APPENDIX A:

CASE EXAMPLES

CONTENTS

IMPROVING THE HEATING SYSTEM BALANCING SERVICES OF BUILDINGS (SF)

Submitted by:

Finn Barents (for MOTIVA)

Urho Kekkosen katu 4-6 A, FIN-00100 Helsinki, Finland

Contact: Ms. Ulla Vuorio

Tel.: +358 9 5657 0513

E-mail: ulla.vuorio@urova.fi

http://www.motiva.fi

INTRODUCTION

The Information Centre for Energy Efficiency, since the autumn 2000 MOTIVA Ltd, started a market transformation programme for improving the heat balancing in buildings in 1993. The programme also had features from load management and customer retention type programmes. The programme aimed at improving living conditions in residential buildings and reducing heating costs by savings of 10% in energy consumption. The programme altogether with two follow-up studies lasted 4 years till 1996. During this period, heating systems were balanced in 3,600 buildings, 180 HVAC contractors, 200 engineers were trained and the systematic engineering tool was designed. The programme partners were MOTIVA, Oras Ltd (manufacturer), and Ensel Engineering Ltd. (Energy Service Company).

The total programme costs were 2,080,000 EURO. The Government's financial support was 20%; the programme partners covered 80% of the total budget.

The target of the programme evaluation was to assess the current market situation on heating system balancing after the programme and the governmental support was finished. The target was to estimate how many buildings were balanced, how many persons trained on the basis of the programme. The objective of the evaluation was to estimate total energy savings as well as the total reduction in CO_2 emissions, which were calculated by engineering methodologies using data from the Finnish District Heating Association. The methodologies used in the programme evaluation were interviews, questionnaires, and collection of consumption data in specific buildings from the utility companies.

In 2000, MOTIVA asked Finnbarents, University of Lapland, to co-ordinate the programme evaluation. Espoo-Vantaa Institute of Technology and Suomen Talokeskus Ltd. participated in the evaluation work.

BACKGROUND

Flat temperatures in multi-family building blocks and terraced houses connected to the district heating network varied within the range of 26°C to 18°C depending on the location of the flat. MOTIVA started the development of the programme in 1993. The basic idea was to create pleasant living conditions with even flat temperatures of 20-22°C and to justify the heating costs among the residences. A saving of 10% in energy consumption was a target. One of the objectives was to increase public awareness of energy saving potential in residential buildings. The programme aimed to overcome this market barrier of higher investment costs resulted of the new equipment and installations: the complete heating system balancing demands investments, approximately 0.7-1.4 EUR/m^3.

The Finnish Ministry of Trade and Industry supported the programme. Motiva, Oras Ltd., the manufacturer of equipment, and Ensel Engineering Ltd participated in the programme.

The first phase of programme started in May 1993 and it finished in 1994. The programme was followed by two follow-up studies during the years 1995 and 1996.

EVALUATION METHOD

The objective of the evaluation was to estimate the current situation of heating system balancing according to the programme or other methodology in the market. The eligible market i.e. the number of unbalanced buildings at the time being is approximately 80,000 buildings. Altogether this means a large potential for energy savings.

The evaluation can be divided into two phases: data collection and evaluation.

The first step in data collection was to get information of the programme and the follow-up studies and to interview partners involved in the programme.

The second step was to prepare two questionnaires for the house managers involved in the programme. The first questionnaire focused on information of the buildings of which heating system balancing was carried out during 1996-99. The objective was to get actual data on concrete buildings that have been renovated. Thus the questions related to the building itself and the renovation:

- Name of the building
- Location, address
- Type of building
- Type of heating system
- Total costs of the project
- What was renovated
- Has any other renovations made during 1996-99 e.g. ventilation, windows, insulation of walls, etc.

The second questionnaire focused on the programme and is presented below.

RESULTS AND CONCLUSIONS

The main results and findings of the evaluation are briefly discussed below. The detailed results of evaluation will first be presented to Motiva Ltd, which decides on the further activities, publishing and information dissemination.

Questionnaires were sent to over 500 house managers. The reply percentage was 25%.

One fourth of potential target group of buildings were renovated meaning that heating system balancing is still needed. Every house manager indicated that they intended to continue renovating the heating systems in their buildings. The most important driving force is the pleasant living conditions, not energy savings nor environmental aspects.

The investments were in most cases considered to be beneficial.

Information on the programme and more over the heating system balancing should be increased.

The 100 buildings with energy consumption follow-up data were studied in more detailed for estimating the savings. Savings and CO_2 reductions are estimated on an annual basis.

The reduction in CO_2 emissions was estimated as 77,500 t/a; the potential of 231,000 t/a. The gross primary energy saving was calculated to be 22,400 TJ/a; the potential of 67,200 TJ/a. The figures have been calculated on the basis of the total annual production of DH in 2000 /1/: 27.4 TWh, of which 77% produced by CHP and 23% by separate production. CO_2 burden in CHP production is 211 gCO_2/kWh and in separate production 217 gC0_2/ kWh.

REFERENCES

Information of the Finnish District Heating Association.

HEATING SYSTEM BALANCING ENQUIRY

	Yes	No	Don't know
1. Has the heating system of residential buildings managed by you been balanced?			
2. Do you allow your buildings' heating energy consumption figures to be used for this study?			
(Enclosed is a power of attorney for the acquisition of information from the local DH company)			
3. Has all the heating system balancing been carried out according to the Motiva quality standard?			
4a. Are you satisfied with the heating system balancing and with the Motiva quality standard as a whole?			
4b. Do you have any suggestions as to which area should be further developed?			
5. Has there been follow-up of the heating system balancing in the buildings managed by you:			
a) Measurement of room temperature?			
b) Were the measured temperatures within ±1°C range of the planned room temperature?			
c) Follow-up of the energy consumption?			
d) Enquiry about user satisfaction?			
e) Follow-up and regulation of the heating adjustment curve?			
f) Other follow-up			
6. Why has the heating system balancing been carried out in the buildings managed by you?			
a) Uneven temperatures in the apartments			
b) In order to save energy			
c) Leaking radiator valves			
d) Other reason			
7. Is the heating system balancing a profitable investment to the building?			
8a. Will there be in the future heating system-balancing projects in the properties managed by you?			
8b. If yes, will they be conducted according to Motiva quality standard?			
9. According to your estimate, in how many cases out of ten has the heating system balancing not been carried out because the state contribution (20%) was cut off?			
10. Should there be more public information about the heating system balancing?			
11. In your opinion, is there a need for training concerning the heating system balancing?			
a) for property managers			
b) for maintenance personnel			
c)			

12. Opinions/ experiences concerning the heating system balancing:

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EVALUATION OF THE ENERGY EFFICIENCY CHECK (N)

Submitted by:

Norsk Enøk og Energi

Øvre Eikervei 14, P.O. Box 4101, Gulskogen, N-3002 Drammen, Norway

Contact: Ms. Liv Randi Lindseth

Tel.: +47 32 20 16 18

E-mail: lrl@nee.no

http://www.nee.no

INTRODUCTION

The Energy Efficiency Check (EEC) is a standardised EE audit for households, which was first introduced in a national EE campaign by The Norwegian Water Resources and Energy Directorate (NVE) in 1997. It was sent to 1.26 million households in 1997 and has continued to be an important element in several campaigns both locally and nationally. In a white paper from the Norwegian parliament, nr.58 (1996-97), regarding environmental politics for a sustainable future it is an expressed goal that all the households in the country (houses and semidetached houses) built before 1980 will undergo an EEC of their residence within a period of 5 years. The EEC is thus intended to be a main tool for EE in private households.

On the background that the EEC is one of the EE tools of the residential sector that has required the most resources in the last years, and that its goals and effect has been disputed, it is important to strike a balance for this activity. Both the use of public funding, organisation and implementation of this programme would benefit from being the subject of evaluation. The present "Ex-post Evaluation Guidebook for DSM and EE Service Programmes" and the assistance of an evaluation expert from the guidebook project team have been used to raise the quality of the evaluation strategy and the implementation of the evaluation work.

Furthermore, the organisation of all Norwegian EE activities is currently under revision by the Ministry of Petroleum and Energy. The authorities plan to establish a new administrative body with a freer position in relation to the public administration than what NVE as a directorate has today. The services and programmes that are offered by the Energy Efficiency Centres today will to a greater extent be exposed to free competition. It is therefore important to be competitive and able to show well-documented results. Hence evaluation of existing EE services and programmes is getting increasing attention.

The evaluation of the EEC includes impact assessment, cost-benefit analysis, and customer utility value. This, along with the potential consequences for the involved parties is presented in the following.

Of total of 1,200 telephone interviews was completed in September 2000. This is a relatively large evaluation of a full-scale EE programme in Norway. The findings are interesting and, by first glance, quite depressing for the parties that have put a lot of resources in this particular EE programme.

The following will give a general overview of the EEC programme and its goals. The evaluation strategy, the methods, and the survey will be presented along with the most important findings. Finally, it is discussed whether the goals of the EEC programme have been fulfilled and recommendations are given for further use of the EEC programme.

PROGRAMME DESCRIPTION

The EE Centres send the EEC by direct mail to end-users. It consists of a form with a number of simple questions about the building in relation to energy use. The questionnaire is filled in by the customer and returned to the EE Centre. Based on this questionnaire the customer will receive a letter where the specific building's consumption is compared to norms for how much energy a normal house should use. The letter also includes the estimated saving potential of the building and a recommendation of specific EE measures.

The EEC offer, which was distributed to the customers in Akershus in 1999, consisted of an introduction letter and the EEC form printed on the EE Centre's notepaper. A stamped envelope was also included. When the customer filled in and returned the EEC, it was processed manually by an energy adviser at the EE Centre. The resulting response from the EE Centre consisted of a letter stating simple EE measures that the customer could benefit from as well as a graph of the electricity consumption adapted to the individual house.

The **main goals** for the EEC programme and the EE Centre in Akershus were:

1. More energy efficient households.

2. The programme effects must exceed its costs.

3. The programme shall create possibilities for follow-up activities.

The goals are diffuse and not formulated with an ex-post evaluation in mind. They are not very precise or easy to verify and they say more about the thoughts and opinions of the EEC's role in the general national EE policy. The first goal could be about documenting kWh saved and would hence be possible to verify. The second goal says nothing about what the effect should be or who would benefit from it – the customers, the EE Centre or the authorities? This goal would have been good if there was a tracking or monitoring system that would provide comparable values. The third goal does not specify the follow-up activities. There is some doubt that the EE Centre in Akershus and other EE centres had specific goals as to what kind of follow-up they wanted at the end of the EEC programme. It is also likely that the various counties/centres has had different goals. To clarify this issue was outside the limits of this evaluation.

The evaluation itself and the Ex-post Evaluation Guidebook project have taught us a lot about the need to specify clear and precise goals that are possible to meter and evaluate.

THE EVALUATION

Evaluation Objectives

Initially the objective was defined as: "Document kWh saved for the participating households". This goal was redefined while working with the questionnaire. It proved to be too complicated and time consuming to answer this question through phone interviews. Also the effective output of an exact kWh number for each household is doubtful compared to the use of resources to prepare, design the questionnaire, the length of the interviews and the data processing. The questionnaire was hence redesigned to answer the following:

1. Describe **how many more EE measures** the participants in the programme have implemented and measure the value of these compared to norms.

2. Document possible **other effects** resulting from the EEC beneficial to the involved partied (national authorities, the EE Centre in Akershus, other EE centres).

3. Evaluate the **use of resources** against possible alternative use.

The first goal is the main focus of the evaluation. The questionnaire and the survey have been designed mainly to fulfil this goal. In addition questions were added to create a basis to evaluate whether the last two goals have been fulfilled. Redesigning the first goal to not include documentation of kWh savings has also resulted in changes to the last two as the kWh documentation was removed.

The evaluation has attempted to answer the above. In accordance with the project plan we will also make a recommendation for future use of the EEC intended for relevant decision-makers.

Evaluation Strategy and Method

Our choice of strategy is based on the European Ex-post Evaluation Guidebook. It has proven useful as an introduction to evaluation of EE programmes as it provides a description of various evaluation methods. We have focused on the methods that seemed relevant to the evaluation of the EEC. The following theory is taken from the guidebook to present a background for the chosen strategy.

Evaluation is particularly important when the EE programme is free of charge. The demand for a service will in these cases not be sufficient to defend the advantages, effects, or results. If the customer had to pay to participate, a high response would in itself be a good indicator of a successful programme. An evaluation of the EEC will make it easier to argue for or against the programme.

The goals for the EEC have been described above. We would however like to add that there have been several goals for the national EE policy in Norway including reduction of the energy import, increased employment, and promotion of the authorities or EE centres. The electric utilities have operated with customer retention goals to increase profit margins and profitability. We need good, clear and realistic goals and a precise EE policy to be able to meter the effect of EE programmes. If the goals are as described but the monitoring is focused on kWh savings we will soon end up with a lot of “failed” EE programmes and tools.

Key Areas of Uncertainty

We have focused the evaluation around the question of results and effect in the form of more implemented EE measures (kWh reduction) and the market response to the EEC. Evaluation of the process and implementation of the programme could have been interesting but was not included in this evaluation.

The questions below were formulated to answer the goals of the evaluation.

- **Did the participants energy use alter as a result of participating in the programme?** If not, why not? Recommended savings compared to actual savings? What parts of the savings did the EEC cause directly? Other causes for a lower energy use: weather, personal economy, increased energy price, changes in attitude, more electric devices, more inhabitants.

- **What would the energy use have been without the EEC?** Past and present consumption data, control sample, baseline studies.

- **What measures would the household have carried out without the EEC and why?** Free riders: the exact same measure with the exact same savings, partially the same measure, the same measure, but at an earlier date than planned.

- **Are the achieved savings larger than the costs of implementing the programme?** Cost/benefit analysis.

- **Have the participants carried out other or more EE measures than those recommended and advised by the programme?** Spill-over effects: increased awareness, change in attitudes, changes in habits, measures that do not require investments, household implementing measures because of the EEC without returning the EEC form.

- **Are there other benefits than actual reduction in energy consumption?** Rebound: comfort, higher indoor temperature, new electrical devices etc.

- **Self selection** Are the participants already “best in class” regarding energy? Are the savings due to the background of the participants rather than the EEC itself.

Investigating the lifetime of the implemented measures, delayed effects, and follow-up values would be interesting but was not part of our evaluation.

Vintage of Programme

The EEC programme is a second/third year programme. A thorough evaluation is hence right. The decision-makers will have to decide whether to continue, improve, alter, or terminate the programme. Surveys suitable for newer programmes were carried out in the earlier stages of the EEC programme. These showed a good response and sufficient customer satisfaction. It was assumed that the detected savings were due to the programme and thus indicated that the programme was on the "right track".

Level of Evaluation Effort

The funds available are a decisive factor in the choice of method. In general a more comprehensive evaluation like we chose is necessary when considerable resources have been used to develop and implement a programme, special findings are expected or the expectations to the programme is large and the programme is subject to discussion.

Our conclusion was that a different and more expensive data collection than what was done in the previous surveys was needed to provide answers to our questions.

Key Decision-Makers

Identifying the important decision-makers for continuation or development of the EEC was relatively simple.

The EEC was, as mentioned earlier, first introduced as a priority EE programme in a national EE campaign initiated by NVE in 1997. It has since been an important element in several campaigns. NVE is subordinate to the Ministry of Oil and Energy (OED) and responsible for administration of national water- and energy resources in addition to management of national EE activities.

The EE Centre in Akershus has used considerable resources on developing and implementing this EE programme and is hence the EE Centre in Norway with the longest experience with use of the EEC. We have used material from Akershus and based our survey on the goals set for the EEC in their area. Akershus is a county in Norway consisting of small and large towns and villages and should hence be representative of Norway as a whole.

The EEC is and has been part of the total service offer provided by the EE centres in Norway for some time. Documented results will be increasingly important in a new situation where the centres to a larger extent will be subjected to a free market. This will also imply a reconsideration of all the existing EE tools and programmes including the EEC.

Planning the Survey

Several possible data collection strategies were considered based on the details of the EE programme, existing data and investigations of former surveys and evaluations.

In brief, the former evaluations of the EEC performed by the EE Centre in Akershus have focused on market response and simple impact assessments. The response rate has been considered satisfactory and the customer satisfaction has been considered high. These evaluations have also shown an average saving per household of 450 EUR for the benefit of the programme. No control samples have been used. There have been made no attempts to check what the household would have done without the EEC. The documented savings were not compared to customers who did not participate in the programme and are hence merely assumptions of the effects of the programme.

As mentioned earlier, a low budget evaluation is correct at an early stage of a programme. Our initial strategy was a qualitative survey using 400 telephone interviews including a control group. Based on the new examination of the programme history we decided to perform a larger survey to ensure significant results. We chose a main sample and two "control" samples to answer our questions regarding effects related to "non-participants", self selection, rebound, free-riders and spill-over effects, etc. As a result we decided to use an agency specialising in market analyses and not an initially chosen agency focusing on psychology and depth interviews.

Sample 2 and 3 are comparison samples. A real control sample does not exist as this would mean two 100% identical samples where the programme is the only difference. Theoretically a baseline, i.e. a sample group with the same “starting point” as the participants, could have been established. This could only be done before the programme was implemented in this kind of programme and is better suited to evaluate technical EE measures. Comparison samples like the ones we have in this evaluation will provide a good indication to the situation without the programme.

RESULTS OF THE EVALUATION

The evaluation has given useful experience on several levels. Increased knowledge of evaluation theory and methods and the results of our evaluation have shown how crucial a systematic lifetime evaluation is to EE services and programmes.

Formulating the survey questions correctly and placing them in the right order to ensure that the respondents are not influenced to give the "correct answer” is in general a large and important task. Our experience is that co-operating with experts with thorough knowledge of the programme is crucial as even small errors can have relatively large effects.

We recommend that all types of EE evaluations should answer questions on self-selection and general social commitment. Such information will make it easier to differentiate between results caused by general energy and environmental attitudes and results directly due to the EE programmes and services.

The Survey and Important Findings

The survey was implemented in September 2000. It was carried out by the company Norsk Gallup on behalf of Norsk Enøk og Energi AS that is responsible for the Norwegian case project. Three groups of a total of 1,200 customers in Akershus were interviewed.

The three sample groups were:

1. Customers who participated in the EEC programme

2. Customers who received the EEC, but not completed or returned the form

3. Customers who did not receive the EEC (or other EE material from the EE Centre over the past year)

The most important findings of the survey are:

- The EEC has little effect on implementation of EE measures.

- Customers who did not receive the EEC (the third sample) seem to have implemented most EE measures overall.

Other findings are:

- The wish for a reduced energy bill and reduced energy use is the main cause for implementing EE measures.

- The main cause for not implementing new EE measures is that EE measures were already implemented in the past.

- The customers who have already implemented several EE measures in the past are the most likely to complete and return the EEC. The same people seem to be more interested in EE than the average person.

- There are significant differences between the three samples on the issue of behaviour. Customers who participated in the programme (Sample 1) have a higher score than the two other groups regarding EE behaviour. This again implies that this is the most EE aware part of the population.

- The participants of the programme are the people that are most eager readers of the EE newspaper and their general knowledge on EE is significantly higher for those who have not been exposed to any EE service or material the last year (Sample 3).

- Customers, who return the EEC, are generally more focused on their energy use, which may partly be due to the EEC.

- The EEC works, in combinations with other distributed material, as "name branding" for the EE Centre.

- Knowledge of EE is higher among the customers who have received or completed the EEC. These two samples have also received an EE newspaper and other material from the EE Centre.

- Installation of energy efficient light bulbs is the most common EE measure.

It seems like the problem of self-selection is more evident than anticipated in spite of the fact that people's attitudes towards EE and environmental issues seem to be almost the same. The EEC also seems to have been used as a tool to verify that measures already implemented are the right ones and truly are energy efficient.

Who Participates in the Programme?

The survey gives several characteristics of the participants. 72% of the 2,400 people that completed the EEC were men. This shows that men are most interested in implementing EE measures in general. There are no large differences regarding age, but it seems that older people are more interested. The number of people in the household does not influence the reaction to the EEC. The income, however, seems to make a difference in whether you use the EEC or not. People with high income are more likely to participate in the programme. It seems that the medium size households with a living area of 100-250 square metres are more likely to return the EEC. The heating system of the houses has little influence.

Other Interesting Findings

The main reason for implementing EE measures is to save energy and reduce electricity bills. More than 40% give this answer in all sample groups. 10% want increased comfort and about 10% say that general maintenance is the main reason. Women and people in older houses are more interested in increased comfort. The houses in the third sample group are in general older and hence they require more maintenance. In the same sample there are more young people in older houses. This can of course be a contributing factor to why this sample group has implemented more EE measures on the whole.

The reasons why people do not implement EE measures vary between the sample groups. In the first sample 71% said that they had already implemented the measures. In the two other samples only 50% gave the same reason. This shows again that the people who have used the EEC are already very aware of EE. Other reasons given are "no need", "new house", and "can not afford".

The survey also shows that very few people plan to implement EE measures over the first year. 74% of the participants in Sample 1 and 57% of the people in Sample 3 will not implement measures in this period.

When asked about EE habits people answer that they do things very "energy correct". About 90% of all the samples say that they switch off lights in empty rooms. 90% fill up the dishwasher and washing machine before they switch it on. The participants in the EEC programme are in general the best. As for age, the older you get the better your energy behaviour is according to the survey.

Exhibit 1: Survey of the Energy Efficiency Check
(Implemented by Norsk Gallup on behalf of Norsk Enøk og Energi AS, September 2000)

Approach (some examples from the survey)	**Sample 1** Participants Given other info	**Sample 2** Not participants Given other info	**Sample 3** No offer No other info
Number of implemented EE measures pr. household	**7.65**	**6.57**	**8.48**
Number of implemented EE measures in buildings built			
before 1900	0%	5%	1%
1900 – 54	16%	14%	11%
1955 - 69	23%	18%	23%
1970 - 83	36%	29%	33%
1984 - 97	18%	27%	26%
after 1997	7%	7%	7%
Implemented measures in % of total			
Installed photocell for outdoors lighting control	4%	4%	4%
Installed new windows	13%	15%	11%
Installed energy saving light bulbs indoors and outdoors	52%	51%	48%
Sealed air leakage around windows	8%	7%	11%
Sealed air leakage around doors	5%	3%	9%
Replaced balcony door	1%	1%	2%
Installed new door	2%	2%	2%
Insulated roof	1%	1%	1%
Insulated walls	1%	2%	2%
Installed energy saving shower head	4%	5%	4%
What are the main reasons for not having implemented EE measures?			
Have already implemented EE measures	71%	53%	50%
No need	19%	18%	15%
New building	18%	22%	13%
Do you have plans to implement any EE measures the next 12 months?			
No plans to implement any measures	74%	71%	57%
Will replace doors or windows	4%	8%	9%
Will start using energy saving light bulbs	4%	5%	3%
Behaviour: Do you do one of the following things?			
Turn off light during the night	21 %	17 %	21 %
Air out short and effective	82 %	76 %	78 %
Take short showers	41 %	36 %	41 %
Rinse dishes in cold water	29 %	22 %	21 %
Fill up dishwasher and washing machine before use	89 %	83 %	87 %
Reduce temperature in rooms that are not in use	74 %	73 %	74 %
Turn off light in rooms that are not in use	91 %	90 %	88 %
Can you remember to have received a newspaper about EE during the last 12 months?			
Yes	70 %	62%	47%
No	26%	33%	48%
I don't know	4%	5%	5%
Knowledge: Identification of EE measures. Four alternatives given - two were correct.			
Share that gave the right answer	78%	77%	67%
Do you follow up your energy use by reading the meter at least every month?			
Yes	42%	31%	30%
Do you know of the EE Centre?			
Yes	66%	48%	38%
Have you made use of one or more offers from the EE Centre during the last 12 months?			
Yes	12%	11%	4%

WERE THE EVALUATION GOALS REACHED?

How Many More EE Measures?

The evaluation aimed to describe how many additional EE measures the participants in the programme had implemented and then calculate the impact of these measures using to norms for energy use. Looking back we can see that even at the design of this aim we assumed that the customers who had implemented the EEC would have carried out more EE measures than the other two groups in the survey. This was, however, not the result of the survey. It was group 3, who had not even received the EEC, who had implemented most EE measures in total. We saw therefore no reason to perform these calculations.

Other Possible Effects

The involved parties are as mentioned NVE, the Ministry of Oil and Energy, the EE Centre in Akershus and other EE centres in Norway.

The initial programme goals seem to have resulted in too high expectations regarding the effects. Other goals could have been used. Building customer relations, name branding, marketing of other services by the EE centres as well as providing positive feed-back or “insurance” to energy efficient house owners could have been possible goals which would have resulted in more positive evaluation results.

Suggestions have been made that the EE centres had different goals and expectations to the programme. Not all the EE centres thought the main goal of the EEC to be kWh savings.

We think that it is important to be clear about programme goals and design the contents and implementations according to this. It seems that one expected the EEC to result in reduced energy consumption (kWh) while the programme was designed to give other results.

The EEC has been successful in transferring knowledge and in marketing the EE Centre. Knowledge of EE and where to obtain more information and advice are central goals for the national EE work in Norway. We think that this evaluation has documented that the EEC has made a positive contribution towards these goals and thus not been a total loss for any of the involved parties.

Use of Resources

The evaluation of use of resources against obtained savings for distribution and processing of EEC data are based on the campaign implemented by the EE Centre in Akershus in 1999 as this is the most resent mass distribution of the EEC. This distribution is the basis for the survey implemented by Norsk Gallup. All completed EECs were processed manually. The cost of producing and distributing 30,000 EECs was 1.6 EUR/EEC. Total costs divided on 2,300 processed EECs were 59.7 EUR/EEC.

In comparison a 16 page EE newspaper like the one distributed by several EE centres in Norway costs between 0.25 to 0.5 EUR delivered to the customer. An EE magazine like the one distributed by the EE Centre in Oslo and by some others will cost between 1.2 and 2.4 EUR. These are not directly comparable to the EEC, but the evaluation shows that the main impacts of the EEC are increased consumer knowledge of EE and promotion of the EE Centre. A comparison of costs can therefore be considered relevant. Based on the performed survey one can argue that every single EEC has a value and hence calculate the cost price to be 4.6 EUR/EEC distributed. This shows that the EEC is an expensive way of promoting EE and EE behaviour.

There is little evidence that the EEC as an independent programme has fulfilled its main goals. The customers who accept the EEC in a mass distribution campaign are already the most energy effective households. Further it is not possible to document any kWh savings for the participants. The programme, however, seems to have a marketing value and it can result in increased knowledge of the EE Centre. The EE Centre can also use the EEC as a basis for contacting households with particularly high energy consumption.

RECOMMENDATIONS

Although the evaluation has shown some negative results we are not all negative with regards to the future of the EEC. Positive results exist and it is possible to implement the EEC in a more cost-effective way in the future.

There is little evidence that the EEC as an independent programme has the desired effect based on the main goals of the evaluation. It is still the most energy efficient households who decide to participate in the programme when it is used as a mass campaign. It is not possible to document that the participants implement more EE measures than households in the two other sample groups do. On the contrary it is the third sample group that has implemented the most EE measures on a whole. The programme, however, seems to have a marketing value and hence it can increase the knowledge of EE and the EE Centre.

Who you reach with the EEC is crucial to the effect of the programme. The lack of results in the form of kWh suggests that the EEC does not reach the households with the highest energy consumption and/or the highest saving potential. We see no possibility of recommending the EEC as the main element of a mass campaign for households. The risk of providing the wrong customers with the wrong feedback is too large and the benefit is questionable. Indications that the most energy efficient households is the most frequent users of the EEC supports our conclusion that the EEC is unsuited as a service for all houses built before 1980.

Still, the EEC is a good EE tool for selected customers.

The EEC should be used in dialog with customers who have contacted the EE Centre as basis for giving individual EE advice. The energy advisers should first evaluate the total energy use of the customer compared to general norms. If the consumption is judged to be high, the EEC can be filled in by talking to the customer or by the customer himself. After processing the data the results should be reviewed face-to-face together with the customer. This use of the EEC can be a valuable tool in achieving more energy efficient households. Used this way one avoids the use of the EEC solely as a “proof” for the most energy effective customer (they want someone to tell them that they are doing a good job). Data errors are also avoided by filling in the form in co-operation with the customer and explaining the form. In addition, this form of communication builds positive relations crucial to ensure knowledge and motivation for implementing EE measure.

We recommend that an “EEC Online” would be considered used and marketed as this provides the customer with instant feedback. Still, the EEC may also require direct contact with an energy adviser, because the form itself can be complicated and data errors often result in the wrong feedback.

In the “aftershock” of this evaluation the EE Centre in Akershus has started a small national project of restructuring the EEC to be a data tool in a personal advice situation one-on-one with selected customers.

EVALUATION OF A CAMPAIGN FOR LOWER WASHING TEMPERATURES (DK)

Submitted by:

Elkraft System

Lautruphøj 5, DK-2750 Ballerup, Denmark

Contact: Mr. Mikael Togeby

Tel: +45 44 88 32 00

Email: mit@elkraft.dk

http://www.elkraftsystem.dk

INTRODUCTION

This paper presents the successful experience of a Danish campaign regarding clothes washing. The aim of the campaign was to shift the clothes washing behaviour of consumers in an energy-efficient direction.

The overall purpose was to contribute to reducing Denmark's CO_2 emissions. More specifically the campaign was aimed at lowering the energy consumption of the household sector, which is a major source of CO_2 emissions. At the campaign's outset in 1995, electricity consumed in conjunction with washing and drying clothes accounted for approximately 18% of the Danish households' total electricity consumption. Washing alone accounted for 4.5%. Washing at 90°C or more accounted for 15% of all washing in 1997 - a high percentage in comparison with other European countries. This combined with the fact that washing at 90°C uses approximately twice as much electricity as washing at 60°C, and modern detergents make washing at temperatures above 60°C superfluous, motivated the campaign. The aim and message of the campaign was therefore that one could lower the washing temperature, and thereby improve the environment and save electricity, without lowering the cleanliness of the clothes or comfort of the consumers.

In 1995, a co-ordination group was formed on the initiative of the Danish Energy Agency. The group consisted of the Energy Agency, the Danish Environmental Agency, the National Consumer Agency of Denmark and the Danish electric utilities. The aim of the group was to find a campaign object within the area of household clothes washing. After examining the different possibilities it was decided to concentrate on reducing the amount of washing above 60°C. This target was chosen in spite of the fact that more electricity is used for tumbling-drying clothes, and hence the saving potential within that field possibly be bigger. But it was assessed that it would be easier to change the washing temperature, and that thereby the campaign would stand a greater chance of success. The main argument was that lowering the washing temperature does not impose extra work or other discomforts on the consumer.

Background for the Campaign

One or two generations ago washing at high temperatures was the only way to get the laundry clean. In those days detergents had little effect at low water temperatures. A copper or wash boiler was a labour-saving way of getting the washwater in circulation. The alternative was doing it by hand.

This situation has changed: Modern detergents contain a number of active ingredients, such as enzymes, which, even at low temperatures, are able to dissolve organic dirt, to loosen inorganic dirt trapped between fibres and to prevent dirt in the water from redepositing on fabrics.

It is becoming increasingly common for people to change their clothes daily and the number of people whose work involves their clothes getting heavily soiled is declining. Today most laundry is thus only lightly soiled and normally free from old, dried-up stains. This means that the demands on the washing effect, including the temperature, are not the same as earlier.

Due to the developments outlined above, the percentage of all 90°C wash cycles is declining. However, as washing habits are deep-seated, the population's washing behaviour seems to be lagging behind. It was thus estimated that 90°C wash cycles were used unnecessarily frequently.

It was also estimated that the biggest obstacle towards changing the washing habits in the target-group was objections that the clothes would not be completely clean, odours would not be removed or washing at lower temperatures is unhygienic.

As background and foundation for the campaign the National Consumer Agency therefore made a study together with the Danish Technological Institute, which showed that there were no health or hygienic problems connected with washing household clothes at only 60°C.

Starting Point

A qualitative study consisting of three focus groups with a total of 30 participants was carried out. This study showed among other things that the respondents were fully aware of the amount of laundry they washed per cycle. Nevertheless, two factors make people decide not always to fill up their washing machine:

- Small households do not have enough underwear, for instance, to fill their washing machine.
- In some households people sometimes have to wash one particular garment separately, for instance a child's outer garment.

It was judged that in these two cases it would be difficult to change people's behaviour.

The tumble-drying issue played an important part in the working group's discussions as the energy consumption used for tumble-drying is quite considerable and may in some cases be regarded as unnecessary. Also, the findings suggested that in all probability the potential energy savings would be moderate. Thus, although almost every second household has access to a tumble-dryer, the survey showed that only 14% of these households always tumble-dry their laundry. All others regard tumble-drying as one out of several alternatives and choose this method only when necessary. The qualitative study explained why: Apart from the fact that the Danish population is conscious of the necessity of saving energy, the average housewife regards tumble-drying as only the second best solution. She believes that tumble-drying causes wear and tear on clothes as well as creasing. Furthermore, clothes that have been tumble-dried do not feel as fresh as clothes dried on a line.

Although a campaign might bring about a certain change in people's behaviour in this respect, the individual consumer would regard it a sacrifice and therefore would need to be constantly reminded to keep up the new habit. It was therefore decided to concentrate the campaign on lowering the washing temperature.

Before starting the campaign, the Danish washing habits were assessed. The first survey was done already in 1995, and the second was done in the summer of 1997, just before the campaign start.

The survey in 1997 showed that washing at 90°C or more accounted for 15% of all washing. The earlier assessment in 1995 showed a higher percentage (21%), but the figures cannot be compared directly, as the people who were interviewed in the first assessment where not always the persons responsible for clothes washing in the households. Nevertheless, it can be assumed that already before the campaign started there was a tendency toward, washing at lower temperatures.

According to the 1997-survey, the best estimate of the total number of wash cycles in private households in Denmark per year was around 318 million, corresponding to 1.2 per week per capita. The distribution between the different washing temperatures and the corresponding electricity demand was as shown below.

Washing temperature	Electricity consumption	Frequency (1997)
90°C	2.00 kWh	15%
60°C	1.20 kWh	38%
40°C	0.65 kWh	47%

The aim of the campaign was to change the population's attitudes and habits. More specifically, over a period of three years the objective was to convert approximately one fourth of all wash cycles at 90°C or more to 60°C. In addition it was presumed that the message of the campaign would have a rub-off effect, resulting in conversion of some of the 60°C wash cycles to lower temperatures. It was estimated that each time two 90°C wash cycles are converted to 60°C, one 60°C wash cycle will be converted to 40°C.

As the energy saved per wash cycle converted from 90°C to 60°C amounts to 0.8 kWh and the corresponding figure per wash cycle converted from 60°C to 40°C is 0.55 kWh, the potential energy savings were expected to amount to 13-17 GWh.

Campaign Design – Clean Washing at 60°C

After these preliminary actions an advertising agency was assigned and it was decided to run a three-year campaign combining a mass media strategy with a network strategy. The budget for the three-year period was set at EUR 1.1 million. In 1997 tenders were invited for the campaign. A total of 40 companies showed an interest and three of them were pre-qualified to tender for the contract. EUR-RSCG in co-operation with Kommunikationskompagniet won.

The overall campaign message was simple: *Clean washing at 60°C*. Where "clean" refers to both the clothes being clean and to the environment being less polluted. As an eye-catcher a washing label with the simple message was used on all campaign material.

Campaign message: Clean washing at 60°C

It was chosen that the main argument for changing washing habits should be the effects on the environment while less attention was drawn to the potential savings on the electricity bill. One reason for this priority was that the message, that less electricity is used when lowering the temperature, was expected to be accepted straight away. Environmental aspects were expected to be less well-known and therefore more interesting.

The main target group for the campaign was women between 25-49 years with private washing machines in the household. This group represents the largest amount of washes, as women are often the ones who are responsible for washing in the family, and women in this age group often are part of families with children still living at home. It was also concluded that changing the habits of older women would be more difficult. Women do 74% of all washes. 86% of all households have their own washing machine.

Mass Media Campaign

The mass media strategy consisted of two parts. The first part was advertising in newspapers, women's magazines and local papers. This was aimed at creating interest in washing habits and getting the topic on the agenda in the households and among other parties. The other part of the mass media strategy was public relations work aimed at getting press coverage of the campaign and thereby increasing the exposure of the message. Also an Internet site was created.

Network Campaign

The aim of the network part of the campaign was to use electricity utilities, NGOs (e.g. local environmental groups) and local Agenda 21-workers as ambassadors for the campaign. This was done in order to spread the message more effectively and in order to catch the consumers in situations where washing was on the agenda, anyway. In addition to these ambassadors also libraries and pharmacies were used for distributing campaign material.

Special educational material was made for schools, with the aim of teaching the schoolchildren about environmentally friendly washing and through the children putting the message on the agenda in the families.

Collaboration with commercial parties was another element in the network part of the campaign. Contacts were made with producers of washing machines and detergents, traders and electricians/service mechanics working with washing machines and retail traders. The general idea was to get the commercial parties to include the campaign message in sales information about washing machines and detergents.

This mix of activities created a strong synergy and the fact that the message was communicated through many channels gave it much more strength and credibility. The participation from the networking organisations and companies was clearly positive as the visibility of the campaign and the possibility of combining it with their own activities inspired them.

The campaign started in the autumn of 1997 and measurements of the development have been carried out during the summers of 1998 and 1999. Each survey included about 1,000 persons selected at random and interviewed by telephone. All surveys were done in late July/early August. The response rate was high, e.g. 73% in the 1999-survey.

The objective of the campaign was to lower the proportion of washes at 90°C or more from 15% to 11%. Towards the end of the campaign the proportion of 90°C washes had decreased to 9%, which is regarded as highly satisfying. Another measurement of the effect of the campaign is the percentage of the population, which say that they never or seldom wash at temperatures above 60°C. Also this percentage has increased, as has the percentage of people who agree, they do not boil laundry as often as they used to. Likewise the share of people who agree that underwear must be boiled has decreased. The figures are shown below.

	Survey 1997	**Survey 1998**	**Survey 1999**
Share of washes at 90°C	15%	12%	9%
Share of washes at 60°C	38%	42%	39%
Share of washes at 40°C	41%	44%	49%
“Never wash at temperatures above 60°C”	33%	46%	51%
“Underwear must be boiled”	45%	44%	27%
“Do not boil laundry as often as used to.”	55%	69%	70%

With the realised savings the campaign is highly profitable, even if only half of the change is due to the camp aign. The consumers' annual savings in energy costs of e.g. 3% of the washes moved from 90°C to 60°C exceed the total costs of the campaign.

The share of consumers who knew about the campaign was about 45-50% in 1998 and 1999.

It can be interesting to comp are the development in the Danish washing habits with other sources. In Norway washing at 90°C is rare. Data from Germany show a declining rate of washing at 90°C. The level of washing in Germany is the same as in Denmark. The intensity of hot washing decreased by 5% over 5 years, or 1% per year. In Denmark the reduction was 3% per year.

Comparative data from Germany	Survey 1991	Survey 1996
Share of washes at 90°C	19%	16%
Share of washes at 60°C	39%	38%
Share of washes at 40°C	42%	46%

VDEW-Haushaltskundenbefragung 1991 and 1996, Auswertungsbericht

The savings generated from the campaign are substantial and prove that a campaign with a relatively low budget can be successful if the right strategy is chosen.

Why did the Campaign Succeed?

In addition to the surveys a more thorough evaluation of the campaign was made in 1999 by PLS Consult. The evaluation team concluded that the campaign was well planned and carried out in all aspects.

The fact that the campaign message was repeated often throughout a fairly long period of time is important for the success. Changing habits demands prolonged and continuous activities in order to have impact and in order to maintain the new habits after the campaign is over. Especially the combination of mass media and network campaigns is emphasised as a reason for the success. The many different campaign parts set focus on the message from many different angels and supported each other.

A common campaign-identity – the washing label – increased the attention to the campaign. The fact that the message was both simple to understand and simple to comply with is also important.

Another very important aspect was the co-operation with the National Consumer Agency, which ensured the credibility of the message that 60°C is enough for hygienic washing.

The mass media campaign was successful as it resulted in a high exposure, which is important for putting an issue on the agenda among the consumers. Without using television advertising it was still possible to get a high exposure through women magazines, newspapers and especially through local papers. The public relations activities were most successful with the local papers – resulting in 813 press releases in 1997 and 1998.

The network campaign was useful as it resulted in contact with the consumers in situations where washing was on the agenda, and as the many different ambassadors resulted in the message being repeated frequently.

In the network campaign especially the role of the electrical utilities was a success. Many utilities had a very active role as ambassadors, while it was more difficult to involve the NGOs and local Agenda 21 workers in the campaign. This is partially explained by the fact that the campaign message fits naturally into the normal activities of the electric utilities. Most Danish electricity utilities have practical experience in advising consumers about energy efficiency (Benediktson and Hein, 2000).

Also the collaboration with the commercial partners was successful as a number of the largest retail and electrician chains in Denmark used the campaign in their sales activities. Commercial partners are in general positive towards taking part in public information activities if they can see a synergy potential for their own products and because a "green" profile is regarded as something positive both ideologically and commercially.

By combining mass media activities with local activities in electric utilities, schools and among sellers of relevant products, it was possible with a fairly small budget to maintain focus on the issue over a period of three years and thereby possible to influence the behaviour of the Danish consumers.

Discussion of the Evaluation Method

The evaluation method can be described as monitoring (or gross impact, see Section 5.1 of the guidebook). The washing habits were monitored before, under, and after the campaign. This was done by telephone interviews with a representative number of people.

The surveys showed a remarkable decrease in the frequency of washes at 90°C or more and that the general shift was from 90°C towards 40°C washes. It is difficult to conclude what part of the change is caused by the campaign. A background trend towards reducing the frequency of 90°C washes does exist. When a trend already exist it is imprecise to use the start year (1997) as the baseline.

German data indicate a trend towards reducing the number of 90°C washes by 1% per year. During the campaign the reduction was 3% per year in Denmark. However, it is close to impossible to determine which cultural differences exist between Denmark and Germany concerning washing habits.

In 1995 (two years before the campaign) a survey was made, but the methods were not comparable to those applied in the other surveys. If the same methods had been used here, an indication of the trend could have been calculated (assuming a constant trend).

A survey in 2000 or later could indicate the long-term impact of the campaign.

All surveys were done at the same time of the year (late July/early August). The evaluation report indicates that the weather in 1999 was unusually hot, and that this may have influenced both the actual washing activities and thus the responses.

CASE RELEVANT REFERENCE MATERIAL

Benediktson, H. H. and M. Hein (2000): Ambitious DSM activities in a liberalised market.

2nd International Conference on Energy efficiency in Household Appliances and Lighting, Naples.

Changing the Danes' Washing Habits (http://www.ens.dk/Vask/Rapwash.htm).

PLS Consult (1999): Evaluering af kampagnen "Vask rent ved 60°".

Hein, M. and B. Jacobsen (2000): Influencing consumer behaviour - Danish clothes washing as an example. 2nd International Conference on Energy Efficiency in Household appliances and lighting. Napels.

Jysk Analyseinstitut A/S (1999): Vask rent ved 60 grader. Effektmåling.

ENERGY EFFICIENCY STANDARDS OF PERFORMANCE (UK)

Submitted by:

Electricity Association

30 Millbank, London SW1P 4RD, United Kingdom

Contact: Mr. Derek Baggs

Tel: +44 207 963 5709

Email: derek_baggs@electricity.org.uk

http://www.electricity.org.uk

INTRODUCTION

Energy Efficiency Standards of Performance (EESoP) were introduced in 1994 in England and Wales as part of the Public Electricity Suppliers' (PES) Supply Price Controls, and a year later in Scotland. These standards ran until March 1998 and gave obligations to each of the 14 PESs to achieve specified energy savings and the ability to fund them through a special revenue allowance, equivalent to 1 GBP per franchise customer per year. The aggregate target for the 14 PESs for the first phase was 6,103 GWh in accredited savings, with an allowance of 101.7m GBP. subsequent to that, a similar programme was launched for a 2-year period from April 1998 to March 2000, with an aggregate target of 2,713 GWh and an allowance of 48.1m GBP.

Energy suppliers undertake a variety of energy efficiency measures in residential and small non-residential properties, including the supply and installation of:

- low energy lamps;
- energy efficient domestic appliances;
- cavity wall insulation;
- loft insulation;
- condensing boilers;
- heating control systems;
- combined heat and power installations.

Energy suppliers are responsible for delivering all aspects of the scheme including design and development of programmes, marketing, installation of measures, monitoring and reporting. However, there is flexibility in how energy suppliers fulfil these tasks, for example they may:

- Contract out the design or management of the programmes; and/or
- Enter into collaborative arrangements with other energy companies, local authorities, housing associations, energy efficiency or other charities, local organisations and commercial companies.

But in all circumstances responsibility for delivering the scheme remains with the energy company.

The EESoP programme maintains a strong focus on providing energy efficiency services to disadvantaged customers, particularly the fuel poor, the elderly and the sick. The energy efficiency measures are usually installed free of charge in these properties. However, in other homes the customer normally makes a contribution towards the costs.

Energy suppliers are required to design their programmes to ensure that the risk of free-ridership is minimised. This occurs where a customer takes advantage of a financial incentive to install a measure, but would have done so with or without the incentive. The most common approach used for, say, owner-occupier insulation schemes is to direct mail to customers within a specific geographical area, with the offer open for only a limited period.

</DIV>An essential part of the programmes has been to monitor the energy efficiency projects in three fundamental areas:

- Energy monitoring.
- Customer satisfaction monitoring.
- Quality monitoring.

MONITORING

Energy Monitoring

In order to compare the actual energy savings with predicted savings, a methodology was devised in which the first step was to estimate how much energy could be saved from various measures in each property type, assuming standard heating patterns. This was derived from the Building Research Establishment's BREDEM computer model of residential energy consumption, then, an assumption was made about how much of the savings would be taken in increased comfort:

- 50% for lower income households (one third of all UK households).
- 20% for others.

This gave a weighted average for the UK across all income groups of 30%. In reality, the low-income sector accounted for around two-thirds of measures, giving an average comfort uptake of 40%.

For each project, a sample of at least 5% of properties was selected for monitoring. Meter reading data for a year before and after installation of insulation measures were analysed, taking care to eliminate estimated readings or other anomalous data. Readings were adjusted to take account of weather variations nationally and from year to year. For smaller projects the sample size of 5% was insufficient for a high confidence in the results, accordingly the sample size was scheduled as shown below:

Number of Properties in Project	Minimum Sample Size
Up to 100	10 properties
100 – 300	10%
300 – 600	30 Properties
Over 600	5%

Results show that individual properties may save much more or less energy than the average predicted by the computer model. The reasons for this depend upon a wide range of factors including occupancy, heating patterns, ownership of electrical appliances and construction details. However, although individual differences may be large, on average they are not significant enough to demand modifications to the existing model. Furthermore, the variations do not relate to customer perception or acceptance of the programme and do therefore not justify a modification of the programme (e.g. alternative marketing approach or different target group). Please consult Section 2.5.1 in the Ex-post Evaluation Guidebook for information related to variations.

Customer Satisfaction Monitoring

Energy suppliers undertake and report on the monitoring of customer satisfaction in a minimum of 5% of homes for all measures installed, with the exception of CFLs.

For each type of CFL scheme undertaken (e.g. bulk delivery/mail order CFLs etc) customer satisfaction monitoring includes 1% or 1,000 customers, whichever is the less.

So that some collective analysis of the results of this monitoring can be undertaken, energy suppliers include, where appropriate, a standard set of questions in their customer satisfaction questionnaires (presented at the end of this case description). This standard list is added to, as is considered appropriate.

Quality Monitoring

The installation of energy efficiency measures through Standards of Performance schemes are carried out to very high standards. It is considered important that standards are maintained and are part of a “quality culture”' that energy suppliers adopt in their approach to delivering energy efficiency. With this in mind, energy suppliers include within the written description of the scheme the quality assurance approach they intend to adopt when undertaking the scheme. Issues such as the quality of materials used, products installed and working practices are addressed.

During the EESoP programmes energy suppliers survey and report on the quality of installation in a minimum of 5% of homes receiving fixed 'fabric' measures such as insulation or heating measures. This quality monitoring checks whether or not the measures have been installed in line with approved British/European Standards etc. For CFL schemes, quality criteria are fulfilled if lamps included on an approved list are used.

For appliance schemes, assuming that all products used have relevant CE marking, there are no additional quality monitoring requirements.

When energy suppliers undertake schemes in conjunction with local authorities it is often the case that the local authority will undertake quality monitoring themselves. Should this be the case, energy suppliers provide an outline of the quality assurance procedure adopted by the local authority to the Energy Regulator.

National Audit Office

In addition to monitoring carried out within the scheme itself, the Government’s National Audit Office (NAO) has examined the cost-effectiveness of the initiative. The NAO considered that the energy companies had done well to introduce, without serious problems, a scheme that is the first of its kind. They made the following specific comments:

- **Customers saved energy** – Total energy savings over the life of the energy efficiency goods and service supplied to customers up to 31 March 1998 totalled some 6.8 billion units of electricity (kilowatt hours), 12% more than the total of the targets set for companies by the Energy regulator. These savings are equivalent to around 1.5% of the electricity used by domestic customers since the start of the scheme;

- **The bills of three million customers were reduced** – The bills of the 3 million customers that have benefited from the scheme were reduced by an average of around £120 each;

- **Customers benefited from warmer homes** – Insulation installed through the scheme provided some 173,000 customers with extra warmth. Low-income customers have benefited particularly from the scheme - half of expenditure has gone to help such customers; and

- **The environment has also benefited** – By saving electricity, the scheme helps to reduce the amount of carbon dioxide emitted by power stations by around six million tonnes over the life of the energy efficiency goods and service supplied to customers. This amount is equivalent to around 0.25% of United Kingdom carbon dioxide emissions since the start of the scheme.

THE FUTURE

In the light of the experience gained in the first two phases of the Energy Efficiency Standards of Performance programme the Energy Regulator also consulted extensively on the issue of future Standards, with the main conclusions being that:

- the first two EESoP programmes proved effective in delivering energy efficiency improvements for electricity customers;

- EESoP can make a useful contribution to reducing CO_2 and other emissions in line with the Government's Climate Change objectives;

- in terms of social considerations the EESoP programmes can help to tackle fuel poverty;

- increasing convergence in gas and electricity supply markets make it desirable to adopt a common approach for energy efficiency in gas and electricity; and

- the EESoP programme, set on a reasonable scale, is fully consistent with the development of competition in supply.

In light of these considerations a third EESoP programme (EESoP III), operating from April 2000 to March 2002, was set for gas and electricity companies on the basis of an assumed annual cost of £1.20 per customer per fuel. EESoP III requires companies to achieve gas savings for customers of 6,200 GWh and electricity savings of 5050 GWh.

Following on from the success of the programmes, the Government is currently consulting on a fourth phase of the scheme with the size of the programme effectively being trebled, resulting in an assumed annual cost of £3.60 per customer per fuel.

The fundamental structure of this phase is the same as its predecessors. However, from the lessons learned over the years of implementing energy efficiency schemes and because of the development of the competitive fuel supply market, energy suppliers will be able to undertake energy efficiency schemes in any household, not just their own customers. They will also be able to save any fuel, not only that which they supply. These two developments will make the task of energy suppliers more straightforward.

What has become evident during the course of the EESoP programmes is the lack of awareness of householders of the need for energy efficiency, which forms a significant barrier to the take up of even very heavily subsidised offers from energy suppliers. The Government is now considering a publicity campaign to increase awareness of the issue and to promote the activities of energy companies.

It is anticipated that the EESoP programme will continue until at least 2010.

Customer Satisfaction Survey

for Energy Efficiency Standards of Performance

Your name:
Your address:

CFL Schemes

Q1 **Where were the lamps installed?**

Hallway	
Kitchen	
Living Room	
Bathroom	
Bedroom	
Other (please state)	

Q2 **Were you already using energy saving lamps before installing low energy lamps?** (please circle how many)

1 2 3 4 5 6 Other ___

Q3 **Do you use your lighting more or less than Before installing low energy lamps?**

Much less	
A bit less	
About the same	
A bit more	
Much more	

Q4 **Are you likely to fit another energy saving lamp when the current one(s) fail?**

Yes	
No	
Don't know	

Q5 **What do you think are the main advantages of energy saving lamps?**

Save energy	
Save the environment	
Save money	
They last longer	

Q6 **What do you think are the main disadvantages** (tick any that apply)

Different tone of light	
They are ugly	
Take time to brighten up	
Other (please specify)	

Q7 **What is your overall level of satisfaction with the lamps you have received?**

Very satisfied	
Quite satisfied	
Neither satisfied nor dissatisfied	
Not very satisfied	
Not at all satisfied	

Customer Satisfaction Survey

for Energy Efficiency Standards of Performance

Your name:
Your address:

Heating/Insulation Measures

Q1 **How satisfied were you with the quality of work undertaken by the installers?**

Very satisfied	
Quite satisfied	
Neither satisfied nor dissatisfied	
Not very satisfied	
Not al all satisfied	

Q2 **Is your home warmer than before the Energy saving measure(s) were installed?**

Yes	
No	
Don't know	

Q3 **Are your fuel bills lower since the energy Saving measures(s) were installed? (may not be applicable if no bill received since installation)**

Yes	
No	
If yes, please comment	

Q4 **Were you given energy saving advice at the same time as the work was carried out?**

Yes	
No	

Q5 **How would you rate this energy advice?**

Excellent	
Good	
Satisfactory	
Poor	
Very Poor	

Q6 **Overall, how would you rate the energy Saving scheme?**

Excellent	
Good	
Satisfactory	
Poor	
Very Poor	

EVALUATION OF A CFV PROGRAMME – POWERSHIFT (UK)

Submitted by:

Energy Saving Trust

21 Dartmouth Street, London SW1H 9BP, United Kingdom

Contact: Mr. Andrew Amato

Tel: +44 (0)20 7222 0101

Email: andrewa@est.co.uk

http://www.est.org.uk

INTRODUCTION

This paper presents the experiences of UK Energy Saving Trust mainly between 1996 and 1999 regarding the ongoing and successful PowerShift programme. The programme seeks to transform the markets for vehicles which run on alternative, clean fuels and which are practical and available today. These include vehicles running on such fuels as liquefied petroleum gas, natural gas, and electricity (including hybrids).

PowerShift is funded by the UK Government through the Department of Environment, Transport and the Regions (DETR) and the Scottish Executive (SE), it has also received support from a range of industrial sponsors including General Motors, Ford, Peugeot, Toyota, Volkswagen, Transco, BG Plc, British Gas, Shell, Calor, and Powergen.

The programme budget (excluding sponsorship) for the first three years (1996-99) was £6m in total. In 1999-2000 and 2000-2001 it was raised to £3.6m and £10.4m respectively. For the period 2001-2004 a budget of £33m has been secured.

The Energy Saving Trust (EST) is required to evaluate and publish results of its programmes by the EST's primary funder the DETR. The results of these evaluations are published in the EST's Annual Report and are also to be made available on the EST's website.

A methodology for programme evaluation has been agreed with DETR for all government funded programmes. In the past this methodology was based around the direct energy and carbon saving impacts resulting from programmes such as condensing boiler and insulation grant schemes. The savings have been calculated using engineering data supplied from sources such as the Building Research Establishment (BRE). Other analysis looking at the effects of rebound (comfort) etc have been undertaken and these have been taken into account. At present a full impact evaluation is being undertaken to assess the overall impact of EST programmes in terms of indirect savings made and the full market transformation of the EST's activities.

The context of evaluation is also changing; in previous years the EST provided a significant proportion of energy efficiency activity in the UK in terms of priming and incentivising the market through grant schemes. This role however is changing. The EST will continue to raise awareness etc., and will facilitate the delivery of energy efficiency and develop infrastructure. The Energy Efficiency Commitment run by the energy suppliers will be delivering the vast majority of installed energy efficiency measures through the subsidy of measures and the provision of energy services. In this way EST evaluation is moving away from quantitative carbon savings that are directly attributable to EST activity and moving towards the evaluation of facilitation and the development of the infrastructure for the delivery of energy efficiency via other mechanisms. It is this shift in emphasis in programme activity, which presents the new evaluation challenge to the Energy Saving Trust.

BACKGROUND

Transport accounts for approximately 25% of energy/fuel use in the UK and is one of the only sectors in which energy use continues to grow each year. It is responsible for more than 90% of the UK's urban air pollution and around 25% of greenhouse gas emissions. Consequently, clean fuel vehicles have a significant role to play in reducing these emissions from the transport sector.

In 1995, the clean fuel vehicle market in the United Kingdom was virtually non-existent. A very limited number of vehicles were being sold and registered and these were mainly demonstration vehicles or conversions. These demonstration projects were sponsored by organisations such as British Gas, Ford, the European Union, and a number of local authorities. The scale of these operations was modest and there was no co-ordination between different initiatives. Consequently, PowerShift acts to bring all such demonstration projects together and co-ordinate activity.

The PowerShift programme promotes three clean fuels: liquefied petroleum gas (LPG), natural gas (NG) and electricity (EV). Subsequently, the programme has been extended to cover hydrogen fuel cell and hybrid vehicles. These alternatives produce significantly less air pollution and greenhouse gas emissions than conventional vehicles and at present, are the most economically viable of the wide range of alternative fuels for vehicles.

PowerShift aims to transform the markets for clean fuel vehicles in the UK by breaking down the barriers to their development. The main barriers identified were:

- The lack of refuelling infrastructure;
- The extra initial capital cost of vehicles;
- Misconceptions about vehicle safety;
- Low awareness of the benefits of Clean Fuel Vehicles (CFVs);
- Limited numbers and choice of vehicles available.

To address these barriers, the programme objectives were to:

- demonstrate CFVs in a variety of operations across the UK;
- expand the infrastructure for refuelling and recharging CFVs;
- encourage CFV manufacturers to reduce the cost of vehicles by increasing the number of sales and improving economies of scale and encouraging competition;
- ensure appropriate information was available for vehicle operators, to promote the benefits and standards of CFVs;
- monitor emissions and energy consumption of CFVs to test the extent to which energy savings can be achieved by switching to alternative fuels.

The programme addresses these barriers by the activities Demonstration, Stimulation, PowerShift Register, and Information and Awareness Raising.

Demonstration

The technical and economic viability of alternative fuelled vehicles was demonstrated through 14 pilot programmes, while 138 CFVs were tested, ranging from small electric cars and vans to 32 tonne articulated lorries running on LNG.

The programme provided £700,000 for these first year activities. The level of each grant was set on a case-by-case basis, and most ranged from 20% to 50%, with several grants being for slightly more than 50%.

Stimulation

To stimulate the supply of vehicles, the EST liaised with stakeholders to form procurement groups called PowerShift Funding Partnerships. These groups consisted of private companies and local authorities, and by 'pooling' their orders for CFVs, they were able to approach manufacturers and negotiate the purchase of CFVs. These procurement groups stimulated £20m in vehicle orders, from grant funding of just £700,000. Eight separate contracts were awarded for the supply of 351 clean fuel vehicles – this included almost 200 work vans, 22 refuse collection vehicles, 17 buses and a range of cars and trucks.

To develop refuelling infrastructure, the programme targeted depot based fleets, where refuelling infrastructure could most easily be supplied. Originally it was planned to secure agreement from depot based fleet operators to allow access for third parties to refuel at their sites, as well as their own depot fleet. However, this third party access has developed more slowly than expected, due to problems relating to access rights to sites. This has been an issue mainly for the natural gas market. However, public access to LPG sites has developed more quickly with a number of fuel suppliers investing in LPG dispensers on petrol station forecourts.

Significant efforts were also made to increase the supply of clean fuel vehicles to non-depot based fleets. Considerable progress has been made on this front, as commercial operators have made important public commitments to bring LPG to public garage forecourts. Shell has committed itself to having 200, and BP 300, by 2002.

PowerShift Register

In response to the needs of the growing CFV market, The PowerShift programme initiated a number of important quality control mechanisms. As the clean fuel vehicle market started to develop over the past three years, it became apparent that some vehicle manufacturers and converters were supplying products, which had not been designed and built to the best standards and in some cases, produced worse emissions than petrol or diesel.

The programme responded by creating the PowerShift Register, to identify the best clean fuel vehicles and to encourage vehicle manufacturers to optimise the CFVs they offer.

The Register is a list of quality-approved clean fuel vehicle suppliers and products. It includes companies and products, which meet approved safety and technical standards as well as providing emissions benefits compared with conventional vehicles. To be listed on the register, a manufacturer or converter must satisfy European, national, and industry standards. The EST will only provide grants for clean fuel vehicles listed in the register, unless an application is for vehicles supplied for the first time to the UK and accepted as a demonstration project. Once listed, products receive an EST 'Clean Seal of Approval'.

As a minimum requirement all vehicles awarded the Seal of Approval must:

- Produce no more carbon dioxide than the equivalent diesel vehicle and 10% lower than the equivalent petrol vehicle. (In the case of diesel vehicles this is a 'well to wheels' calculation based on a tailpipe emissions test or, for petrol, a straight tailpipe test), and

- Produce no more regulated emissions than the equivalent petrol or diesel vehicle.

Grants are then awarded according to how much the Euro III Emission Standard is exceeded:

- Band 1 - Failure to meet minimum standard or emissions not proven (ENP) (no grant funding);
- Band 2 - 0-49% reduction over Euro III (grant of 40% of premium costs);
- Band 3 - 50-64.5% reduction over Euro III (grant of 60% of premium costs);
- Band 4 - 65%+ reduction over Euro III (grant of 75% of premium costs).

Originally there were only three bands; Band 4 was introduced in recognition of the tightening emission standards for petrol and diesel vehicles when Euro III came into force.

The creation of the Register has been an important mechanism for ensuring confidence in the growing CFV market and the Register is fast becoming the standard reference for CFV buyers seeking safety, build quality, and enhanced emissions performance. The Register now maintained on the Internet lists in excess 350 vehicles. It can be accessed at http://www.transportaction.org.uk/.

Information and Awareness Raising

As part of the strategy to increase awareness of CFVs and demand for them, the programme runs 6-7 regional workshops per year, spread geographically across the country. These workshops were specifically targeted at appropriate decision makers – for example, transport and fleet managers and 'Local Agenda 21' staff within local authorities.

PowerShift programme managers have been invited to provide speeches about the programme and the CFV market to a wide range of targeted events, including the following:

- National Society for Clean Air Conference (24/2/99);
- Motor Industry Local Authority Network Seminar (10/2/99);
- G8 Alternative Fuel Summit (25-26/1/99);
- Innovation in Urban Transport, Graz (25-26/11/98);
- Natural Gas Vehicles, Belfast (18/11/98);
- Gatwick Seminar on Cleaning Transport (3/3/99);
- Transco Launch of 40 CNG Vans (15/3/99);
- NEI Conference – Clean Green Vehicles (18/3/99);
- World Natural Gas Vehicle Conference, Sydney (4/99).

The internet is also heavily utilised with a dedicated website providing the ability to apply to access the PowerShift Register, apply for a grant or workshop place, and of course gain more information regarding alternative fuels. A telephone hotline (0845 602 1425) has also been set up to provide information.

DISCUSSION OF EVALUATION METHOD

To date the main emphasis with regard to the evaluation of the PowerShift programme has been monitoring the programme results as well as some analysis of programme cost effectiveness. As the programme has grown, this methodology has continuously evolved in order to meet the requirements of Government. Consequently, in collaboration with DETR, a new evaluation methodology is currently under development. This methodology will also include the complex mathematical modelling of the CFV market to use as an additional baseline against which performance of the programme can be judged. The European Ex-post Evaluation Guidebook is being used as a tool in this process.

The initial baseline for the evaluation was chosen to be the state of the CFV market in the UK during 1995. This was chosen, as it was the first full year prior to the launch of the programme. As has already been stated, the UK clean fuel vehicle market was virtually non-existent so the effects of the programme could be readily monitored.

The evaluation currently employs a number of **key criteria** as performance indicators. These indicators range from purely quantitative carbon and regulated atmospheric emission savings and cost-effectiveness indices to more qualitative (non-emission) indicators such as awareness, cost differentials and the development of refuelling infrastructure.

The Energy Saving Trust is required as to report to Government annually on the total savings and policy cost per tonne of the following:

- CO_2 ;
- Total Green House Gas (GHG);
- CH_4;
- NO_x;
- Particulate Matter (PM).

Both savings and policy cost are calculated on an annual and a lifetime basis. The policy cost equates to government funding and is effectively the total programme expenditure less partner and customer contributions. Emission factors used are sourced from the report of the alternative fuels group of the Cleaner Vehicles Task Force (CVTF).

Apart from emission indicators, which are required as part of Government reporting, a number of other **prime indicators** for the success of market transformation of PowerShift are monitored. These are listed as follows:

- CFV sales per year;
- Total vehicle populations;
- Number of refuelling stations;
- Financial price premiums between CFVs and conventional equivalents;
- Residual values of vehicles.

Other **secondary indicators** are also employed. These include, for example, data reflecting attitudes and the level of information dissemination. Such as:

- Number of grant applications;
- Number of workshop delegates;
- Number of press articles;
- Number of hotline calls;
- Number of website visitors;
- Number of approved vehicle manufacturers;
- Number of approved converters;
- Number of fuel suppliers.

These indicators are monitored using market research involving vehicle manufacturers, converters, and fuel suppliers. An indication of the results can be seen in Exhibit 2.

Annual surveys of participants are undertaken to determine the extent of any 'drop-out' from participants. Further investigations into free driver and free-rider-ship are also planned as part of the developing methodology.

OTHER ACTIVITIES

Alongside PowerShift, other government mechanisms for the promotion of CFVs include the fuel duty differential, changes to vehicle excise duty, and the proposed introduction of Low Emission Zones. Of these the fuel duty differential is by far the most important initiative; the latter two are not yet in operation but will undoubtedly have some effect on the market. While the lower fuel duty on LPG (the predominant cleaner fuel) is significant, the availability of fuel, awareness of technology, and the lowering of prices to transform the market have been driven by PowerShift. It is for this reason that to date that additionality and the impact of fuel duty has not been accounted for. This is, however, changing, as the new methodology will address additionality in greater detail.

RESULTS AND CONCLUSIONS

The PowerShift programme has directly funded approximately 10,000 vehicles since its launch in 1996. The programme has also stimulated the growth of the CFV market in the United Kingdom to the extent that the CFV stock has increased to over 32,000 vehicles resulting in annual carbon savings of 8,300 tC/a.

The results of this and other evaluations are disseminated in the first instance to Government and then to the general public through mechanisms including the EST's Annual Report and other literature as well as the EST website.

Exhibit 1: Current CFV UK populations and carbon savings.

Fuel	Vehicle type	Stock at Q1/01	Clean fuel (CO2 g/km)	Replaced fuel (CO2 g/km)	km/a	tC/a avoided
LPG	Car	20,680	188	229	16,000	3,699.84
LPG	LCV	9,762	188	229	16,000	1,746.51
LPG	Bus	167	1,309	1,472	48,000	356.35
LPG	HCV	640	1,480	1,644	40,000	1,145.02
CNG	Car	15	176	229	16,000	3.47
CNG	LCV	207	217	223	16,000	5.42
CNG	Bus	30	1,343	1,472	48,000	50.66
CNG	HCV	419	1,574	1,644	40,000	319.96
EV	Car	333	130	229	16,000	143.86
EV	LCV	318	130	229	16,000	137.38
EV	Bus	85	850	1,472	48,000	692.12
Total		**32,571**				**8,300.58**

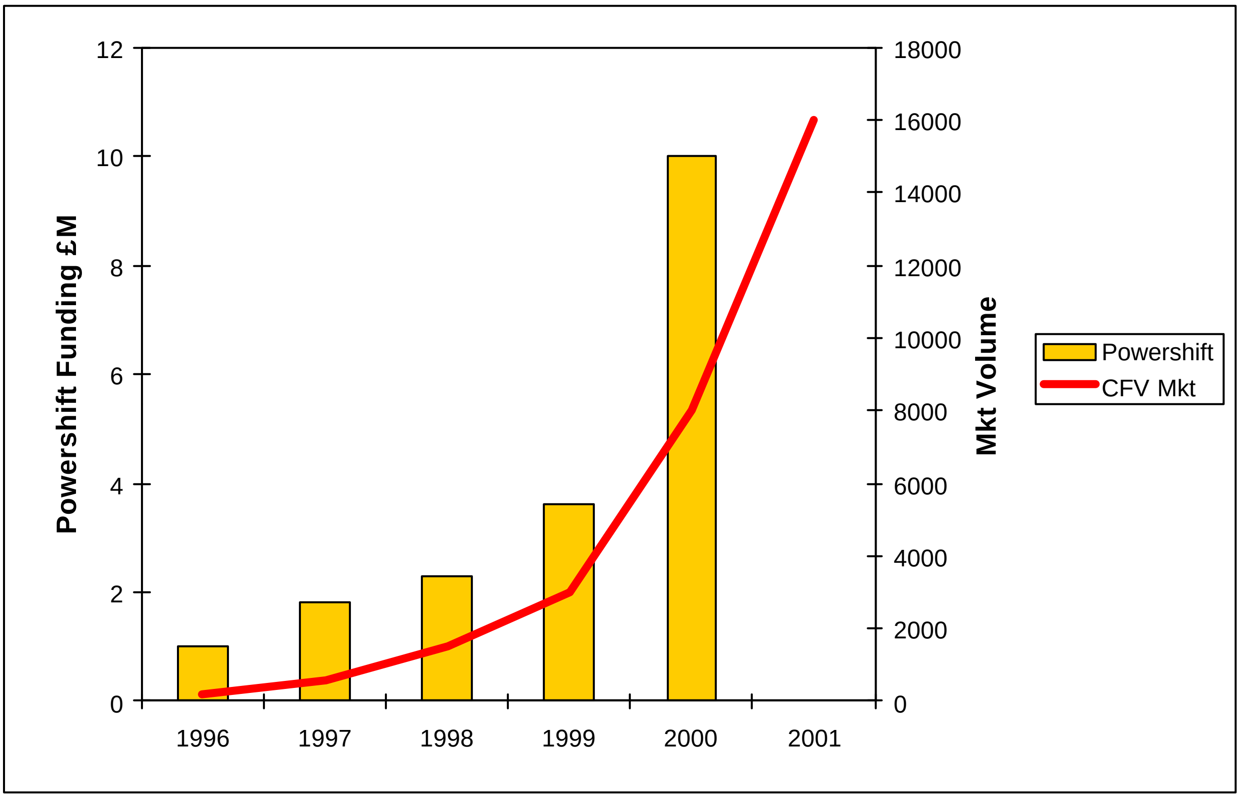
Sources: (1) Vehicle populations survey carried out for EST by Transtech Consultancy Services; (2) Emission Factors sourced from CVTF; and (3) Vehicle travel distances were estimated from national travel statistics published by DETR.

Exhibit 2: Market indicators (PowerShift Scenario).

Market Transformation Indicators	**Baseline**	**To date**			**Forecasts**			
	1995	1996	1997	1998	1999	2000	2001	2010
Market share								
CFV registrations	200	280	511	1,200	3,500	13,000	40,000	723,000
CFV population	12,500	11,700	11,300	11,600	14,000	26,000	65,000	2,641,000
Market penetration								
No of refuelling points	170	170	188	250	350	500	700	6,650
Premium price								
LPG cars	2,000	2,000	1,700	1,500	1,200	1,000	700	500
NG trucks	-	20,000	18,000	18,000	16,000	14,000	12,000	8,000
Electric vans	-	10,000	8,000	5,000	5,000	5,000	5,000	5,000
Market players								
No. of vehicle manufacturers	2	4	6	9	11	13	16	25
No. of converters	4	5	7	20	30	30	25	10
No. of fuel suppliers	3	4	5	7	8	9	10	12
Attitudes and information								
no. workshop delegates	-	-	230	642	515*		-	-
no. of press cuttings			78	492	298*		-	-
No. hotline calls	-	-	-	1,400	600*		-	-
no. website users	-	-	390	5,179	1004*		-	-

** - As at March 1999.*

Exhibit 3: Growth in DETR funding for PowerShift.



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Useful Websites

www.est.org.uk

www.transportaction.org.uk

www.detr.gov.uk

NATIONAL ENERGY EFFICIENCY PROGRAMME (CZ)

Submitted by:

SEVEn

Slezská 7, 120 56 Praha 2, Czech Republic

Contact: Mr. Martin Dazek

Tel.: +420 2 2424 7552

E-mail: seven@svn.cz

http://www.svn.cz

SUBJECT OF EVALUATION

The subject of the present evaluation is the state programme for supporting energy efficiency in the Czech Republic. The programme has the following objectives:

- Decreasing the primary energy consumption.
- Air pollution abatement.
- Increasing the effectiveness of energy project financing.
- Demonstration of economically effective, progressive, and replicable solutions.

Since 1996, the Ministry of Industry and Trade annually authorises the Czech Energy Agency (CEA) to arrange, promote, and manage the programme. The main task of the CEA is to encourage activities leading to energy conservation and reduced energy intensity. Financial support to greater utilisation of renewable and secondary sources of energy and minimise environmental burdens from emission is in compliance with these aims.

The state programme is divided into subprogrammes:

- Schools,
- Hospitals,
- Public sector buildings,
- Housing estate supplies,
- Industry, and
- Renewable energy sources and cogeneration.

Important elements of the state programme are promotion, consulting, and education in the area of energy saving and environmental protection. In recent years, emphasis has also been put on the support of energy performance contracting and processing energy concepts for cities and villages.

Each subprogramme contains a detailed set of requirements that must be met to obtain support. These requirements concern the technology involved and the targeted energy savings of the proposed projects.

Subjects applying for CEA support are obliged to carry out an energy audit, describing the actual state of energy consumption and the energy saving possibilities. Demonstration projects approved by the CEA receive 40% support while replicated projects receive 15% of investment costs.

MONITORING

Supervision of the supported projects is carried out through direct inspections that check that the performed technical measures, the physical installations, and the operation are in compliance with the original project proposal.

The recipients of support are obliged to inform CEA about their annual energy consumption after implementation of the technical measures. An annual monitoring report specifying the energy consumption by type of energy for the past year must be submitted to the CEA. A list of simple questions guide the recipients in making their monitoring report. Part of the contents of the monitoring report is based on the recipient's energy bill (which in the Czech Republic contains information on energy units consumed, unit price, and total cost per energy type).

THE OBJECTIVES OF THE EVALUATION

The applications for financial support under the state programme were earlier evaluated by SEVEn to determine whether the proposed projects were economically and technically sound and likely to achieve the proposed energy savings. The evaluation was based on the assumed input data presented in the required application documentation.

The present evaluation, also carried out by SEVEn, was carried out ex-post to the actual implementation of the proposed projects. The objectives of this evaluation were:

- To determine the actual savings achieved and compare them to the potential estimated in the tender documentation.

- Collect information on the monitoring process with the aim to improve the support programme.

The object for comparison of estimated and achieved savings were the subprogrammes II and III aimed at implementation of energy savings measures in schools and hospitals. Subprogrammes II and III were chosen because a suitable number of projects had been completed within these sectors, the project had relatively high estimated savings per project, and had verifiable results of the implemented measures.

The implementation of the projects takes a relatively long time and some projects are granted support more than once. This means that the values of the indicators necessary for evaluation are usually not available until at least one year after granting of financial support. Consequently, the projects subsidised in 1997 were chosen for evaluation. The main declared objective of the projects granted in 1997 was to demonstrate new innovative and replicable solutions. The technical measures implemented in these projects particularly concerned improvement of space heating and hot water heating, including regulation, metering, grid reconstruction, fuel switch, and thermal insulation.

EVALUATION RESULTS

The table below shows the estimated parameters of the subsidised projects in subprogrammes II and III in 1997. The values are based on energy audits, which are an integral part of the contracts.

	Number of supported projects	Total investment costs	Subsidy	Estimated energy savings
		1,000 EUR	*1,000 EUR*	*GJ*
Schools	17	1,555	529	10,336
Hospitals	14	2,518	743	53,191
Total	**31**	**4,073**	**1,272**	**63,527**

1 EUR = 34,6 CZK (December 2000)

The following table shows the evaluation results of the projects, which were possible to evaluate by virtue of documents obtained during the monitoring process. The change in hospital occupancy and the number of children at schools before and after implementation was adjusted for in the evaluation to recognise the changes in building utilisation. In most cases, there were no changes. Projects, where significant changes in building utilisation occurred against the tender documentation (e.g. a sanatorium changed to a bathhouse with a completely different energy consumption pattern), were excluded from the evaluation. Furthermore, monitoring reports, which contained incorrect values of the investigated parameters, were excluded from the evaluation.

	Number of evaluated projects	Total investment costs	Subsidy	Estimated energy savings	Achieved energy savings	Achieved energy savings
		1,000 EUR	*1,000 EUR*	*GJ*	*GJ*	-
Schools	11	1,199	410	6,489	6,191	95%
Hospitals	12	2,270	673	51,393	47,496	92%
Total	**23**	**3,469**	**1,083**	**57,882**	**53,687**	**93%**

1 EUR = 34,6 CZK (December 2000)

The investigation indicates that achieved energy savings met 93% of estimated savings. The achieved energy savings of the evaluated projects represent a 30% decrease in the energy consumption in schools and 22% in hospitals – a satisfactory result. The results show that the projects supported in 1997 demonstrated efficient technical solutions.

Considering the fact, that it was only possible to evaluate 75% of supported projects using the annual monitoring reports, it is clear that some improvement must be made to the monitoring process. The 23 evaluated projects represent 85% of the investments spent in both subprograms. In particular less attention is paid to monitor relatively small projects. Importance of monitoring small projects increases in regard of increasing share of small projects.

LESSONS LEARNED

The correctness of the values of the indicators in the monitoring reports is questionable:

- Some mistakes were caused by incorrect conversion of energy units (e.g. m^3 of natural gas conversion to GJ). The monitoring requested conversion to GJ, which appeared not to be a straightforward task.
- There was irregular application of weather adjustment in the monitoring reports. It was sought corrected using standard formulas and local weather data in the evaluation.
- The price of fuel was not filled in correctly taking into account the different prices of fuel in the individual districts and the price changes over time.

Overall, the level of information about technical aspects and parameters of the projects registered via the monitoring report is relatively sufficient. However, most projects lacked or provided incorrect information about economic parameters such as energy costs. Therefore, no calculation of for example the reduction in total energy expenditures as a result of the projects could be made.

The ex-post evaluation thus clearly proved a need for improvement of the monitoring system.

The guiding questions for the monitoring must be further simplified and reassessed. The monitoring reports are not prepared by professionals (contrary to the tender documents). The indicators to be included in the annual monitoring report should therefore be simple, so that the project responsible does not have to carry out the slightest recalculations or adjustments.

It is also recommended that the final monitoring report be replaced by a comprehensive energy audit describing the final state of realisation and operation one year after implementation of energy efficiency measures. Projects supported since 1999 should prove their savings and other benefits in the comprehensive energy audit. An independent auditor should verify the achieved savings and economical benefits and establish the reasons why the targeted savings differ from the anticipated. This would prevent many errors and omissions in the monitoring and make participants to fulfil the criteria specified in the contract for subsidy.

CASE RELEVANT REFERENCE MATERIAL

Evaluation of State Program for Supporting Energy Efficiency in the Czech Republic 1997. SEVEn, Praha, December 1997.

EVALUATION OF IPMVP GUIDE (DE)

Submitted by:

Wuppertal Institute for Climate, Environment, & Energy GmbH

PF 10 04 80, D-42004 Wuppertal, Germany

Contact: Mr. Stefan Thomas

Tel: +49 202 2492 143

Email: stefan.thomas@wupperinst.org

http://www.wupperinst.org

INTRODUCTION

The International Performance Measurement and Verification Protocol (IPMVP) is the evaluation method proposed for monitoring and verification of energy service company projects. It is described in Section 6.6 of the European Ex-post Evaluation Guidebook. Two examples are presented below. Both the following examples tested the relevance and usefulness of IPMVP.

The first example concerns a DSM bidding pilot programme that was carried out by the municipal utility of Düsseldorf (Stadtwerke Düsseldorf AG). The Wuppertal Institute gave scientific support for the development and implementation of the pilot programme, and evaluated the pilot programme. In particular, the Wuppertal Institute proposed the methods for verification of the savings of the individual projects that were bid into the programme based on the IPMVP. It is thus an example of the application of the IPMVP in energy efficiency services or similar projects.

The second example summarises the key findings of a study undertaken by the Wuppertal Institute for the Government of North Rhine-Westphalia. This study examined the importance of monitoring and verification of energy service company projects, as well as the need for, and the usefulness of an IPMVP guide or a similar M&V guidebook based on interviews with both energy service companies and their customers.

EXAMPLE 1: DSM BIDDING PILOT PROGRAMME

Background

In the competitive market, the Stadtwerke were not interested in buying conserved energy and funding this via their electricity prices, as in the "classical" DSM bidding. Rather, they were hoping to

- improve their understanding of the needs of their customers,
- gain experience in technology fields attractive for third-party financing (TPF),
- gain customers interested in TPF projects, and projects for these customers,
- present themselves as a provider for energy efficiency services,
- in short, to give their TPF business a kick-start.

To this purpose a DSM bidding programme was developed. The concept of this programme was as follows:

- Stadtwerke Düsseldorf thought that shortly after the introduction of competition their large customers were only looking for price reductions and would thus not be interested in energy efficiency services. Therefore, Stadtwerke Düsseldorf focused on medium-sized industrial and commercial customers as the main target group.

- The programme was communicated to these customers as a joint effort to realise cost-effective CO_2 reductions.

- The target for the DSM bidding was therefore expressed as reducing CO_2 emissions by **at least** 2,000 tons/year, not in terms of energy (kW or kWh).

- There was no upper limit for the energy conservation or CO_2 reductions, which may be reached: In principle, Stadtwerke Düsseldorf AG offered to realise any cost-effective project with third-party financing.

- The project was not restricted to electricity savings. However, since TPF for electricity conservation is more innovative and more cost-effective than heat conservation (e.g. by installing new boilers in TPF), each tenderer had to allocate at least 50% of the investment to electricity conservation measures; pure load management was excluded. The remaining share of the investment budget could be for innovative heat conservation (i.e. not just renovation of boilers and not CHP) or renewable energy sources.

- To make the project easier to manage, each tender had to have as target at least 100,000 kWh/year electricity savings.

For the awards to the ten best proposals, a total of 150,000 DM (76,700 EUR) was offered by Stadtwerke Düsseldorf AG. One of the awarded projects is described below.

Illustrative Project Example

Bidder (ESCO): Building management unit of the client

Proposed Client: Large service sector company

Energy Conservation Measures:

1. Reduction of air leakage by closing "short-cuts" between air inflow and air outflow;

2. Closing down 7 fans that are no longer needed after the reduction of the leakage;

3. Installation of variable speed drives in the remaining 12 ventilation fan motors to reduce the circulating air quantities as well as the electricity demand further.

The case study was evaluated with the aim of testing the applicability of the IPMVP. Therefore, the Wuppertal Institute proposed the methods for verification of the savings based on the IPMVP.

The bidding company implemented the measures itself, so no TPF took place. Hence, the applicant had to verify the savings to Stadtwerke Düsseldorf to get the full award payment.

Results of the Project Evaluation

To recall, the IMPVP offers four different M&V options, as shown in Exhibit 1 below.

Exhibit 1: IMPVP options.

Measurement & Verification Option	How Savings Are Calculated	Cost
Option A: Focuses on physical assessment of equipment changes to ensure the installation is to specification. Key performance factors (e.g., lighting wattage or chiller efficiency) are determined with spot or short-term measurements and operational factors (e.g., lighting operating hours or cooling ton-hours) are stipulated based on analysis of historical data or spot/short-term measurements. Performance and proper operation are measured or checked annually.	Engineering calculations using spot or short-term measurements, computer simulations, and/or historical data.	Dependent on no. of measurement points. Approx. 1-5% of project construction cost.
Option B: Savings are determined after project completion by short-term or continuous measurements taken throughout the term of the contract at the device or system level. Both performance and operations factors are monitored.	Engineering calculations using metered data.	Dependent on no. and type of systems measured and term of analysis/ metering. Typically 3-10% of proj-ect construction cost.
Option C: After project completion, savings are determined at the "whole-building" or facility level using current year and historical utility meter or sub-meter data.	Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.	Dependent on no. and complexity of parameters in analysis. Typically 1-10% of project construction cost.
Option D: Savings are determined through simulation of facility components and/or the whole facility.	Calibrated energy simula-tion/modelling; calibrated with hourly or monthly utility billing data and/or end-use metering.	Dependent on no. and complexity of systems evaluated. Typically 3-10% of project construction cost.

Source: IPMVP, December 1997, www.ipmvp.org.

For the case study, the Wuppertal Institute proposed a mix of Option A and Option B.

1. For the measurement of the situation before measures, Option A was chosen. It was proposed to measure for a short term the actual value of the power input and the air volume of a representative of each of the three types of fan/motor systems that were present among the 20 fans in total. This was justified because the motors were the same type and size and running continuously before the refurbishment.

2. For the measurement of the situation after measures, Option B was proposed and chosen by the bidding company. The original proposal was to make short-term measurements of the power input and the air volume, and to monitor the operating hours of each of the fans over a longer period. This was needed because the 7 fans, which were closed down, still remained in place as back-up for defects or exceptional heat loads. However, the company found an even cheaper and better way to monitor the energy consumption: It simply installed 2 meters into the 2 electric circuits that exclusively feed the 19 fan/motor systems, and continuously measured the consumption using the building automation system in place.

The following table summarises the findings from the measurements.

Exhibit 2: Measurement findings.

Circuit (Room) 19		Circuit (Room) 23	
Before		***Before***	
Number of fans	10	Number of fans	9
Nominal air flow/unit	7,100 m^3/h	Nominal air flow/unit	7,500 and 10,000 m^3/h
Measured power/unit	7.2 kW	Measured power/unit	9.5/10.2 kW
Measured air flow/unit	6,400 m^3/h	Measured air flow/unit	7,500 and 10,000 m^3/h
Operating hours	8,760 h	Operating hours	8,760 h
Electricity consumption	631,000 kWh/a	Electricity consumption	774,000 kWh/a
After		***After***	
Number of fans	6	Number of fans	6
Measured power/unit	3.3 to 5.9 kW	Measured power/unit	2.0 to 3.0 kW
Measured air flow/unit	average 6,400 m^3/h	Measured air flow/unit	average 5,000 m^3/h
Electricity consumption	264,000 kWh/a	Electricity consumption	145,000 kWh/a
Electricity saving	373,000 kWh/a	Electricity saving	629,000 kWh/a

In total, these measures saved approx. 1 GWh/a, equivalent to 70% of the electricity that was consumed before the measures. The investment needed was no more than 30,000 EUR, so the cost of conserved energy was only 0.37 cEUR/kWh (at 4% societal discount rate and 10 years residual life of the fans, which is a conservatively low estimate, based on the fact that used fan/motor systems were upgraded with the VSDs). Simple payback was just 7 months.

The M&V method based on the IPMVP proved reliable in the sense that it produced consistent and reliable results for the energy savings that were achieved, with a moderate M&V effort. The bidder had the technical and management capacity to carry out the necessary measurement. Stadtwerke Düsseldorf accepted the M&V results and paid out the award to the bidder. Furthermore, the method can be used by non-experts, i.e. without a “clearing house” such as the Wuppertal Institute.

EXAMPLE 2: IPMVP GUIDE FOR EPC/TPF PROJECTS IN NRW

In North Rhine-Westphalia, the state government is promoting the use of energy performance contracting (EPC) and third party financing. Among other things, a working group called "Energy Services" exists, which brings together energy service companies (ESCOs) and other interested parties, and is co-ordinated by the Director of the Energy Division of the Wuppertal Institute.

In the context of this working group, the need and usefulness of a guidebook for monitoring and verification of savings from EPC and TPF was discussed, as an instrument to increase the credibility of EPC and TPF projects, and of the ESCOs that offer them to possible EPC/TPF customers. Therefore, the state government commissioned a study to the Wuppertal Institute and the working group, to examine the need for such a guidebook as well as the appropriateness of the IPMVP under German conditions.

To this end, 30 interviews with suppliers and customers of energy services were carried out. The results are summarised in a report in German (Wuppertal Institute 2000: Möglichkeiten und Grenzen eines Effizienzprotokolls bei der Entwicklung und Förderung von EDL-Märkten). Here, we just want to give a short summary of the main findings on the IPMVP guide in the general perspective of a policy to promote the development of energy services markets.

One main finding is that general guidebooks on EPC/TPF are not sufficient for potential customers to gain confidence and to carry out an EPC/TPF project. The interviewed customers expressed a need for project specific methodological support during the course of their projects such as:

1. Specification of contributions needed from the customers in preparation and implementation of an EPC/TPF project (e.g., documentation of buildings and energy uses);

2. A guideline for the implementation process;

3. Specifications for calls for tenders for EPC/TPF projects;

4. Methods for control and assessment of the engineers/consultants, who assist the customer in the development of an EPC/TPF project, e.g., in launching a call for tender, or in selecting an ESCO for the implementation of the EPC/TPF project;

5. Support in legal questions related to formulating the EPC/TPF contract;

6. Support in promoting the idea of EPC/TPF towards third parties (seniors, customers of the customer, authorities, etc.);

7. Checklists for identification and assessment of factors that may influence the amount of savings reached (e.g., fluctuations in operation or weather).

As can be seen, an IPMVP guidebook for monitoring and verification of the savings would certainly be helpful, but by far not the only thing that is needed to increase the confidence of possible customers in EPC/TPF, or to enable customers to handle EPC/TPF projects. An IPMVP guidebook can directly or indirectly meet some of the need indicated in bullets 2, 3, 4, and 7, but it would have to be specific to the customers' needs, depending on the technology focus. EPC/TPF projects are so complex that the potential customers also need personal assistance in managing the EPC/TPF project. What customers would like to have is **a coach**, who guides them through the process, from the choice of the ESCO and the conclusion of the contract, through the implementation of the energy efficiency project to the management of the contract. This would, however, require coaching programmes that can be costly and need time to be implemented, e.g., for training the coaches.

Therefore, as an alternative, the NRW study proposes **a set of tools for strengthening the capacity of possible customers to manage EPC/TPF projects**. This could include an internet-based "guidebook" on project management know-how, with different levels of detail for different users at different stages of a project, and bifurcations to, e.g., technology-specific contract details, monitoring and verification details, check lists, and examples. An EU-wide database of successful examples could also be helpful, as well as a co-ordination of, e.g., the SAVE agencies on common guidelines for coaching customers through EPC/TPF projects.

Only when potential clients are able to assess whether the technological solutions offered to them would satisfy their production requirements (as well as saving a certain amount of energy), will they feel a need for M&V methods that can verify the energy savings. The interviews showed that, at that stage, an agreed methodology for monitoring and verification of ESCO projects would be considered helpful, as a part of the overall set of tools.

The methodologies described in the IPMVP are certainly state of the art for monitoring and verification of the savings of ESCO projects, and therefore also applicable in the EU. They are, however, very general, and require project-specific adaptation. In many EU Member States, technical rules, norms, or guidelines for assessing the energy consumption of buildings, heating, ventilation, air conditioning, lighting, production plants, etc., do exist, but may not be known to potential customers of EPC/TPF projects.

Therefore, the present **European Ex-post Evaluation Guidebook** should maintain the reference to the IMPVP as an example of guidelines for monitoring and verification of the savings of ESCO projects. The IMPVP may be especially useful for international EPC/TPF projects, e.g., in the context of the Clean Development Mechanism or Joint Implementation.

But the European Ex-post Evaluation Guidebook should also recommend that each Member State compile a national common set of existing or new technical rules, norms, or guidelines for assessing the energy consumption of buildings, heating, ventilation, air conditioning, lighting, production plants, etc. This common set should then be promoted to both ESCOs and potential customers as the national "reference guideline" for monitoring and verification of the savings of ESCO projects.

However, this process should be co-ordinated at the EU level at least in the sense that as far as harmonised methods for measurement or calculation of the energy efficiency and performance of appliances, components, and buildings (e.g., EN 832) exist, these should be included in each of the national "reference guidelines". Furthermore, the need for further harmonisation should be examined.

ENERGY PERFORMANCE STANDARD IN THE DUTCH BUILDING DECREE (NL)

Submitted by:

NOVEM

P.O. Box 17, NL 6130 AA Sittard, the Netherlands

Contact: Mr. Harry Vreuls

Tel: +31 46 42 02 258

Email: h.vreuls@novem.nl

http://www.novem.nl

INTRODUCTION

At the end of 1995, an Energy Performance Standard (EPS) was introduced in the Building Decree of the Netherlands. The aim of this legal instrument was to reduce the energy use in new houses, but give freedom to architects, developers, and house owners regarding how they prefer to reach the required performance level.

As of December 15th, 1995 all new houses were to have an energy performance of 1.4 or lower. As of January 1st, 1998, the maximum level was lowered to 1.2 and as of year 2000 to 1.0. A house with an energy performance equal to 1.0 consumes 30% less energy than a house with an energy performance level of 1.4.

The EPS is regarded as an energy efficiency programme, which uses a legal instrument for its implementation. Prior to deciding whether or not to lower (or even continue the programme) the EPS level, the Dutch Government evaluated the programme. Novem was involved in these evaluations; first to find out at what moment the results of the EPS would become visible in the market and later to assess the real energy consumption of the new houses. The following focuses on the energy consumption evaluation (impact evaluation, the calculated ex-ante compared to the real energy use). At the end of this paper, comments on the use of the evaluation guidebook for this kind of programme are presented.

THE ENERGY PERFORMANCE STANDARD

During the 1970's and 1980's, the Dutch policy on energy savings in houses was implemented by increasing the insulation standards for roofs, walls, glass, etc. for existing and for new houses. In the 1990's, the approach was changed for new constructions. Instead of targeting single elements, the standards were replaced with an overall energy performance standard for the entire house in question. An overall standard leaves the choice of energy-saving measures to the market. Still the existing insulation requirements were retained as basic requirements.

A calculation model for determining the energy performance level of a house therefore had to be developed. A "typical" new house (i.e. average) was defined for each of the categories: Semi-detached house, end-house, one-family house, and multi-family house. An "energy budget" related to the EPS level, i.e. a maximum allowed consumption, was then defined for each category. The calculation model not only included energy consumption related to space heating, cooling and ventilation, and lighting. It also included the water heating as well so as to provide additional stimuli for use of residential solar hot water systems. Using the calculation model it is then responsibility of the architect to prove that the designed house does not exceed the allowed energy budget.

The "typical" house was used in the calculation (ex-ante) of the expected energy savings resulting from the EPS relative to new houses built before the introduction of EPS, i.e. before 1995.

Exhibit 1: Overview of EPS.

Period	EPS	Energy budget for a one-family house	Estimated savings relative to 1995
From Dec 15th, 1995 to Dec 31st, 1997	Max. 1.4	-	-
From Jan 1st, 1998 to Dec 31st, 1999	Max. 1.2	1,200 m3	15%
From Jan 1st, 2000 to …	Max. 1.0	1,000 m3	28%

An energy performance level of 1.2 (or lower) as required for building construction commenced after January 1st, 1998 was estimated to result in 15% energy saving compared to houses built before 1995. This equals a gas consumption of about 1,200 m^3. An energy performance level of 1.0 (or lower), as required as of January 1st, 2000 was estimated to result in 28% energy savings (= 1,000 m^3 gas). These assumptions were used in models for scenarios on energy consumption and policy impact.

ENERGY PERFORMANCE STANDARD IN NEW HOUSES

End 1994, Novem researched the situation for energy saving measures in new houses. This was just before the introduction of the EPS in December 1995. A substantial part of the houses, designed by architects in 1995, had at that moment already more insulation measures and/or measures on a higher level than the level required by law.

On behalf of the Ministry of Economic Affairs, Novem started in 1998 a survey to research the EPS. This study was targeted at houses that were completed by the end of 1997. It showed several important issues. Two are mentioned here:

- The building process had already started for 46% of the houses before the EPS was included in the Building Decree at the end of 1995;

- Of the houses built under the EPS programme little over half met the maximum 1.4 requirement while 30% met the 1.2 requirement, which became the new maximum level as of January 1st, 1998;

In 1999, the survey was repeated for houses completed by 1998:

- Of these houses, 92% obtained a building permit under the EPS 1.4 regime while the remaining 8% started the building permit process before January 1st, 1995. Thus none of the investigated permits were issued under ther EPS 1.2 regime.

- About 42% of the houses held an EPS value of 1.4 (the maximum allowed); 29% of the houses held an EPS value of 1.2; and only 3% of the houses held values of 1.0 or below. The remaining 26% were in the interval between 1.2 and 1.0.

HOW TO RESEARCH THE REAL ENERGY USE?

At the end of 1997, a first attempt was made to compare the estimated energy use (based on the EPS calculation model) and the real energy use. The investigation concluded:

- The EPS is not intended to calculate real energy consumption, but just to calculate the difference between the allowed energy budget for a specific house and the estimated energy consumption prepared by the architect using the calculation model. Although the EPS model should not be utilised on an individual level, it does however on a national level arrive at energy savings estimates comparable to the realised saving (15% for EPS 1.2);

- The impact of behaviour and the penetration of new appliances in real households should be included in the analyses. Furthermore, the energy consumption data for just one year is too little information to allow a good analysis.

In 1998, Novem started a study on energy use in new houses. Using the information from the studies mentioned earlier, it was clear that a representative survey on real energy consumption, related to the introduction of the EPS could not be done. So the research concentrated on two items:

- An indication of the real energy use, related to the EPS for a smaller number of dwellings;

- A research layout for structural monitoring of energy use in new houses at national level.

As real energy use for two or three years are needed to have at least some confidence in the results, the survey on the energy use had to be for houses build before 1997. But for these houses no EPS calculations are available, and it would be much too expensive to inspect houses to sample for all relevant variables for the EPS. So it was decided to use demonstration projects for the survey since building information (and in several cases also EPS calculations) was available for these projects.

Three demonstration projects with 474 houses in total were included in the survey. The structure of the data collection process was as follows:

- **Information related to the construction and the EPS** - Project documentation, collected by desk research and additional information from (former) project managers;

- **Household and behavioural information** - Written questionnaire for households;

- **Energy data** - Collected by the energy distribution companies, using a permit from the households to do this.

At present, a study is ongoing for a greater number of demonstration projects with houses that meet an EPS level of 1.0 or lower. In this study more emphasis is given to behavioural elements. The results are foreseen ready by the end of 2001.

REAL ENERGY USE, THE FIRST INDICATION

It was possible to collect the needed information for about 45% of the 474 houses. The non-response by households to the questionnaire was 49%; missing energy use data only caused a 6% drop out.

The average gas use was almost the same for 1997 and 1998, namely 1,291 m^3 and 1,251 m^3, respectively (the values have been adjusted for the outdoor temperature using the degree days method). Most of the houses had an energy performance of about 1.2.

The use of gas showed a great variation: The lowest value was 422 m^3 and the highest 3.048 m^3. As showed in Exhibit 2, the use differs by type of house, but the standard deviation within each type is also interesting. The gas use of houses with a solar hot water system is not included in Exhibit 2, as these have a lower EPS value.

Exhibit 2: Gas use in 1998 (m^3)

	Average	Modus	Standard deviation	Minimum	Maximum
Semi-detached house	1.709	1.622	411	943	3.048
End houses	1.479	1.160	749	532	2.931
One family houses	1.179	1.110	390	422	2.292
Multi family houses	1.002	932	221	658	1.434
Total	**1.331**	**1.217**	**496**	**422**	**3.048**

Only a small portion of the electricity use is included in the EPS calculations (lighting, ventilation, and boiler pump). It was not possible to establish these specific uses in the survey although the general electricity use gives some indications. But more important is that the gas and electricity use combined give the total real energy consumption of a new house. The average electricity use was almost the same in 1997 as in 1998, namely 2,996 and 2,967 kWh, respectively. (3.000 kWh is equal to 852 m^3 gas). As showed in Exhibit 3, the spread of electricity use is much higher than the gas use. Although also here the variation over the type of houses is evident, the differences between the lowest and the highest users within each category are great.

Exhibit 3: Electricity use in 1998 (kWh)

	Average	**modus**	**Standard deviation**	**Minimum**	**Maximum**
Semi-detached houses	3.956	3.696	1.412	1.844	7.583
End houses	3.008	2.815	1.252	1.299	6.125
One family houses	2.816	2.675	1.091	1.007	6.904
Multi family houses	2.575	2.465	948	1.427	4.563
Total	**3.107**	**2.939**	**1.281**	**1.007**	**7.583**

The general conclusions on the energy use were:

- The real average gas use in new houses with an energy performance of about 1.2, is in line with the estimated gas use of a standard one family house, but the variation in the gas use within the categories is high;
- The variation in the electricity use is much higher than that of in the gas;
- The variation in the electricity use is strongly linked to the kind of appliances in the household (especially with high electricity consuming appliances like waterbed and cloth dryers);
- In about half of the houses the people do additional ventilation independently of whether the house has a controlled ventilation system or not;
- Also houses with a hot water solar boiler system show a great variation in gas as well as electricity use.

THE USEFULNESS OF THE EX-POST EVALUATION GUIDEBOOK

The EPS programme uses as most import instrument the legal situation, but also additional instruments as calculation tools for developers and architects, information material (brochures, papers, and workshops) and an Internet site were used.

The evaluation presented above was just on the overall impact of the EPS programme on the energy use, so the comments on the evaluation guidebook should be seen in this framework.

Section 2.4.1 of the guidebook deals with the practical impact question: "How accurate are the programme initial assumptions regarding specific impact parameters?"

For the EPS programme there was a longer discussion between the policy makers and the researchers on whether the EPS calculation could be used on an individual level. They more or less agreed that it should be on an aggregated level of a country or of a type of house and on the mean values. This discussion proves in our opinion the importance of the practical impact question.

Chapter 3 on evaluation planning

The overall evaluation of the EPS programme is related to the lowering of the EPS levels in the Building Decree. In this case description only the impact is included, but from the personal involvement in several other elements of evaluation it became clear that an (overall) evaluation planning was not well developed before starting the evaluation process. The importance of overall planning should be stressed in the report.

As for the energy evaluation itself, an evaluation planning was used and so from the beginning it was clear what the evaluation goal was, which studies for what elements should be done and what kind of (survey method) should be used.

Chapter 4 on overall impact evaluation strategies

The elements are in general well described, but people should realise that basic knowledge from statistics and survey techniques is assumed and that for specific questions it is better to ask for help by an advisor. From the elements mentioned in the draft guide book we used:

- Primary data sources:
  - New group: survey with houses, not included in the programme, but with elements that make it suitable as a reference group;
  - Energy use/billing data;
- Evaluation techniques: only the random sampling;
- Statistical methods: the weather adjusted comparison/adjustment.

Chapter 5 on key impact evaluation concepts

The net and gross programme impact estimations are not used. The realised energy performance in the houses, used in the sample are all caused by demonstration subsidies, and not by the EPS programme. The element of ‘persistence of savings’ was included in the survey and the conclusions on ventilation and users behaviour.

Chapter 6 on selecting impact evaluation strategies

As the EPS programme mainly uses the legal instrument it could be defined as a market transformation programme, targeted to reduce the direct energy use. The survey indicates energy savings, and the research included a framework for structural monitoring. As the survey was only on the real energy use and the expected energy use, other elements indicated in Section 6.2.3 as market indicators were not relevant.

Chapter 7 on process and market impact evaluation

Market evaluations were conducted in studies for improving the knowledge on the EPS systems by architects, builders, real estate developers etc. In the survey described earlier, a mail survey was used, but with two special elements. The first was a present (a lottery formula) not after the questionnaire was sent back, but already when the questionnaire was mailed to the households. The second one was that the filled out questionnaires where collected in person.

For the questionnaire design, several elements from other available questionnaires were re-used. This saved time and money as a pre-test was not necessary.

CASE RELEVANT REFERENCE MATERIAL

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USE OF ELECTRONIC VSDS IN MOTORS IN THE PORTUGUESE INDUSTRY (P)

Submitted by:

Centro para a Conservação de Energia

Praceta 1, Estrada de Alfragide, 2720-537 Alfragide, Portugal

Contact: Mr. Carlos Nascimento

Tel.: +351 21 472 2800

E-mail: carlos.nascimento@cce.pt

http://www.cce.pt

INTRODUCTION

Electric motor driven systems account for 67% of industrial electricity consumption in Portugal, which means about 8,700 GWh/year or an annual cost of about 516 million EUR. Given the significant share that motive power constitutes in the energy consumption, interest in realising some of the potential EE improvements would seem natural. However, in reality several factors prevent a more intensive search of techniques and equipment to reduce the energy consumption by motor drives.

The design and size of the motor, the motor load, the motor efficiency, and the maintenance level of the equipment the motor all influence the electricity consumption for motive drives. Some process variables (e.g. pressure and flow) still continue to be regulated by devices like throttles, adjustable inlet vanes and by-passes, that waste energy and are cumbersome in operation or complicated to control. In many industries, efficient technologies like high performance electronic frequency converters or variable speed drives (VSDs) are still unknown or not widespread to the desired extent – mainly pumps, fans, compressors and even in other kinds of process and/or ancillary services equipment, requiring speed control. An electronic VSD controls the speed of the motor to match the load imposed on it under varying process and environmental conditions. This reduces power consumption for this equipment. For instance, for a pump or a fan power consumption is proportional to the cube of the motor speed and significant savings can be achieved through speed reduction (e.g., reducing the speed 20% will reduce the power consumption to half).

Depending on the application, an electrically controlled drive is composed of a motor, a variable speed drive (VSD) with a control and a power section, a gear as a torque converter, and other electromechanical and mechanical components. The key component is without doubt the VSD. It controls the speed, among other things, and ensures that a machine only receives the energy it needs for its current task. This minimises power losses and is an advantage for the environment. In the lower power ranges, motors with integrated VSD are increasingly being offered as so-called "intelligent compact drives". These have additional advantages with regard to cabling, space requirements, and electromagnetic compatibility.

Electronic VSDs are able to continuously change the speed of an AC motor. Most VSDs convert the 50 Hz alternating current to direct current and then run the current through a series of electronic power switches (transistors or thyristors) that switch on and off at a controllable rate to form a power supply of variable frequency and voltage, from nearly 0 Hz up to over 100 Hz. This variable frequency permits a motor's speed to be controlled, because the speed of the induction and synchronous motors varies directly with the frequency of the power supply. Provided that the motor and its load are sufficiently mechanically balanced, VSDs allow motors to operate at speeds both far below and well above their normal rated speed.

PROJECT OBJECTIVES

The present project was developed in the scope of PEDIP II programme, Measure 4.9 (energy efficiency missions), supported by the Portuguese General Directorate for Energy (DGE), and was inserted in a DSM perspective. The main aims were to identify the energy savings potential in electric motors in the Portuguese Industry by the use of VSDs and to sensitise the industrial top level decision makers for the application of the VSDs technology as a management priority and for the advantages of a DSM practice.

The project encompassed a pilot action, where electric/electronic equipment, like electronic variable speed drives (VSDs) and soft starters, were installed in several selected industrial installations, allowing "in field" evaluation - trough monitoring - of the resulting energy savings. The target groups of the project were DGE – Portuguese General Directorate for Energy, Industry, manufacturers and suppliers of VSDs and soft starters equipment, installers, electric equipment associations and other technologic infrastructures.

Summarising, the project included the following actions:

- Identification of energy savings potential for the different subsectors of the national transforming industry;
- Selection of enterprises (industrial factories), that belong to industrial subsectors with high energy savings potential;
- Installation of electrical equipment (VSDs and soft starters) in one or more productive sections of the selected enterprises; monitoring of energy consumption before and after the equipment installation, allowing an objective evaluation of the obtained savings.

SELECTION CRITERIA FOR VSDS INSTALLATION

The project consisted of a pilot action, where electronic variable speed drives and soft starters were installed in various industrial plants to allow measurement of the resulting energy savings. The pilot results were then scaled up for each industrial subsector to arrive at an estimate of the national potential for energy savings (ratio estimation). The sample of industrial enterprises selected for pilot testing of VSD technology was, however, not representative of the whole industrial sector since preference was given to the following:

- Enterprises currently employing young technicians in an energy traineeship. CCE is currently conducting an EE programme, which provides 2 months training in EE to newly educated engineers followed by a 9 months traineeship in industrial enterprises with high electricity consumption. Furthermore, the two activities are likely to strengthen one another;
- Industrial sites listed in proposals prepared by VSD technology suppliers and where the suppliers appeared willing and able to provide e.g. the data and co-operation requested by CCE;
- Sites which had the highest possible variety of equipment sizes and types within its industrial branch;
- 50% of the total equipment cost for the pilot project was financed by the government (PEDIP II Programme) and the remaining 50% by the involved industrial sites. However, the budget limit for contribution from PEDIP II was 39,904 EUR in total. Therefore a suitable mix of industries had to be construed which avoided exceeding the permitted co-financing limit of 39,904 EUR;
- The selected projects should allow testing of a great range of motive power (between 11 and 200 kW), types of equipment (drum mills, compressors, fans, etc), and types of industries (ceramics, agro-food sector, cork, textiles, and chemicals);
- The distribution of pumps, fans, compressors, and other motors varies between but also within the different industrial subsectors – mainly due to differences in manufacturing processes even for similar products. Therefore, extrapolation of pilot results to a national level does not necessarily lead to trustful values.

- The consequences of this was not investigated since the aim was to estimate the approximate size of the energy saving potential of VSD introduction on a national level and not to obtain exact values for each industrial subsector.

CHARACTERISATION OF INDUSTRY MOTORS DRIVES END-USE

The following graphic represents the share of electric consumption for Portugal, in 1996, for the main activity sectors; 12,864 GWh for the industrial sector, 9,037 GWh for the tertiary sector, 10,198 GWh for the residential sector and 643 GWh for Agriculture.

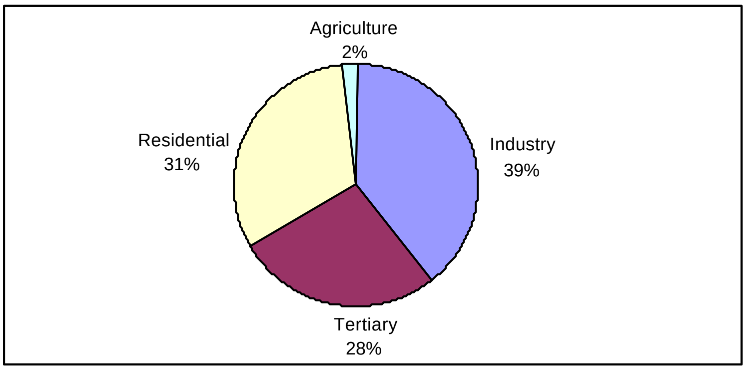

Fig.1 - Electric consumption desegregation for Portugal (reference [8]).

At Industrial level, the following table shows the electric energy consumption desegregation , for the reference year 1996.

Table 1 – Electric energy consumption (GWh) by industrial sector for Portugal in 1996(source: DGE)

Industrial Sector	Consumption (GWh/yr)
Food, drinks and tobacco	1,344
Textiles, footwear and tannery	2,118
Wood and Cork	783
Paper, graphic arts and publications	1,806
Chemical, plastics and rubber	2,290
Mineral and non-metallic products	1,858
Base metallurgy	758
Manuf. of metal prod. and mach., equipm. e transport. mat.	1,200
Other transforming industry	177
Extractive Industries and others	530
Total	12,864

The next graphic shows the consump tion desegregation by the main loads in industry, where is notice that 6% of electricity is used to feed motive power (essentially in tri-phase induction electric motors – about 90%, and 10% for the remaining, mainly DC motors).

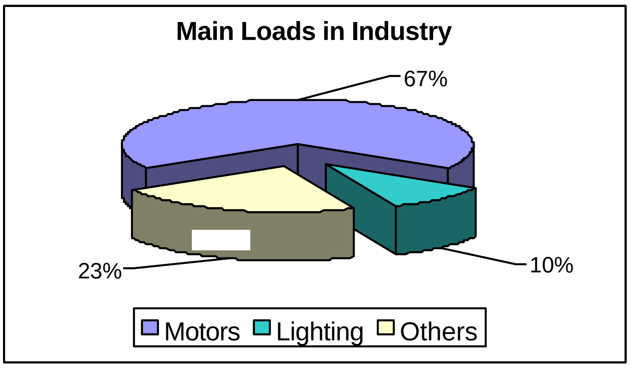

Fig. 2 – Electricity consumption desegregation by the main loads in the Portuguese Industry (Reference [8]).

Electric motors are used in a wide range of applications, mainly in pumps for fluid movement, compressors and fans. The next picture presents the electric motors consump tion desegregation by final uses in industry.

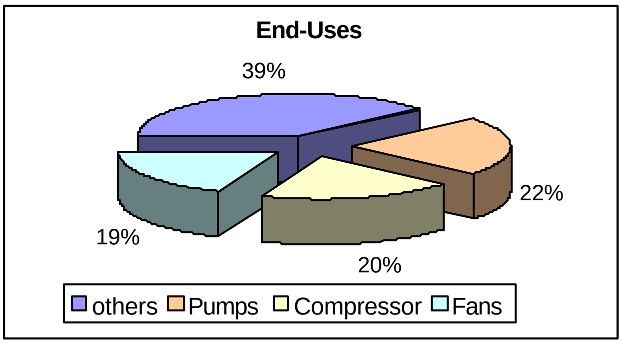

Fig. 3 – Electric motor consumption desegregation by main end- uses in Industry(Reference [8]).

The distribution of pumps, fans, compressors and other motors is very variable in the different industrial subsectors, mainly due to different manufacture processes adopted by the several industrial entities. Therefore from this situation, the extrapolation results for an industry in the same subsector or industrial sector, not always lead to trustful values, due to the enormous variety of manufacturing options to produce similar products.

The figure 4 presents the installed capacity, electricity consumption, losses and average operating hours of motors, by power range, in the Portuguese industry. As a remark, the number of operating hours varies from values higher than 8,000 hours per year in industries with continual processes (as for instance, in chemical and pulp industries), to values near 2,000 hours per year, for light industries with just one shift.

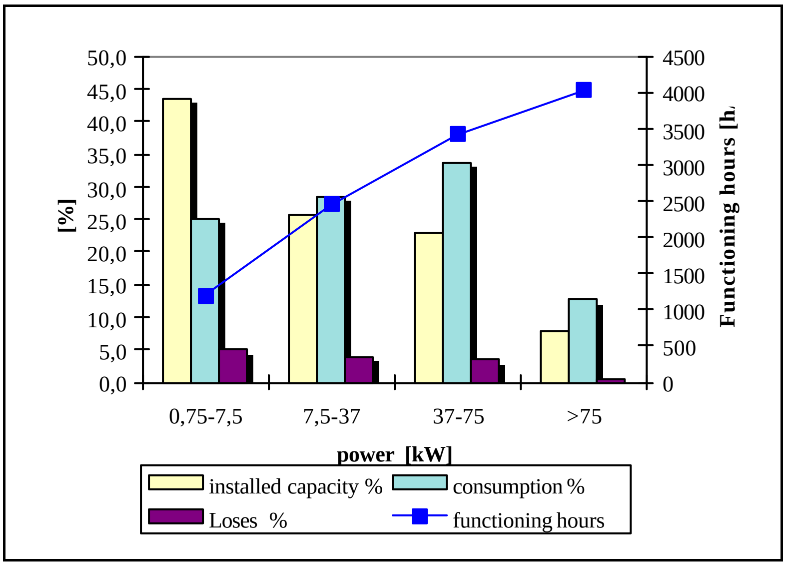

Fig. 4 – Percentage of electricity consumption, installed capacity, losses and average operating hours of electric motors, by power ranges, in industry (Reference [8]).

ENERGY SAVINGS POTENTIAL IN ELECTRIC MOTORS

The very different examples of applications that follows, shows how consumption, and therefore energy costs as well, can be drastically reduced by upgrading the drive solutions on offer. In the examples of calculation, different power prices in PTE/kWh were used. In practice, other factors such as the load cycle and operating hours must be considered from case to case and can lead to deviations in both directions in the result.

Electronic VSD application in an electric motor from one exhaustion fan of a steam boiler in a cork plant industry

The 6 years old fan with an electric motor (45 kW) is responsible for the exhaustion to the atmosphere of the combustion gases from one steam boiler that uses powder cork as fuel. Before the tested application, there did not exist any control in this circuit, i.e., the motor was acting in a nominal regime. It was supposed that it was oversized, conducting to small values of power factor (cosφ) in the circuit.

Actually, an analogue sensor of air stream, installed in the boiler, acts in the velocity regulation of the motor, adapting continuously the rotation velocity to the exhaustion needs. The variation range of velocity is between 45-100% (30-50Hz).

Table 2 – Obtained savings with the electronic VSD application in the exhaustion fan.

Fan's Motor	Average consumption of active energy (kWh/day)	Average consumption of reactive energy (kVArh/day)	Starts (nº /day)
With electronic VSD	489.5	247.3	1.87
Without electronic VSD	363.2	176.7	1.74
Savings (%)	25.8	28.5	7.0

According to the stated results, we can conclude that it was obtained a considerable electric energy savings, nearly 25%, with the installation of an electronic VSD in the exhaustion circuit of the boiler.

The electronic VSD had caused a reduction of about 7% in the daily number of starts of the electric motor, which changed from 1.87 to 1.74 starts/day. We have also verified a better power factor of this motor, caused by the reduction of reactive energy consumption, as consequence of operation nearly to the nominal mechanical regime of the machine.

Table 3 - Synthesis of economic analysis for the VSD installation in the exhaustion fan.

Average consumption without electronic VSD	Average consumption with electronic VSD	Energy savings		Investment			Payback time
				VSD	Software	Total	
kWh/day		KWh/year	10^3 PTE/year	10^3 PTE	10^3 PTE	10^3 PTE	years
489.5	363.2	28,672	293	860	242.5	1,102.5	3.8

In this case the obtained payback time is 3.8 years. We consider this a little bit high value because it is more than 3 years. Nevertheless, if we take into account other savings that result from the electronic VSD application, the payback time will reduce a little, to approximately 3 years, that attests the technical-economic viability of this kind of application.

Electronic VSD application in an electric motor from an exhaustion fan in a spray-dryer of a chemical plant

The equipment with a 200 kW motor, which was the target of our study, was the exhaustion gases fan from the dryer tower (spray-dryer). The asynchronous motor (15 years old) works 5,000 hours/year and it is oversized. The equipment belongs to production sector of detergent powder (drying tower), and contributes for the exhaustion of nearly 70,000 kg/h of air, that transports within the evaporated water in the drying process.

At the outset of this study, the air flow control was achieved with a damper modulation, standing the motor permanently at the synchronism velocity which resulted in significant waste of energy. The introduction of an electric VSD allows the continuous adjustment of motor velocity (motor consumption) to the required power. The introduced variation of velocity permitted a range of motor rotations between 350-1,500 rpm.

The obtained results show that a considerable saving can be achieved by the installation of an electronic VSD. The percentage average values of the obtained savings are listed below in table 4.

Table 4 - Obtained savings with the electronic VSD application in the exhaustion fan.

Fan's Motor	Average consumption of active energy (kWh/h)	*Average consumption of reactive energy* (kVArh/h)
Before the introduction of a VSD	83.7	53.4
After the introduction of a VSD	49.6	9.2
Savings (%)	40.7	82.8

A significant reduction in active and reactive power consumption can be achieved. With the electronic VSD we assisted an alteration in the rotating regime and to smaller values in the maximum demand power. The most important advantages are the effectiveness control of the ventilation adapted to the process requirements, the visualisation in real time of the process variables (flow, velocity, power, torque, etc...), the energy saving higher than 35%, the very important reduction of reactive energy, and the complete elimination of energy relative to the starts tip (5 to 7 In) – providing soft starters with decrease in mechanical stress, and consequently reduction in maintenance costs, that were evaluated in 600 x 10^3 PTE/year.

Table 5 - Synthesis of savings analysis for the VSD installation in a fan's motor.

Cons. without VSD	Cons. with VSD	Savings			Investment			Payback time
		Energy		Maintenance	VSD	Installation	Total	
(kWh/h)		kWh/year	10^3 PTE/year	10^3PTE/year	10^3 PTE	10^3 PTE	10^3 PTE	Years
83.7	49.6	170,500	2,078	600	3,750	550	4,300	1.6

Considering the analysed application, the payback time is 1.6 years, a very interesting value, once eventual savings that result from the diminishing of the maximum demand power on the industrial installation are neglected. As consequence we can conclude that the introduction of the electronic VSDs is worthwhile from a technical and economic stand point of view in similar applications.

The high viability of this application is a consequence of the high power motor. And also from the very significant number of hours in operation, and of course by the inefficient way of control used before.

Electronic VSD application in an electric motor from an extruder in the ceramics industry

The analysed equipment was the extruder located in the slip preparing section (preparation of row materials). The electric motor with a rated power of 75 kW and 10 years old, works 16 hours/day. Some previous tests showed that the motor works continuously, in a constant speed, independently of the charge (load) and with an average power of 33.5% of its nominal power.

VSD application was thought to be able to minimise tariff penalisations (connected to some "peaks" of power resulting from the several starts of the extruders), reduction in the electric consumption of the machine, optimising its operation and all the process. Other benefits like the operation automation, reduction of the operation time (and manpower associated), the expected increase of the useful life time of the motor and the possibility of informatisation of the functioning of the production chain through additional sensors and appropriated software, reinforced the interest on its implementation.

The results of the consumptions monitoring proved a considerable oversize of the motor, the frequent oscillations in the load, with significant savings in active energy and a better power factor. The load variation was detected by the electronic VSD, activating the mode "energy saver", responsible for the obtained savings.

Table 6 – Obtained savings with the electronic VSD application in the extruder's motor.

Extruder's Motor	Average consumption of active energy (kWh/day)	Average power factor
Before the introduction of a VSD	257.85	0.40
After the introduction of a VSD	121.01	0.77
Savings (%)	53.1%	

After the installation of the electronic VSD, it was verified a significant reduction in average power, and consequently a substantial savings of active energy, approximately 53%, which exceeded the initial expectations.

Another reason that justify the application of this kind of technology will be the reduction of electric tariff penalisations, the increasing of the useful life time of the motor and of its associated equipment and the consequent maintenance with lower costs.

Table 7 - Synthesis of economic analysis for the VSD installation in an extruder motor.

Average consumption without VSD	Average consumption with VSD	Savings		Investment			Payback time
		Energy		VSD	Installation	Total	
kWh/day	kWh/day	kWh/year	10^3 PTE/year	10^3 PTE	10^3 PTE	10^3 PTE	years
257.85	121.01	32,842	360	1,175	140	1,315	3.6

In this application the obtained payback is 3.6 years, which is an acceptable result, since only the energetic parameters were taken into account (if other economical advantages were accounted for, this result would improve).

Electronic VSD application in a discontinuous mill's electric motor from a ceramic tiles industry

The electric motor belongs to a discontinuous balls mill, type "alsing", located in the slip preparation section. It has a total capacity of 35,000 litres and it works at full load.

The motor is from ABB with a rated power of 110 kW. It is 4 years old and works 5,824 hours/year. The mill's annual electric consumption represents, in average, 17% of the global electric energy consumption, and 23% of the motive power consumption.

As a consequence of the electronic VSD application, it was expected that an adjustment of the rotation speed of the mill according to the grinding curve of the raw material would be possible. The main advantages obtained from the application of a frequency invertor (VSDs) to the discontinuous ball mill are the following:

- Gradual starting up of the mill;
- Adaptation of the grinding action to the dimensions that the material takes as the grinding process progresses.

The variation in the speed of the mill throughout the grinding allows the mill to grind at the appropriated speed for each part of the grinding curves, optimising the grinding process and reducing energy consumption and grinding time with respect to the initial conditions.

Energy savings and reduction of grinding time depend mainly on the row material to be ground and the relation between the load of the material to be ground and the load of the grinding media. Besides these advantages it were also expected an increase in the production capacity of the grinding division (due to the reduction in the time of the grinding cycle), as well lower operation costs (associated to a less wear of the grinding media and of the internal covering of the mill) and lower maintenance costs (of the motor).

The electronic VSD implementation introduced substantial energetic advantages with reduction in active and reactive energy consumptions, including a reduction in the consumption at start. It was also verified an improvement in power factor (0.81 to 0.92) by adjusting the operational conditions of the motor.

Table 8 - Obtained savings with the electronic VSD application in the mill's motor.

Mill's Motor	Average consumption of active energy (kWh/mill's cycle)	Average consumption of reactive energy (kVArh/mill's cycle)	Power factor
Before the introduction of a VSD	933.59	675.29	0.81
After the introduction of a VSD	833.22	358.52	0.92
Savings (%)	10.75	46.91	

By adjusting the mill motor speed as a function of the material grinding curve it was been optimised the granulometric distribution relation, with reasonable energetic gains. The electronic VSD contributed to the reduction of the electric invoice saving approximately 11% in active electric energy. We also refer the diminishing of 8.2% detected in the total grinding time, having as consequence an increase in productivity.

The foreseen costs reduction associated to with the motor maintenance, in addition to others advantages reasons not specifically energetic ones were not quantified by the industrial users.

Table 9 - Synthesis of economic analysis for the VSD installation in a mill's motor.

Average consumption without VSD	Average consumption with VSD	Savings		Investment	Payback time
		Energy		VSD (incl. installation)	
KWh/mill cycle		kWh/year	10^3 PTE/year	10^3 PTE	years
933.59	833.22	48,680	570	3,850	6.8

The obtained payback period of 6.8 years, taking into account only the energy savings, is very high. However the economical viability of such application can't be analysed in this way. According to this, the payback time must be calculated including all the benefits associated to the technology, including the ones referred before. We estimate that if taken into account all these benefits, it would be obtained a value of payback of about 3 years.

Electronic VSD application in a granulator´s fan from an agro-food industry

The equipment analysed was located in the granulation section of a factory that produces food (rations) for animals, i.e. the electric motor coupled to the cooling fan of the granulate in a granulator machine. The 30 kW asynchronous motor, 6 years old, works 2,600 h/year. Before the introduction of the electric VSD the airflow control was achieved trough a valve actuated manually according to the temperature in the final product granulated. The expected savings would be caused by the frequent oscillation of the load (that was thought it would be significative), which activates an optimisation function integrated in the electronic VSD, causing the permanent adjust of the torque to the conditions required.

Table 10 – Savings obtained with the electronic VSD application in the granulator´s fan motor.

Granulator Fan	Average consumption of active energy (kWh/h)
Before the introduction of a VSD	30.96
After the introduction of a VSD	28.69
Savings (%)	7.33

The obtained charge diagrams revealed only a small diminishing, which is not sensitive in the maximum demand power after the installation of the electronic VSD. As a result, the savings are not as significant as expected, with a value of 7.3%. The motor operating mode, nearest of the nominal regime that was verified before the introducing of the electronic VSD justifies this result, besides the inexistence of load variations of the motor as expected, as well .its oversize.

The savings detected are probably a consequence of the better conditions in the start and stop of the motor; due to mechanisms of soft-start and soft stop integrated in the VSD, that limit the current peaks (diminishing the mechanical stress).

Table 11 - Synthesis of economic analysis for the VSD installation in a fan's motor of a granulator machine.

Average consumption without VSD	Average consumption with VSD	Energy savings		Investment			Payback time
				VSD	Installation	Total	
kWh/h		kWh/year	10^3 PTE/year	10^3 PTE	10^3 PTE	10^3 PTE	years
30.96	28.69	5,902	60.26	610	79	689	11.4

Here, the payback time of 11.4 years is not reasonable, once it is extremely high, which makes the investment not viable economically. Another fact that contributes to the value obtained in the payback time is related to the payback calculation that not takes into account other economical advantages resulting from this technology, like the reduction in the maintenance costs of the motor. However, even if taking these benefits into account, it wouldn't be enough to the investment be worthwhile in this particular case.

Electronic VSDs applications in an electric motor of a tank's agitator and in an electric motor of a dust removal system of a porcelain ceramics industry

The tested applications involved the analysis of two pieces of equipment, namely:

- 1 fast agitator, moved by an electric motor of 32 kW, located in a tank with a capacity of 50 m^3 installed in the slip preparation section, for the raw-materials dilution;

- 1 dust removal dry system, involving a cyclone separator, where the centrifugal force generated by a ventilator, moved by an electric motor of 55 kW, is responsible for the cleaning of the polluted air (with powder provenance of different machinery). This system was responsible by 5% of the electrical energy consumption of the factory, when regulated by a damper (before the introduction of the VSD).

In the original motor of two velocities, which moves the agitator, the programmed automate (PLC) and electronic VSD introduction has caused a reduction in velocity until 25 Hz (in the lower speed).

In the dust removal system, the electronic VSD introduction influenced the rotating speed of the ventilator's motor, which remains constant at 40 Hz.

Table 12 - Obtained savings with the electronic VSD application in the agitator and ventilator motors.

Agitator motor	**Average consumption of active energy (kWh/cycle)**	**Average power factor**
Before the introduction of a VSD	155.19	0.75
After the introduction of a VSD	108.65	0.88
Savings (%)	30.0	
Ventilator motor	**Average consumption of active energy (kWh/h)**	**Average power factor**
Before the introduction of a VSD	35.58	0.83
After the introduction of a VSD	20.66	0.77
Savings (%)	41.9	

Concerning the energy savings obtained in the turbo-dilution tank, it was about 30% by cycle of operation. This involves a time reduction per operating cycle (that involves one dilution and one discharge phases), that becomes 12.0 hours, contrasting with the 16.3 hours observed before the introduction of VSD. The eradication of a human error that controlled the duration of the cycles before the VSD installation, was the main factor to the obtained results, once actually the duration of the cycles are smaller with a reduction proportional in electric consumption. It was also verified a better power factor by optimising the motor working.

With respect to the ventilator, the electronic VSD introduction caused immediately a decrease in the maximum demand power and consequently in the registered active energy consumption. The result was a significant decrease in energy consumption, i.e., 42%, confirming the initial expectation.

Table 13 - Synthesis of economic analysis for the VSD installation in the ventilator and agitator motors.

Equipment	**Average consumption without VSD**	**Average consumption with VSD**	**Savings**		**Investment**			**Payback time**
			Energy		**VSD**	**Others costs***	**Total**	
	kWh/cycle		**kWh/year**	**10^3 PTE/year**	**10^3 PTE**	**10^3 PTE**	**10^3 PTE**	**Years**
Agitator	155.19	108.65	12,100	136	570	120	690	5.1
Equipment	**Average consumption without VSD**	**Average consumption with VSD**	**Savings**		**Investment**			**Payback time**
			Energy		**VSD**	**Total**		
	kWh/h	**kWh/h**	**kWh/year**	**10^3 PTE/year**	**10^3 PTE/year**	**10^3 PTE/year**		**Years**
Ventilator	35.58	20.66	65,648	739	860	860		1.2

**Instalation+swichboard*

According to the results it was proved that in similar applications, namely in ventilators, it is possible to obtain considerable energy gains, which can give a payback time extremely attractive (lower than 1.2 years), taking into account other beneficial effects not quantified.

The VSD application in the agitator of the turbo-dilution tank demonstrated to possess a payback time not very attractive (higher than 3 years) as a consequence, in this case, of the reduced consumption registered. We think that in cases where the power involved is higher we get better results.

Electronic VSD applications in electric motors of 4 centrifugal pumps, 2 of water-supply and 2 of dyeing equipment of a textile plant

The tested applications involved the analysis of 4 pieces of equipment, namely:

- 1 superficial pump moved by an electric motor of 11 kW. It is located in the supplying water central of the factory, and it has the distribution function to the consumer equipment. It has a continuous working regimen (24 hours/day), equivalent to 6,300 hours/year.
- 1 submersible pump moved by an electric motor of 15 kW. It also belongs to the supplying water central of the factory, having the same function and working regimen of the previous pump.
- 1 pump of dyeing equipment (jet), moved by an electric motor of 30 kW. This equipment is located in the finishing jersey section. The maximum annual operating hours are 5,760 hours/year.
- 1 pump of dyeing equipment, moved by an electric motor of 15 kW. This equipment is equally located in the finishing jersey section. The maximum annual operating hours are also 5,760 hours/year.

The electronic VSDs installed in the water-supply central were programmed to operate in a frequency regimen between 25-50 Hz (connected to a pression transducer), varying continuously the operation frequency by adjusting to the load.

At the dyeing equipment the VSDs were also programmed to a variation speed in the range between 25-50 Hz, but the adjustment of the speed is not regulated automatically, depending on the rotation speed of the type of jersey involved in the dye-work process. This operation is handled and regulated by a potentiometer.

Table 14 – Obtained savings with the electronic VSD application in the tested equipment.

Superficial pump	**Average consumption of active energy (kWh/h)**	**Average consumption of reactive energy (kVArh/h)**	**Power factor**
Before the introduction of a VSD	7.61	4.23	0.87
After the introduction of a VSD	5.98	0.64	0.99
savings (%)	21.4	84.9	
Submersible pump	**Average consumption of active energy (kWh/h)**	**Average consumption of reactive energy (kVArh/h)**	**Power factor**
Before the introduction of a VSD	9.73	9.14	0.73
After the introduction of a VSD	7.51	1.66	0.99
Savings (%)	22.8	81.8	
Jet pump	**Average consumption of active energy (kWh/h)**	**Average consumption of reactive energy (kVArh/h)**	**Power factor**
Before the introduction of a VSD	11.65	8.06	0.82
After the introduction of a VSD	2.52	0.34	0.99
Savings (%)	78.4	95.8	
Other dyeing pump	**Average consumption of active energy (kWh/h)**	**Average consumption of reactive energy (kVArh/h)**	**Power factor**
Before the introduction of a VSD	14.48	--	0.88
After the introduction of a VSD	9.40	--	0.90
Savings (%)	35.1	--	

The introduction of the electronic VSDs in the pumps of water supply conduct to similar results, with the decreasing of consumptions of active energy (22%) and reactive energy (≈80%). The power factor suffers an increase. These results provide a potentiality application of VSDs in similar equipment.

The results in the jet application demonstrate a better energetic utilisation in this equipment, in all the points analysed. It was registered an oversize in the motor's capacity and a frequent start/stop of the motor, with very frequent load oscillations. These situations are adequate and justify the application of this technology.

In the other dye-work pump it were observed similar results to the other equipment, as reduction in active energy and increasing in power factor. The reactive energy was not measured because the analyser model involved in the monitoring did not allow this kind of measure.

The monitoring results proved to be very attractive (see table 15), once the obtained savings were substantial, with repercussions very favourable in the payback time period, (lower than 3 years in all projects). The results would be more attractive if we taken into account all the savings generated by the electronic VSD, which were not considered (motor maintenance, eventual power factor and maximum demand power of the plant, ...). All the equipment demonstrate a potential for savings through application of VSD.

Table 15 - Synthesis of economic analysis for the VSD installation in the tested equipment.

Equipment	Average consumption without VSD	Average consumption with VSD	Energy savings		Investment			Payback time
					VSD	Installation	Total	
	kWh/h	kWh/h	kWh/year	10^3 PTE/year	10^3 PTE	10^3 PTE	10^3 PTE	years
Superficial pump	7.61	5.98	10,254	129	291	25	316	2.45
Submersible pump	9.73	7.51	13,986	176	384	25	409	2.32
Jet pump	11.65	2.52	52,584	663	384	25	409	0.62
Other dyeing pump	14.48	9.40	29,212	368	608	25	633	1.72

CONCLUSION

Electric motors represent the largest end-use in the Portuguese industry, i.e., about 2/3 of the total consumption. The main applications are pumps (25% of industrial electricity consumption), ventilators (20%), compressors (20%), transporting systems (8%), and other machinery (17%).

The electricity savings that can be obtained by introduction of electronic VSDs depend of the specific application, once possible savings are conditioned by some factors. We stress that reduction of oversizing of the systems and the load variation requirements can lead to energy savings up to 50% in average.

The biggest savings are obtained when the application requires a torque that increases with the square of the speed of the motor. Typical examples are ventilators, centrifugal pumps and compressors. Overall the estimated savings for pumping and ventilation systems as a result of VSDs application are about 30-35%, for compressors and refrigeration systems 18-23%, and for machinery and transporting systems approximately 7%. In average, a potential of 25% saving can be assumed for the process industry with the application of electronic VSDs in loads where this technology is well succeeded.

The cost of electronic VSDs depends of the range of power of the motor, which is controlled by the VSD. Nevertheless, there are other factors that influence the acquisition of a VSD, like the number of operating hours and the type of charge. Almost all VSD suppliers claim high efficiency for their products varying between 95-97% for the more recent models.

The application of electronic VSDs is however limited to only a part of the existing motors in industry taking into account the viability of a project, not only in terms of technical but also economical aspects.

The number and use of motors in pumps, ventilators, compressors, and other equipment varies within the different industrial subsectors due to differences in production processes. Consequences of this was not taken into consideration in the evaluation (it was assumed that the situation observed in the factory is representative of the average of its correspondent subsector).

Table 16 presents the potential electricity savings related to the application of electronic VSDs in the Portuguese transforming industry. The values for the various industrial subsectors are "theoretical potentials", not taking into consideration economic aspects and/or the expected real penetration of the technologies, which both are functions of specific barriers existing in the market that will influence the dissemination and implementation.

The global data of electric consumption in each subsector (more recent values) was obtained from DGE (the Portuguese General Directorate for Energy), using 1996 as reference year.

Table 16 – Potential electricity savings in motors in the Portuguese process industry.

Industrial Subsector	Total electric consumption (MWh/year)	Motive power Electric consumption in		Potential for VSDs application	Electric energy savings	Maximum energy saving potential (MWh/year)
		%	MWh/year	%	%	
Food compounds for animals	105,572	70%	73,900	17%[(a)]	25%	3,141
Textiles	1,349,378	92%	1,237,733	17%[(a)]	35%	73,645
Wood and cork	638,520	70%	446,964	17%[(a)]	25%	18,996
Pulp and paper	1,632,078	70%	1,142,454	33%[(c)]	25%	92,824
Soaps, detergents and cosmetics	22,217	70%	15,552	17%[(a)]	25%	661
Ceramics (excluding earthenware pottery)	244,479	67%	163,907	20%[(b)]	20%	6,556
Earthenware pottery	39,377	70%	27,564	17%[(a)]	25%	1,171
Cement	832,719	70%	582,903	18%[(c)]	25%	25,502
Others	7,469,367	70%	5,228,557	17%[(a)]	25%	222,214

(References: (a) ABB- Espanha, (b) CCE- Estudo Sectorial, 1995; (c) ISR – Universidade de Coimbra)

Some of the average savings presented for the subsectors do not correspond precisely to the obtained values in the referenced projects, once they are reduced or by the perception that they are anomalous, or exceptionable, not being representative for the subsector average. More credible values have therefore been created based on a comparison with other subsectors.

We estimate that 444,710 MWh/year could be saved in an actual consumption universe of approximately 12,334 GWh/year. Then, we obtain a reduction of 3.6% in the national perspective of total electric consumption in industry, that is equivalent to a saving of about 5% relatively to the motive power consumption - a value that corresponds to five billions and three hundred millions PTE (with a basis price of 12 PTE/kWh).

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COMMENT ON THE PARTICIPATION IN THE GUIDEBOOK PROJECT (EE)

Submitted by:

Regional Energy Centre of Viljandi

Vabaduse Plats 4-313, 71020 Viljandi, Estonia

Contact: Mr. Kalle Jöks

Tel: +372 43 33 620

Email: kalle@rek.vil.ee

The Regional Energy Centre (REC) of Viljandi participated as a “sleeping” partner in the project team for "A European Ex-post Evaluation Guidebook for DSM and EE Services - Phase II". As a sleeping partner, the REC did not test the guidebook methodology on a case example but instead participated actively in the project meetings and the review of the project material prepared by the team including the guidebook itself. The information that this effort provided was used in the daily work of the REC. In this way the collaboration in this project was welcome opportunity to obtain evaluation know-how and experience.

The lack of ex-post evaluation projects is an acute problem in Estonia as in the other Baltic States. As a rule, all energy efficiency projects are evaluated before implementation, but feedback about real results is sparse. For example, do all applications from municipalities to obtain financing from the national Energy Saving Fund need to be evaluated by a regional energy centre. However, results after implementation are not compared with the estimates. Comparison of benefits and costs would help assess and improve the effectiveness of the projects.

It is not always clear which method is the most appropriate for a given project in need of evaluation. It is therefore very useful to learn from applied real-life examples as the illustrative cases presented in the guidebook. The guidebook helps generate ideas on to how evaluate different Estonian energy efficiency programmes. The selection of cases in the guidebook are very relevant seen from an Estonian perspective. An example, the case on “Improving the Heating System Balancing Services of Buildings” (Motiva, Finland) contains good ideas on how to approach yet weak homeowners associations and achieve a noticeable energy consumption decrease in residential buildings.

Ex-post evaluation is a good tool for determination of what kind of energy saving activities bring about true savings at a reasonable cost and what activities should be given higher priority in Estonia. Observance of the guidebook recommendations would thus consequently save money, which could be used for additional energy saving activities.

The participation of the REC of Viljandi offers a unique opportunity to introduce ex-post evaluation and the existence of an ex-post evaluation methodology guidebook to the staff of other RECs. The RECs will in turn be able to disseminate the concept and methodology of ex-post to local consultants, public organisations, and municipalities evaluation via different seminars and training arranged by the RECs. There is reason to hope that in this way ex-post evaluation will be used to a much greater extent in the future.

The energy efficiency problems facing all the Baltic States are similar. Specialists from Latvia and Lithuania would thus also stand to gain from the existence of this guidebook.