E F F L O C O M

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

EU/SAVE 132/2001

Description of the EFFLOCOM Pilots

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Energy Piano	Partner 4	Denmark
EDF	Partner 5	France
E-CO Tech	Partner 6	Norway

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1 Objectives of the Pilots

Phase 4 of the EFFLOCOM project is dealing with the problems how to remove barriers for energy efficiency and load curve impacts in competitive market. In practice Phase 4 quantifies the potential for load impacts related to Smart-house technology, dynamic tariffs and web based energy efficiency information through pilot studies.

According to the project plan phase 4 will consist of several different pilot cases studying different means to improve energy efficiency:

1. *Smart-house technology:* A Smart-house system involving central load management based on Internet will be tested out with commercial customers. The potential for energy reduction and peak power reductions will be estimated for the customers prior to the testing in order to target the pilot study to the appliances with the largest potential. Relevant appliances include electric boilers, heating cables, processing plants and ventilation. In addition, a tool that will be developed and tested undertakes end use metering at domestic appliances. A questionnaire among 25 domestic customers that have participated in a home automation project including DSM incentives will be evaluated.
2. *Dynamic tariffs:* Analysis of the load profiles from a sample composed of 450 customers with the tempo tariff over a period of 4 years. Customers with the dynamic tempo tariff are measured by 10-minute intervals. In addition the project will include TOU tariffs for larger customers. For nearly 10 years larger customers in Denmark has used time of day tariffs with shifting between peak, shoulder and valley prices over the year, week and day. Experience on which customers benefit from this kind of tariff will be analysed.
3. *Web based energy efficiency information:* Two different types of web based energy efficiency services will be tested out in the project. Customers can follow their consumption on the web. One of the systems includes comparison of different offers where the customer can change supplier.

The following chapters describe the actual pilots related to the above means in Denmark, Finland, France and Norway.

Table 1 gives the summary of the pilots.

Table 1 Summary of the pilots.

Pilot/objectives/technologies	Responsible Partner
Hourly metering with two-way communication and web-based interface for control and following consumption *The objectives of the Danish pilots are 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 and demand response*. • *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.* *Technology is based on* • *Two-way communication (GPRS, internet)* • *Remote meter reading and smart house* • *Web*	Energy Piano
Effect of web-based feedback on the electricity consumption and load curves *The main objective of the pilot is to study what effect the improved extranet-based information on energy consumption has in the real-estate and household energy and water consumption in terraced houses and in the block of flats.* *Technology is based on* • *Remote meter reading of hourly data of total electricity consumption and real estate electricity consumption (household consumption can be calculated) as well as of water and heat (district heat) consumption.* • *Extranet-based feedback on consumption is given to building energy managers and partly also to final consumers*	VTT
Tempo tariff feedback at EDF *Main objective is to study the effect of dynamic tariff tempo on the electricity consumption.The tempo option divides the year into three types of random days: 300 blue days (the least expensive), 43 white days (medium price), and 22 red days (the most expensive). Each day is divided into two fixed periods: peak hours (day) and off-peak hours (night). The colour of the day is chosen by the national operating system at the end of each day for the next day.* *Technology of the pilots include* • electronic meters • a notification equipment fit to inform the customer about the tariff of the present day and of the day after • energy management systems • ripple control (one-way communication technique for sending tariff signal using the electric power lines).	EDF
Implementation of Demand Side management in Oslo *Main objectives are* • *to avoid/expose planned grid reinforcement with use of DSM (energy efficiency actions) and* • *to increase knowledge about electricity end-users behaviour and compose a motivation model that can be used by the grid-owner and his coadjutant partner for energy economising.* *Technology includes* • *the smart house solution based on Internet and wireless radio communication and* • *the Ebox "plug and play" units implemented among residential end-*	E-CO Tech

Pilot/objectives/technologies	Responsible Partner
users containing a switch, a radio receiver, a thermostat and a clock.	
New technology for Controlling of Power load in Oslo *Main_objective of the project is to initiate remote controlling of minimum 2 MW uninterruptible power load among various categories of commercial customers. The grid owner (project) shall initiate implementation of necessary actions among the commercial end users through offering new tariffs related to controllable or interruptible load.* *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 shall also gain knowledge concerning "what makes the end user carry out the necessary actions?"*	E-CO Tech
Consumer flexibility by efficient use of ICT *The objective of the 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 ICT-solutions for direct communication and load management.* • *Develop, test and evaluate different incentives, which stimulates to flexibility in consumption, with basis in network tariff, power prices and other market solutions.* *The technology of the project involves establishment of Direct Communication (two-way communication), including hourly metering and separate channel for remote control, to altogether 10 000 customers in 2 different network areas.*	SINTEF

2 Danish Pilot. Hourly metering with two-way communication and web-based interface for control and following the consumption

2.1 Introduction

Danish participation in the EU SAVE project EFFLOCOM as well as the Danish demand response pilots are sponsored by Elkraft System and ELTRA. Results and conclusions from the Danish pilots will be available for the EU EFFLOCOM project.

2.2 Objective of the Pilot

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 pilots includes establishment of Direct Communication (two-way communication) including hourly metering and Web interface for control and following the consumption. To types of pilots are performed:

- 25 domestic homes with direct electrical heating
- 10-15 commercial customers within different customer categories

The objectives of the Danish pilots are 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 and demand response.*
- *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.*

2.3 Partners and target group

Energy piano manage the Danish project with reference to and co-operation with the system operators Elkraft System and ELTRA.

The pilot including domestic customers with direct electrical heating is carried out in close co-operation with a grid company, who is largely involved in finding customers for the pilot and responsible for installation of the equipment.

The manufacture Amplex A/S is providing equipment for the 25 domestic customers with direct electrical heating and will take care of the remote reading as well as the WEB costumer interface for individual set up of boarders for the demand response.

The company IT Energy develops and runs the WEB server providing daily updated reports for the customers containing their consumption per day and month and the saved bonus by control.

Concerning the pilot including commercial customers, the system operators invited in Spring 2003 all Danish suppliers to participate with customers having a spot price related tariff. Customers and utilities are for the time being identified. This pilot might also involve the companies responsible for power balance in the areas where he customers are situated.

2.4 Technology

The IT configuration for domestic customers is making use of GPRS and Internet communication. The configuration for the commercial customers is similar but without automatic control. GPRS is used for communication to the load control equipment Amplight. Amplight is storing the load per hour or quarter of an hour and proving possibility for control of five zones. A Web application is providing the customer possibility for setting up limits for the maximum duration of interruption for the different control zones. The Web is also used for reporting to customer on the daily and monthly use of electricity and the saved bonus by control.

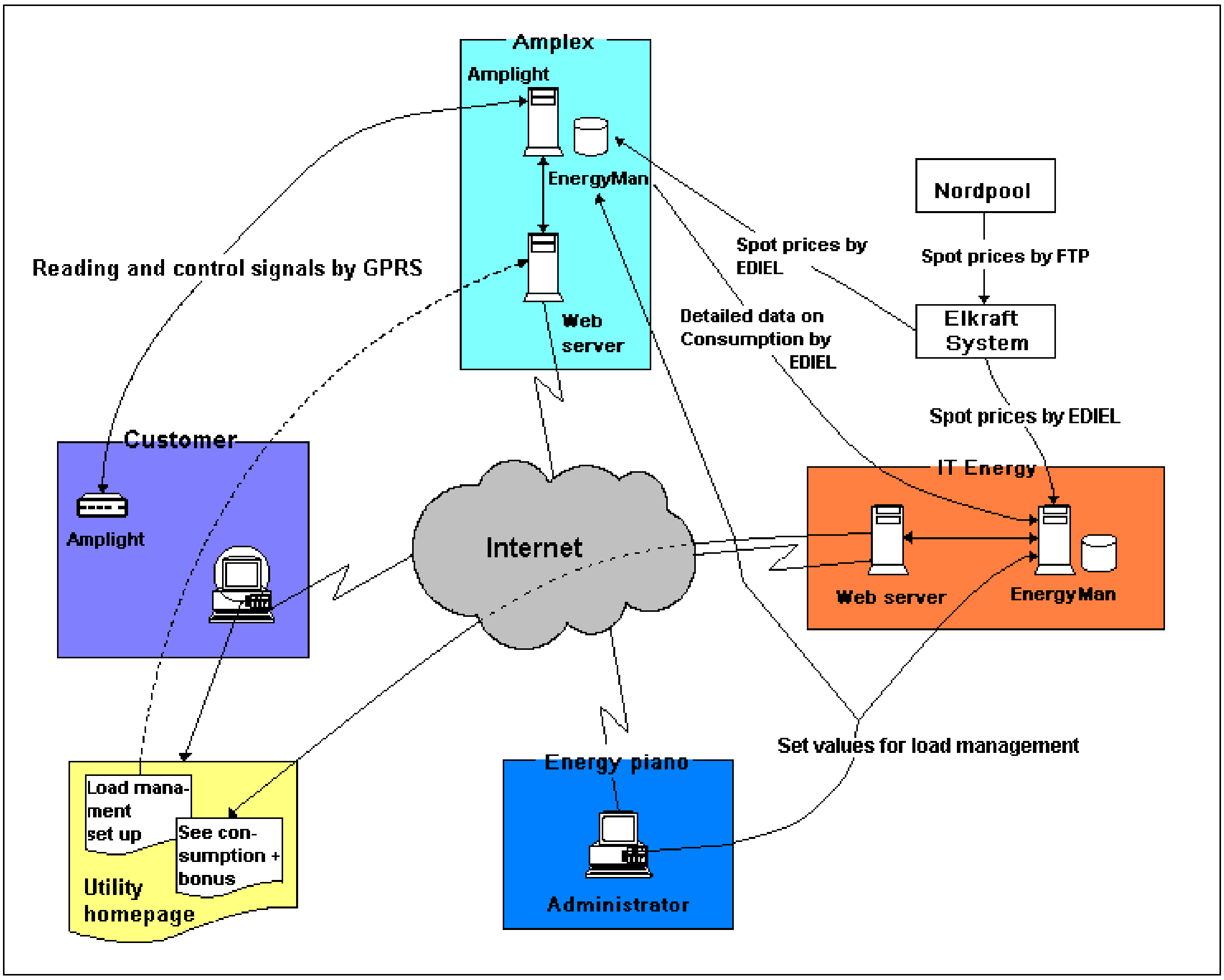

Figure 1 IT configuration in the Danish pilot for domestic customers with direct electric heating

2.5 Methodology

Prices at the market place Nordpool are studied. Actually the yearly need for demand response includes around 12 hours per year. In the pilots is simulated a near future situation with 100 hours need for demand response. In the project, the economical incentives for demand response are higher than the actual level simulating a situation expected to be meet within few years. An overview of technology for two-way communication for smaller customers is drawn up. Internet based Web services are developed as a part of the two-way communication. The customer load curves are studied in order to set up simple models for the reference consumption to compare with during days with demand response periods.

2.5.1 Previous research

The following research work is relevant:

- The yearly peak load in Denmark is around 6.000 MW. Analysis of the potential for demand response expose different ways and potential which can be combined making it possible to reach 10 % of the maximum load equal to the 600 MW.
- Time-of-use tariffs including daily and seasonal variation has been in use for more than ten years. In total, the tariff has only resulted in small changes in consumption but some customer categories have been able to take benefit of the tariff in a large scale.
- Elkraft System is financing a third pilot started in 2001 including two very large industrial customers: a cold store and a natural gas storage.

2.5.2 Internet based services

Internet is a universal channel for communication and represents a potential for two-way communication between customers and the players in the power markets. These properties gives the opportunity to add additional services to the traditional two-way communication, which is establish in the pilots:

- Information the day before at 4 pm when the next day contains demand response periods.
- Web application where the customer can follow the consumption on a daily, weekly or monthly level along with the economical savings generated.
- Web application for the domestic customers with direct electrical heating making it possible for the customer to set the maximum length of the interruption in the home dependent on: zone (rooms or electrical water heater) in the home, outdoor temperature and time of day.

2.5.3 Price signals and criteria for load reduction

In Denmark the customers are paying for electricity by a network tariff from the Network Company and an electricity price from the supplier. The customers are free to choose supplier and a lot of customers receives two separate bills in case they have shifted supplier.
The network tariff in Denmark is actually a time-of-day tariff with three prices during the day where the highest price nearly is coincident to the demand response periods of the day. The pilots are not related to the network tariff.
Hourly metering and the potential of load control in peak hours give opportunity for new products from the supplier of electricity. When customers dynamically are reducing their cost by load reduction in demand response hours the power supplier is able to reduce the risk connected to periods with huge fluctuations in spot price.

In the pilots, the demand response periods are related to the actual development in the spot price at Nordpool. A near future development at the market place is simulated by transferring the actual spot prices to a situation with 100 hours demand response hours with the following saving: 40 hours of 0.13 Euro/kWh, 30 hours of 0.27 Euro/kWh and 30 hours of 0.40 Euro/kWh.
For practical reasons the savings option by demand response will be paid to the customer separate from the billing. This too gives a benefit in form of more exposure.

2.6 Time schedule and reporting of the pilots

The pilots are running from Sep. 2003 to Sep. 2004. The main testing activities are carried out in the winter 2003/04.
A questionnaire will be executed in the summer 2004.

- Reporting on the pilots will include:
- Quantification of demand response from different kinds of customers
- Savings for different kind of customers
- Cost of technology
- Potential of cost reduction in large and due to new technology
- Cost-benefit for different kind of customers
- Customers attitude to demand response

Success in the pilot project may form the way for a future large scale testing of equipment, data flow and load reduction will take place in close cooperation with suppliers and network companies.

3 Finnish Pilot: Effect of Web-based feedback on the electricity consumption and load curves

3.1 Objectives of the pilot

Small customers receive usually feedback of their electricity consumption in the form of a bi-annual or tri-annual electricity bill. This is not very informative and accurate and only states the total consumption. The real-estate consumption in terraced houses and blocks of flats, which may include yard and staircase lighting, common sauna, etc., may not be followed at all.

In this study the effect of feedback to the people who can affect consumption decisions at the building level is studied. The ability to see the hourly load curves instead of just total consumption from a longer period may have effect on how electricity is used.

The main objective of the pilot is to study what effect the improved extranet-based information on energy consumption has in the real-estate and household energy and water consumption in terraced houses and in the block of flats. Especially changes

- in the level of energy consumption and
- in the load shape of the electricity consumption are studied

The barrier to be reduced is the lack of information

3.2 Partners and target groups

The main partner of VTT is VVO, the Finnish housing company who owns and manages about 1100 buildings with 40100 households in Finland. The daughter company VVO Sähkö (VVO Electricity) acts as electricity supplier to the buildings and to the most of the households in buildings. The consulting and expert firm Suomen Talokeskus Oy is involved in gathering and administrating the consumption data. Internet-portal developer company is acting as a subcontractor in developing web-based portal.

Some 30 buildings owned by VVO have been taken into the pilot. Their electricity consumption in 2001 was some 1.5 GWh. The customers could not be freely chosen into the study because not all customers were equipped with hourly consumption measurement. The main selection criteria for pilot groups were

- some homogeneous group (building types: terrace houses, block of flats), groups large enough for statistical analysis
- age of buildings
- available historical data on consumption > 10 years on monthly bases
- available hourly data on electricity consumption of buildings at least from one year (in most cases from 2 – 3 years) before the pilot phase

The whole electricity consumption of the buildings managed by VVO is about 150 GWh, from which 50 GWh is the real estate consumption and the rest 100 GWh is consumed by the households.

The main target groups in the pilot are the so-called energy experts who are the persons living in the target buildings and who are educated to take care of the energy questions in their buildings. The secondary target groups are the households of the buildings

The general target group of the project is the residential sector, especially housing units that comprise several apartments, i.e. terraced houses and blocks of flats. The size of the target groups depends on how many housing corporations want to acquire their electricity from the competitive market. The corporations must in most cases install hourly consumption meters and feedback is thus possible. In 2000 the residential sector used about 9 TWh electricity in Finland, excluding space heating.

3.3 Technology

Electricity consumption is measured on-site in buildings. Electricity consumption is measured on hourly bases in buildings including

- total electricity consumption and
- real estate electricity consumption
- (household consumption can be calculated)

In addition, automatic hourly measurements of water and heat (district heat) consumption is made. The measurements are remote-read into a database controlled by Suomen Talokeskus oy.

Monthly feedback reports have been available from the database through the web to energy experts assigned to each building since 1999. These include the monthly consumptions of electricity, water, district heat (MWh), cooling of disctrict heat water (degrees). The values can be compared to the values of the previous year and normalized with respect to temperature. Automatic graphs are available. In practice, experts don't have usually used web, but the printed reports have been delivered to the energy experts.

At the moment the hourly consumption data is also available next day after operation day to the experts.

During the pilot project

- The format and content of feedback information will be further developed including advice to improving energy efficiency as well as the use of the data through web is improved and
- the feedback to final customer as a part extranet will be developed and tested

3.4 Methodologies to measure and analyze the effects on customers

The hourly electricity consumptions are measured from each housing unit. A housing unit may comprise several terraced houses or blocks of flats and dozens of apartments. Load curves are calculated from these measurements by grouping the housing units into suitable groups. The grouping may be based on the type, facilities or resident profiles of the housing units. For the purpose of grouping background information is collected from the housing units. These include the number of apartments and residents, resident mean age, floor area of apartments, type of buildings, electrical appliances installed, etc. Temperature measurements must be obtained to normalize for temperature. Changes in load curves and in consumption level are studied as a result of information given to energy experts and households. Questionnaires to the energy experts can useful in asking the experts' own opinion on how the feedback has changed the use of lighting, air conditioning, common sauna, resident car heating, drain pipe heating, etc. Economic analysis are carried out on energy/money saving possibilities on the basis of results. Since electricity is a relatively small cost to residents in apartments that don't have electric space heating, it is unlikely that feedback, if given to residents, would cause dramatic changes in resident consumption.

3.5 Time schedule and reporting

The pilot lasts for two years. Hourly consumption measurements are made since winter 1999–2000, in some buildings since spring 2000. Measurements are continued until spring 2004. Monthly measurements are available since around 1992. Housing units were chosen to the study in October 2002. Background information was collected in November and December 2002. In summer 2003 the improved use of web by experts (including hourly data) is started and at the same time the development of the new customer portal including feedback of energy consumption is started. The analysis of the effect of improved information will be carried out in spring 2004 and the final reports are delivered during summer 2004.

4 French Pilot: Tempo TARIFF FEEDBACK AT EDF

4.1 The context

In a monopoly situation, two basic principles underlay EDF's tariff policy:

- equality of treatment. That means that all customers with the same utilisation characteristics are offered the same rate;
- economic efficiency implies passing on to each customer the costs that he occurs to the power system.

Consequently the tariffs had to be a true image of electricity supply costs.
Before the 80's EDF used to propose:

- to industrial and commercial customers: seasonal day tariff (from 2 to 4 periods in a year, and from 1 to 3 periods in a day);
- two options to residential customers: a single tariff (one single price all day and year long), and off-peak hours (every day lower price for 8 hours).

Nevertheless these fixed periods did not allow coping with random factors (weather, generation failure…). Typically the increase of thermal uses has made the daily consumption very sensitive to the temperature.
Two options had been successively proposed to residential customers:

- the option named with the French acronym EJP (Peak Day Withdrawal) was made up of 2 types of days
  - ➢ 22 mobile peak days with a very high rate for 18 hours
  - ➢ other days with a low rate all day long.

  This option is no longer proposed since 1996
- The *tempo* option that divides the year into three types of random days: 300 blue days (the least expensive), 43 white days (medium price), and 22 red days (the most expensive). Each day is divided into two fixed periods: peak hours (day) and off-peak hours (night). The colour of the day is chosen by the national operating system at the end of each day for the next day.

The innovative nature of *tempo* has required the deployment of major technical and commercial means.
Consequently we can consider 3 main different steps:

- Experimental step (1989-1992)
- Launching step (1993-1995)
- Generalization, (after 1995)

This document presents both the experimental and launching steps.

4.2 Step 1 - Experimental Step

Before launching the *tempo* option (1995), EDF organised an experimentation (between 1989 and 1992) in order to evaluate customers' reaction to prices and satisfaction level.

4.2.1 Who are the partners?

Several departments within EDF (economic, technical, sociological, commercial, statistical…),

4.2.2 What are the target groups?

Different customer classes have been defined according to their heating system, typically:

- only electric space heating
- electricity space heating and wood-burning fire place
- dual energy system (electricity + oil)
- heat pumps
- without electric space heating.

4.2.3 Pilot size

800 customers in 6 different geographic regions (Alsace, Lorraine, Massif-Central, Rhône Alpes, Poitou-Charente, Ile de France).

4.2.4 Technology in pilot

- electronic meters
- a notification equipment fit to inform the customer about the tariff of the present day and of the day after
- energy management systems
- ripple control (one-way communication technique for sending tariff signal using the electric power lines).

4.2.5 Methodologies to measure and analyse the effects of the pilot on the customers

Within the 800 customers' sample, 70 were subject to extremely precise measurements concerning their consumption. Their electric heating, hot water (storage tank) and total consumption were recorded every 10 minutes. Also available for these customers was information such as dwelling surface area, type of main heating, presence of automatic control units according to tariff commands for electric appliances, especially for heating, as well as external temperature.

4.2.6 Results

<u>The main result concerns the consumption reduction</u>: on average for the sample the daily consumption has been reduced by 15 % on a white day, and by 45 % on a red day compared with blue days. On average, the transfer of consumption from peak hours to off-peak hours was 1.3 times higher on a white day than on a blue day. It was even higher for red days. The reactions to prices were strong. The major consumption reductions concerned electric heating. Some customers reduced their heating consumption during the most expensive days either by using a fireplace or by accepting a lower indoor temperature. It also appears that the behaviour of customers was extremely variable, even though they had the same electrical equipment. This variety of behaviour and adaptation is one of *tempo*'s strong points because it shows a great flexibility in the use of this option. <u>Another result is customers' satisfaction level</u>: to evaluate it, the pilot has included a survey of these customers. The following results have been observed:

- 84% of the customers have been quite or very satisfied with this option,
- 59% have told that they had made savings (average or substantial for ¾),
- 53% have considered the option as slightly restrictive or entirely unrestrictive,
- 87% have understood the tariff principle very well.

4.3 Launching step

After 1993 every EDF commercial agency has been encouraged to propose *tempo* to its residential customers. In order to ensure the tariff development successfully, EDF has had to work both on economic, technical and commercial side. Moreover EDF has defined an organisation aimed to have a feedback after 3 years.

4.3.1 From an economic point of view

The GUITARES software has been developed in order to predict the tariff that was the most profitable for a customer according to electric end uses, house's or flat's size and insulation, number of family members. This software is able to calculate the customer's bill vs. the tariff (normal, off-peak, or *tempo*).

4.3.2 From a technical point of view

EDF has promoted the development of new products:

- "Notification signal", a small box which can be plugged into any power socket and indicates the day's colour and the current hourly rating. It also indicates the colour of the next day as from 8 p.m.;
- Electronic meter able to manage the 6 tariff periods. It provides the same information as the "notification signal" box and also indicates the power level being used and the consumption per tariff period while allowing the remote reading of the meter by EDF.
- Various energy control systems. The most sophisticated energy controllers enable customers to program their energy consumption with a great accuracy and flexibility according to prices and chosen level of indoor temperature. They can send messages to appliances through special cables or through the normal electric wiring (PLC).

Moreover EDF has carried out analyses in order to ensure a high reliability level of its ripple control system through its distribution network.

4.3.3 From a commercial point of view:

4.3.3.1 Within EDF

Training courses have been organised for commercial agents. These agents have received a small *tempo* suitcase containing different brochures explaining *tempo*.

4.3.3.2 Toward customers

A whole range of services including the following technical products have been designed

Decision-making services

- ✓ A self-assessment questionnaire allows the customer to find out whether *tempo* is adapted to his life-style,
- ✓ An "Electric Heating and Domestic Hot Water" diagnostic may be carried out in the customer's home, usually by an EDF representative,
- ✓ EDF also often carries out a customised tariff study described as the Right Price Advisory

- ✓ And then 4 different versions of *tempo* linked to the devices able to manage the electricity consumption are proposed to the customer:
  - “standard *tempo”* using the meter to manage end-uses
  - “dual energy *tempo”* for customers equipped with a dual-energy boiler that can be switched automatically from a type of energy to another depending on the tariff rating.
  - “thermostat *tempo*”: a thermostat is set on each convector that adjust the heating level according to electricity price
  - “comfort *tempo”* with a sophisticated system which manages various end uses (heating, water-heater, large electric appliances).

Customised start-up service

Once *tempo* has been set, an EDF *tempo* specialist visits the customers to teach them how to use the tariff, offer advice about their electric facilities, and demonstrate how the electric meter works.

Permanent services

After having completed the installation, it was necessary to ensure that the customer could easily get information about *tempo*. To do so EDF has used several ways:

- brochures such as “Bien vivre avec *tempo*” (How to live comfortably with *tempo*), the guide book “Comment profiter au mieux de la nouvelle option tarifaire *tempo* (How to take the best advantage from *tempo*, the new tariff option) and the guide book “Confort Chauffage Electrique” (Comfort through electric heating),
- possibility to call an EDF employee able to answer any question about *tempo*
- one year after the signing of the *tempo* contract, EDF can propose an Anniversary Report mainly aimed to assess the billing differences over the whole year.

4.3.4 The feedback after 3 years

Two means have been used to carry out this feedback: surveys and load curve measurement

- surveys

500 customers have been asked to answer questions after the installation of *tempo*. These questions concerned:

- ➢ the customers’ features (dwelling, end uses, previous EDF contract…),
- ➢ the works in the dwelling linked to the installation of new devices,
- ➢ the starting with an EDF coaching,
- ➢ the global satisfaction level.

EDF has determined the features of a fictitious average *tempo* customer from this survey. This customer:

- ➢ Had an electric water heater,
- ➢ Had 4 big electric appliances,
- ➢ Had no air-conditioning system,
- ➢ Owned his dwelling,
- ➢ Lived in a family of four,
- ➢ Had been informed on *tempo* by EDF,
- ➢ Did not have an energy controller before *tempo,*
- ➢ Had an electric space heating and a fireplace using wood,
- ➢ Kept an indoor temperature between 19°C and 20°C,
- ➢ Had opted for standard *tempo,*
- ➢ Declared that starting *tempo* did not take more than one hour,
- ➢ Firstly asked questions about electricity price.

The main result is that 90 % of the customers were satisfied or very satisfied

- Load-curve measurement

A pilot test including 150 customers has been organised in order to analyse customers' behaviour regarding electricity consumption vs. price.
From these load curves, it has been estimated that:

- the customers have reduced their electricity bill by 10% on average (compared to the off-peak hour tariff),
- if customers have decreased the indoor temperature by 1°C on red days, the annual bill has decreased by about 4%.

4.3.5 Conclusion of the launching step

At the end of the launching step, there were about 20 000 *tempo* customers (less than expected).
At this time EDF decided that:

- *tempo* would soon be introduced in the list of EDF tariff for residential customers whereas EJP would not be proposed any longer.
- in the next future the follow-up of *tempo* would be composed of:
  - the *tempo* panel which means a permanent measurement of the global electric load curve in 450 dwellings,
  - a satisfaction barometer including two telephone surveys, the first approximately three months after the installation of *tempo*, and the second, one year later.

5 Norwegian Pilot 1: Implementation of Demand Side Management in Oslo (abbreviated as the IDO project)

5.1 Introduction

The Norwegian project “Implementation of Demand Side Management in Oslo” is by the Norwegian sponsors of the EFFLOCOM project defined as an EFFLOCOM pilot project. This means that the main results and general conclusions from this project are available for the EFFLOCOM project group.

5.2 Objective of the Pilot

Main objective: Avoid/expose planned grid reinforcement with use of DSM (energy efficiency actions). To postpone planned grid reinforcement, 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 end-users 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 organization.
<u>Objective - removing barriers</u>:

- From the end-users point of view: Through dialogue with different kind of commercial and household end-users, feasible barriers, which can effect implementation of energy efficiency actions, were mapped. Motivation analysis and model tool were made. The model/analysis deal with barriers connected to owner structure/organisation, type of end-user, type of actions, cost-benefit from the actions, different ways (besides tariff) of affecting end-users energy consumption, DSM working methodology for the grid-owner and his coadjutant partner for energy economising etc.
- From the grid owner point of view: 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 owners organisation.

5.3 Partners and target group

Partners:
E-CO Tech and Viken Nett mainly completed the pilot project. In selected parts of the project concerning analysing end users motivation for energy efficiency actions Sintef Energy Research and Sintef Industrial Management were engaged. Energy analysis accomplished within the end-users building (energy auditing) were completed partial by E-CO Tech and partial by other energy advising consultants engaged in the project.
Target groups:

- Residential customers in 156 blocks of flats
- Residential customers in 17 semi detached houses
- 40 commercial customers with different kind of activity. 13 out of 40 customers decided to implement energy efficiency actions.

5.4 Methodology

Based on project experiences, a working process for the network planning considering DSM was established. The flow chart diagram in the figure below shows the project's recommended approach of how to evaluate and consider DSM actions as an alternative to grid reinforcements.

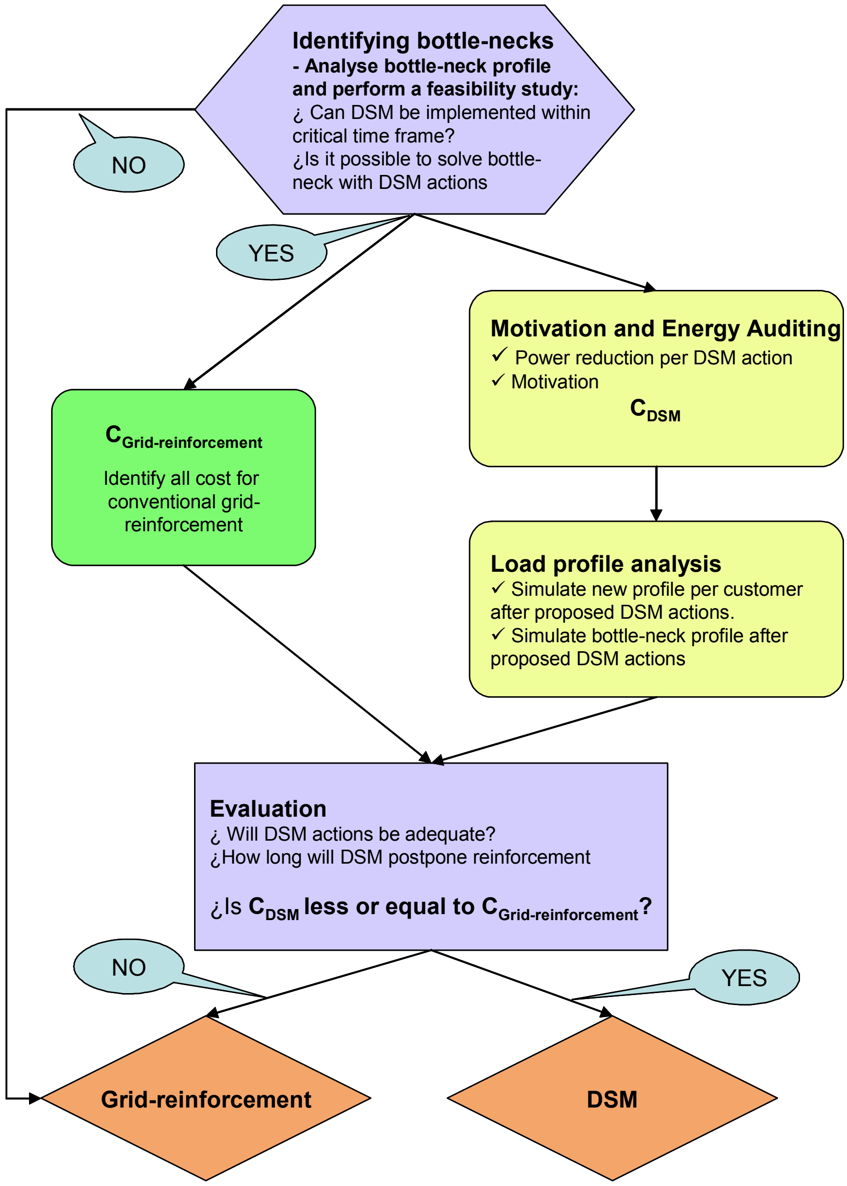

Figure 2 Flow chart showing methodology for considering DSM actions.

5.5 Technology

The figure below illustrates the smart house solution that was implemented among the 17 residential customers. The solution is based on Internet and wireless radio communication. The solution included also implementation of several "plug and play" units called Ebox among all the residential end-users. The Ebox contains a switch, a radio receiver, a thermostat and a clock. Each component (electrical heaters and boilers), which is to be controlled, has got its electricity supply through the Ebox.

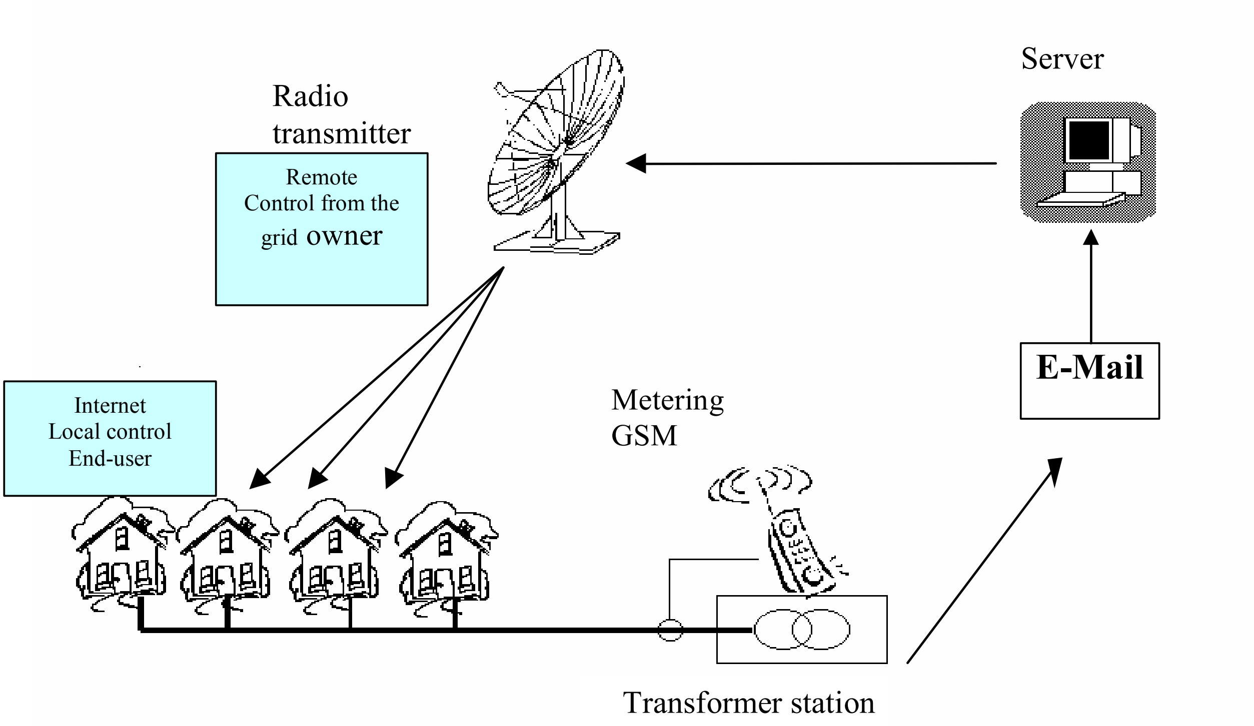

Figure 3 Smart house solution for residential customers.

Local load control of electrical boilers was implemented among 8 blocks with 156 flats. The smart house solution is based on two-way communication inside the building. The figure below illustrates the solution. The technology, which is used, is an enlarged solution of "Orion 512" delivered by the Norwegian company Nobø.

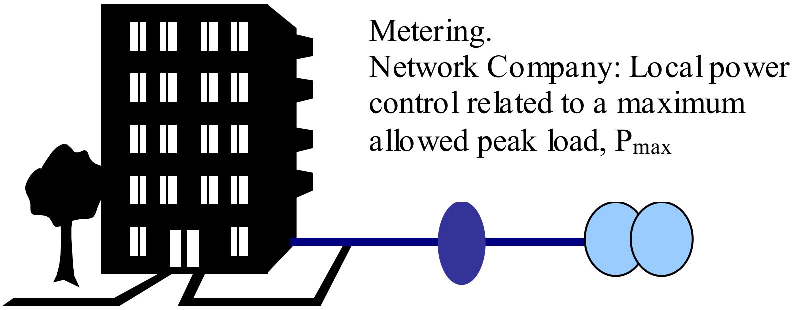

Figure 4 Smart house solution for the control of electrical boilers.

Among 13 commercial end users with a wide type of activity different kind of energy efficiency actions were implemented. Building automation, including local peak load control, was one of the actions. Some example of implemented actions will be described, among them an example of building automation.

5.6 *Expected and Gained results*

Project period: January 1998 – December 2001.

- Implementation of smart house concept, DSM-actions: Two different concepts 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 end-users adjusted the smart house equipment as well as changes in the households' electrical equipment. The time horizon for realizing such DSM actions is empirically 1-2 years for residential customers.

- Improved energy efficiency, long-term DSM actions: Installation of new equipment, replacement of electrical energy carriers, renovation of buildings, installation of smart house solutions for a wide type of buildings (end-users). The research project, related to implementation of integrated DSM-package for 40 industrial customers, situated in an area with limited transmission capacity, is carried on in Oslo. A peak load reduction is to be achieved within the year 2003. The peak load reduction is divided in two different grid areas and is estimated at 3.7 MW (11%) from the existing 34.2 MW and 0.8 MW from existing 25.0MW (3%). From the 40 participating end-users, 13 end-users started implementing actions in 2001. These 13 end-users have an estimated peak load at 15.7 MW. This implies an aggregated peak load reduction of 28.4% (4.46 MW) achieved within the year 2003. For the 13 end-users, it is also estimated an expected energy saving at 25%, equivalent to 14.7 GWh/year. The time horizon for realizing the DSM actions is 3-4 years.

6 Norwegian Pilot 2: New technology for Controlling of Power load in Oslo (abbreviated as the CPO project)

6.1 Introduction

The Norwegian project "New technology for Controlling of Power load in Oslo" is by the Norwegian sponsors of the EFFLOCOM project defined as an EFFLOCOM pilot project. This means that the main results and general conclusions from this project are available for the EFFLOCOM project group.

6.2 Objective of the Pilot

Main objective: The project shall initiate remote controlling of minimum 2 MW uninterruptible power load among various categories of commercial customers. The grid owner (project) shall initiate implementation of necessary actions among the commercial end users through offering new tariffs related to controllable or interruptible load. 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 shall also gain knowledge concerning "what makes the end user carry out the necessary actions?"

Objective - removing barriers:

- What is the potential for interrupting different kind of load that through the existing tariff agreement (grid owner - end user) is defined as uninterruptible load? What kind of limitations for load control do different end users with different consumption have?
- What kind of tariff of agreement gives different end-users the best incentive for letting the grid owner remote control power load? 7 end-users have received an offer of new tariff agreement for letting the grid owner control load in limited space of time.
- There are barriers connected to implementing new technology for load control for the end-users as well as for the grid owner (Viken Nett). Barriers regarding the tariff agreement and the solution of remote control, such as durability and frequency of interruption related to the end users activity. These barriers will be mapped.

6.3 Partners and target group

Partners: E-CO Tech and Viken Nett carry out the project.
Target groups: The target group is 14 commercial customers with different kind of activity. Due to the potential for remote load control or remote load interruption, 7 out of 14 customers have received an offer of new tariff.

6.4 Methodology

The grid owner Viken Nett has established a new solution for remote control of power load. Compared to the traditional solution based on phone communication, this new solution is based on radio communication and Internet application software. Viken Nett is the first grid owner in Norway using this load control technology and several other grid owners in Norway are considering or have started implementing similar solutions. The new load control system is adjusted for demand side bidding in the Market for Auxiliary Reserve, i.e. sale of load from the grid owner (Viken) to the system operator Statnett. The Market for Auxiliary Reserve requires immediate load control with no need for alerting the end user before interruption. Today Viken Nett controls only loads with backup systems, such as electric boilers. In this project Viken Nett wish to map and test the potential for immediate control of other power load by exploiting the loads slow operation. A group of 14 different end users is selected for this pilot project. 7 of these end users have been offered a new tariff of agreement from Viken Nett, tariffs which are supposed to give necessary incentive for implementation of remote load control.

6.5 Technology

The figure below illustrates the remote control solution that Viken Nett will make use of in the project. The remote control solution is similar to the solution used in the IDO project.

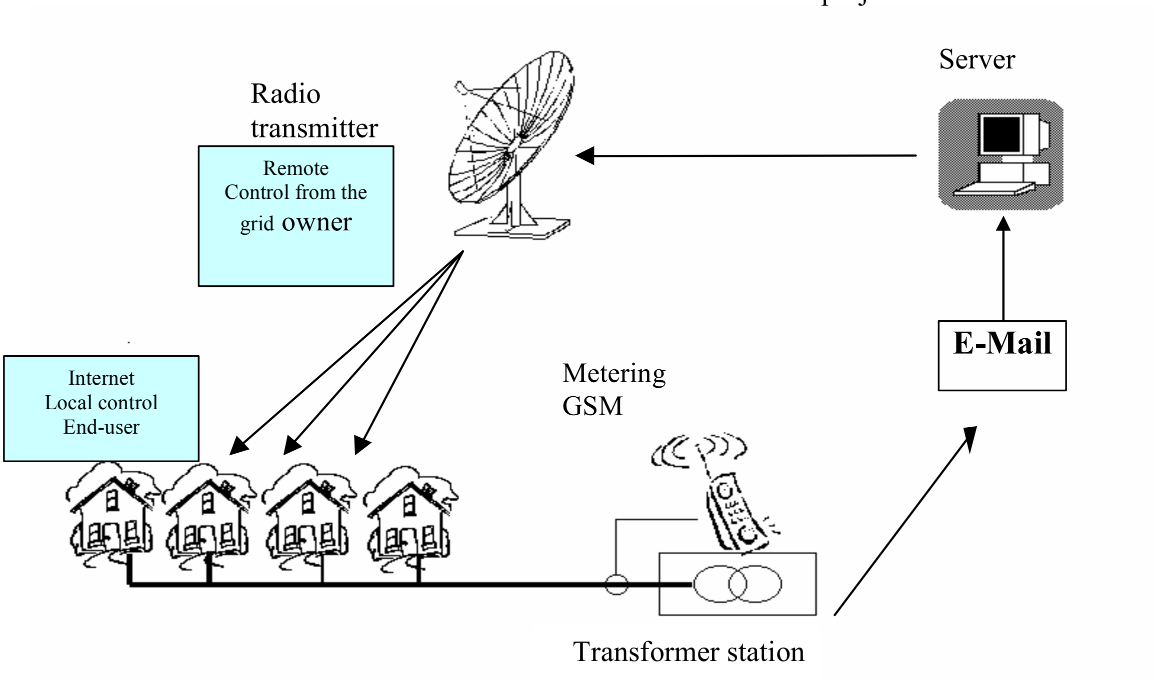

Figure 5 Remote control solution

The solution may be some modified depending of the agreement that will be obtained in the project. The solution is based on Internet and wireless radio communication. Among the 14 commercial end users with a wide type of activity, 7 end-users have received an offer of new tariff agreement for letting the grid owner control load in limited space of time. The choice of smart house solutions and the achieved tariff agreements among the 7 customers will be described.

6.6 Expected and gained results

Project period: July 2000 – July 2003
The project expects to achieve tariffs agreements and technical solutions for remotely switching off or regulate uninterruptible power load. The project will gain knowledge regarding what makes the end-user letting the network company control uninterruptible power load remotely. Reduced tariffs were offered to a chosen group of commercial customers. The offer involves allowing the network company to remotely control power load in limited time period (maximum 3 hours). The network company require controlling the load momentarily or within 1 hour. The technical solution for remote control for one thing concerning, alerting the customer and durability of the interruption, will ensure no impacts on the end users activity. A considerable potential for controllable power load is documented among 7 of 14 participating end-users. These 7 end-users have a maximum peak load of 18.1MW and

are offered a reduced tariff from the network company. The potential for controllable load among the 7 end-users is estimated at 8.8 MW or 49% referred to maximum peak load. The time horizon for realizing this kind of short-term actions is 0.5-1 year. To what extent this potential will be realised will come to light during 2003.

7 Norwegian Pilot 3: End User flexibility by efficient use of ICT

7.1 Introduction

The Norwegian project “End User flexibility by efficient use of ICT” is by the Norwegian sponsors of the EFFLOCOM project defined as an EFFLOCOM pilot project. This means that the main results and general conclusions from this project are available for the EFFLOCOM project group.

7.2 Objective of the Pilot

The peak power balance in the Nordic power system is very tight. Hardly any investments in new production are carried out. Of 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. This project involves establishment of Direct Communication (two-way communication), including hourly metering and separate channel for remote control, to altogether 10 000 customers in 2 different network areas.

The objective of the 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 ICT-solutions for direct communication and load management.

- Develop, test and evaluate different incentives, which stimulates to flexibility in consumption, with basis in network tariff, power prices and other market solutions.

7.3 Partners and target group

The Norwegian Electricity Industry Association (EBL) runs the project, and both the Norwegian Regulator (NVE) and Transmission System Operator (TSO) Statnett SF are involved. In the autumn 2001 the project in close cooperation with the regulator NVE invited all Norwegian network operators to make a tender concerning increased revenue cap to finance large-scale building of two-way communication for use in the project. 11 offers were received and 3 network companies were chosen. One of the companies had to withdraw from the project of technical reasons. The two remaining companies Buskerud Kraftnett, Skagerak Energi Nett are according to contract obliged to install technology for two-way communication to 10.000 customers within 1 October 03. The main test activities will be carried out from November 03 to March 04.

The customers involved in the project are divided into following two main categories:

- Household (8-40 MWh/år)
- Industry and commerce (40-100 MWh/år)

Minimum 75 % of the customers are supposed to be household and 50 % of the houshold customers will be equipped with potential for load control via the two-way communication link.
75 % of the remaining customers (industry and commerce) will be equipped with load control.

7.4 Methodology

The project activities build on previous research and test projects carried out in Norway the last 5-10 years. The main aspects and conclusions from these activities were collected and prioritised in the starting phase of the project. Price signals and economic incentives for load control is studied and developed, and Internet based services as a supplement to two-way communication were investigated in the early stage of the project. The main testing activities are carried out winter 02/03 and 03/04.

7.5 Basis from previous research

Short summarized the following aspects from relevant research and test project are taken into consideration:

- The potential for power control in general consumption and power intensive consumption is analysed and estimated to respectively 1750 MW and 3360 MW.
- Time-of-use tariffs is developed and tested. Based on this the authorities has decided that all network operators should offer network tariffs with seasonal variations to their customers.
- Test projects in Drammen, Oslo and Trondheim have shown that it is possible to motivate for and perform load control at smaller end-users.
- Technologies for load control at the site of the end-users have been tested.
- An overview of technology for two-way communication is drawn up.

An additional important experience is the establishment of an Options Market for Power Reserves by the Norwegian Transmission System Operator (Statnett), which due to a fixed compensation for availability has included a considerable share from the consumption side.

7.6 Internet based services

Internet is a universal channel for communication and represents a potential for two-way communication between customers and the players in the power markets. These properties gives the opportunity to add additional services to the traditional two-way communication, which is establish in this project. Existing solution of relevant Internet services used in Norway together with a few examples from other countries were mapped in the first year of the project, and a basic model for development of a new service adapted to this project were proposed. Further development of this model will not be carried out in this project due to limited economic resources.

7.7 Price signals and criteria for load reduction

In Norway the price the customers are paying for electricity comprises a network tariff from the Network Company and an electricity price from the supplier. The customers are free to choose supplier and a lot of customers receives two separate bills.

7.7.1 Network tariff

The network tariffs in Norway are traditionally yearly or seasonal basis. In this project it is of interest to motivate for load reduction in the peak hours and two different tariffs, amplifying the price signal in the morning and after noon hours, are developed:

- Fixed part + value of network losses + "energy" part only active in the peak hours
- Fixed part + value of network losses + "power" part only active in peak hours.

The peak hours are defined as the time between 0700-1100 and 1600 –1900 on weak days from November to March. The extra cost in these hours are 0,15 €/KWh on the energy part and 10 €/KW on the power part. The energy tariff will be offered to the household customers in the Buskerud area and the power tariff to the customers in the Skagerak area.
For the industrial customers a low priced tariff for reducible loads is considered. Customers using this tariff are obliged to reduce their load on 15 min. notice.

7.7.2 Electricity price

Hourly metering and the potential of load control in peak hours give opportunity for new products from the supplier of electricity. In co-operation with the major suppliers in the two network areas following products are developed for the test activities in this project:

- Spot price on hourly basis
- Fixed price with discount providing automatic load reduction in periods with high spot price
- Combination of fixed price and spot price

The idea is that the customers should be able to reduce their cost by load reduction in the peak hours. The benefit for the power supplier is primarily connected to reduced risk in periods with huge fluctuations in spot price. The fixed price product should therefore be formulated in such a way that the given discount correspond to the alternative costs of price hedging.

7.7.3 Criteria for load reduction

The two-way communication link gives the opportunity to perform remote control of the "low prioritised" objects selected by the end user. Those of the end users who have accepted load control are asked to define such objects. So far only hose hold objects are defined and most of them are water heaters and heating cables (out door or floor heating).
Experiences from earlier projects show that load control based on manual decisions is unstable and of limited efficiency. In this project the network company will offer load control schemes based on following predefined criteria:

- Spot price criterion
- Max load criterion
- Reserve criterion

The first and the second criterion will be used for automatic actions. The first when the spot price exceeds an agreed predefined limit and the second when the load curve exceeds an agreed maximum power limit. The network company will use the third criterion for load reduction, based on manual decision, when problems with transmission or production capacity occur.

7.8 Large scale testing

The large scale testing of equipment, data flow and load reduction will take place in close cooperation with the involved network companies. These companies have the direct connection with the customers regarding both installation of technical equipment and information of tariffs and schemes for automatic load reduction. The main tests will take place winter 03/04. As a part of the preparation for the main test activities two minor pilots were carried out in 01/02. The first was a test of a network tariff, with an amplification of the spot price included, for 21 household customers. The second was about remote control of different loads for reserve purposes at the university in Trondheim. In the winter 02/03 the functionality of the implemented two-way communication links were tested including remote control of household water heaters. The detailed program for the coming testing activities is presently under development.

7.9 Technology

The requirements with regard to functionality were specified in the specification for the tender.

Altogether four different vendors for the two-way communication equipment were chosen. The table below summarizes the technology involved.

Table 2 Technology used in Norwegian pilot.

Vendor	Communication	Meter
Enermet 1	Power line carrier (LV+HV)	Electronic, pulse counting
Enermet 2	Power line carrier (LV) + GSM	------------- “ ------------
ITP	Power line carrier (LV) + GSM	Electronic, pulse counting
Senea	Radio	Electronic, pulse counting
E-link (load control only)	Phone	No meter

7.10 Expected results

Both socio-economic and corporate aspects will be focused in the cost-benefit analyses that will conclude this project. Following main aspects will be evaluated:

- Quantification of load response from different kinds of end users
- Costs for technology for different kind of end users and geographic orientation
- Potential of cost reduction for the network companies due to new technology
- Socio-economic effects (national power balance, network capacity, improvements in power market performance, benefit for involved actors)