END USER FLEXIBILITY BY EFFICIENT USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

INTRODUCTION

This was a large scale pilot project involving 10,984 mainly residential customers carried out in Norway between 2001 and 2004 by two network operators and six technology vendors.

In the Nordic power market, the bid curves in the day ahead market (Elspot) were rather steep in the higher price ranges, which meant that price elasticity was very low. The tight peak power balance, periods with shortage of energy, and very little investment in new production capacity focused attention towards increased price elasticity on the demand side. The purpose of this pilot project was to investigate manual and automatic demand response to prices in the day ahead market.

DESCRIPTION OF THE PROJECT

As shown in Figure 1, the project included:

- two way communication to customers using radio, PLC, GSM, GPRS and PSTN;
- automated meter reading with hourly readings;
- a separate channel for direct load control of water heaters.

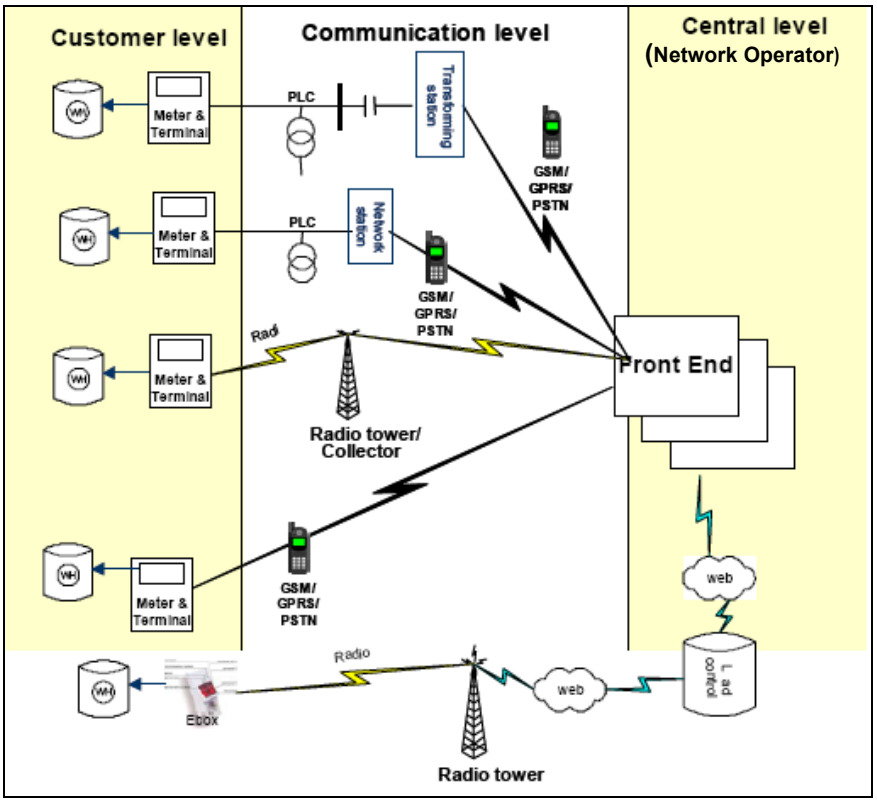

Figure 1. Information and Communication Technologies Used in the Pilot Project

In Norway, the electricity industry has been unbundled with separate network service providers and energy retailers supplying end use customers. Customers therefore receive electricity bills containing four main components based on:

- a network tariff;
- a retail energy tariff;
- value added tax (VAT); and
- government charges.

The residential customers involved in the pilot project were offered a specially designed time of use (TOU) network tariff. This tariff consisted of three components:

- a fixed component;
- a component for network losses; and
- an energy-related component which was only activated during peak periods.

The TOU network tariff had a two-level rate structure as shown in Figure 2. The rates were:

- a peak price of about NOK 0.88 (excluding VAT) during peak load periods (defined as 7 to 11 am and 4 to 8 pm on working days from November to April); and
- an off-peak price of NOK 0.02 (excluding VAT) in all other hours of working days, weekends and holidays.

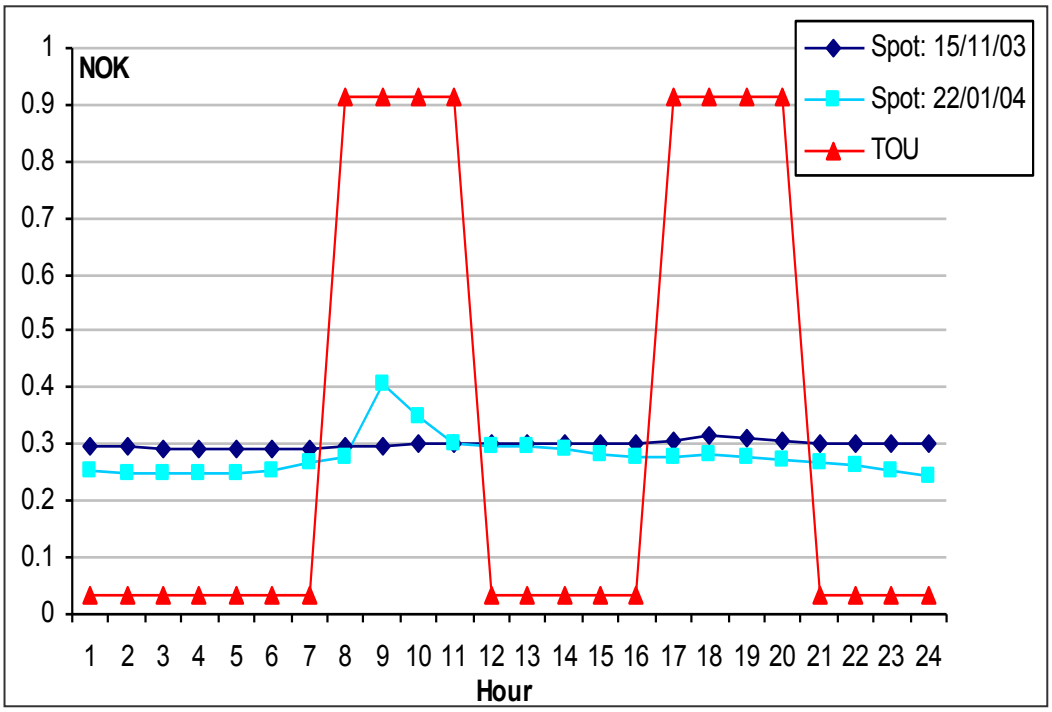

Figure 2. Tariffs Used in the Project

The 44:1 differential between the peak and off-peak network tariff was very large. However, when the retail energy tariff, VAT and government charges components were added to the customers' electricity bills, this differential was reduced to about 3:1.

In addition, the energy retailers in the area offered customer contracts based on the spot prices in the electricity market on an hourly basis.

One of the retailers also offered an hourly spot price in combination with remote controlled automatic disconnection (load control) of water heaters in the periods from 9 to 11 am and 5 to 7 pm on week days. The energy spot price was expected to be high during these periods. Load control of water heaters was available to 50% of the customers in the pilot project.

Load control operated through a separate channel to automated meter reading and required an agreement with the network operator to carry out the remote load control in the specified periods. Load control was implemented for short test periods of between two and three days several weeks apart as shown in Figure 3.

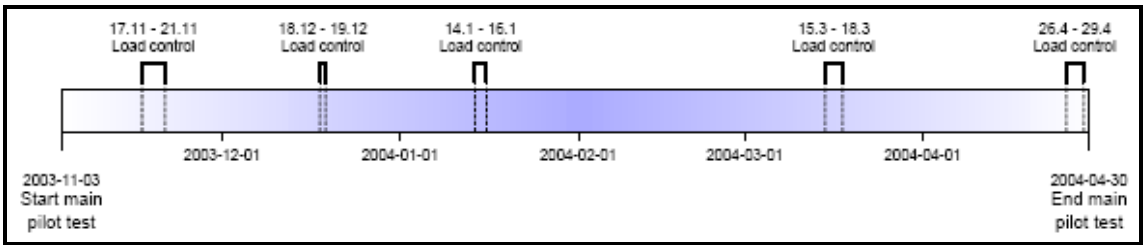

Figure 3. Test Periods for Load Control

The two network operators offered slightly different load control options as shown in Figures 4 and 5.

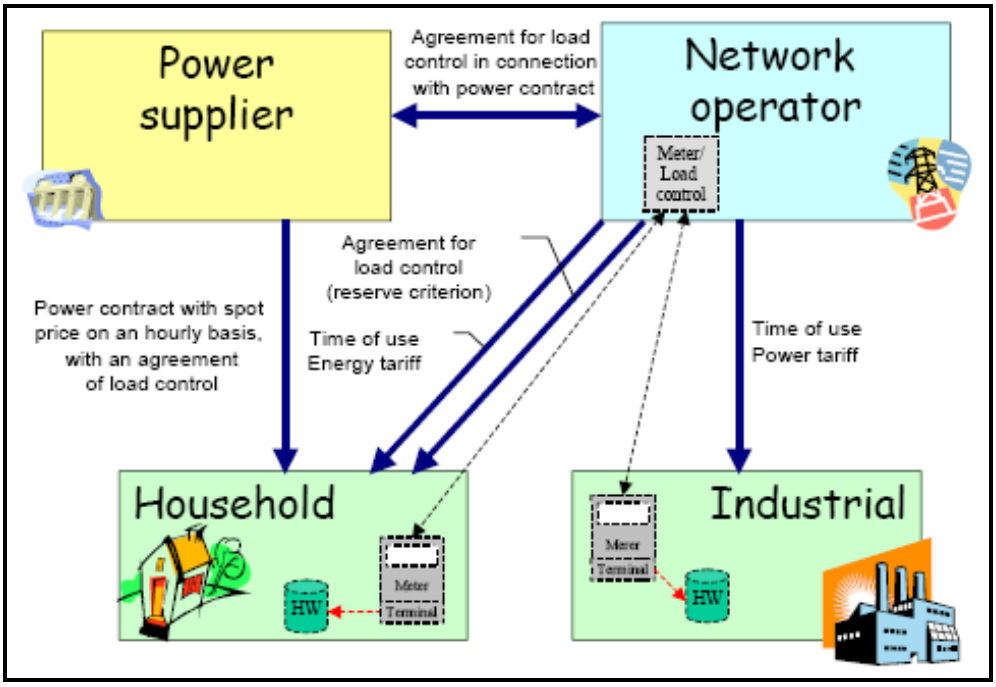

Figure 4. Tariff and Load Control Arrangements for Buskerud Kraftnett AS

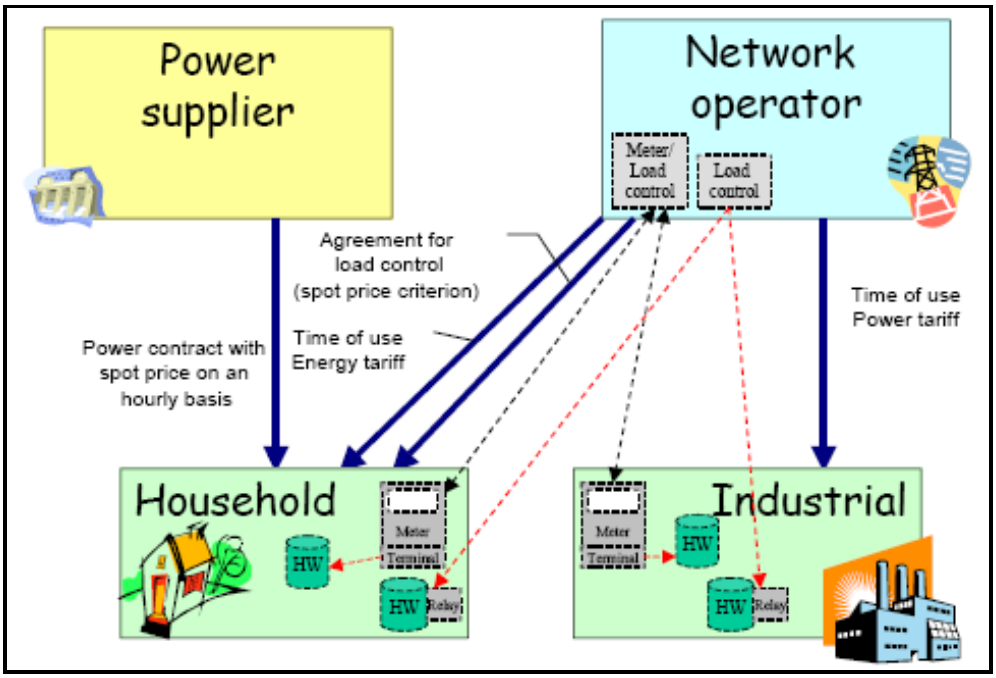

Figure 5. Tariff and Load Control Arrangements for Skagerak Energi Nett AS

Water heaters were switched off as follows:

- Buskerud Kraftnett AS: during the hour with the highest energy spot price plus the hour before or after;
- Skagerak Energi Nett AS: during two hours in the peak load periods when the energy spot price reached a predefined limit.

In the case of Skagerak, the energy spot price limit was initially set at 0.0625 NOK/kWh. However, spot prices during the test period were low with little volatility. In the last months of the pilot project the spot price limit was removed and the water heaters were disconnected for two hours every morning and evening, when the spot prices were highest.

Therefore, there were five possible tariff options from which customers in the pilot project could choose:

- TOU network tariff and standard-offer energy tariff; or
- TOU network tariff and spot price energy tariff; or
- TOU network tariff, spot price energy tariff and direct load control of water heaters; or
- standard-offer network tariff and spot price energy tariff; or
- standard-offer network tariff, spot price energy tariff and direct load control of water heaters.

RESULTS

The main test period was from November 2003 to March 2004. During this period, the average load reductions per household achieved through the various options are shown in Table 1.

Table 1. Average Load Reductions per Household

Option	Buskerud Kraftnett AS	Skagerak Energi Nett AS
TOU network tariff	~0.18 kWh/h	~0.18 kWh/h
Hourly spot price for energy	~0.6 kWh/h	~ 0.4 kWh/h
Direct load control of water heaters	~0.5 kWh/h	~0.57 kWh/h
TOU network tariff plus hourly spot price for energy (no load control)	~1 kWh/h	~0.3 kWh/h

Detailed results are shown in the following Figures.

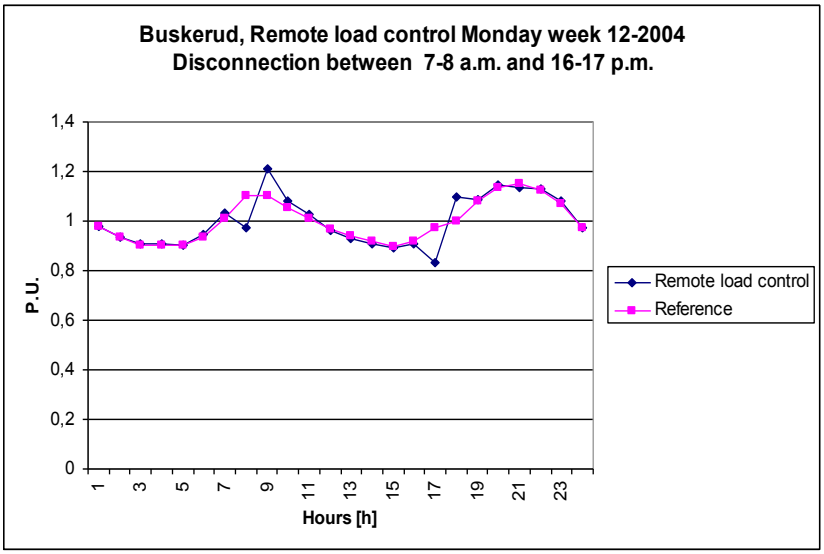

Figure 6. Results for Load Control

In Figure 6, the results are for residential customers with both TOU network tariff and spot price energy tariff and load control. The reference curve is based on consumption by similar customers in the same period and the same location. Compared with the reference group, electricity use by the load control group is reduced during the two peak load periods. The reduction is 12% in the morning and 14% in the afternoon. Number of customers: 1230.

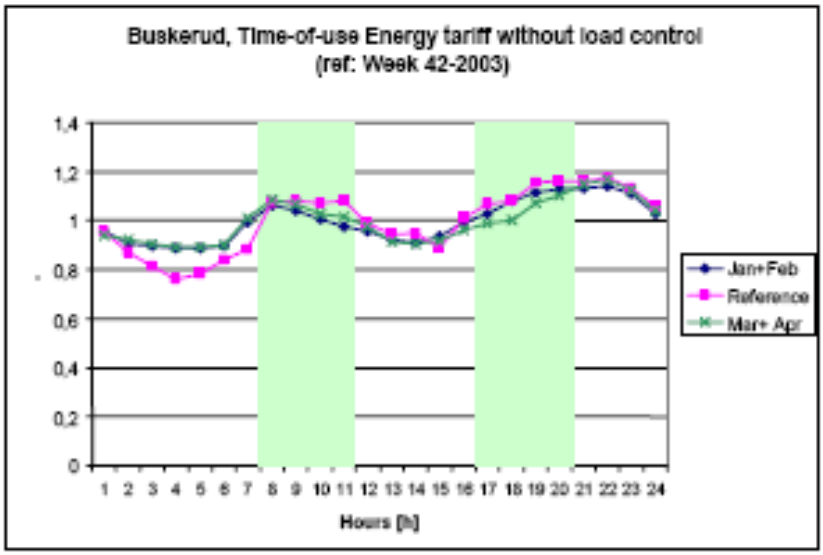

Figure 7. Results for TOU Network Tariff Without Load Control

In Figure 7, the results are for residential customers with TOU network tariff and standard-offer energy tariff with no load control. Compared with the reference group, electricity use

by the TOU network tariff group is reduced during the two peak load periods. The reduction is 10% in the morning and 7% in the afternoon. Number of customers: 39.

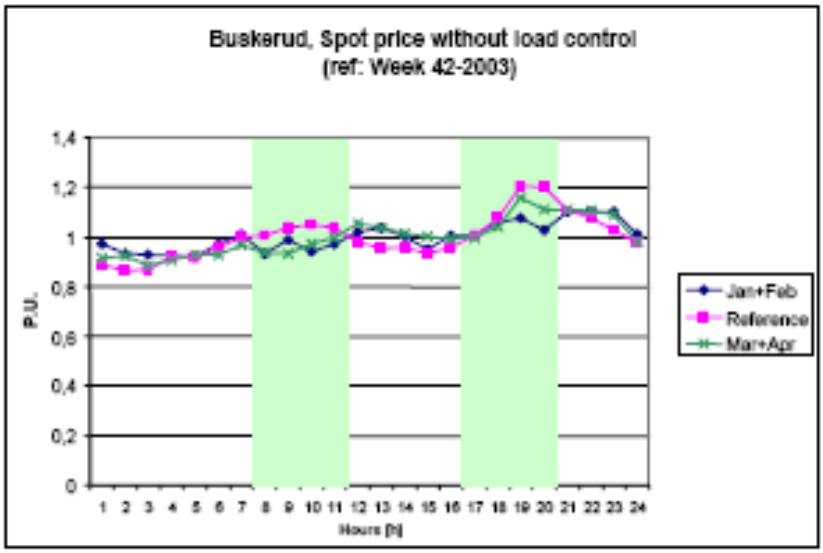

Figure 8. Results for Spot Price Energy Tariff Without Load Control

In Figure 8, the results are for residential customers with standard-offer network tariff and spot price energy tariff with no load control. Compared with the reference group, electricity use by the spot price energy tariff group is reduced during the two peak load periods. The reduction is 15% in the morning and 22% in the afternoon. Number of customers: 17.

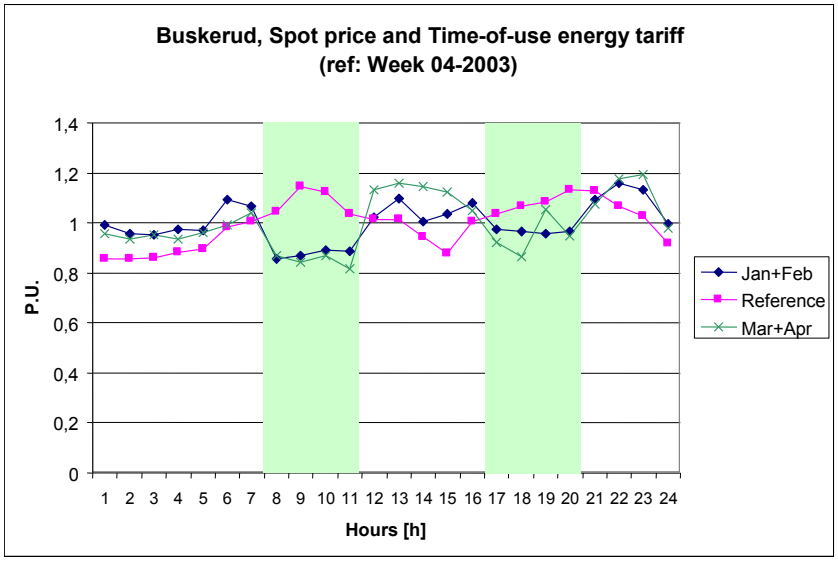

Figure 9. Results for TOU Network Tariff and Spot Price Energy Tariff Without Load Control

In Figure 9, the results are for residential customers with TOU network tariff and spot price energy tariff with no load control. Compared with the reference group, electricity use by the TOU network tariff/spot price energy tariff group is considerably reduced during the two peak load periods. The reduction is 35% in the morning and 31% in the afternoon. Number of customers: 6.

In summary, the largest response was achieved for the households with both the TOU network tariff and the hourly energy spot price and no direct load control of water heaters. However, only a very small number of customers (6 out of 10,894) chose this option and it is possible that these were households with an interest in the issue and the willingness and ability to modify their energy-using behaviour.

For those customers who were offered remote controlled automatic disconnection of water heaters, the average load reduction from water heaters was estimated to be about 0.5 kWh/h during peak periods.

The load curves for the customers with direct load control showed some increases in load towards the end of peak periods. This increased load was probably caused by the simultaneous reconnection of the water heaters with a loss of diversity in the water heater load as a result.

In addition, the decision to disconnect the water heaters to coincide with the two most expensive hours for the energy spot price meant that the water heater reconnection took place when the TOU network price was still high and remained high for the first hour after reconnection.

CONCLUSION

In this pilot project, a large experimental area with installed technology for automatic meter reading and remote load control was established. The average reduction in electrical consumption per household was 0.5 kWh/h. Taking network losses into account, this is equivalent to 0.6 kWh/h in reduced electricity generation.

Assuming there are 2 million household customers in Norway, and 50% of these install technology for remote load control, the estimated potential for peak load reduction through remote load control in the residential sector in Norway would be 600 MW (an average of 0.3 kWh/h per customer).

The data from the pilot project enabled an estimate of the average annual cost to achieve peak load reduction in the residential sector across Norway of NOK 680/customer/year ÷ 0.3 kWh/h/customer = NOK 2,260/kW.

This estimate was from a pilot project with many technological and organisational challenges. It was expected that lessons learned from the pilot project would make it possible to improve this figure considerably in future projects.

This article was contributed by David Crossley, Managing Director of Energy Futures Australia Pty. Ltd and Senior Advisor at The Regulatory Assistance Project. For more information on this case study and others, visit Task XV, Network Driven DSM at:

http://www.ieadsm.org/ViewTask.aspx?ID=17&Task=15&Sort=1.