How to achieve energy efficiency actions as an alternative to grid reinforcement!

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Abstract
This paper analyses possibilities and barriers for the end user and for the network owner using energy efficiency actions as alternatives to grid reinforcement. From 1998 throughout 2001 E-CO Partner and the network owner Viken Nett have completed a project called "Implementation of Demand Side Management in Oslo" [1]. Results from this project are used as input to the ongoing project "New technology for controlling power load in Oslo" which started in 2001. The paper is based on results from these projects which have produced interesting results regarding methodology of motivating different end users for DSM actions, as well as methodology of DSM analysis for the network company.

A huge potential for postponing reinforcements at different grid levels through intelligent energy solutions among the end users is documented. It is possible to reduce or curb the peak load with 10-15% in a city area within a 3-4 year period. This implies energy efficiency actions such as building automation including load control, ordinary rehabilitation and converting from electrical heating to district heating or other energy carriers. For the network owners, the project has shown that DSM actions in a certain city area can be realized at a 30% lower cost than the costs of grid reinforcement. The paper is focused on motivation of the end user, as well as technical and economical approaches of DSM. Results are presented from both the end users' and the network companies' point of view.

Definitions
Several concepts are used in this paper. These concepts are defined as follows:

ENERGY AUDITING
Energy analysis accomplished within the end-users building. Mapping all kind of energy consumption both electrical and energy based on other carriers. Energy consumption and historical peak load for the actual building are compared to similar buildings and similar group of end-users. All possible energy efficiency actions are localized and a cost-benefit analysis regarding all possible actions is carried out.

ENERGY EFFICIENCY ACTIONS
Actions which improve the end users energy consumption as regards the volume of energy consumption (energy saving), the time/profile of using energy (peak load reduction) and the energy state (choice of energy carrier).

DEMAND SIDE MANAGEMENT ACTIONS (ABBREVIATED AS DSM-ACTIONS)
Energy efficiency action accomplished by the end users i.e. management on the demand side. The end-user adapts his consumption to the existing capacity of the electricity grid.

LONG-TERM DSM ACTIONS
DSM actions which is completed by the end-user and do not require any involvement by the network company. The end-

user adapts his electrical energy consumption to the existing electricity grid without involvement from the network company. There is no need for follow up of the end-user after accomplishing the DSM action.

SHORT-TERM DSM ACTIONS

DSM actions which is completed by the end-user and do require some involvement by the network company. The end-user adapts his electrical energy consumption to the existing electricity grid. There is need for continuous follow up of the end-user after accomplishing the DSM action. Remote control of the end users power load is defined as a short-term DSM action.

Introduction

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

$$\sum C_{DSM} \leq \sum C_{\text{Grid reinforcement}}$$

Where:

$$\sum C_{DSM}$$

– the utility's total cost concerning implementing DSM actions

$$\sum C_{\text{Grid reinforcement}}$$

– 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 end-users. All experience shows that end-users have to be strongly motivated to implement energy efficient actions, in spite of the fact that the end-users will reduce their own costs.

Planning and design for conventional grid reinforcement actions are well described tasks with predictable parameters. However, DSM actions in Norway 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. The paper will concern methodology of DSM analysis for the network company and methodology for motivating end-users to participate.

Technical Approach – Methodology for DSM

Based on project experiences, a working process for the network planning considering DSM was established. The flow chart diagram in Figure 1 shows the project's recommended approach of how to evaluate and consider DSM actions as an alternative to grid reinforcements [1].

IDENTIFYING BOTTLENECKS

A bottle-neck means a grid constraint due to load exceeding capacity. The bottleneck can appear in different parts of the network, e.g. a power transformer in the substation, distribution transformer, lines or cables in any part of the distribution network (MV or LV). The ordinary way to solve such a problem is to install larger transformers and/or larger lines or cables.

Bottlenecks are identified through supervision and load forecasting. To be able to consider DSM actions, one has to gain knowledge of the load profile of the actual component or section. Through measurement and time-registering of the peak load, analyses of the profile will tell when the problem will arise. What time of year, what time of the week and most important, what time of the day will there be a capacity problem?

By conducting a rough search of the network- and customer information system of the utility, one can get an idea of what kind of customers and consumption which are served by this particular section of the network. By concentrating on the biggest consumers, one can sort out the consumers that are time-recorded (in Norway, all customers with an annual consumption above 100 MWh/year are hourly metered). Next step will be to sort out the actual consumers with a load profile that coincide with that of the bottleneck's profile. Once this is accomplished, one can establish from empirical data whether it is possible to meet the capacity constraint with DSM actions. In addition to consider the potential peak-load reduction of these customers, one also has to consider the time frame from when the capacity problem will arise with the time available for implementing DSM actions.

Experience from the project shows that a realistic time frame from initialisation of long DSM actions to achieving actual load reduction, will take at least 3-4 years. Generally most end-users prefer to invest in DSM actions in connection with maintenance plans or other investments. Several other motivation key factors influence the time frame of DSM actions. These are studied more closely in later chapters. If a realistic potential for load reduction through DSM actions is established, within a realistic time frame, one can move on to the next level, see Figure 1. Regardless of the results from the above mentioned initial work, the conventional grid reinforcement alternative must be mapped according to the necessary technical actions and total cost ($C_{\text{grid-reinforcement}}$).

MOTIVATION AND ENERGY AUDITING

Based on the results from the previous activity,"Identifying bottlenecks", a certain group of end-users are chosen for further studies. Each end-user is to be contacted to be informed about the project and to map the status of the present energy consumption. Through the first contact with the end-user the project has to clarify if the end-user recently has made an energy auditing or done similar evaluation of the energy consumption. Moreover, the project has to map if the end-user recently has completed energy efficiency actions and if the end-user in the close future has plans for rehabilitation or extension of buildings. Viewed in the light of the first contact, the project arranges a meeting with each end-user to evaluate the need and possibilities for an energy auditing, as well as possibilities for realizing DSM actions. A second goal from a first meeting is to gather required information for further motivation work as described in chapter below: "Implementation of energy efficiency actions". In the pilot projects [1] and [2] in Oslo, all activity among the end-user regarding mapping and implementation of DSM actions were paid for by the end-user himself and the local authority in Oslo. In certain parts of Norway, among them Oslo, there are possibilities for subsidies from the local authority regarding energy auditing and certain energy efficiency actions. To what extent the DSM actions are to the benefit of the network company, the possibilities for subsidize the end-user have to be evaluated. For instance changing the network tariff is one way to reward the end-user for implementing DSM actions.

LOAD PROFILE ANALYSIS

Once the energy auditing is conducted and the different DSM actions are identified, the effect of these actions on the power system can be analysed. A model was established to simulate the new improved load profile for each customer, based on the detailed energy auditing with definite proposed actions for peak load reduction. The new calculated load profiles for each customer are added up, and then subtracted from the original load profile of the bottleneck. By analysing this "new" bottleneck profile, one can determine whether the DSM actions can solve or postpone the bottleneck problem and thus serve as an alternative to conventional grid reinforcement.

EVALUATION

Possible peak load reduction of DSM measures is compared to the load forecast in the particular grid area. Based on an expected progress plan of DSM actions of 3-4 year, a conclusion is made whether DSM actions will be sufficient for postponing the planned grid reinforcement or not. Figure 2 shows a picture of how the evaluation is done. If DSM actions are considered as an adequate alternative to the planned grid reinforcement, estimated DSM costs (C_{DSM}) and grid reinforcement's costs ($C_{grid\text{-}reinforcement}$) is to be analysed using the Net Present Value method.

Taken in consideration the exposure-period of the grid reinforcements that can be achieved from DSM actions, the net present value of $C_{grid\text{-}reinforcement}$ is compared to the C_{DSM} of to day. Based on these evaluations a decision is made whether DSM action is to be an alternative to grid reinforcement or not.

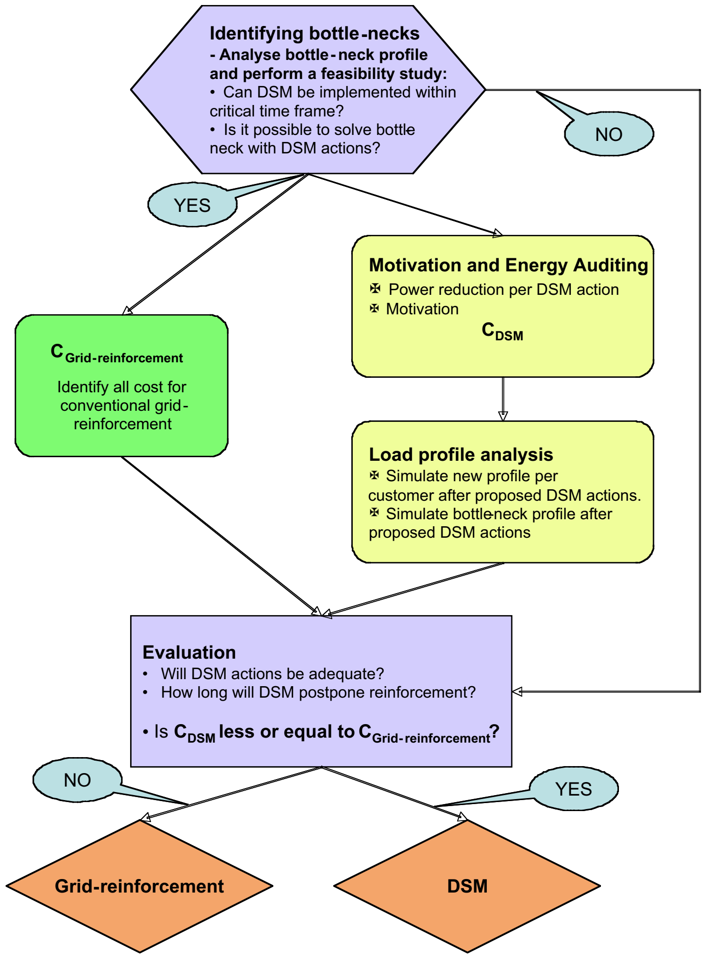

Figure 1. *Flow chart showing methodology for considering DSM actions.*

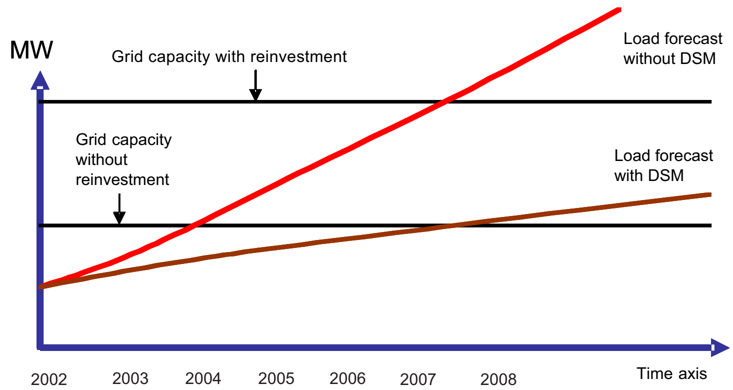

Figure 2. *Example- Load forecast with and without implementation of DSM.*

However, in many cases the best approach might be a combination of both grid reinforcement and DSM measures. Then the most cost-effective DSM actions are chosen to reduce the level of investments otherwise required. This approach is not further discussed in this paper.

Table 1. Empirical DSM costs in the project "Implementation of DSM in Oslo", [1].

DSM activities	DSM costs [Euro/kW]
Identifying bottle-neck:	7,4
Motivation and energy auditing:	34,3
Load profile analysis:	13,1
Evaluation:	5,2
Implementation:	13,8
Total DSM costs:	**73,9**

Implementation of Energy Efficiency Actions – Three Pilot Tests in Oslo

Three pilot tests were carried out in Oslo in the period 1998-2003, [1], [2]. These projects evaluate the existing potential of peak power reduction for residential customers and commercial customers, as well as potential for energy savings and choice of alternative energy carriers to electricity. Consequences and limitations for implementation of DSM were further studied in the pilot cases, including analysis of metered data, questionnaires and model simulations. The following alternatives for Demand Side Management were studied in Oslo:

- 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 were dependent on how the end-users adjusted the smart house equipment as well as changes in the households electrical equipment. [1], [6]. 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 expected 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 MW (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. [1], [9].
- Switching off or regulating uninterruptible power load, short-term actions: The end-user is letting the network company control uninterruptible power load remotely. Reduced tariffs were offered to a chosen group of commercial customers who allow 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 18,1 MW 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. [3], [9].

THE COSTS OF DSM ACTIONS - EXPERIENCE FROM THE PILOT STUDIES

Some of the most important results for the network company are the experienced costs of DSM actions.

Up until recently, DSM actions have not been used as an alternative to grid reinforcement because of the uncertainty concerned with costs and time frame of implementation. Referred to Figure 1, the studies regarding commercial customers in Oslo have experienced costs for the network company as shown in Table 1. The network company's cost regarding grid reinforcement in the particular area was estimated to approximately 110 Euro/kW. Compared to the actual DSM cost at approximately 74 Euro/kW, DSM actions were preferred to the planned grid reinforcement. All energy efficiency actions which were implemented were profitable to the end-user. However, the cost-benefit incentive was not always the most vital incentive for the end-user to accomplishing DSM actions.

MOTIVATION OF RESIDENTIAL CUSTOMERS

Evaluating motivation, related to implementation of technology for controlling electrical heaters and boilers (DSM-actions) was initially carried out as a part of a research project, IDO [1]. The following stakeholders were defined:

1. Network company, operating in a given concession area,
2. Resident, owner/leaseholder of the housing unit.

Two different DSM actions were implemented, see Figures 3 and 4:

Both local and remote control of electrical heaters and boilers were implemented in 17 row houses. The 17 residents represent a small test group with large variations. We find couples with adult children, couples with small children, single parents, single pensioners, and couples without children. Some of these are skilled in the use of computers and the Internet, while others are unskilled and without access.

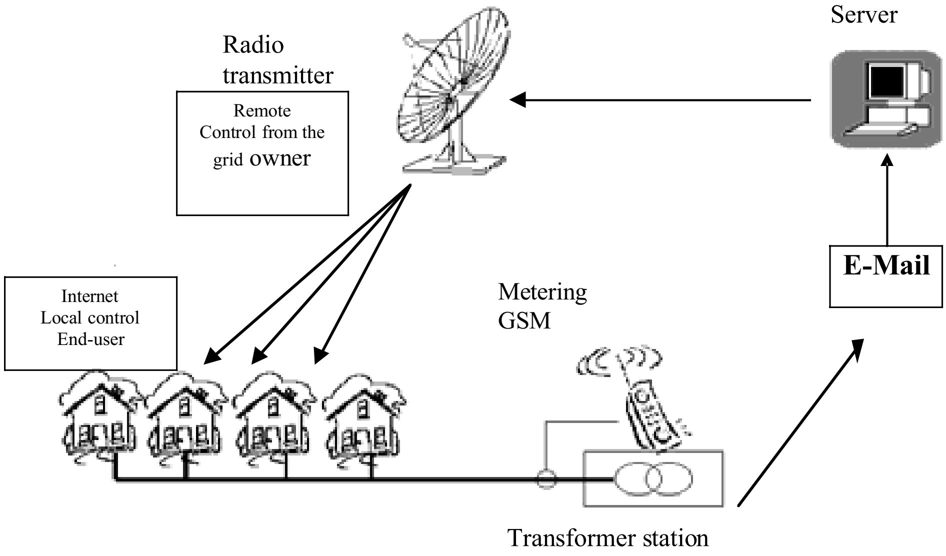

Figure 3. "Smart house – solution" Ebox based on Internet and wireless radio communication – short-term DSM.

Local load control of electrical boilers was implemented among 8 blocks with 156 flats. The 156 residents represent a large group with wide variations. Common for the two DSM actions which are implemented, is that the network company is given the opportunity to control the energy consumption among the residents. The load control (remote or local) directed by the network company is limited by a maximum allowed peak load for both the customer groups. The row house participants have an active participation in the project through their possibilities to controlle their energy consumption manually or from an internet home page. Former ECEEE paper [6] gives more details regarding the row house residents experience to the chosen equipment for load control called Ebox. Compared to the row house participants, the block residents have equipment for power control which requires no involvements from the end-user himself. The network company automatically controls the electric water heater in each apartment referred to the total peak load for the actual block. This is done without any impact to the residents' hot water consumption.

KEY MOTIVATION FACTORS FOR RESIDENTIAL CUSTOMERS

When implementing DSM actions among the residential customers, the following incentives and goals were identified:

1. *Network Company:*

- Reduced net load via decreased peak load or improved load profiles of their customers
- Maintained or increased incomes from transmission of electricity[1]

2. *Resident:*

- No intervention in the surrounding outdoor area due to avoid grid reinforcement

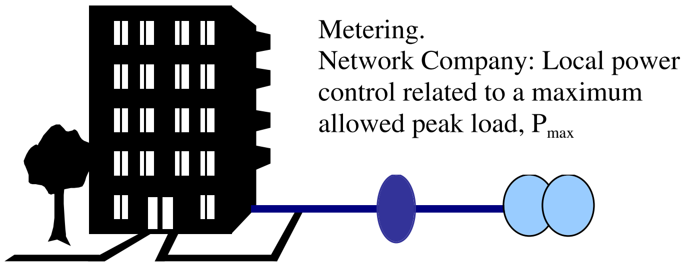

Figure 4. "Smart house – local solution" based on two-way communication inside the building – long-term DSM.

- A safe alternative load control solution which do not impact on comfort
- Reduced electricity costs

The project experienced that several key factors were of vital importance to comply with these goals and incentives:

Cost allocation

All the participating residents are a part of a cooperative building society. The administrative board was given the possibility to participate in the implementation of DSM actions to avoid grid reinforcement. The reinforcement would involve paying about 62 000 Euro to the network company and extensive civil works in the surrounding area to the blocks. To participate in the project, avoiding the civil works was much more important to the building society than avoiding the required payment for grid reinforcement.

Contact persons and decision-making process

Dialogue with the chairmen of the board of the housing corps was vitally important to promote the project. The project wan the boards confidence and participation through

1. Network companies in Norway have income regulation-regime.

documentation regarding the alternative DSM actions and through written agreements.

Electricity costs

Seeing that the households today only pay to the network company for energy consumption and not for peak load, the reduction of peak load gave no direct incentive to each resident. The project evaluated the need for changing the tariff to make them participate. Through the dialog with the board, it was obviously no particular need for changing the tariff regarding their participation. However, reduction of electricity costs through reduction of energy consumption was of importance to make the row house residents use the Ebox equipment.

Human factors

Row house residents:
The motivation for using the Ebox is linked to its functions as a device for private control of the cost of energy consumption, and a device that enables the network owner to control the peak load. The different members of the test group claimed varying motivations in relation to these. One part of the group was highly motivated and found it interesting to participate in the project as such. They wanted to test the technology and followed the project closely. They also thought that the Ebox worked well. Another part of the test group was sceptical. They considered it a duty to participate, and loyally used the device. To some of these the Ebox was a foreign body and not integrated into the household. Others used it actively even when they were not satisfied with its functions. A third group was mostly indifferent. They were not particularly conscious about energy consumption, and were prepared to pay the costs of electricity whatever they might be. The Ebox was installed, but they did not pay much attention to it and had not tried to adjust it.

Block residents:
The major part of the participants, 83%, answered positively to the question if they were satisfied with the network company controlling their electrical water heater without influencing their comfort. Six of the participating residents have during two years of the project experienced some problems with access to hot water. The reason to this could be low boiler capacity compared to consumption or faults with the boiler. The project experienced that all problems related to the boiler very easily was blamed to the project even if it was not the actual reason.

MOTIVATION OF COMMERCIAL CUSTOMERS

When implementing long term and short term DSM actions among the residential customers, the following stakeholders were identified:

1. Network company, operating in a given concession area.
2. Owner of premises – a company or organisation, owning a commercial building. Owner of premises may use a building himself or rent it to other companies.
3. Leaseholders – a company or organisation, renting premises from the above-mentioned actor.

Long term DSM actions

Mapping of structure for motivation and incentives, related to implementation of long term DSM-actions was initially carried out as a part of the research project IDO [1]. Following incentives and goals were identified among the stakeholders:

1. *Network Company:*

- Reduced net load via decreased peak load or/and improved load profiles of their customers
- Maintained or increased incomes from transmission of electricityMaintained or increased incomes from transmission of electricity

2. *Owner of premises:*

- High profitability of his investments
- Strengthening of his position on the real estate market
- Low operation and maintenance costs

3. *Leaseholders:*

- Low rent fees
- Good standard in the rented building, including ventilation and air conditioning

Short-term DSM actions

Mapping of structure for motivation and incentives, related to implementation of short term DSM-actions was initially carried out as a part of a research project "New technology for controlling power load in Oslo" [2]. Following incentives and goals were identified among the stakeholders:

Incentives and goals regarding short-term DSM actions

1. *Network Company:*

- Alternative 1: The major goal is to conclude a tariff agreement with the end user which implies the opportunity to switch off or remotely control uninterruptible load for at least 3 hours duration. The interruption of the power load shall occur immediately with no alert. This is called "momentary control of uninterruptible load".
- Alternative 2: The second best solution to the network company is to "control uninterruptible load with 1 hour alert". Compared to "momentary control of uninterruptible load" the only difference is the one hour of alert.
- A secure solution for remote load control, preferably an automatic remote control solution without any manual operations.
- Maintained or increased incomes from transmission of electricity. Maintained or increased incomes from transmission of electricity

2. *Owner of premises:*

- High profitability of his investments.
- Strengthening of his position on the real estate market.
- Low operation and maintenance costs.

3. *Leaseholders:*

- Low rent fees.

- A secure solution for remote control which do not affect the comfort and the activity to the end-user. The end-user prefers a minimum of installation and a manual routine for load control followed up by the end-user himself. The end user usually prefers one hour of alert from the network company, before activating load control.

As it appears from the above, the network company and the end user have contradictory goals regarding the solution of load control. The tariff agreement will be the key for solving these conflicting goals.

Key motivation factors for commercial customers

Regarding both long and short-term actions, the pilot studies experienced that several key factors were of vital importance to comply with the abovementioned goals and incentives:

Ownership vs. rent of premises

The experience shows that the organisation of the ownership itself is crucially important to companies' relations to DSM. Three main different organisation types were identified: Self-ownership: The most simple organisation model, when a company both owns and uses a building itself. In this case companies have usually a continuous overview over electricity consumption and have the least problems compared to others when it comes to evaluation of proposed DSM activities and further implementation of them. Companies belonging to this group have a clear incentive structure: to minimise its electricity bills, minimise required investments and related risk exposures.

Single owner with several leaseholders: This is a common practice with several companies renting their premises from an owner company as shown in Figure 5. In this situation the owner usually covers a small share of electricity costs for common areas and transfers the major share of costs directly to his leaseholders.

This leads to opposite incentives between owners and leaseholders: an owner wants to invest as little as possible in DSM, since electricity costs are paid by leaseholders. The renters wish to reduce their electricity bill, but usually do not have an opportunity to make the required investment.

The situation is even more complicated since rent contracts often have a fairly short duration (2-3 years) and have to be regularly renewed. Leaseholders do not want to commit any substantial investments since they may have to move to another building. Planning and implementation of DSM actions become complicated for owners since the situation becomes unpredictable in the long run. Additionally, implementation of DSM actions meet practical complications since certain types of activities have to be implemented at the same time in order to be efficient. Our experience shows that it becomes difficult to reach an agreement about this with leaseholders.

Joint ownership with several leaseholders: The situation is different when several companies own the premise in joint ownership, which is led by a manager as it is shown in Figure 6.

This model usually includes the same set of complications as the previous one. The decision making process in this type of company assumes that all owners are agreeing,

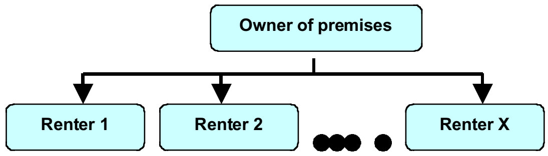

Figure 5. *Owner of premises with several leaseholders (renters).*

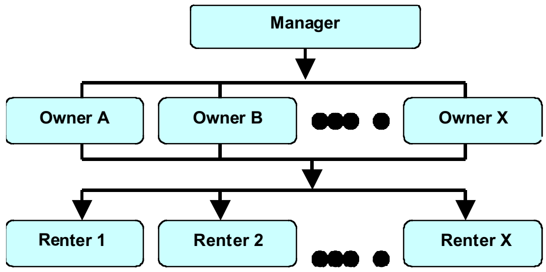

Figure 6. *Joint ownership with a manager and several leaseholders (renters).*

which is difficult in practice when it comes to DSM-related investment.

Cost allocation

Allocation and accounting of costs related to electricity bring additional complications in implementation of DSM actions. As it was mentioned before, an owner of premises transfers electricity costs directly to leaseholders. Allocation of costs in companies, participating in the study, was done in two ways:

- Each leaseholder had an individual electricity meter and paid according to the metered data.
- Leaseholders paid a share of the electricity costs, usually according to sq. meters of the rented floor space.

The last variant creates additional barriers for DSM since it makes use of electricity anonym and in practice removes all incentives from leaseholders.

Contact persons and decision making process

Both interest and personal engagement of those responsible for technical operation in a company have a crucial importance in planning, implementation and continuous follow-up of DSM activities. Competent persons should be informed about both the economic and technical sides of the company's operations. The experience shows that low interest, lack of responsibility or negligence from technical staff can complicate considerably both evaluation and implementation of DSM.

Financing of DSM and recovering of investments

Companies usually prefer to base their investment analyses on so-called payback period estimation. It is a relatively simple and easy to understand method for estimation of investment profitability over relatively short time periods. (For longer periods it is more appropriate to use Net Present Value method.) The experience shows that commercial customers prefer to initiate DSM activities with 2-3 year payback period, while DSM with payback periods exceeding 4 years are strongly opposed by company's management and usually rejected by owners (board of directors). On the other hand, companies are willing to accept DSM actions with longer payback periods if they have a maintenance-related profile, like installation of new windows, new ventilation, doors etc. [5]. Commercial customers have pointed out that there is a considerable risk factor in DSM-related investments since the power electricity market has become highly volatile and unpredictable when it comes to spot prices. Possibilities in alteration of existing network tariffs may also contribute to a considerable risk exposure.

Financing of DSM and corporate organisation

Results from our study give the impression that companies and organisations have very different requirements to the financing of DSM. Private companies with relatively low-built horizontal organisation structure, decentralised financing and decision-making tend to require very high profitability from proposed DSM-actions and expect correspondingly short payback periods. At the same time, according to the contact persons, these companies are better positioned to commit the required investment as long as it is feasible from a financial point of view. Other type of companies, usually public, have absolutely opposite behaviour: They consider approval and obtaining of the required investment to be the most complicated part, while the profitability of the investment and future operating costs are less important.

Electricity costs

Electricity costs usually have a relatively small share in a company's costs, when e.g. compared to labour costs. The result is that a company avoids implementing any DSM activities if they are expected to increase labour costs, as for example movement of energy-intensive production processes to low-load periods (night). Additionally, it may cause a conflict with existing legislation, regulative working norms and standards. Companies which traditionally used to work during night time, as for example bakeries, are much more flexible when it comes to adjustment of load profiles.

MOTIVATION MODEL – STRUCTURING OF INCENTIVES FOR COMMERCIAL END USERS

The following model is a proposal for structuring the end user's motivation and incentives, based on experience and results accumulated within the IDO project [1]. In this paper key motivation factors related to financial aspects are defined as incentives. The main objective in the motivation model shown in Figure 7 is to systemise key factors, which are essential for definition of appropriate DSM actions for a given customer and, therefore, have the highest possibility to be implemented. The proposed model includes two parts as it is shown on Figure 7.

Part A

Organisation form is related to a composition of different factors and details, related to a given company implementing DSM. The model summarises previously mentioned differences in priorities between companies with a flat organisation (usually private companies) and companies with vertical structure (usually public institutions) related to investment and profitability of DSM.

Recommendations for implementation: A possible solution for companies with a flat structure is to emphasise initiatives with low risk and high profitability (even though they may require high initial investments). These companies require follow-up and intensive advisory services throughout the implementation process.

Companies with a vertical structure prefer solutions with low initial investment, but can accept high operation costs.

Part B

Part B is related to analysis of existing potential for reduction of energy- and power consumption, which can be realised via DSM.

Objectives: Development of proposals for DSM should start from definition of concrete objectives in a given network area, including required reduction of peak load or alteration of load profiles.

Actions: Definition of actions, which can be implemented, starts with a preliminary technical evaluation of the potential for load management and energy efficiency improvements existing in a given company.

Economic analysis: The analysis of the proposed actions includes investment analysis, profitability, operation and maintenance costs. The analysis also considers support schemes, based on expected consequences from actions. Development of several scenarios, based for example on different electricity contracts and network tariffs, may improve the evaluation process. Choice of the most appropriate actions: Comparative analysis of the proposed actions, together with factors related to company's priorities, choosing the set of most appropriate actions.

It is important to note that the model relates to information and data which are usually publicly available. It is therefore assumed that it is possible to work on Part A before or at the same time as Part B.

Network Tariff – The Motor Oil in the Motivation Model

Today the electricity price in Norway consists of three parts: energy price, network tariff and taxes. Most end users in Norway have an energy price which follows the spot price in the competitive Nordic electricity market, Nordpool. This implies that most end users today have an energy price which makes about 40-60% of the total electricity price, while network tariff makes about 20-40% and the taxes make about 20%. The price signal form the network company affects the majority of the motivation key factors. The network company Viken Nett decided two different strategies related to the tariff agreement for the two projects "Implementation of DSM in Oslo" [1] and "New technology for controlling power load in Oslo" [2]. To promote long-term DSM actions the network company did not offer the end-user any new tariff or changes in the existing tariff agreement. To promote short-term actions the network company offered the actual end-users a new tariff related to the limited controllable or interruptible load. In Table 2, the existing tariffs for uninterruptible consumption and the new offered tariffs for limited remote control of uninterruptible con-

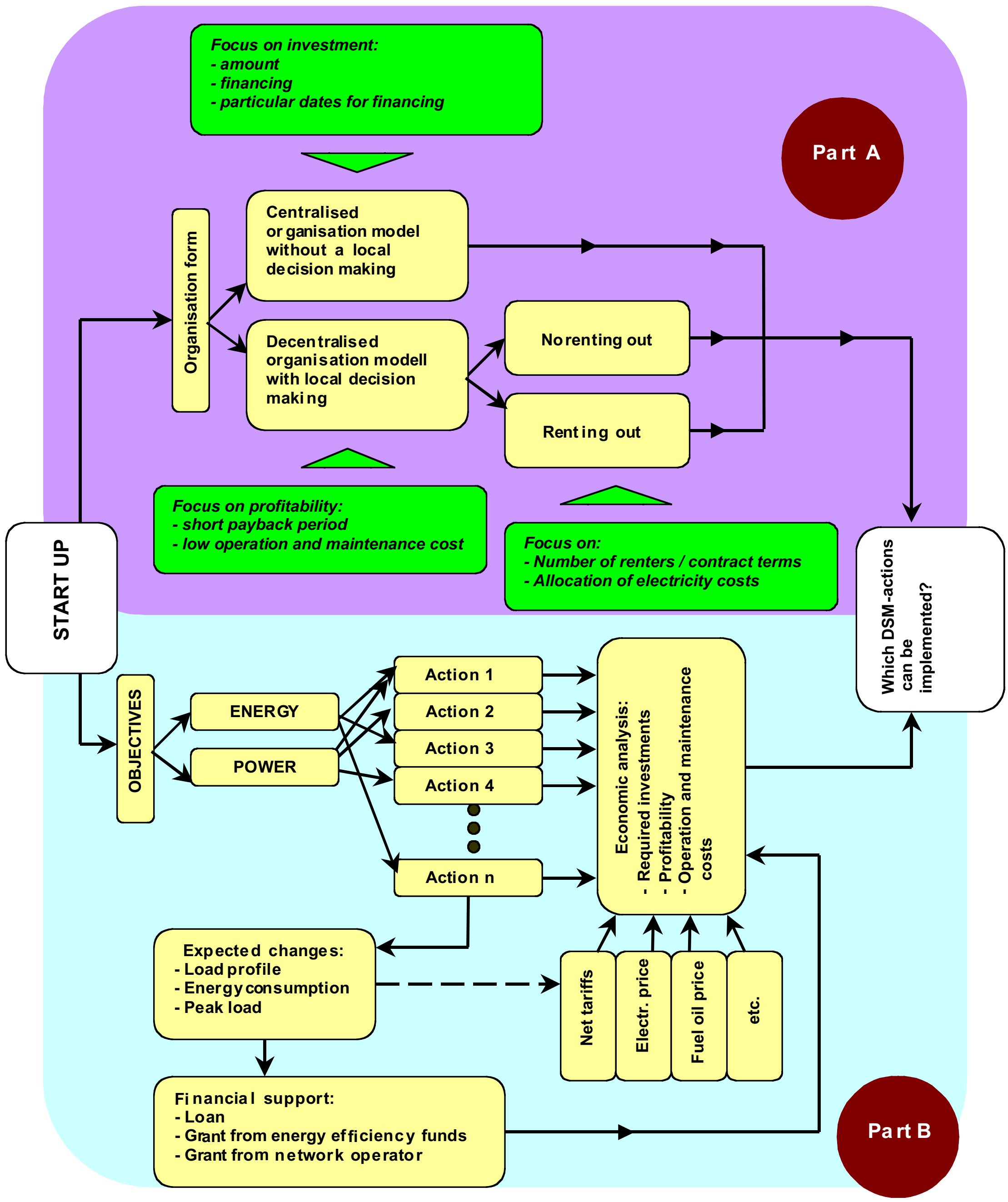

Figure 7. *End user motivation and incentive structure.*

sumption is shown for an end-user connected to the lowest grid level.

Table 2 shows that the pilot customers were offered 40-60% reduction of the power load costs related to the load which is controllable or interruptible in limited periods. The network company require duration of at least 3 hour of each remote interruption or load control.

Conclusions – Experience and Knowledge Gained

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 end user. All experience shows that end users have to be strongly motivated to implement energy efficient actions, in spite of the fact that the end users 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, so called long-term DSM actions, of 10-15%. This potential is related to a wide type of measures, among them installation of new equipment, replace-

Table 2. Network tariff agreement concluded with pilot customers.

Type of network tariff	Grid level	Fixed price (Euro/year)	Power load interval (kW)	Power load price (Euro/kW)	Energy consumption price (Euro/kWh)			
					week no 2-14	week no 15-27	week no 28-40	week no 41-1
Tariff for uninterruptible consumption, ordinary tariff for commercial customers in Oslo Pilot project [1]:	230V or 400V	689	0-200	53	0,0127	0,0057	0,0034	0,0048
			200-1000	45				
			> 1000	37				
New tariff offered for limited controllable or interruptible load "momentary remote control". Pilot project [2]:	230V or 400V	689	-	17	0,0041	0,0028	0,0028	0,0041
New tariff offered for limited controllable or interruptible load "remote control with 1 hour alert". Pilot project [2]:	230V or 400V	689	-	28	0,0041	0,0028	0,0028	0,0041

ment of electrical energy carriers, renovation of buildings and installation of smart house solution. There is a similar potential among residential end-users related to electrical heating and electric boilers. In difference to Central Europe, Norwegian households are mainly dependent on electrical heating. The time horizon for realizing long-term DSM actions is empirically 3-4 years for commercial customers and 1-2 years for residential customers.

From studies of a random group of end-users in Oslo, the potential for short-term DSM actions seems to be pretty large. Considering only uninterruptible consumption, it has been documented that 49% of peak power load can be controlled or interruptible for a limited period of time i.e. duration of at least 3 hours. The time horizon for realizing these kinds of actions is empirically 0,5-1 year.

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 end-user. However, the cost-benefit incentive was not always the most vital incentive for the end-user 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. 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.

Due to increases in energy and peak load consumption, as well as the need for grid maintenance, grid reinforcement will always be an important topic to all Network Companies. These studies of DSM implementations provides useful results and methodologies to energy planning among network owners and local authorities, as well as district heating suppliers in Norway and in other European countries.

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