nordic coordination of authority regulations is necessary since all the Nordic countries benefit from flexibility in electricity consumption.

4 Conclusions and recommendations

The results and conclusions from the different phases of the EFFLOCOM project and from the parallel national pilots are presented in the previous chapter. On this background, and with reference to the national framework for the participating countries and the proposed EU directive on energy efficiency and energy services described in chapter 2, the EFFLOCOM project group has agreed on the following general conclusions and recommendations with focus on Demand Response (= load reduction of limited duration, from one to a few hours).

A. Load profiles and demand response potential

From the load curve analyses, including studies of total system load as well as customer category hourly load profiles from six countries: Denmark, Finland, France, Norway, Sweden and UK (England and Wales) we have learned that:

- All the involved countries have quite high temperature sensitivities during spring and autumn, being the result of electric space heating. Some countries show positive temperature sensitivities during summer – a result of cooling and air conditioning.

- For all the involved countries the consumption is higher during winter than the other seasons. This can be explained by use of electric space heating and use of lighting during the cold and dark season. France and UK, that have moderate temperatures during winter, also show a much higher demand during colder seasons due to less restricted building codes, and fewer requirements for insulation standards of buildings.

- All the involved countries show a big difference in the day profiles for working days compared to weekends.

- All the involved countries show reduction in the load during nights. All countries have two high activity periods during working days, one in the morning and one during evening. No radical changes in temperature sensitivity, peak load profiles, utilisation factors and distribution of annual energy consumption caused by deregulation are found.

- A large potential for demand response/load management in the industrial and the residential sector are found for all the involved countries. Estimates of the sector vice potential is available only from the Nordic countries where about 10-20 % of the peak load is reducible on hourly basis provided that the needed technology and economical incentives are in place. The load duration curves for all countries show that 5 % peak load reduction could be achieved by concentrated demand response efforts in 20-75 hours.

- Peak load reduction in one Nordic country gains the whole region due to high degree of coincidence in the peak hours.

Recommendation:

I. The potential of demand response should be identified for all countries.

II. Country based targets for annual released demand response potential, e.g. referred to yearly increase in peak load, should be considered as a supplement to the proposed EU Directive on energy efficiency and energy services [10] , Chapter II, where "Energy Saving Targets" for the member states are recommended.

B. Enabling technology

New technology for metering, direct communication for automatic meter reading and remote load control, together with web-based services for customer information and communication, makes utilisation of reducible loads more feasible.

The technology for direct communication used in the pilot tests has shown too low quality Further development and testing of equipment is necessary to achieve cost effective solutions and quality, required by the power market, of transferred meter values.

Standardisation of the interfaces involved in the Direct Communication system and between this system and other IT-systems, like customer information systems and meter value database, is needed.

More frequent metering of a major part of the total load is needed to promote market based demand response:

- Hourly metering is needed to give incentives to load reduction in peak hours (capacity shortage).
- Weekly or monthly meter reading is needed to favour load reductions in periods with energy shortage.

The experiences with remote load control on price criteria in the Danish and Norwegian Pilot 3 were good. The concept provides automatic price elasticity in the market without continuously involvement from the customers.

Web-based solutions give a lot of opportunities for customer information and communication:

- Information of load control options, network tariffs and power products
- Display of customer metered time series and current electricity costs
- Interface to load control systems

So far investments in technology have been limited of economical reasons because the different actors do not find profitability alone. More cooperation between the stakeholders and regulatory arrangement are needed to secure that projects that are proven socio-economic beneficial will be accomplished.

Recommendation:

III. Improvements of Technology for metering and load control is needed

IV. Standards for the interfaces in "the meter value chain" should be defined

V. Hourly metering, alternatively weekly/monthly metering should be required by regulation

VI. The concept of market based automatic load control, e.g. when spot price exceeds a predefined limit, should be further developed.

VII. Economical incentives for a cost-effective development of infrastructure for automatic meter reading and load control should be provided through regulations from the authorities

VIII. Stable regulations and tax policies from the authorities are needed to reduce the regulatory risk of investments.

C. Incentives for demand response

In a deregulated environment the electricity price paid by the customers consists of the following elements:

- Network tariff (from network owner)
- Energy price (from the supplier)
- Taxes (from the authorities)

The following price signals give the best motivations for load reduction in peak hours in a deregulated market based system:

Network tariffs:

- Time of Use -tariffs with inter day variations in price
- Dynamic tariffs that are amplified in periods with shortage

Energy Price:

- Hourly spot price
- Hourly spot price combined with automatic load reduction when the spot price is high
- Time of Use -price e.g. with day /night variation

The taxes represent in most cases a major share of the electricity bill. In case the tax is a fixed price independent of the consumption, this represents a barrier for more extended use of price variations provided by the network tariffs and energy prices mentioned above.

Bilateral contractsfor load reduction are proven efficient options for reserves and reliability purposes. Mainly larger industrial loads are used. An option market for reserves designed by the Norwegian TSO has led to increased demand side participation in the balancing market.

Recommendation:

IX. Time of Use tariffs and spot price energy products should be offered to all customers.

X. Bilateral contracts for load reduction should be further developed for reserves and reliability as well as demand side bidding purposes. Both industry and smaller aggregated loads should be involved.

REFERENCES

[1] EFFLOCOM report no. 1: “Phase 1 – Basis for Demand Response”

[2] EFFLOCOM report no. 2: “Phase 2 – Influence of Competition on load curves”

[3] EFFLOCOM report no. 3: “Description of Technology for Direct Communication”

[4] EFFLOCOM report no. 6: “Incentives for load reduction and for Investments in Infrastructure and Technology”

[5] EFFLOCOM report no. 7: “Results from the EFFLOCOM Pilots”

[6] "An energy-efficiency policy - Problems, barriers and possibilities" Peter Bach, ECEEE 2001 Summer Study Proceedings

[7] FOR 1999-03-11 nr. 301, Norway, “Regulation for metering, settlement and coordinated behaviour for power trading and invoicing of network services”.

[8] White paper 41 (2002-2003), Norway, “Tariffs for distribution of electricity and two-way communication”.

[9] White paper 18 (2003-2004), Norway, “Concerning security of electricity supply etc.”

[10] “Proposal for a Directive of the European Parliament and of the Council on energy end-use efficiency and energy services” /* COM/2003/0739 final - COD 2003/0300 */ 10 December 2003
The complete text can be found on:
http://europa.eu.int/comm/energy/demand/legislation/end_use_en.htm.

[11] www.efflocom.com