Creating Markets for Energy Technologies

Case Studies

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Table of Contents

CS 1

The Deployment of Biomass-District-Heating in Austria

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Introduction

Since 1980 a new technology providing domestic heating in rural areas was introduced: small scale district heating plants that use wood chips, industrial wood waste or straw as fuel. By 1999 more than 500 Biomass-District-Heating (BMDH) plants have been established.

The principle of a BMDH is simple. A big boiler filled with biomass heats water, that passes through a grid of insulated pipes and supplies the energy for the heating of individual houses and enterprises in a village. Austrian villages with BMDH plants usually have between 500 and 4000 inhabitants and are of predominantly rural character. Accordingly the power of BMDH plants is between a few hundred kW and up to ten MW with corresponding grids between 100 metres and 20 kilometres. About 2/3 of all plants have a power of less than 1500 kW.

The introduction of BMDH was not managed at a national level but at the level of federal states („Länder"). The different attention given to the deployment of this technology in the nine federal states had strong effects on the different diffusion characteristics in these states. While the early innovators - the states of Lower Austria, Upper Austria, Salzburg and Styria - started diffusion in 1980 and reached the level of maximum annual dissemination in 1993, the laggards Burgenland, Carinthia, Tyrol and Vorarlberg had the first plants established in 1990. Figure 1 shows the diffusion in the early innovating states. It is interesting to note, that small plants (< 800 kW) start a new cycle of diffusion in the most recent years, while larger plants > 800kW have decreased since 1994. Smaller plants are associated with a new concept: the heating plant is not designed to supply the whole village but only a few larger buildings in the vicinity. This is both more economic and easier to organise.

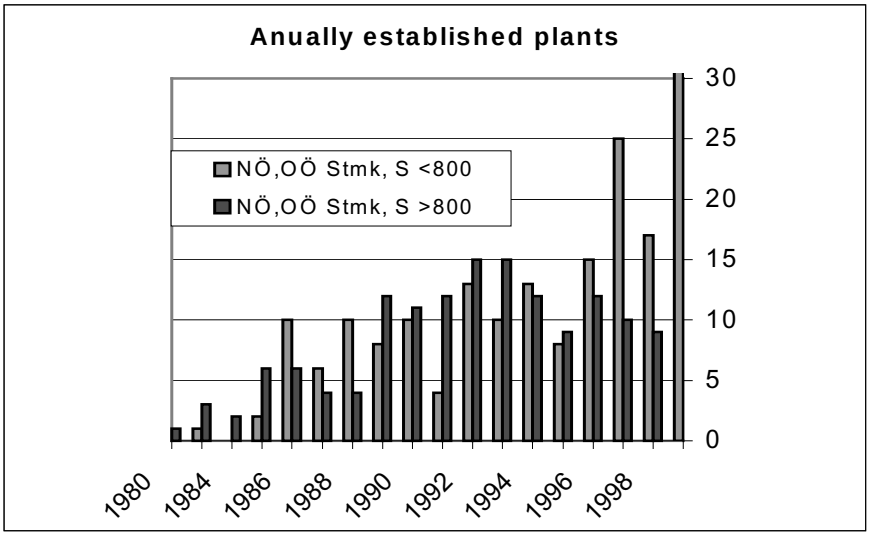

Figure 1: Diffusion of BMDH in 4 states – the influence of plant size on diffusion

The case of BMDH in Austria is interesting for a number of reasons:

It is a rather successful case of renewable energy diffusion

while being a success in numbers of deployed plants the diffusion process was not a success in terms of technical performance of plants and learning speed.

These deficiencies can be clearly related to weaknesses in the management on the technology-deployment-program. It is an interesting case example as its success is based to good part on a strong bottom-up-movement, while at the same time significant conflicts took place at the local level during the implementation-process. Thus it serves as an example for the complex issue of public acceptance of renewable energy technologies.

(2) Objectives of the program

As the deployment of BMDH was both the result of local initiatives and public policy it is useful to consider both the objectives of the local project promoters and of the program-managers at the level of federal states. At this level, the policy level, the prime objective was clearly to support agriculture. In Austria most farmers are both owners of farmland and forests. Especially in the mountainous areas the economic situation of farmers is very difficult. The deployment of BMDH should give farmers the opportunity to build up a new source of income by providing energy services. Consequently most resources dedicated to the development of BMDH came from agricultural funds. Only in a later phase of deployment also environmental subsidies contributed to the financing of plants.

At the local level the motivations for deploying the new energy system were different. A survey among residents[1],[2] showed that top motivation for residents connecting to the new

[1] Rakos, C.: Doctoral thesis „Fünfzehn Jahre Biomasse-Nahwärmenetze in Österreich“, Technische Universität Wien 1997. This theses was written in the course of the EU funded project “Pathways from small scale experiments to sustainable regional development” “EXPRESS PATH”, CEC Contract No EV5V-CT92-0086. See also:

[2] Danielsen, O., Koukios,E., Rakos, C.: „Pathways from Small Scale Experiments to Sustainable Regional Development“ („EXPRESS PATH“), CEC Contact No. EV5V-CT92-0086. The project was

BMDH was enviromental protection (mentioned by 95%). 75% of the responding residents declared an important aspect for them was also the support of local farmers and local self-sufficiency. 87 % responded that the convenience of District-Heating was an important motivation. Thus local motivation is based on three basic aspects: enviromental protection, enhanced heating comfort and sustainable local development.

The objectives of the federal agriculture ministry have been described most recently in the federal decree 21 200/50/II/00 of 27th July 2000. In this decree that enacts the new subsidy program for BMDH the following motivations are mentioned: creation of new possibilities for income in rural areas, creation of added value in rural areas, creation of jobs and contributions towards securing the existence of farms. In another programmatic document, the "Austrian Program for the Development of rural areas"; part 2 chapter 11.3.5 two additional motivations are mentioned: making a contribution to the fulfillment of the Kyoto-Agreement and making a contribution to the policy goals as stated in the Whitebook for Renewable Energy of the European Commission.

The programmes for the deployment of BMDH addressed two barriers:

While biomass is a cheap fuel that is competitive with conventional fuels, biomass boilers are significantly more expensive than conventional boilers. Also the establishment of a district-heating-grid is very costly. Consequently it is almost impossible to realise BMDH-projects without subsidies for the high initial investment-costs.

While biomass boilers for the combustion of woodwastes have been used in the forest-industry for decades, and district-heating as a technology has also existed for a long time, the combination of both elements was a real innovation. Especially its application in small scale rural areas was new and requested both modifications and improvements of the boilers and of district-heating technology. In addition to that also the concept of operating BMDH plants by agricultural co-operatives was completely new. The technical start-up problems and the fact that the developers and operators of these plants had no previous experience neither with the technology nor with the economics of providing energy-services were a significant barrier. In order to overcome these barriers focal points were established in the states promoting BMDH.These focal points were small institutions that facilitated the technology-deployment-process and gave advice to the developers of new projects. They were established either at the agricultural chambers, within the state-administration, as independent consulting-institutions that received public funding or within existing state energy agencies.

(3) Process of definition and design of the program

The deployment of BMDH started as a bottom-up-process in which individual farmers supported by a regional development agency developed the idea and realised the first projects. The success of these projects created an exceptional interest and some of the BMDH plants received thousands of visitors annually. At the beginning no formal subsidy-program was available for this innovation. The development of formal subsidy-programmes and the establishment of the different support-units in the federal states was more of a reaction to the bottom-up-development than a planned technology-deployment activity. The

funded within the framework of the Socieconomic Environmental Research Area of the Environment Research Programme of DG XII.

design of the programmes in the different states was similar: Create a subsidy scheme and provide-funding for one or two persons that help the farmers to set up their projects. While R&D was very important for technology-improvement it was not part of the state deployment-programmes but funded by national R&D-programmes and a fund dedicated to support R&D in industry with informal links between the responsible actors that created co-ordination.

The programmes were not directly affected by liberalisation as the heat-market has always been open for competition. There was an indirect effect of market-liberalisation, however, as some utilities entered the market seeking a stable complementary business. As significant subsidies were only available for farmers, these utilities created interesting new forms of co-operation with farmers co-operatives to establish and operate BMDH-plants jointly.

Consumer choice is an issue, when a BMDH project is planned and as many customers as possible are needed. In this case a positive public perception of the project however is critical. Suggestion, to establish laws for mandatory connection to District-Heating-grids equally to the mandatory connection to the waste-water-system were repeatedly put forward. Such legal provisions were not made in any of the Austrian States however

(4) Main-actors and their roles

From the local point of view the main-actors are the local promoters of the project that subsequently both develop and operate the system. Successful local promoters are typically well respected young residents of the village that are personally highly motivated and that manage to create a consensus in the whole village to realise the project. For these local promoters, in turn, their key-actor is the focal point in their federal state, regardless whether it is the agricultural chamber, the state energy agency, the consultant or the person in the state-government.

This focal point helps them in all aspects of the project. The focal point makes feasibility studies, helps the operators to manage the complex administrative procedures for getting a subsidy, they give advise on how to create the cooperative, on how to develop the project, on the contracts with the heat-customers, etc. The function of these focal points might be best described by the concept of „Strategic Niche Management“ that has been developed in modern innovation theory[3]. Thus their role is very important for the whole technology deployment process. Unfortunately there was a mismatches between the significant resources available for subsidies and the small resources for the focal points, a fact that a led to significant setbacks and inefficiencies.

Who were the main-actors for the “niche-managers”? On the one side it were the officials at the state and the federal level, that were responsible for subsidies. The niche managers also kept the contact to the the boiler-manufacturers and discussed with them the different problems that occurred in the beginning. Another important group for the niche managers were the village majors.In some federal states they visited almost all majors in the whole state to inform them about the new technology and to raise interest in realising a project. Still further up the hierachy federal state politicians played a key-role for providing sufficient financial resources needed by the rapidly expanding number of projects. These actors also

[3] Kemp,R., Rip,A., Schot,J.: Constructing Transition Paths Through the Management of Niches. Paper for the Workshop „Path Creation and Dependence“, Copenhagen 1997.

need to be pleased e.g. in opening ceremonies of new plants, with lots of media and public involvement.

Important actors that did not receive sufficient attention were the planners of the projects. In Austria planners are typically small companies with only few employees and a fairly broad portfolio of projects. None of the planners that designed BMDH-systems in the beginning had any experiences with District-Heating-Technology. Consequently many mistakes were made in the beginning, the most common of which was gross overdimensioning of all components of the system.

Research was also a main-actor. Both researchers and research-funding reacted flexibly to the sudden demand created by the new technology for reliable and environmentally sound combustion-systems. In co-operation with industry significant improvements of combustion technology were introduced. For a long time however research failed to identify and address the issue of systems performance. While boiler performance was pushed to ever further limits, no attention was given to optimising the whole design of a District-Heating-System in terms of technoeconomic performance.

(5)Policy mechanisms

The main-policy mechanism used was to give subsidies for investment-costs.

While the programmes for deploying BMDH were managed at the level of federal provinces, the national ministry of agriculture provided a significant amount of financial resources for the programmes. The subsidies provided for agricultural co-operatives usually included both a soft loan and a direct financial subsidy with a net-cash-value corresponding to about 50% of the total investment-costs of the project.

In 1988 the ministry started to subsidize BMDH with 950 k EURO, a sum that increased continuously up to 7,3 M EURO in 1993. This subsidy was complemented to an approximately equal amount from the federal provinces. In 1999 approximately 11 M EURO were provided by the ministry, complimented by 7,3 M EURO from the federal states and 5,1 M EURO from the European Union, that contributed subsidies since the Austrian accession from regional funds.

These subsidies were available only for farmers. Commercial operators as for example sawmill-owners could only receive a 30% subsidy from the environmental fund of the ministry of environment.

Besides the subsidies procurement also played a key-role at the local level, as public buildings as schools, the townhall, etc. are often among the largest heat-users in the villages. The connection of all public buildings in a village was in many cases a very important support for the District-Heating-Project. At the federal level systematic procurement policies were never established however, due to conflicts of interests between the different ministries.

Another indirect financial support is the low VAT of 10% on wood (compared to 20% VAT generally).

Also as mentioned the focal points or “niche managers” in the federal states were an-other key-mechanism for supporting technology-deployment.Typically one to two persons per federal state were responsible for the management of BMDH start up.

Another support mechanism applied at the national level (and only informally connected to the deployment programmes at federal state level) were R&D policies. These were based to one part on a very efficient fund for company research that provides 50% support for R&D in small and medium scale enterprises.To the other part they were based on long term R&D programmes of the ministry of science and research (now ministry for traffic, infrastructive and technology). National R&D funds dedicated to biomass research in the 1990s were in the order of magnitude of 5 M EURO per year.

(6) Monitoring and evaluation-process

Monitoring and evaluation took place primarily at the level of individual projects. As mentioned a key-role in this process was taken by the focal points which performed an in depth evaluation of every project before suggesting it for subsidies. They also performed an informal ex post monitoring by keeping the contact to the individual plant-operators for example in regular annual meetings etc.

In contrast to the evaluation at the project level, no regular evaluation was made at the program level - at least for the part of the federal subsidy program. A first evaluation was made only recently, more than 10 years since the beginning of the programm. More recently also a number of evaluations were made for the subsidy-programmes at the state level.

Due to the fact that the state programmes were fairly independent a consistent monitoring and evaluation of the whole process never took place. A consistent and comparative evaluation of the work of the focal points was not performed either. Consequently deficiencies in the work of these focal points were overseen and had serious impacts on the overall success of the program. Among these deficiencies are three important problems:

Too little attention was given to the role of conflicts at the local level. The consultants of the focal points were educated only in technical and economic issues. Consequently they were not able to give appropriate advise to the project-promoters on conflict-management techniques.

It turned out that the state focal points had different strategies regarding pricing which led to significant differences in price-levels for distrcit heat. Particulary negative consequences arose for the operators in states with low price levels.

In some states the focal points had a particulary strong pro-project bias in the feasibility study phase which led to the financing of projects with rather poor economic preconditions. In the course of the programmes an increasingly critical economic evaluation was implemented as a consequence of problems with projects that were economic desasters. With respect to the monitoring of technical plant performance a number of studies were made (Stiglbrunner[4], Rakos[5], Stockinger[6]). The first of these studies gave an early indication of the serious lack of technical optimisation. However, unfortunately nobody felt responsible to act upon this issue.

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[4] Stiglbrunner, R., Lübke, A., 1992, Bericht Betriebsdaten; Hackgutheizungen in Oberösterreich. Österreichische Arbeitsgemeinschaft für eigenständige Regionalentwicklung. Wien.

[5] Rakos: see above

[6] Stockinger, H.: “Systemanalyse der Nahwärmeversorgung mit Biomasse”. Doctoral Thesis, Technical University of Graz 1998.

The researches that found out about the problem felt only responsible for submitting the study, the focal points did not feel responsible for the topic of technical planning, the operators only realised one project each of them and had no chance to build a second better plant and the planners did not receive any feedback from technical performance measures of the plant they had built. This led to the fact that after 15 years little progress had been made with respect to critical plant parameters as specific electricity consumption heat losses etc[7]. Only after the most recent study dedicated to system optimisation[8]in 1999 an expert group addressed this issue and agreed upon technical performance criteria that were specified as a type of technical standard (ÖKL-Merkblatt Nr.67). The. performance criteria laid down in this document have to be met as a precondition for receiving a subsidy since 2000. At the same time seminars were offered for planners in which they learned how to meet the new technical standards. These courses were a great success and were attended by a large number of planners. As a result of the reform process all newly established plants have to deliver data on plant-performance on an annual basis for a national benchmarking exercise and to verify, if the new standards are met.

(7)Discussion of Results

Achieved Objectives

The programmes presented in this article were certainly highly successful with respect to the actual implementation of the technology. By 2000 more than 500 BMDH-Plants have been established in Austria. While this is a large number of plants, in terms of energy the contribution is limited.The energy provided by these plants corresponds to less than 10% of the heating energy provided by conventional fuel wood in individual households. Which is in turn about 17% of the whole heating energy-demand of households.

The programmes were also successful in most villages in creating a positive image of heating with biomass. A survey among district-heating-customers shows a very high degree of satisfaction. Another achievement of the programmes was certainly the development of a mature plant technology. However, this achievement took too long to be realised. With sufficient ressources and attention to this issue technological learning could have happend much faster.

Additional income from the forest,a key program target, could be achieved to some extent. However the amount of woodchips from the forest used in BMDH-Plants is below 20% of total fuels used in this plants due to cost-reasons. Most plants use bark and woodwastes from sawmill industry.

Key-elements of Success

Three elements of success can be identified: the provision of significant subsidies, a significant bottom-up interest to realise projects and the existence of focal points, that facilitated technology deployment and project development. Another natural reason for success was the abundance-of cheap biomass in Austria.

[7] Rakos: see above
[8] Stockinger: see above

Subsidies

The fact that subsidies were not only high (50% of investment costs), but also available in sufficient amount was certainly a key-element of success. Total subsidies available for the development of BMDH rose progressively together with the deployment rate thus anabling a continued development without financial disruptions.An important contribution to the ability to provide rising financial resources was the accession of Austria to the European Union, which allowed access to resources from the regional funds that added considerably to the national and federal state subsidy-budgets.

Focal points for program-management

A key-role of these focal points or “strategic niche managers” has been discussed. They were responsible for preparing feasibility studies, consulting project developers, managing administrative barriers and for facilitating communication between all related players in the technology deployment-process.

Bottom-Up-Interest

Bottom-up-interest in BMDH was a key-driver for the whole deployment process. This bottom-up-interest cannot be explained by a strictly economic point of view as district-heating with biomass was more expensive than conventional heating-systems in most cases. Of course district-heating improves heating-comfort considerably in areas where natural gas is not available. Technological studies have shown that the community-aspect of the project is a very important driver. The project is an opportunity to enhance community cohesion, it adds to the self-respect of the village and can also be an issue of competition between neighbouring villages.

Main-sources of problems

A main-source of problems could be called „disintegrated support-policies“. This means that different parts of the administration were responsible for different aspects of the program on the national and on the state-level. These distributed responsibilities led to gross mismatches of the resources available for subsidies and the ressources, for the operation of the focal points and for evaluation and monitoring. They also led to the lack of integration of deployment-policies and R&D policies. As a consequence the key issue of techno economic optimisation was not addressed for more than 15 years of deployment.

Another interesting-source of problems was created by what could be called “periferal technologies“. In this case the periferal technology is the domestic heating-system that distributes the heat in the house.

The house heat distribution system were often inadequate for connection to a district heating system. Local plumbers were not educated to adapt and connect the “secondary side” properly to the district heating system which led to significant problems, economic losses and angry customers. Later specialised companies were established that adapted these secondary side in most new BMDH projects. An obvious problem for the deployment of the technology were of course the low energy prices during the observed period. Optimistic assumptions that energy prices would rise again created significant problems for many heating-plants that were established under these assumptions. The most recent developments of oil prices improved the economic situation of BMDH plants. Price insecurity

of could speed up a new diffusion phenomenon – so called micro grids. These are very small BMDH projects that are easier to organise as no consensus of the whole village has to be achieved. Typically microgrids suplly heat to a few neighbouring houses or larger buildings.

Impulse Programme: Thermoprofit

Introduction

Thermoprofit is a „trade mark“ for total service packages in order to reduce the amount of energy consumed in the building concerned. Thermoprofit was first conceived as part of the Graz Municipal Energy Concept (Kommunales Energiekonzept KEK Graz) in Austria. Aim of the impulse programme is to disseminate Thermoprofit as a tool for energetic and economical optimisation of buildings. As part of the Thermoprofit-service, a specialised enterprise – the so-called Thermoprofit partner – is carrying out an overall energy related optimisation for the building.

The essential characteristics of Thermoprofit are:

- reduction of energy used in buildings
- economic advantages for owners and users of buildings
- direct or indirect reduction in pollutants and CO_2 emissions
- planning and implementation carried out by a Thermoprofit partner
- Thermoprofit guarantees that energy costs will stay below a defined limit

Thermoprofit contains the key elements of Third Party Financing and Energy Performance Contracting, while being organised in a more flexible way. In particular, Thermoprofit is focused less on advance financing by the contractor. It also includes models in which the ESCO optimises energy use on the basis of either an energy saving guarantee or a performance-based fee, while the owner of the building remains in charge of the financing itself.

While Thermoprofit projects are above all designed for the renovation of existing buildings, they can also be applied to the construction of new buildings. The complete range of possible and economical measures able to produce "Thermoprofit" is examined in every case in order to find the best possible solution in terms of optimisation.

The Thermoprofit model was primarily developed for the owners of larger real properties. The model is profitable for all kinds of public buildings, for residential property developers, banks, insurance companies and businesses from trade and industry.

The Thermoprofit- Project **“Improving the Energy Management of the Jägergrund primary and Webling secondary school in Graz/Austria”** was realised with the innovative Thermoprofit-model, developed by the Graz Energy Agency. It took place in the period from May 1999 till Janurary 2000, when the contractor was commissioned. The measures include the heating system, electrical installations and construction measures as well as motivation and training of the users of the building. The special innovation of the project in comparison to other TPF-projects is the inclusion of constructional measures and the contractual

guarantees for energy savings, comfort parameters and services. The project won the contracting prize „Energieprofi 2000“ from the Austrian federal ministry for the environment. For further details see attachment.

Objectives of the program

With the help of energy services that include financing schemes, obstacles standing in the way of rational energy utilisation can be overcome. At present, however, these innovative models are still largely unknown and their potential is far from being fully utilised. With the impulse programme Thermoprofit the confidence in the functioning of TPF models can be enhanced. The medium-term goal of the impulse programme is to disseminate Thermoprofit as a tool for the energy-related and economical optimisation of buildings. These innovative approaches and solutions are supposed to develop from their current status as model projects into established modes of practice in this field. This will lead to a saving of energy costs, a reduction in energy consumption and environmental pollution, and a stimulation of the regional economy.

A study of the Technical University of Vienna analysed the economic effects of increased energetic renovation through energy services in the city of Graz. In the next 15 years between 600 and 1250 million Euro of investments could be produced. Up to 700 jobs could be created through this market development.

The market development and penetration of Thermoprofit is to be reached via four main strategies:

1. Creation of a Thermoprofit network
2. Thermoprofit information and marketing initiative
3. Support for Thermoprofit projects, provided by the Graz Energy Agency
4. Assistance in establishing framework conditions for the smooth implementation of Thermoprofit projects

Process of definition/design of the program

Thermoprofit was developed within the Graz Municipal Energy Concept. The development of Thermoprofit contained the following steps:

1. Market analysis, conception and development of the programme
2. Development, realisation and documentation of model projects (positive examples)
3. Development of a network with ESCOs (Thermoprofit-Partners)
4. Marketing initiative: Activities for communication and networking to disseminate the developed solutions and to inform potential users and multipliers

5. Competent and neutral support of building owners during preparation and implementation of the project
6. Support of suppliers: standardised project implementation (contracts, bidding procedure), project-controlling
7. Continuous project realisation

Main target groups of the project are:

- Municipality buildings
- Public buildings
- Residential property
- Businesses from trade and industry

The Graz Energy Agency functions as a turntable, competence centre and impetus behind Thermoprofit. It takes care of the promotion, relevant networking activities and evaluation of the programme.

The definition of the programme was worked out by a project-team consisting of representatives of the Chamber of Commerce, the Chamber of Labour, the City of Graz, the Energy Representative of Styria and the Graz Energy Agency.

Main actors and their roles

The Thermoprofit Network consists of suppliers of total service packages – the so-called Thermoprofit partners. Primarily, Thermoprofit partners are prime contractors. They co-operate with regional enterprises in the execution of projects and thus contribute to stimulating the economy of the respective region.

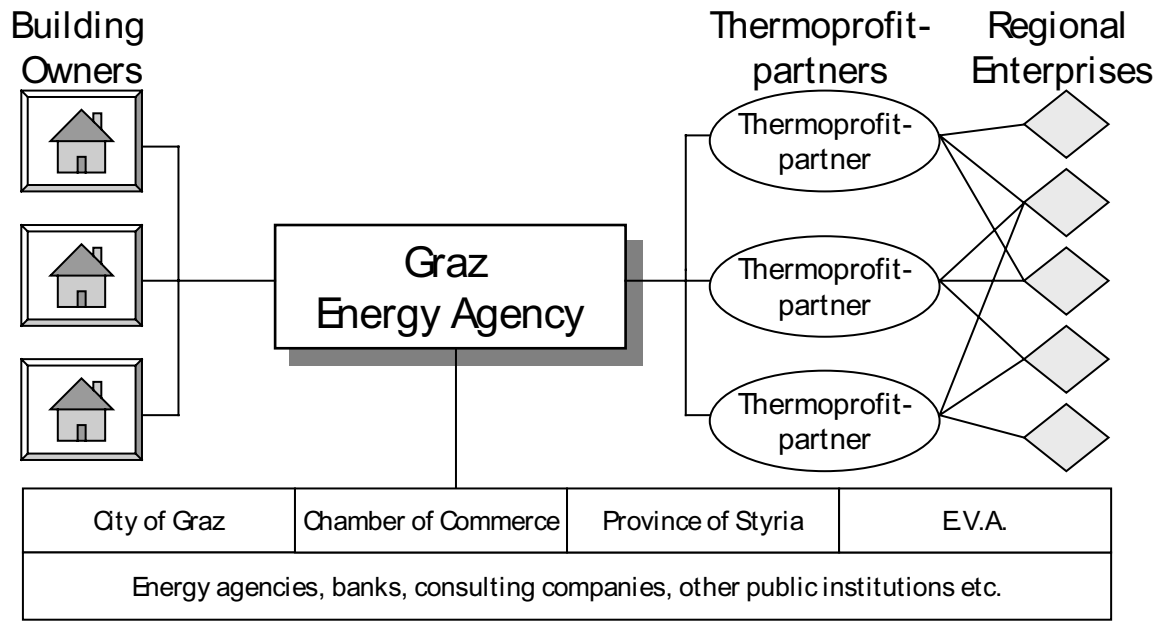
Their special characteristic is that they offer a Thermoprofit guarantee for undisturbed operation, the observance of comfort parameters, guaranteed energy and cost savings, etc. In providing the energy services required, they do not only take on comprehensive tasks on behalf of the user of the building, but also technical and economic risks.

Thermoprofit constitutes a **quality label** linked to a series of standards to be met by enterprises and their projects. The owners and/or users of buildings are guaranteed reliable high-quality offers. The Thermoprofit label may be used exclusively by Thermoprofit partners who will be evaluated by the Graz Energy Agency in regular intervals with regard to their observance of Thermoprofit standards. This will lead to an increase in confidence by the building owners.

The development and dissemination of Thermoprofit is supported considerably by various public agencies, in particular by the city of Graz and the Styrian Chamber of Commerce (Wirtschaftskammer Steiermark). A close co-operation takes place with a number of further partners at institutional and expert level.

These are the particular goals of this networking:

1. Reaching high quality in Thermoprofit offers and working with competent enterprises
2. Providing rational and cost-effective project handling
3. Successfully implementing a number of Thermoprofit projects
4. Finding qualified enterprises as partners for Thermoprofit



The Graz Energy Agency co-ordinates the network and acts as a turntable for Thermoprofit issues. It is responsible for the project management and in charge of implementing and supporting the required networking and marketing activities.

The Graz Energy Agency is also in charge of evaluation and of preparing the certification of enterprises as Thermoprofit partners. This certification takes place every two years. In order for an enterprise to be certified as a Thermoprofit partner, or to keep its certification, it must fulfil certain conditions and observe certain quality standards in project handling. In the end, an independent committee decides whether the enterprise in question is admitted to the network and certified as a Thermoprofit partner. Certified enterprises are entitled to use the quality label.

Concerning favourable framework conditions the Graz Energy Agency is pointing out barriers for energy services in laws, decrees and subsidy guidelines, mainly on the regional government level, and making suggestions for improvements. In this area the agency is co-operating closely with politics and the authorities on the regional and on the municipal level.

Policy mechanism used

The policy mechanism used by the programme is based on an information campaign. Information and communication activities as part of the impulse programme are primarily directed to private and public owners of larger real properties. These are above all the municipalities, public authorities and institutions at Federal Government or regional level, co-operative building societies, property management firms, banks, insurance companies, business enterprises, etc.

As part of this information campaign, property owners and users are introduced to the way this model works and to the advantages it offers. Completed reference projects are documented and introduced. In order to support property owners in the preparation of projects, they are provided with useful contacts and information and offered concrete assistance in project development.

The Graz Energy Agency is preparing information materials for this campaign (e.g. a Thermoprofit folder providing target group-specific information). In addition, informative events and workshops are organised for the owners and users of buildings and the municipality's representatives in charge. A first focus is put on public buildings, especially on buildings of towns and communities.

The information campaign is supported by the City of Graz and the Chamber of Commerce.

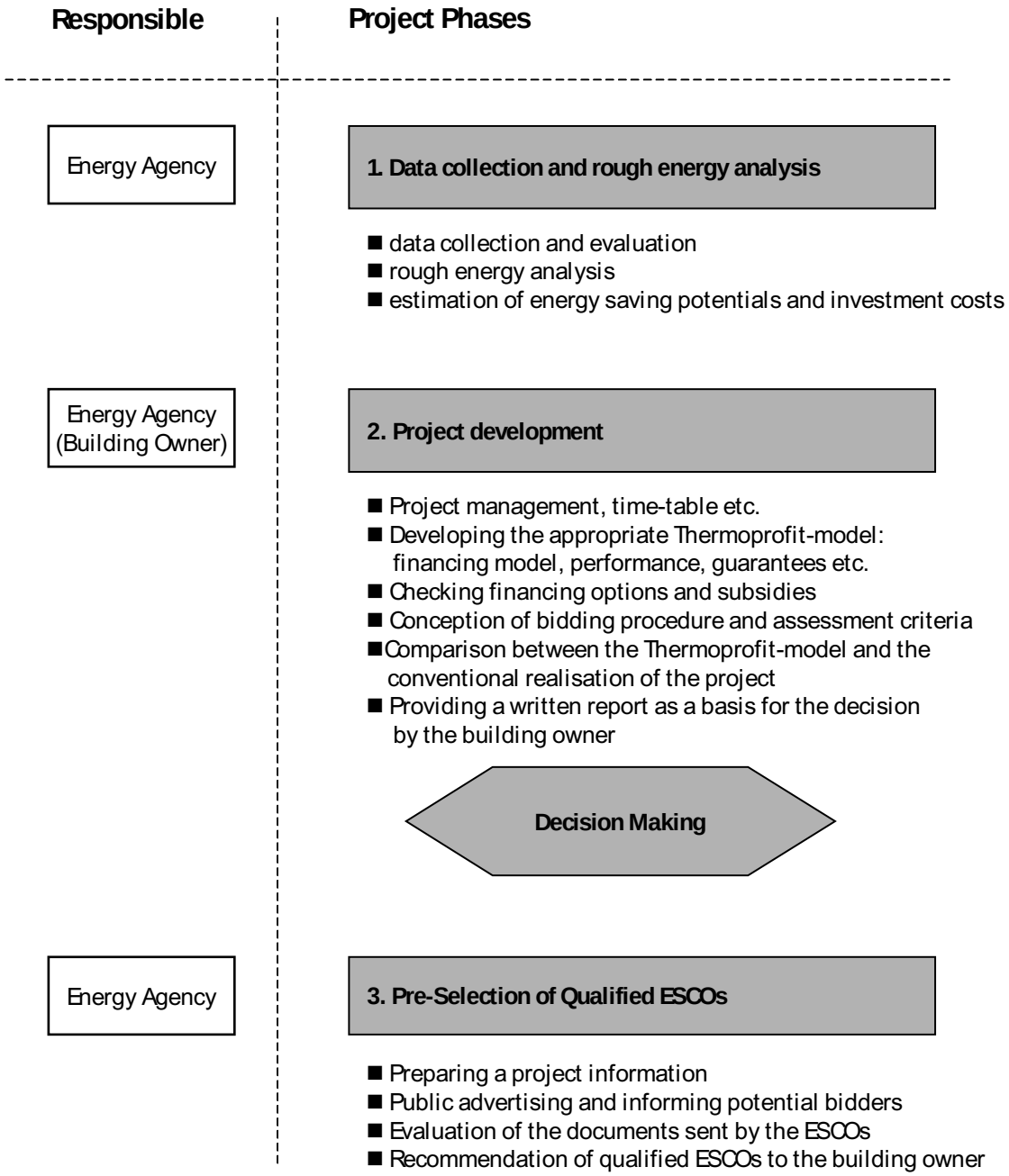
Monitoring and evaluation process

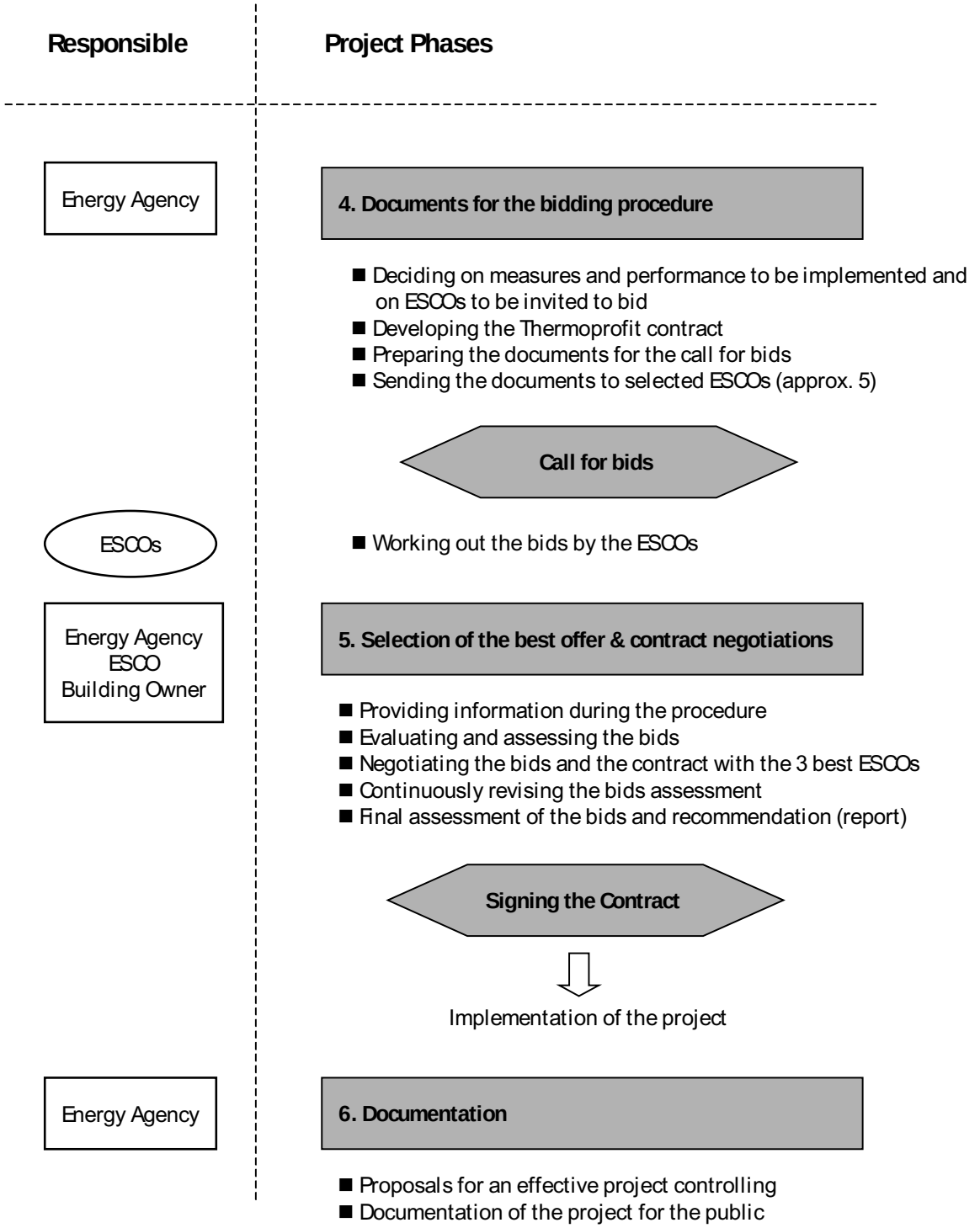
Evaluation factors of the impulse programme are

- Market development: Number of Thermoprofit Projects, investments
- Environmental benefits: reduced energy supply, reduced CO_2 emissions
- High quality energy services
- High quality of the projects (satisfied customers, guaranteed energy savings, quality of energy services, etc.)
- Notoriety and acceptance of Thermoprofit as a trade mark

Concerning the development and realisation of concrete projects the typical procedure of a Thermoprofit-Project is described below.

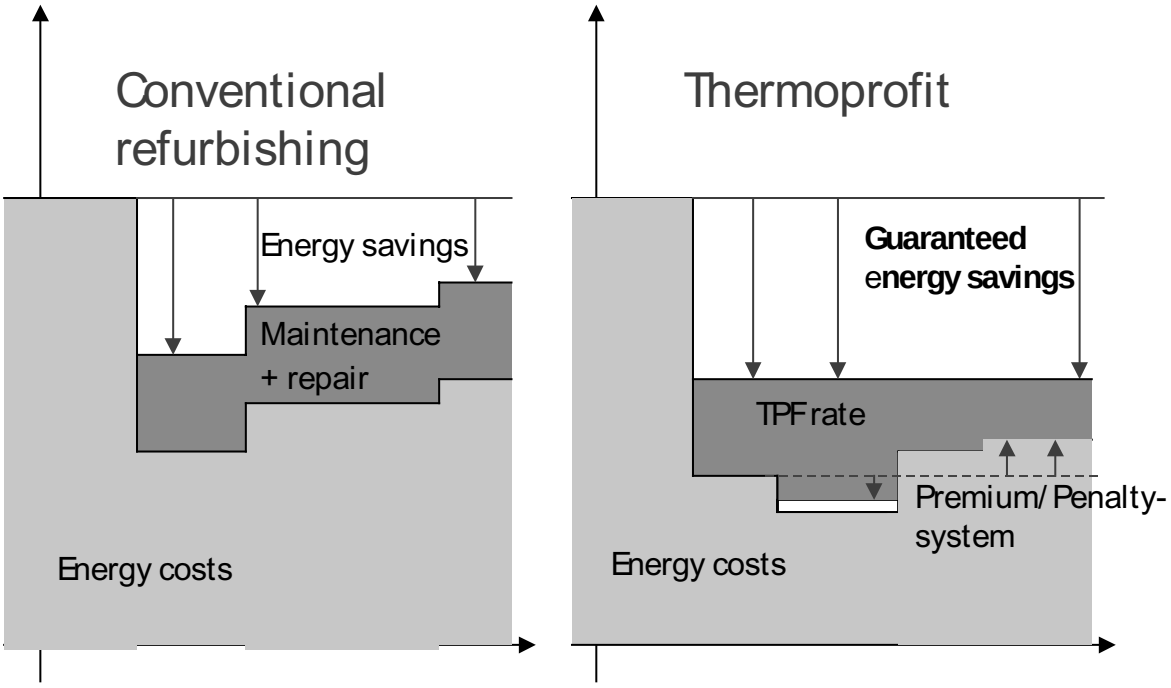
Development of a Thermoprofit-Project




Responsible
Project Phases
Energy Agency
4. Documents for the bidding procedure
■ Deciding on measures and performance to be implemented and on ESCOs to be invited to bid
■ Developing the Thermoprofit contract
■ Preparing the documents for the call for bids
■ Sending the documents to selected ESCOs (approx. 5)
Call for bids
ESCOs
■ Working out the bids by the ESCOs
Energy Agency
ESCO
Building Owner
5. Selection of the best offer & contract negotiations
■ Providing information during the procedure
■ Evaluating and assessing the bids
■ Negotiating the bids and the contract with the 3 best ESCOs
■ Continuously revising the bids assessment
■ Final assessment of the bids and recommendation (report)
Signing the Contract
Implementation of the project
Energy Agency
6. Documentation
■ Proposals for an effective project controlling
■ Documentation of the project for the public

Within the context of realisation of a project the Graz Energy Agency offers the building owner to carry out the project controlling.

All guaranteed services like annual reduction of energy costs, quality of services and products, maintenance of comfort, realisation of investments to a certain amount, etc. are fixed by a contract. A cost-benefit analysis is performed before the implementation. The financing model is worked out in detail: the realisation of the project with Thermoprofit is compared with a conventional refurbishing TPF-model (see figure below).



Discussion of results

The main activities of the impulse programme have started during 1998 and several materials have been worked out. The Thermoprofit network was presented to ESCOs in June 1999 with the objective to inform about the network and awake the interest of energy contracting suppliers.

The first certification of companies took place in October 1999 and meanwhile 5 big companies are certified as Thermoprofit partners. Further companies show interest to participate.

Several materials like a Thermoprofit map or animated power point presentations to promote the impulse programme were worked out. Through press activities and presentations at conferences and events Thermoprofit was introduced to the public.

An Internet-Platform with information about Thermoprofit was developed. The platform consists a database where Thermoprofit partners can present their company. A database with success stories about Thermoprofit projects is available. Moreover, interactive tools

which give the opportunity to find partners for a project and to exchange information are provided.

At the moment an information campaign especially designed for municipalities is conducted.

Concerning the development of the Thermoprofit network it is sometimes difficult to persuade the ESCOs to accept the quality standards defined by Thermoprofit. In the beginning ESCOs consider it as an interference in their business policy, before they realise their advantages. A standardised quality label enhances the acceptance of customers.

As it appears, a stronger involvement of ESCOs is necessary concerning the working out of regulations and principles for the market and to get feedback on the so far realised objectives. Thus, in a next step a workshop with ESCOs will be organised to discuss the organisation and aims of the network. Further workshops for the exchange of relevant know-how (e.g. legal information about third party financing, etc.) will be prepared. An annual Thermoprofit meeting is planned where all relevant key-actors are invited. This meeting serves as a possibility to exchange information and experiences. Activities of the passing year will be presented and goals for the future will be discussed and worked out.

The initiation of Thermoprofit projects also requires a lot of information work because it is necessary to eliminate the distrust of clients. Customers who already have bad experiences with third party financing because of low quality offers are very sceptical to start new projects.
The Thermoprofit quality standards and guarantees help to reduce the existing barriers. The initiation of new projects is getting easier as first Thermoprofit projects are successfully implemented.

The Graz Energy Agency supports building owners with development and implementation of TPF projects. The main focus is on public buildings, but also interest from the estate market is shown. First concrete Thermoprofit projects, like the above mentioned Energy Management of the Jägergrund and Webling primary and secondary school were carried out. Also a Thermoprofit project for a housing estate including a solar collector system is carried out. All in all about 8 Thermoprofit projects are realised or in preparation:

- Improving the Energy Management of the Jägergrund and Webling primary and secondary school/Graz
- Thermoprofit-Project Walfersam, Kapfenberg: Energetic optimisation of a coliseum and primary school by a comprehensive TPF package
- Solar installation for hot water in the grammar school Oeversee in Graz
- Technical maintenance and service of the town-hall in the city of Graz with a Thermoprofit-model
- Installation and maintenance of the heating and solar system in a dwelling-house (77 apartments) in Graz.
- Redevelopment and energetic optimisation of 3 schools in Weiz/Styria
- Restoration and energetic optimisation of the primary school Thörl/Styria
- Redevelopment of an indoor bath in Leoben/Styria

Other Austrian energy agencies are also interested to co-operate with Thermoprofit and to offer the same kind of services. Currently a franchising system is worked out to form a network of “partner agencies” and to promote Thermoprofit as a joint initiative. Through this system Thermoprofit can get a more than regional importance.

Training and co-operation of the partner agencies is difficult as there is a lack of staff and know-how. Thus, the over-all realisation of Thermoprofit-projects by the partner agencies is sometimes a problem and support by the Graz Energy Agency is required. The sphere of activities of local energy agencies is wide and it is not possible for them to concentrate mainly on Thermoprofit. Also the instructions concerning marketing, promotion, project development of Thermoprofit, etc. are sometimes considered as patronizing. Although the proceedings are discussed with partner agencies and their objections and proposals are considered.

Despite some difficulties modifications of the programme are not necessary so far. Although the programme is still in the development the response up till now is promising and the first objectives were successfully achieved.

CS 3

Canada's Renewable Energy Deployment Initiative

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Introduction

The introduction should give some initial information on the program name, the country where the policy has been implemented, the technology involved and the sectoral application(s), and the period covered (starting date and closing date, if applicable). A paragraph summarising the reasons why the case study is particularly interesting should also be included.

Suggested length: about ½ page.

The **Renewable Energy Deployment Initiative** (REDI) was launched on April 1, 1998, by Natural Resources Canada (NRCan), the department responsible for energy at the federal level in Canada. REDI is aimed at stimulating demand for reliable, cost-effective renewable energy systems for space and water heating and cooling, with the primary goal of reducing greenhouse gas emissions. REDI is a product of Canada's unique energy situation and international climate change commitments.

Four types of systems are supported under the program: solar ventilation air heating systems, solar hot water systems, high-efficiency/low-emissions biomass combustion systems, and ground-source heat pumps. REDI was introduced as a three-year, $12-million program (all figures in Canadian dollars). However, the 2000 federal budget provided funding to extend the program for an additional three years, until March 31, 2004.

Canada is blessed with abundant and varied energy resources, including conventional oil and gas, oil sands, hydroelectricity and coal. As a result, Canada enjoys relatively low energy prices, stable supplies and a well-established infrastructure for conventional energy sources. This makes it difficult for new contenders – including emerging renewable energy sources – to make inroads in the marketplace.

Canada is also an energy-intensive country because of its northern climate, long distances for moving people and goods, the structure of its economy and its favourable energy prices. On a per capita basis, Canada is a large producer of carbon dioxide, the principal greenhouse gas contributing to climate change. NRCan introduced REDI to accelerate the deployment of low- or zero-emission renewable energy technologies that can displace fossil fuels.

REDI focusses primarily on buildings in the industrial, commercial and institutional sectors, with the expectation that investments in these buildings will have a greater impact (i.e., larger emission reductions per dollar invested) than would be the case in the residential sector. Intervention in the residential sector is more limited and is achieved through pilot projects.

Participants in the program include both representatives from the renewable energy industry who supply heating and cooling systems and their customers. Customers include three distinct groups involved in the procurement decision:

I.engineers, architects and energy service companies (who usually specify or recommend the type of systems to be used);

II.building contractors and construction trades (who install the systems); and,

- building managers and owners (who make the final procurement decision).

A key objective of REDI is to ensure that this “decision-making triumvirate” is knowledgeable about and comfortable with renewable energy systems in order to sustain REDI-induced market growth after the program ends.

Objectives of the Program

Have strategic goals (such as energy security, global climate change, pollution abatement, economic productivity, etc.) been used to define the goals of this technology deployment programmes?

This section should provide information on the stated objectives of the programme, referring to the official documents where these objectives are established, both as general policy objectives and as specific goals. (Example of general objective: reducing carbon emissions from energy sector, as stated in First National Communication to UNFCCC; example of specific objective: installation of 100 MW wind power capacity). Specific barrier(s) to technology diffusion addressed by the programme should also be discussed.

Suggested length: about ½ to 1 page.

The Government of Canada has supported the development and deployment of renewable energy technologies for more than 20 years. This support was triggered by the oil supply disruption of the late 1970s and early 1980s, when federal energy policy focussed on reducing Canada’s dependence on imported oil. Off-oil fuel substitution programs were

viewed as critical to ensuring that Canadians had access to a secure and competitively priced energy supply. As a result of these programs, natural gas and, to a lesser extent, bioenergy experienced increased use in Canada.

With the collapse of world oil markets and the deregulation of Canada's natural gas markets in the mid-1980s, oil and gas prices dropped and the issue of energy security became less pressing. These developments significantly slowed the market penetration of many emerging renewable energy sources, including wind and solar energy. However, over the past decade the global problem of climate change has become a new driver for federal support for renewable energy.

Canada's commitment to renewable energy was reaffirmed in 1996, with the release of NRCan's *Renewable Energy Strategy*. The Strategy is a blueprint for cooperative action with stakeholders to accelerate the development and commercialisation of emerging renewable energy sources and the evolution of a more dynamic and self-sustaining renewable energy industry that will become a leading provider of energy solutions in Canada. This, in turn, will help Canada reduce greenhouse gas emissions and meet its international climate change commitments.

REDI was launched two years later as a component of the Strategy and part of a package of initiatives to help Canada achieve its Kyoto Protocol target of reducing greenhouse gas emissions to six percent below 1990 levels by the period between 2008 and 2012. At the time of REDI's launch, the markets for renewable energy heating and cooling systems were very small, but technology developments and economic intelligence pointed to significant market potential. Nevertheless, REDI is not in itself a short-term answer to the climate change challenge; it is only one element of a long-term Canadian strategy that incorporates a variety of responses.

In addition to responding specifically to the climate change challenge, REDI is consistent with NRCan's corporate vision, which sees Canada becoming a world leader in applying sustainable development principles to all aspects of natural resources development. As well, it will help Canada's thriving energy industry expand into new and growing world markets.

All four types of systems supported under REDI are considered technologically reliable and have been used successfully in Canada and around the world. Furthermore, these systems are considered cost-effective on a life-cycle basis in several important energy markets in Canada. Nevertheless, several barriers and challenges are restricting their rapid deployment, including the following:

III. Prospective customers have limited knowledge about, and experience with, renewable energy systems. Preference is usually given to well-established, off-the-shelf

space and water heating/cooling solutions that are perceived to be risk-free and affordable.

IV. Negative experiences with earlier renewable energy technologies may have tarnished the reputation of certain systems. For example, system reliability issues plagued some first generation technologies introduced in the late 1970s and early 1980s. In other cases, the promised financial savings did not materialize due to the drop in oil and gas prices in the mid-1980s.

V. Some renewable energy systems have higher purchase and installation costs compared to conventional technologies. Building owners in Canada are generally averse to increasing construction budgets unless payback periods are short. Where construction budgets are pre-determined, increasing the cost of the heating system would require cuts in other areas of the project. As well, if an owner does not expect to pay the future operating costs of the building (either because the building will be sold or because costs will be passed on to tenants), there is little incentive to minimize life-cycle costs.

VI. Heating and cooling constitute a relatively small portion of overall building costs in Canada. Owners tend to focus instead on managing costs that are core to their business, such as labour, inventory and key input costs. Unless payback periods are extremely short, there may be limited interest in reducing space and water heating/cooling costs.

VII. Environmental benefits arising from renewable energy systems are usually of no direct value to the building owner. Thus, environmental considerations often have limited impact on the decision-making process, except when the decision makers are willing to take into account non-monetary values.

VIII. The long period of low energy prices in Canada (from the mid-1980s to 1999, with the exception of the oil price spike around the Gulf War of 1990-91) created a climate of comfort with end-users, where little value is placed on moving away from conventional fuels to protect against future price increases.

REDI is working with the industry to address these barriers and challenges and to better position renewable energy to compete with conventional energy solutions in the years ahead.

Defining and Designing REDI

This section should provide information on the process followed to define this specific technology deployment programme and its goals. Have the industry and consumer organisations been involved or consulted in the design of the programme? Have links with R&D policy been taken into account and how? How are policies of market liberalisation and new attention to consumer choice factored in?

Suggested length: about ½ to 1 page

Two separate consultation processes influenced the design and implementation of REDI. Both processes involved key stakeholders from the renewable energy industry, resulting in strong industry support for this initiative.

In the fall of 1996, NRCan and the federal Department of Finance undertook consultations to examine options for improving the treatment of energy efficiency investments and investments providing heating and cooling from renewable energy sources. With respect to renewable energy investments, participants identified a range of impediments and suggested options to overcome them. As a result of these consultations, the Minister of Finance announced in the 1997 federal budget that funding of $60 million ($20 million per year for three years, beginning in 1998) would be set aside for programs to promote energy efficiency investments in commercial buildings and investments in renewable energy for heating and cooling.

Based on the feedback received during the 1996 consultations, and within the overall framework of the *Renewable Energy Strategy*, NRCan subsequently developed a proposal for a new program to address market development issues for the renewable energy industry. In August1997, a consultation document for the proposed Renewable Energy Deployment Initiative was distributed to approximately 40 industry and government stakeholders to seek comments before completing the design of the program. Overall, the proposal was well received and most of the recommendations put forth were addressed in the final program design.

Yet another consultation process – this one involving a broad cross-section of Canadians who provided input on Canada's Kyoto implementation strategy – may result in future changes to REDI. Through this process, which took place in 1998 and 1999, a roundtable of stakeholders considering emission reduction opportunities for buildings recommended that REDI be expanded into other markets and other renewable energy technologies. As a result, some changes to REDI were announced in June 2001 and additional ones may be considered in the future.

Key REDI Participants and their Roles

This section should provide information on who are the main actors involved in the implementation of the policy/programme and what is their specific role. Actors may include Government agencies or institutions, producers of the technology (industry or members of an industry association), users (other industries or consumers via consumer associations) and trade associations (providing technical assistance or monitoring and verification), lobby groups or NGOs.

Suggested length: about ½ to 1 page.

NRCan's *Renewable Energy Strategy* identified the supply industry – generally defined to include manufacturers, distributors and installers – as the main stakeholder to deploy renewable energy systems. With this in mind, REDI has established partnerships with key industry associations, such as the Canadian Solar Industries Association, the Earth Energy Society of Canada and the Hearth Products Association of Canada. These partnerships have been mutually beneficial in that they encouraged industry "buy-in" to REDI while maximizing the program's usefulness to the industry.

REDI and industry associations work together in a number of ways. For example, the associations regularly consult members on the design and implementation of REDI and provide feedback to NRCan. Associations are also invited to participate in the drafting of work statements for market assessment and development studies, the selection of contractors (using the government open-bidding process) and the review of study results. NRCan also engages industry associations in implementing the recommendations arising from market assessment and development studies, providing financial support for this and other work through contribution agreements.

Partnerships have also been developed within NRCan to efficiently and effectively deliver REDI. The program authority (or sponsor) – NRCan's Energy Resources Branch – has contracted specific tasks to other groups in the department while retaining overall responsibility for REDI. For example, program administration and interface with the public is undertaken by NRCan's Office of Energy Efficiency, which manages a related program offering a financial incentive for the design of energy-efficient commercial buildings. Technical expertise for REDI is provided by the Energy Technology Branch, which manages NRCan's research and development programs for renewable energy. REDI officials also work closely with another NRCan initiative, the Renewable Energy in Remote Communities Program, which helps off-grid communities make sound energy supply decisions. Some 300 Canadian communities, mostly in remote northern parts of the country, are not connected to the main North American electricity grid and face high energy costs. These communities have been identified as a promising niche market for on-site renewable energy solutions under NRCan's *Renewable Energy Strategy*.

Although end-users and their associations would appear to be natural partners for a market deployment program such as REDI, little interest has been shown by these groups. End-user associations, including engineering and architectural societies, are generally focussed on broad issues affecting their memberships, rather than on discrete issues of interest to REDI. To date, a successful partnership has been developed with the Federation of Canadian Municipalities, which is one of the first energy end-user groups in Canada to become actively involved in reducing greenhouse gas emissions.

Electric and gas utilities are also recognized as potential partners that could play a significant role in the deployment of emerging renewable energy systems, since these utilities have well- established relationships and high levels of credibility with energy end-users. Several utilities in Canada have developed new lines of business – such as providing space or water heating/cooling equipment or home renovation services – to take advantage of their market position. To support these new lines of business, utilities often offer leasing or financing services, which could facilitate renewable energy projects with higher initial capital costs. Efforts are under way to secure these utilities as partners in the delivery of REDI.

Although the participation of academics and independent organizations in REDI is viewed as useful (e.g., to ensure impartiality and credibility), limited resources are available for this effort. Nevertheless, some success has been achieved. For example, the National Solar Test Facility (NSTF), an independent body that conducts research on solar energy equipment, agreed to review REDI's quality assurance requirements and to propose specific criteria for solar systems supported by the program. This has led to the creation of a committee of government and industry representatives who assess the suitability of proposed solar equipment under the program. The NSTF also tests systems to ensure that they meet REDI's eligibility criteria. In a separate project, work is under way to review and update relevant equipment and installation standards promulgated by the Canadian Standards Association.

REDI Policy Mechanisms

This section should provide, with some detail, a description of the specific policy mechanism used by the programme (e.g.: subsidies, taxes, tax credits, mandatory standards, guaranteed price schemes, information programmes, technology procurement schemes, Government purchase programmes, combinations of fees and rebates, voluntary agreements, etc.). Information is also requested on how and by whom the programme is funded (if funding is required) and on what is the amount of financial appropriations involved from the Government (if any). Mention of other costs (administrative costs, for example), if applicable, would be also helpful.

Suggested length: about 1-2 pages.

Two broad policy mechanisms are used to achieve REDI's objectives: targeted market development initiatives and financial incentives.

The term “targeted market development initiatives” refers to a broad range of activities delivered as part of an overall market development strategy for a given renewable energy system and market. Development and implementation of such a strategy typically involves several steps:

IX. Market Assessment – Detailed market assessment studies are undertaken to define existing markets and identify promising new markets. At the heart of such studies is an analysis of the economics of renewable energy systems compared to conventional solutions. If the studies demonstrate that significant potential markets exist, NRCan may develop and implement a market development strategy.

X. Strategy Development – A market development strategy identifies a course of action to accelerate the deployment of a specific renewable energy system in a given market or set of markets. First, market barriers are identified and analysed (these can pertain to the manufacturers and their supply chain or to the demand side of the equation), and then an intervention strategy is outlined identifying concrete actions and expected results.

XI. Marketing Research – Given the lack of consumer awareness about some renewable energy systems, marketing campaigns are often a key component of a market development strategy. Marketing research may be necessary to guide these campaigns. For example, research on consumer attitudes and motivation in choosing energy systems allows REDI to identify key communications messages and the most efficient media to deliver them.

XII. Partnership Development – Implementing a market development strategy may require the participation of one or more partners. For example, participation of the supply industry is key, and the involvement of other partners may be needed to address specific barriers. Partners may be able to deliver market development activities in a more efficient and cost-effective manner than NRCan.

XIII. Implementation – As a result of the previous steps, a wide range of implementation activities are undertaken by NRCan and its partners, often over a period of several years.

To date, REDI has created market development strategies for ground-source heat pumps, solar water and air heating systems and biomass combustion systems. All three strategies

have focussed on the industrial, commercial and institutional markets. A fourth study is under way on the residential solar pool heating market. All strategies and their related studies are made available to stakeholders to promote transparency and partnerships.

As noted earlier, REDI market development strategies typically involve a range of activities. For example, information campaigns to raise awareness of the environmental and cost benefits of renewable energy systems are a major component of all market development strategies. The information provided ranges from general consumer advertising to detailed technical information for architects and engineers. Many of the documents produced are published by NRCan, which ensures their recognition by end use customers as impartial and of high quality.

Other market development activities are aimed at improving the industry's ability to meet increased demand for its products and services. In this regard, funding is sometimes provided to industry associations to develop and deliver training programs for professionals involved in the selection, design and installation of renewable energy systems. REDI funds have also supported the development and dissemination of a pre-feasibility analysis software tool called RETScreen^{TM}. This software allows for an early assessment of the energy performance and cost effectiveness of a given renewable energy project without a large outlay of money by the proponent.

In some cases, REDI market development strategies may involve the use of other policy instruments. For example, the creation or updating of standards – combined with information campaigns to increasing awareness of these standards – can help increase consumer confidence in renewable energy systems and guard against low-quality systems and installations.

Most market development activities are delivered through direct spending by NRCan. When specific activities involve partners such as industry associations, NRCan may seek a funding contribution from the partner. However, given the limited financial resources of these associations, their contributions are often small and of an in-kind nature.

REDI's second broad policy mechanism is to provide financial incentives to eligible end-users for purchasing and installing qualifying renewable energy systems in Canadian facilities. Financial incentives are used for three reasons:

XIV. An incentive can encourage a potential customer to gain experience with a product (especially a new product entering the market), with the expectation that the customer will be satisfied and will purchase additional systems in the future, even in the absence of an incentive.

XV. Financial incentives can help the industry achieve a sufficient number of high-quality installations to demonstrate that the renewable energy system is reliable, cost-effective and environmentally friendly. This will set the stage for further installations after the incentive has lapsed.

XVI. An incentive artificially decreases the price of systems, providing shorter payback periods for customers and increasing demand for the system. This increased demand, sustained over a period of time, should allow the industry to optimize its production and distribution practices and achieve economies of scale. Eventually, this should lead to price reductions that offset the phase-out of the financial incentive.

REDI incentives are provided in two ways: a general *REDI Incentive* is available to a list of qualifying recipients for eligible systems; and pilot projects are undertaken in specific markets not addressed by the general incentive.

The *REDI Incentive,* initially offered to business customers and later extended to institutional clients as well, offers a financial contribution of 25 percent of the cost of purchasing and installing a qualifying system in a Canadian facility, to a maximum of $80 000 per installation. Ground-source heat pumps are not eligible for this incentive, because the industry had instead requested a stronger focus on marketing activities.

To qualify for the incentive, systems must meet detailed terms and conditions, including strict quality criteria for the system hardware and installation. In the case of biomass systems, an emission standard must also be met. Where the system is purchased and installed under an energy performance contract, the energy service company may receive the incentive.

The *REDI Incentive* is also available to departments and agencies of the federal government. As Canada's largest enterprise, the federal government represents a promising market for the renewable energy industry. Furthermore, federal leadership in implementing sustainable development practices in its own operations is another means to encourage the use of renewable energy systems. The availability of the incentive is being promoted through NRCan's Federal Buildings Initiative, which promotes energy efficiency retrofits of federal facilities through the use of energy performance contracts.

With respect to incentives for pilot projects, REDI has initially focussed on small-scale pilots for domestic solar hot water systems. A call for partners interested in managing such pilots has resulted in three projects being launched in specific geographical areas. These pilots are being delivered by local non-governmental organizations closely associated with municipal governments. Additional domestic solar hot water pilot projects are being negotiated. REDI will also consider pilot projects in other markets and considers unsolicited proposals for incentives on a case-by-case basis. Criteria for approval include the level of awareness generated by the project and the potential for replication.

Monitoring and Evaluation Process

This section should contain information on what processes and mechanisms, if at all, have been put in place to monitor the implementation of the programme and to evaluate its outcome. Hence information requested concerns the main actors or institutions involved in the monitoring process, the existence of "checkpoints", the existence of feedback systems designed to adjust the programme to changing or unforeseen conditions. Further information is needed on both the ex-ante and ex-post evaluation process: e.g. whether it is designed into the programme (e.g. a cost-benefit analysis is performed either before or after the implementation), who are the subjects performing the evaluation, what are the criteria for the evaluation, and whether there are explicit ways to incorporate learning from that experience into new programmes. It would be interesting, for instance, to know whether, due to these review mechanisms a program has been changed in mid-course.

Suggested length: about 1-2 pages.

At its inception, a broad range of performance indicators were identified to help evaluate REDI's impact. However, since REDI was the first government attempt to stimulate the market for renewable energy heating and cooling systems since the oil and gas price collapse of the mid-1980s, no specific targets were announced. The program authority also recognized that performance measurement could be difficult in the short term because several years will be required to fully implement REDI's market development strategies. As a result, their true impact will be felt only in the medium term.

Nevertheless, various mechanisms have been developed to allow financial auditing and performance measurement of REDI. These include a detailed database that documents the receipt and processing of applications for the *REDI Incentive*. As well, a financial audit was performed during the second year of REDI (at the request of the program authority) to determine whether the program incorporated all the features needed to ensure proper financial administration. The audit report was generally positive and was posted on NRCan's web site at http://www.nrcan.gc.ca/dmo/auev/Reports/Redi/index_e.html. The program authority developed a plan to address the auditors' recommendations.

During REDI's third year, recipients of a financial incentive and suppliers of renewable energy systems were asked to complete a detailed questionnaire about the first two years of the program. The purpose of the questionnaire was twofold: to measure the level of customer satisfaction with renewable energy systems, and to provide feedback on the program itself. The questionnaire, with a response rate of about 50 percent, proved to be useful in identifying minor issues with a few installations which NRCan is addressing. A shorter survey is being developed to obtain timely feedback on system performance.

Also in REDI's third year, a formal evaluation of the program was performed by an external contractor. The objective was to gather information on the key results achieved by REDI over its first two-and-a-half years and to help NRCan make decisions on the future direction of the program. Information was gathered through a review of program files; analysis of relevant publications and research; and structured interviews with program staff and a random sample of incentive recipients for each system type across geographical areas. The evaluation was generally positive and contributed to the renewal of the program for a further three years (until March 31, 2004). A plan has been developed to address recommendations in the evaluation report.

Finally in regard to monitoring and evaluation, NRCan has produced two year-end reports for REDI stakeholders describing activities implemented under the three market development strategies and listing the recipients of the *REDI Incentive*. A third report being prepared for 2000-01 will include statistics on the financial value of systems installed, their energy contribution and estimates of greenhouse gas emission reductions.

REDI's Results to Date

This section should focus on the evaluation of the results of the programme. In particular, whether the objectives of the programme have been attained, whether the results can be and have been quantified, what are the direct (on deployment of the targeted technologies) and indirect impacts (reduced GHG emissions, increased industrial competitiveness, job creation, etc.).

This section should also give an overall evaluation of the policy or programme under examination and discuss the key elements of its success or the main sources of problems and failures (at least three failures/weaknesses and as many as wanted strengths or positive elements should be mentioned). The dynamic relationship among the parties involved in the programme implementation is probably a key element to be analysed here.

Suggested length: about 1-2 pages.

REDI' first three years have been deemed a success by major participants and evaluators. Early implementation of the market development strategies and aggressive, targeted advertising of the *REDI Incentive* have created awareness of, and interest in, renewable energy options for space and water heating and cooling. One industry representative was of the opinion that advertising the incentive under NRCan's name in recognized business and engineering magazines may have had a bigger impact with customers than the incentive itself. Architects and engineers have also been targeted through presentations on REDI and RETScreen™ at trade shows and training sessions.

Nevertheless, the REDI evaluation report noted that a large percentage of architects, engineers, builders and other target groups remain unaware of the program or of options for using renewable energy. Given that three years is a short time frame for achieving major impacts on the marketplace, REDI should be considered a "work-in-progress." The program's extension for an additional three years will result in greater awareness and increased deployment of various renewable energy systems.

As noted earlier, ground-source heat pumps are not eligible for the *REDI Incentive*; instead, work has focussed on developing and implementing a market development strategy for these systems. A key element of this strategy is to establish a national coalition comprising representatives from various levels of government, the supply industry and electric and gas utilities. This approach, which has been successful in the United States, will allow Canada's ground-source heat pump industry to take advantage of the utilities' financial viability and customer networks. Given the cost effectiveness of ground-source heat pumps in many markets (based on life-cycle costing), utilities can earn significant revenues from these systems by providing leasing or financing services to customers. Efforts to build a national coalition in Canada have been well received by several major utilities, and the coalition is expected to be in place later in 2001.

Although REDI has increased awareness of renewable energy systems, this has not yet resulted in significant growth in overall sales. This is particularly true for the first two years of the program. Anecdotal evidence indicates that, compared with pre-REDI years, some suppliers realized a twofold increase in sales in the first two years of the program, while others experienced only a marginal increase in sales. The situation changes significantly during the third year, when momentum generated by the increased awareness is reflected in both the number of applications to REDI and the number of projects that received contributions. In fact, more projects were funded in the third year of REDI than in the first two years combined. Similarly, the number of projects funded in the fourth year of REDI is expected to exceed the total for the first three years combined.

It should be noted that there is usually a significant time lag between the receipt of an application, which demonstrates a customer's intention to install a qualifying system, and the provision of the incentive, which is made only after the system has been installed. This reflects the time required to secure financing, obtain permits and approvals, select an architect and builder, and install the system. This process can take more than a year. This is viewed as another indicator that REDI's extension until 2004 will result in progressively more installations under the program.

Although REDI has received applications from almost all parts of Canada, the program has generated interest in two provinces in particular: Quebec and Ontario. Notably, these provinces experience higher natural gas costs because of their distance from production areas in the Canadian west (natural gas is the fuel of choice for space and water heating in most parts of Canada). In fact, the recent increase in natural gas prices in Canada may provide yet another boost to the deployment of renewable energy systems. Rising prices are expected to encourage consumers to consider renewable energy alternatives, given their lower and more predictable operating costs.

The market readiness of the renewable energy systems supported by REDI, together with their general environmental appeal, have been key elements behind the program's success. The ability of some industry members to include the incentive in their sales approach has

also been a factor. However, REDI's impact could have been greater if the three market development strategies had been developed and implemented more quickly. Delays were due in large part to limited human resources at both NRCan and its partner industry associations. Although outside contractors have been used to do much of the work, the efforts required by NRCan and association staff have proved more substantial than anticipated.

For more information on Canada's Renewable Energy Deployment Initiative and renewable energy in general, contact Richard Godin, Senior Advisor, Renewable Energy Policy, Telephone (613) 992-9845; E-mail address: rigodin@nrcan.gc.ca

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CS 4

Energy Labelling in Denmark

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Introduction

The name of the scheme is Energy Labelling in Small Buildings. The scheme is implemented in Denmark, but some other countries have implemented or are implementing similar labelling schemes based on the Danish experiences.
The Danish energy labelling is mandatory in all new and existing buildings of less than 1.500 m² used as residences, public institutions, private service or trade. Buildings used for production and buildings with very low energy consumption are not included. The most important target groups for the scheme are one-family houses and owner occupied flats.
The energy labelling is based on an energy audit made by an approved consultant, typically an architect or an engineer. The energy labelling must be made by the seller before sale of property, and it must be available before the sale. The labelling results in two different papers:

- *an Energy Label* including information on consumption of energy and water compared to other buildings with a similar use
- *an Energy Plan* including proposals for improvements and documentation for the labelling.

The energy labelling of small buildings is an important part of the overall Danish energy policy to meet the targets from Rio and Kyoto called *Energy 21.* The energy labelling was implemented January 1 1997. The scheme is still running and no closing is planned.
The energy labelling is important because it is a way to achieve energy savings in existing buildings. In most European countries existing buildings built before high requirements for insulation were implemented are a very large part of the building stocks. These buildings can not be addressed by traditional initiatives such as Buildings Codes or Improved Building Standards and the potential for energy savings in existing buildings are huge.

There is another scheme in Denmark concerning large buildings called Energy Management in Large Buildings but it is different in many ways and is not included in this paper.

Objectives of the program

The energy labelling scheme is a part of the overall Danish policy to reduce the emission of greenhouse gases and especially is an important part of the policy to reduce the energy consumption in existing buildings.
It is a long term initiative because a large new potential for energy savings is identified every year and because most of the savings have a long technical lifetime and many will even last until after 2030 without any additional costs.

The energy labelling of small buildings is based on a national Danish act from 1996*, Act to promote energy and water savings in buildings*. The act also gives the rules for the Energy Management in large Buildings, special rules for public buildings and rules for maintenance schemes for heating systems or other large energy consuming installed devices.

When the Act to Promote Energy and Water Savings in Buildings was laid down in 1996 the yearly energy savings and consequences for environment each year were expected to be:

- 4 - 6 PJ Reduction of Heating in 2005
- 300 – 600 GWh Electricity saved in 2005
- 5 – 10 million m^3 Water saved in 2005
- 0.6 – 0.8 million tons of CO_2 pr. year in 2005
- 2 – 3 % reduction of total Heating and Electricity Consumption in the included sectors

The yearly energy saving obtained by the scheme will be increasing year by year because new buildings will be labelled every year. Nearly half of these reductions are expected to come for the energy labelling in small buildings.

In addition to the saving of energy and less environmental impact the energy labelling has a positive impact on local employment because energy savings in buildings in general requires a large amount of local work.

Process of definition/design of the program

The energy labelling in small buildings in Denmark was developed in the context of a long history of energy auditing activities, including the Heat Consultant Scheme which was in power from 1982 – 1996. The development of the energy labelling was based on a need to improve and modernise this scheme.

The energy labelling was developed by the Danish Energy Agency in close co-operation with some private consulting companies. Repesentives for consultants, consumers, real estate salesmen and other bodies took a small part in the development of the scheme.

When the scheme came into force in 1997 it was exposed to a lot of critics from different sides, for instance because the consumers and the professional users wanted more information, found the labelling to colourful and found that some of the calculation rules were wrong. The Danish Energy Agency decided to redesign the formula for the labelling and to change some of the rules for the labelling. This new design was done in the period June 1997 to June 1998, and it was done in close co-operation with all major groups with interest in buildings sale and labelling, this includes representatives for consumers, lawyers, real

estate sales agencies, architects, engineers, handicraftsmen, the finance sector and experts in communication and experts in different parts of technology in the labelling.

As a result of this work a totally different labelling form was introduced in July 1998, with far more information on the actual building and heating installation, much new and additional information to the consumers in the labelling, some assumptions used by the labelling and many specially made conclusions and remarks from the consultant in each labelling. Some of the rules for calculating consumption ware changed as well, for instance the way a cellar or special equipment in the building was treated.

The new scheme came in act into power in July 1998 and was well received by consumers and all the important professional users of the labelling. Especially the faith in the labelling was improved and the total amount of information was better accepted.

Main actors and their roles

The overall administrator of the scheme is the Danish Energy Agency, part of the Civil Service of the Danish Government. All major rules for the Energy Labelling of Small Buildings are given by the Danish Energy Agency. But a special council for the energy labelling is established and all the decisions on approving consultants, control of the quality, education of consultants, handling of complaints from consumers etc. are made by this council.

The council has a special secretary, which is placed at the Danish Technological Institute. The secretary is responsible for the actual training course, the information for the around 800 consultants and for the collection and validation of data from the labelling, because all labellings must be reported. All costs for the secretary and the budget for the council are based on an administration fee paid by the consultants.

The members of the council for the energy labelling are representatives for different organisations or bodies of Consumers, Real Estate Salesmen, Lawyers, Engineers, Architects, Tradesmen, Assurance companies and Power Production and representatives without vote from the Ministry of Energy & Environment and the Ministry of Building & Construction. A representativ for Danish Consumers Council is the President of the council.

The energy consultants play a very important role in the scheme as the persons, who actually carry out the labelling. In order to be approved as an energy consultant the consultant must be a trained engineer, architect, construction designer or the like and must have at least 5 years documented, relevant experience in building technology and energy consultancy. The consultants must have a compulsory professional liability insurance and must have taken the admission course for the Energy Labelling Scheme and must have passed a special test.

Other professional groups are also taking a part in the implementation of the energy labelling and the information about the rules. For instance the real estate agencies have an obligation to tell both the selling part and the buying part about the rules for the labelling. But other groups such as banks and lawyers have been used as carriers of information to the consumers.

Policy mechanisms used

The scheme is mandatory and the major target is to give information to the buyers on the energy consumption and the possibilities to save energy and water. The information has to be drawn up on a standardised form and the information can be separated in three different parts with a different function.

The Energy Label is one page and it includes a standardised energy rating or labelling of the building containing information about the energy and water consumption and the CO_2 emission compared to other buildings with a similar use. The energy label also contains information on the expected total energy and water consumption in the building in a reference year (average of 25 years) and the energy costs in this particular building. The

use of energy and the costs are calculated under normal conditions concerning behaviour, use of building and a typical family size, from the registration of building parts and the heating system etc. The aim of the energy label is to make the consumers more aware of the energy consumption when buying real estate because the energy costs will be a large part of the future costs.

The energy plan for the building including proposals for profitable saving possibilities for all types of energy and water use in the building. Furthermore the energy plan shall include an estimate of the necessary investments and annual savings of the proposals. The plan also gives information on the estimated technical lifetime of the proposals. This information should give the consumer a possibility to calculate how profitable the individual proposals are under a given financing. The aim of the plan is to promote energy savings in the building and to give the new owner possibility to select the most interesting savings.

Information as documentation of the labelling and the energy plan. The documentation contains information on the present state of the building, the heating system, the use of energy under the present owner, information on the expected use of the building and typical conditions such as price of energy, heating, size of household etc. The aim of the documented information is to give credibility to the labelling and to the plan and to give further information on the present building condition which are important for the buyer.

The general rules for the scheme are given in the Act to Promote Energy and Water Savings in Buildings from June 1996 and the two Executive Orders on Energy Labelling etc. in Buildings and on Fees and Liability Insurance for Energy Labelling in Buildings from September 1999.

The specific rules for the energy audit, the calculation and the proposals etc. are given in the Energy Consultants Handbook which is a quality manual for the energy labelling of small buildings. The calculation of the use of energy is based on standards for calculation on heating needs in buildings and specific developed rules for energy efficiency in the heating system and for the calculation of electricity and water consumption in small buildings.

For the education of the consultants a special training course is used. The consultants have to follow a yearly additional training course on 1 day and at least four times a year the consultants receive a newsletter telling about new rules, clarifications, frequently asked questions and general information of the development of the scheme. The information for the consultants are based on experience from the quality control, reported energy labelling and technical research and development.
The quality of the labelling is inspected in a special quality control system including new labelling of some of the buildings chosen by a random selection, visual control of some of the labelling forms, new calculation of the consumption etc. Consultants who don't meet the quality of the labelling will lose their registration.
Complaints about the energy labelling of a building are treated by the council of the energy labelling of small buildings and the secretary. If larger failures are identified the consultant has to provide a new labelling and can be held responsible for economic losses by the owners. If the consultant doesn't meet the requirements the council can withdraw the registration or can make additional quality inspections.
The energy consultants have to be insured with a liability insurance, which can cover losses made by a failure or wrong information in the energy labelling or energy plan. The insurance must be kept in force at least 5 years after the labelling. There are maximum prices for the energy labelling of a typical one family house but the consultants are in a competition for lower prices.
In addition to the information given to the consumers on the energy labelling and the energy plan there is additional standard information material, for instance in brochures. A new

Internet site giving information in accordance to the measures in the energy plan and giving good advice when carrying out the energy savings is under construction and will be operating by the end of 2000.
Professional parties in financing and sale of real estate are used to pass on information to the consumers. For instants real estate salesmen have to give information of the rules for the energy labelling whenever they sell a building.
All the costs for the energy labelling, the energy audits and for the administration of the scheme is paid by the consumers. People selling their house have to pay the consulting engineer or architect for the energy labelling, including the energy audit and the necessary calculations. The typical price for the labelling of a one-family house is 2.000 – 3.500 DKK or 300 – 500 EURO. The consultant pays an administration fee of 100 DKK or 12.5 EURO for each labelling for administration costs and a yearly fee for being registered as a consultant. The total yearly costs for the administration of the scheme paid by the consumers are 5 – 6 million DKK or about 750.000 EURO.
All the costs for developing the scheme were paid by Danish Energy Agency as a part of the national budget, and the Danish Energy Agency provides the consumers with all additional information on the labelling scheme and additional information on the proposed energy savings.

Monitoring and evaluation process

Every energy labelling must be reported to the secretary of the council for the energy labelling, this includes the date, information on the building, the information registered by the audit, most of the calculation results and all proposals from the energy plan including investment, estimated saving and the proposal. All data are registered in a database and are controlled on receipt by the secretary. Labelling data not meeting the requirements or suspicious data are investigated further.

The data in the database are on regular basis used to calculate the number of labelled buildings and it is compared to the buildings sold. The data are also used to calculate the number of proposals, the investments and the possible savings and a lot of other information from the scheme.

The quality assurance system is designed to identify the general situation of the labelling and to identify special problems in the labelling. The general status and the problems are used for information to the consultants in training courses or in the regular information letters. Whenever it is necessary additional training or additional control is carried out.

There have been made several quantitative and qualitative investigations on the consumers acceptance of the scheme and the number of measures carried out and investigations of the barriers for the use of the scheme and for carrying out the energy savings. The results have been used for improvement of the scheme.

A large evaluation of the energy labelling of small buildings is going on until the end of 2000. The aim of the evaluation is to find out whether the goals for the scheme are reached until now, how many savings are actually carried out, to find possible barriers for the full implementation of the scheme and to propose possible improvements of the scheme and if necessary to propose needs for further information on the energy labelling or on the energy plan. The evaluation is done by a large consulting engineering company and some experts in communication (PR) etc.

It is expected that the evaluation will lead to further improvement and development of the energy labelling of small buildings.

Discussion of results

Until now the known results of the energy labelling in small buildings are:

- 45 - 50,000 labelling each year
- nearly 70 % of all one family houses are labelled when they are sold
- in all more than 160.000 buildings or more than 10 % of all one-family houses in Denmark has got an energy label in the first 3½ years of the scheme
- in 1999 energy savings for more than 1 billion DKK or 130 mill. EURO was identified
- the result of implementing all the possible savings would be nearly 150 mill. DKK or 20 mill EURO lower annual energy bills for the consumers
- on average the one family houses could lower their energy costs with about 20 %
- 26 % of the owners of labelled houses tell that they have implemented energy savings shortly after buying the house and an additional 22 % tell that they are planning to do investments from the plan in the near future

The evaluation will give more information on the obtained results.

Problems:

A large problem in the scheme is that the person who sells a house has to order the energy labelling and has to pay for the labelling and sometime gets a negative impact of the energy labelling. If the labelling results in a low rating of the building and the energy plan includes many proposals the energy labelling can reduce the price of the building.

It is difficult to let the buyer, who has the major interest in the energy labelling, pay for the energy labelling because often more buyers are in competition and they would either have to make a common agreement or they have to make several energy labels of the same house.

Many real estate salesmen feel that the energy labelling gives additional work to selling a house and in some cases the labelling even has to be paid by the salesmen out of the total fee for selling the house.

It is a problem for the labelling of houses that two of the important shareholders who plays an very important role in the ordering of the labelling in some cases has a very small or even a negative value of the energy labelling.

To overcome this problem there is a special rule giving, the buyer has the right to have the energy rating and an energy plan drawn up at the expense of the seller if this takes place within a reasonable space of time. But it can only be used if the buyer, who is not be informed about the buildings energy labelling and energy plan before agreement to sell has been reached and the owner, on demand, has not handed over the energy rating and energy plan.

Forces:

The energy labelling scheme has identified a large energy saving potential in existing buildings. Energy savings witch would be difficult to identify in other ways.

The energy labelling scheme is a very large source of information on the present building stock in Denmark, because data from more than 40.000 one family houses are reported

every year. This information can be used in monitoring and evaluation of other initiatives and can be used to identify possible savings and measures such as general information etc.

CS 5

DIESEL ENGINES FOR COMBINED CYCLE POWER GENERATION

WTFI/Gösta Liljenfeldt 22.10.2000

Introduction

Engine building has long traditions in Finland. Actually, engines have been built in this country already before the nation became independent. Today, there are two Finnish companies continuing this tradition: Sisu Diesel and Wärtsilä Corporation. Of these, Sisu Diesel specializes in high-speed engines for tractors, combined harvesters, military vehicles and other mobile applications. Wärtsilä – the short name for Wärtsilä Corporation - is today in the global aspect the leading manufacturer of medium and low speed diesel and gas engines for marine and stationary applications.

Up to the end of 1980's, Wärtsilä's activities were totally dominated by manufacturing and sales of marine engines. However, throughout the second half of the1980's and the whole of the following decade intensive work was laid down into creating a wider business basis by the development of manufacturing and sales of engines and equipment for power stations operating on diesel and gas fuels. With this investment Wärtsilä has in an essential way contributed to the fact that diesel and gas engines all through the 1990's have become increasingly popular as prime movers for power plants with electric output from a few megawatts up to 200 … 300 MW.

One could claim that Wärtsilä went ashore with nothing but marine equipment when they first entered the power plant market. The engines that were sold to power customers were on the whole identical to those used in ships and other marine installations. There were only minor application details that were adjusted according to the special conditions and requirements of power stations. A significant potential for specializing was recognized, and the decision to develop a "real power plant engine" was taken in 1994.

In the following the ongoing product development process aiming at the realisation of a "real power plant engine" is shortly described. The intention is to deal with the development of an engine especially adapted to be used as prime mover in large single cycle as well as in combined cycle power plants with electrical output up to 300 MW. The program was initiated in 1995 and has at the moment this is being written reached the demonstration and verification phase.

The case study is of general interest as it does not only cover the development of a special product but also the introduction of new technology as well as the demonstration of functionability of this technology in a commercial application/environment.

Objectives of the program

Today and with access to all the facts and knowledge that have appeared during the process, one could easily claim that special attention was paid to the environmental and climate factors when the program was first drawn up. Anyhow, to do so would be nothing but a reconstruction of facts and thus no such claims will be presented in this context! Due to the fact that Wärtsilä is a privately owned enterprise for which profitability to a very large extent is the primary value and goal of all activities, it is natural that the business economy point of view has played a decisive role in the setting of the program goals. If the outcome of the efforts for whatever reason is a product not only corresponding to the set program goals but also fulfilling the high environmental requirements, etc., is quite another story!

The main objectives of the program are

1. to create a diesel engine concept – the HOT COMBUSTION concept - specially adapted to the conditions prevailing in power plants in general and in combined cycle diesel power plants in particular
2. to create a diesel engine – the REAL POWER PLANT DIESEL ENGINE – which is a competitive alternative to the diesel engines' main competitors i.e. the gas turbines as prime movers in both single cycle and combined cycle power plants
3. to verify the validity of the engine concept as well as the performance of the real power plant engine in a demonstration power plant

The medium speed 4-stroke diesel engines that enabled Wärtsilä to gain significant shares of the power plant market during the late 1980's and especially during the 1990's were more or less identical to the engines delivered for marine applications. A characteristic feature of these engines is that they are "outstanding" among the thermodynamic engines when it comes to the ability to transform fuel energy into mechanical work. With the largest medium speed diesel engines existing today, a thermal efficiency of over 47 % is achieved. Thanks to its high efficiency, the marine diesel engine is well fitted to be used as prime mover in a single cycle power plant.

Like all the other thermodynamic engines, a diesel engine generates not only useful power but also some waste heat. In a diesel engine the waste heat leaves the engine with exhaust gas and coolant flow as well as via convection and radiation from the surfaces of the engines. Unfortunately, the total amount of waste heat carried by the coolant is unproportionally high. In combination with the fact that the exhaust gas temperatures of a modern diesel engine seldom exceed 350°C, this makes it, if not technically complicated, at least less cost effective to recover a competitive amount of heat out of the waste heat flow for generation of secondary useful power, e.g. in a steam circuit. The adaptation of a diesel engine to the conditions of a power plant must therefore primarily be directed to refining and/or re-distributing of the diesel engine waste heat flow. Of course, this development must

not have a negative impact on the otherwise eminent engine performance in single cycle applications.

From the maintenance point of view, it is essential that a power plant is built up of a reasonable amount of prime movers/power units. This means that conventional diesel engines with cylinder output seldom exceeding 1000 … 1500 kW become a less attractive alternative as the power plant output increases. Therefore, the development of the REAL POWER PLANT DIESEL ENGINE must result in a product that gives a higher unit output than the present day power plant prime movers do. All the same, the engine with a higher unit output must still be transportable, meaning that the engine weight should not create an obstacle for transportation of the engine with the available transportation methods and along common transportation routes.

To enable a credible verification of both the HOT COMBUSTION concept and of the performance of the new engine, the demonstration plant must comprehend all the features that can be expected to be present in a full-scale power plant. This means that the demonstration plant must have the equipment needed for heat recovery and generation of secondary mechanical power. In addition to this, the plant must be equipped with the necessary equipment for exhaust gas cleaning.

It is unavoidable that the erection and operation of a model plant of this kind creates significant costs. Thus it is of high importance for the plant economy to be able to sell the products, in this case electricity and district heat. Access to the local distribution networks for electricity and district heating has to be secured in one way or another. One natural way of doing this is to establish a co-operation with the local power and district heat producers and distributors.

Process of definition/design of the program

As this case study deals with a technology deployment program primarily carried out by a privately owned company, Wärtsilä Corporation, it is only natural that the process for defininig and drawing up of the program follows the routines established within this company. The needs of a special, power-plant-adapted diesel engine with high unit/cylinder output have been identified by those parts of the Wärtsilä organisation that are in direct daily contact with customers and end users. In this particular case, Wärtsilä's Power Plant business unit has identified the needs to update the company's power plant engine portfolio.

Wärtsilä's Technology unit has been responsible for creating a detailed specification for the novel engine concept as well as for THE REAL POWER PLANT DIESEL ENGINE. Both the specification and the implementation plan of the program have been drawn up in close co-operation with Power Plant, Service and Manufacturing units.

The decision to carry out the technology deployment program was made by Wärtsilä's top management.

Main actors and their roles

Public institutions, national research institutes, component suppliers and end users are represented among the actors that have contributed to the implementation of the technology deployment program THE REAL POWER PLANT DIESEL ENGINE besides the main actor, i.e. Wärtsilä. Among the public institutions the following can be mentioned:

- the European Union, Directorate-General XVII, Energy has participated in the financing of the presentation/demonstration power plant

- the Ministry of Trade and Industry of Finland has likewise participated in the financing of the presentation/demonstration power plant

- the Ministry of Finance of Finland has contributed to the coverage of operational costs of the demonstration power plant by awarding the owner of the plant tax reduction for fuel used for district heat production

- TEKES, the Technology Development Centre of Finland, has participated in the financing of the development work of both the HOT COMBUSTION concept and “THE REAL POWER PLANT DIESEL ENGINE”

Research institutions:

- VTT Energy, which belongs to the Technical Research Centre of Finland, has contributed to the realisation of the program both with theoretical evaluation of the HOT COMBUSTION concept and the initial testing ("small scale tests") of an engine built according to the this concept

- Helsinki University of Technology has, within the framework of a parallel project, developed and carried out engine tests with components designed for and adopted to the requirements prevailing in an HOT COMBUSTION engine

Among the industrial enterprises participating in the technology deployment program the following should be mentioned:

- Wärtsilä Corporation, the main actor in the development of the HOT COMBUSTION concept and THE REAL POWER PLANT DIESEL ENGINE. The company has, in

addition to this, participated in the building of the demonstration plant and is today one of the owners of this plant.

- ABB Power, today a part of the Alstom Power organisation, that has delivered equipment to the demonstration power plant and also become a partner-owner.

- a big number of engine and power plant component and equipment suppliers, including morethan 50 different companies, that can be classified as SME's. These companies have assisted in the program with, among others, their special know-how about new technologies that have been introduced when developing the HOT COMBUSTION concept

Two companies, which in this context belong to category "users" and which have contributed in a significant way to the realisation of the program, are:

- Vaasan Sähkö Oy/AB, a local electricity distribution company and also one of the owners of the demonstration power plant

- Etelä-Pohjanmaan Voima Oy, a regional power producer and also one of the owners of the demonstration power plant

Policy mechanism used

In order to facilitate the monitoring and the control of the progress of the development process, a four-step method has been found useful. The program has thus been divided into four sub-programs as follows:

1. Evaluation of the feasibility of the novel engine concept, i.e. the HOT COMBUSTION concept
2. Verification of the novel engine concept by means of “small scale tests” carried out in VTT Energy’s and in Wärtsilä Corporation’s engine laboratories

3. Design and realisation of THE REAL POWER PLANT DIESEL ENGINE

4. Erection and operation of a 38 MW diesel combined cycle demonstration power plant

When executing the individual sub-projects, public product development support has been used whenever possible. Consequently, the Technology Development Centre of Finland, TEKES, has so far funded the development and the evaluation of the feasibility of the HOT COMBUSTION concept as well as the development of THE REAL POWER PLANT DIESEL ENGINE with totally xxxx MEUR.

The European Commission has via its Thermie A program contributed to the erection of the demonstration power plant with x MEUR. The same activity has been funded with xxx MEUR by the Ministry of Trade and Industry of Finland.

The company, that has been founded to take care of the building and operation of the model power plant, has been awarded tax reductions by the Ministry of Finance of Finland. These tax reductions are applicable to the fuel that is used for district heat production. In this way, the Ministry of Finance helps to reduce the net operation cost that otherwise totally had to be carried by the owners when, to keep the plant in operation, the products must be sold to prices that do not fully cover the costs for the production of district heat and electricity.

The erection and operation of an expensive demonstration power plant can only be justified with the provision that it is in one way or another guaranteed that it is possible to operate the power plant over a longer period of time. This means that a primary requirement is that a market really exists for the products, in this case district heat and electricity, and that the power plant has access to this market. In this case, this market has been secured by inviting the local and regional distributors and producers of electricity and district heating into a shared ownership.

Wärtsilä, the main actor of the deployment program, owns 49 % of the Wasa Pilot Power Plant Ltd, i.e. the company that was founded for the erection and operation of the demonstration power plant. The remaining 51 % are equally distributed between ABB Power, Vaasan Sähkö OyAb and Etelä-Pohjanmaan Voima Oy

Monitoring and evaluation process

To the extent that the technology deployment program has been executed as a part of Wärtsilä's activities, this company's established routines for monitoring and evaluating of the progress of a product development program have been followed. For the most important sub-programs included in the current technology deployment program, special project organisations have been created comprising as well operative as monitoring and advisory elements. In such an organisation the **project leader** has the ultimate responsibility for the realisation of the product development project. For the practical work the project leader has a **project team** headed by a **project manager**. In its daily work the members of this project team consults both internal and external experts, e.g. component experts, calculation experts and application experts.

The project organisation includes two elements with monitoring and/or advisory functions. These are the **Advisory Board** and the **Support Group**. In the Advisory Board there are senior representatives of both the Wärtsilä Corporation management and the involved business area managements. Before start-up of a new project, the project leader is expected to present the project plan for approval to the Advisory Board. Further, he reports throughout

the project process to the board about the progress of the project. Usually the Advisory Board meets two or three times during the execution of a typical product development program.

The members of a Support Group are typically senior management level technical experts . The Support Group has, primarily, an advisory function as a test forum for the solutions created by the project tea. However, the Support Group is also a monitoring element as it can either accept or reject the suggested technical solutions. The Support Group meets as often as the project related activities require. In practice, this means that the group meets at least 2 to 3 times a year during the whole development project. During the most intense periods of the project the Support Group may meet much more frequently, for instance once a month.

During the execution of the technology deployment program the technical part of the activities has been submitted to external evaluation at two different occasions. In both cases VTT Energy was entrusted with the evaluation work. In the beginning of the program VTT Energy carried the responsibility for the realisation of the first sub-project, i.e. "Evaluation of the feasibility of the novel engine concept". After start-up of the model power plant, VTT Energy has carried out and reported the measurements that are required when benchmarking the plant performance against the expectations.

In a project of the current type, also the external financiers have to look after their own interests. TEKES expects that the receiver of financial support reports the technical progress and the cost development on a regular basis, in general every six months. Usually either the project leader or the project manager is responsible for reporting the technical progress. The cost development report is preferably compiled by the support receiver's Business Control and audited by a CPA auditor.

In addition to the above, it can be mentioned that the European Commission, for its part, has monitored the progress of the technology deployment program by auditing the model power plant at three different points of time. For this purpose the Commission has utilised the skills of external energy experts.

Discussion of results

Even though the technology deployment program is not yet brought to an end, there are a considerable number of good reasons to expect that the final results of these efforts will be found very satisfactory:

- the positive statements, that VTT Energy made as a result of their evaluation of the new engine concept

- the results of the small scale tests that have been performed in a laboratory environment both at VTT Energy and at Wärtsilä clearly indicate that the waste heat distribution in the engine can be refined and the engine thereby adapted to the requirements set for a THE REAL POWER PLANT DIESEL ENGINE, if and when a conventional marine diesel engine is modified to meet the specifications for an HOT COMBUSTION engine

- the program has resulted in a THE REAL POWER PLANT DIESEL ENGINE " that, in spite of its impressive dimensions, is fully transportable in most situations
- plant efficiencies widely exceeding 50% have been reached with the model power plant of 38 MW
- both the THE REAL POWER PLANT DIESEL ENGINE ", e.g. the Wärtsilä 64 V-engine, and the model power plant have attracted a great interest among the potential end users

Under the heading “Conclusions” in the evaluation report made by VTT Energy on the HOT COMBUSTION concept it is stated

“The total efficiency of the hot combustion diesel combined cycle will be over 56.5 per cent measured from shafts when the size of the plant is reasonable and the jacket temperature is 150 degrees C. Thus the 55 per cent (net) target is realistic ....”

Tests with engines equipped with power unit components according to the HOT COMBUSTION concept have been made both by VTT Energy and by Wärtsilä. The results are particularly encouraging as they show that it is possible, not only to increase the amount of **recoverable** exhaust gas heat by up to 15 … 20 %, but also to improve the thermal efficiency of the diesel engine with up to 1%-unit, when the combustion chamber is provided with thermal insulation and the amount of scavenging air is reduced in accordance with the HOT COMBUSTION concept.

The sub-project specifically aiming at the realisation of “the real power plant diesel engine” has resulted in a medium speed engine capable of producing a cylinder output of 2000 MW and more. The engine, the cylinder diameter of which is 640 mm, is called Wärtsilä 64. It is a really big diesel engine, which in its V-version with 12 ... 18 cylinders is very well fitted to be used as prime mover in both single and combined cycle power plants with output of 100 MW and above. In its V-version the engines are built from modules, the weight of which in no case exceeds 250 ton. The intention is that, when the situation so requires, the modules can be transported to the site of the power plant one-by-one and then the engine is assembled on site. Thanks to the modular build-up the transportability of the engine is secured even under very unfavorable conditions as regards available means of transportation as well as transportation routes.

Thermal plant efficiencies of up to 53% have been recorded when operating the 38 MW demonstration plant. These plant efficiencies have been achieved with a relatively small size power plant. Thus there are good reasons to expect that plant efficiencies of 55% and above can be realised in large power plants, where not only the prime movers but also the equipment used for waste heat recovery and generation of secondary mechanical power have been optimized for best possible performance. As all experience gathered during more than 6000 hours of mixed commercial and experimental operation of the plant indicates that the exhaust cleaning equipment (DeNOx- and DeSOx-equipment) is working according to expectations, one can only conclude that all main goals defined for this technology deployment program have been achieved!

Based on the above one could easily get the impression that the program has been run until now without a single setback. This is however not the case! During the 6000 hrs of operation of the demonstration plant technical difficulties interrupting the operation have occurred to an extent widely exceeding what is considered acceptable for a plant in commercial operation. It is the reliability of engine components manufactured from new materials and according to new technologies that has caused the problems. As a consequence several engine components have been updated and exchanged during the time the plant has been in operation. The power plant is equipped with two large 12-cylinder medium speed engines and consequently it is easy to realize that the component exchange operations are both time consuming and expensive.

The fundamental reasons to the technical problem that have occurred during the execution of the technology deployment program can mainly be found in a somewhat too optimistic program plan as well in shortages in the communication between users and suppliers of engine components manufactured from new material according to new manufacturing technologies. The original project plan set up for the realisation of the technology deployment program included sub-programs aiming at the verification of the functionability of the new engine concept. However no specific plans for the verification of the durability and reliability of the new components were made. It was simply assumed that it would be possible to demonstrate the durability of these new components during the normal operation of the model plant. Some of the costs burdening the project as a consequence of unsatisfactory reliability of new engine components could most likely have been avoided, if and when these components had been subject for small scale endurance tests in laboratory environment during the early stages of the realisation of the program.

To some extent, the occurrence of problems and disturbances during the realisation of the program and, above all, during the operation of the demonstration plant can be explained by shortages and misunderstandings in the communications between the users and suppliers of new technology and materials. Looking back at the execution of the project one can only conclude that the users and the suppliers do no always understand each other! In this specific case the user is an engine manufacturer owning highly specialised and advanced knowledge about his own product. In his daily communication with the component suppliers, the engine specialist expects the component supplier to be familiar with the vocabulary used in the engine world. Thus he tends to use professional wordings and notions that in the

worst case are completely meaningless to a supplier lacking the necessary knowledge about engines. It is quite obvious that this may have disastrous consequences, for instance, in cases where the component supplier is expected to judge the functionability and reliability of his own product when it used in the environment where the engine manufacturer intend to use it. In this context it has to be pointed out that it is not only the end user that may fail when communicating with other people. This may easily happen to the supplier as well with equally serious consequences.

Although there have occurred some disturbances during the realisation of the program the general impression is that there have been more successes than setbacks and further that the successes have been much more important than the setbacks. Among the key elements behind the successes registered during the execution of the program the following have to be mentioned:

- a competent, motivated and enthusiastic technical staff has carried the main responsibility for the realisation of the program
- the program has been subject to solid financial support and in this aspect the public funding has been of great importance
- local and regional power distributors and producers have been engaged in the realisation and the operation of the demonstration power plant.

Finally, it is worth mentioning that up to date more than 9000 guests and among them more than 4500 investors and potential customers have paid a visit to the demonstration power plant. The popularity of the power plant can only be interpreted as a success from the project point of view!

SolarBau – ENERGY EFFICIENCY AND SOLAR ENERGY USE IN THE COMMERCIAL BUILDING SECTOR

A German demonstration program for the non residential building sector

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INTRODUCTION

The following report presents the description and initial evaluation of the German RD&D program for solar optimised buildings, the so called 'SolarBau Program', which was initiated by the Federal Ministry of Education and Research (BMBF) in 1995 and since 1998 carried out by the Federal Ministry of Economy and Technology (BMWi). Consisting of a number of demonstration projects, spread over all regions of Germany, the program's objective is to demonstrate the feasibility of highly energy-efficient buildings for non residential purposes with special regard to solar optimisation. The technical concepts for all buildings are based on an integrated approach considering heat and electricity consumption. Started in the year 1995, the program was planned to cover a period of 10 years with a budget of approx. 5 MEURO/a.

OBJECTIVES OF THE PROGRAM

The sector of non residential buildings was selected with special regard to the large potential for saving energy and the promising dissemination effect, resulting for instance from the increasing importance of the trade and the services sector in Germany. Considering the present situation in Germany, 16% of the final energy consumption is caused by small scale commercial consumers. Trends, as recently published by PROGNOS 99 [9] and considering the whole sector until 2020 are predicting a slight decrease related to 1995. However more sophisticated analyses show different tendencies, depending on the type of consumer. For instance for the expanding service industry sector and to a less extent the trade industry an increasing energy demand of 19% and 8% are expected. Energy savings due to reduced heat consumption are going to be partly compensated for by increasing demand for electricity.

Being part of the 4 th German Energy Research and Development Program, SolarBau is one of the major activities in the framework of rational use of energy. Addressing particularly the

[9] PROGNOS 99: Die längerfristige Entwicklung der Energiemärkte im Zeichen von Wettbewerb und Umwelt, Basel, 1999

typical properties of commercial buildings, the program is striving to take up existing energy saving opportunities. Its main object is to develop and prepare technical and scientific background information for future legal measures such as the German energy saving ordinance, which should limit energy consumption in the building sector.
SolarBau's general objective is to demonstrate a series of pilot projects with a total primary energy demand for heating, cooling and lighting purposes below 100 kWh/(m^2a) including a space heating demand of less than 40 kWh/(m^2a). This target will be achieved by integrated concepts based on the interplay between solar passive and active approaches, advanced HVAC techniques and innovative thermal insulation measures. The program consists of various parts, comprising the development of components and planning tools, the demonstration of up to 25 pilot buildings and an accompanying evaluation and information program called SolarBau: MONITOR.
Besides the advanced technical targets, economic aspects will be an important consideration for the SolarBau projects. In this context it is anticipated that additional expenses for the integrated design process should as far as possible be compensated for by lower investments for the HVAC–installations and reduced maintenance costs.

PROCESS OF DEFINITION/DESIGN OF THE PROGRAM

SolarBau's concept is based on a sophisticated analysis of specifications and requirements to be met by non residential buildings and determining their heat and electricity consumption. An experts group was set up to develop and design SolarBau's basic concept in close co-operation with the responsible ministries. The group consisted of five representatives from:

- university research
- private research
- architects and engineers
- ministry and project management organisation

MAIN ACTORS AND THEIR ROLES

As in the conception phase, the main actors playing a role in the SolarBau program come from various branches of research, industry and public bodies. The responsibilities are allocated as illustrated in Tab. 1. Although competence and experience of a participant in the field of energy saving engineering is important, it is not the only criteria for participation. Additionally the readiness to contribute to the accompanying SolarBau: MONITOR program, which is based on a high degree of co-operation during all project phases, is being pre-condition to participate.

Main actors and their roles in the SolarBau Program	
Federal Ministries (BMBF, BMWi) Project Management Organisation (BEO)	funding and co-ordination
universities Fraunhofer Gesellschaft private institute	- theoretical background - development - monitoring and evaluation
industry	- development of new materials and systems - production of innovative components - market introduction
architects and engineers	- construction of demonstration buildings - monitoring and validation
SolarBau: MONITOR researchers and developers architects and engineers	- communication - documentation - analysis - training

Tab. 1 Main actors and their roles in the SolarBau program

POLICY MECHANISMS USED

As already mentioned, SolarBau is part of the 4 th governmental funding program for energy research and development, therefore the R&D activities are supported according to usual funding conditions. In the demonstration part, funding is only provided for the design of prototype buildings and for monitoring activities after construction. Complementary development activities, aiming at the production of new innovative components are also supported according to R&D framework conditions. Since no subsidies are provided for investments, it is ensured that all design solutions are realised under normal economic boundary conditions.

MONITORING AND EVALUATION PROCESS

The monitoring, evaluation and documentation in SolarBau is being carried out by independent institutes and companies. An internet platform at www.solarbau.de (German) provides information for participants as well as for the general public. Project reports are being produced regularly and workshops are being held to provide information on the experience gained.

Special emphasis in the area of evaluation has been given to the generation of a neutral basis, allowing the comparison of energetic properties of the monitored objects. Up to now, in the framework of SolarBau eleven non-residential buildings are under construction or have

been already erected. Tab. 2 gives an overview on the building types, net floor areas and status of completion and Tab. 3 contains a description of applied measures and components [10].

Project name	***Location***	***Building type***	**Net floor area**	**Status**
ECOTEC	Bremen	office	3436 m²	finished
Passivhaus Wagner	Coelbe / Marburg	office	1948 m²	monitoring
Hübner	Kassel	production	2122 m²	monitoring
Fraunhofer-Institut für Solare Energiesysteme FhG	Freiburg	research institute	14001 m²	under construction
DB Netz	Hamm	office	5974 m²	monitoring
Fachhochschule Bonn-Rhein-Sieg	St. Augustin	university	26987 m²	monitoring
Gesellschaft für Innovation und Transfer GIT	Siegen	offices and laboratories	3300 m²	planning
Passivhaus Lamparter	Weilheim	office	1488 m²	monitoring
Technische Universität Braunschweig	Braunschweig	computer centre	9415 m²	under construction
SurTec	Zwingenberg	production and office	4423 m²	under construction
Zentrum für umweltgerechtes Bauen ZUB	Kassel	training and research	1108 m²	under construction

Tab. 2 Demonstration projects, status May 2000

According to the focus on office buildings the implied strategies are mostly based on passive cooling and advanced daylighting measures. Both are being addressed in the IEA Implementing Agreements 'Energy Conservation in Buildings and Community Systems' and 'Solar Heating and Cooling'.

[10] Voss, K. (FhG-ISE), Löhnert, G. (solidar) and Wagner, A.(Uni Karlsruhe): ‚Towards lean Buildings – Examples and Experience from a German Demonstration Program for Energy Efficiency and Solar Energy Use in Commercial Buildings'

	Titel	ECOTECC	Wagner	Hübner	FhG-ISE	DB AG	FH-BRS	GIT	Lamparter	TU-B	SurTec	ZUB
Methods	Integrated planning		+	+	+	+		+	+	+	+	+
	Simulations	(+)	+	+	+	+	(+)	+	+	+		+
Strategies	Reduction of space heating demand	+	+	+	+	+	+	+	+	+	+	+
	Passive cooling		+	+	+	+	+	+	+	+	+	+
	Daylighting		+	+	+	+	+	+	+	+		+
	Renewable energy use	+	+	+	+		+		+			
Technologies and measure	Atria				+	+	+			+	+	+
	Transparent insulation						+					
	Solar thermal	+	+	+	+				+			
	Solar electricity	+			+		+		+			
	Heat recovery	+	+	+	+	+	+	+	+		+	+
	Nocturnal ventilation		+	+	+	+	+	+	+	+	+	+
	Slab cooling											+
	Ground heat exchanger		+	+	+	+	+	+	+	+	+	+

	Combined heat & power		+		+		+					
	Combined heat + power + cooling				+							
	Heat pump	+						+				
	Biomass											
	Advanced controls	+	+		+	+	+	+	+			
	Rain water treatment		+	+					+		+	
	“Ecological materials”			+			+		+			+

Tab. 3 Technologies and Strategies

The comparison of investment costs, as indicated in Fig. 1, shows that SolarBau buildings are within the range of the German reference costs for office buildings of medium to high standard as published by the ‘Construction Costs Information Centre’ of the ‘German Chamber of Architects (BKI)’, based on mean building costs per m^2 usable floor area for given building types in Germany. The results so far from the SolarBau projects demonstrate that special features of advanced energy saving concepts do not necessarily have to result in increased building costs.

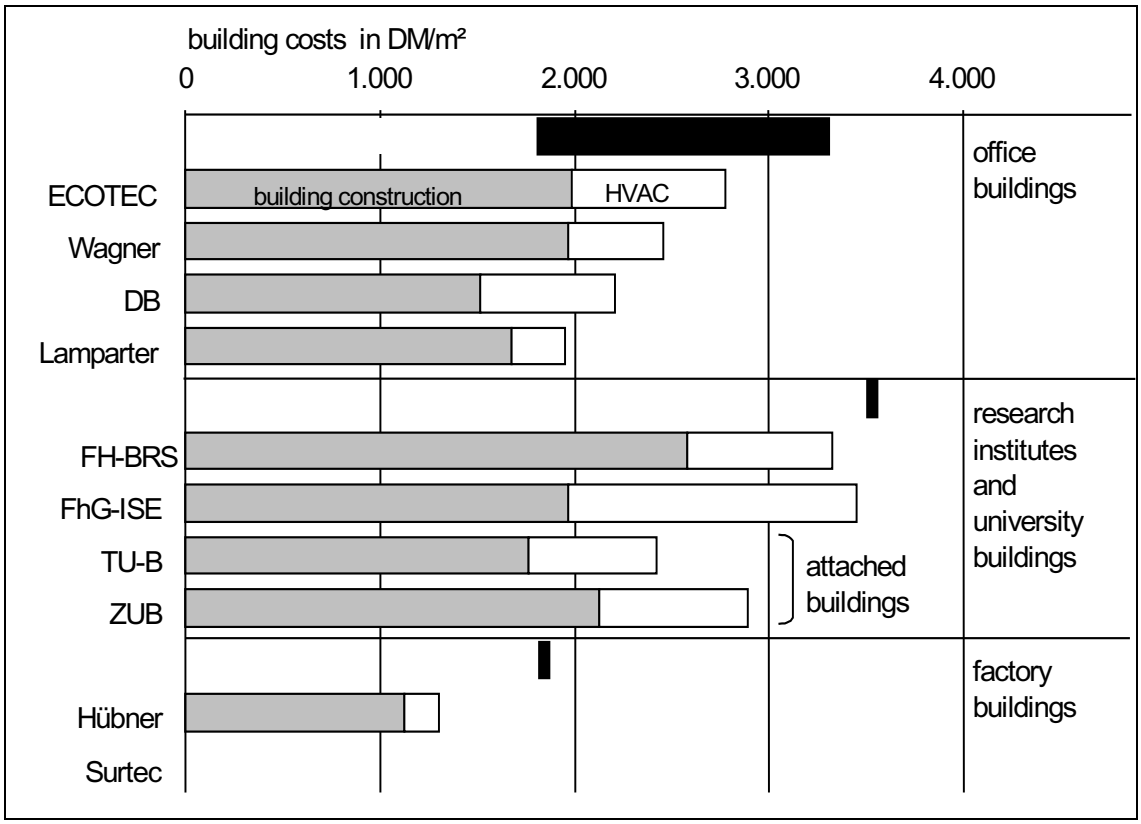

Fig. 1 Investment costs incl. tax per net floor area for construction and HVAC system, excluding planning and site costs. Black bar: Range of reference costs for conventional building practice, Germany (BKI99), Ref.: [10]

DISCUSSION OF THE RESULTS

With regard to energy consumption, data acquisition started recently. First results show that the anticipated limits can be met without significant additional costs. However the program has not yet been finished and an advanced standard for energy consumption in commercial buildings is going to be established. The positive public response, which has led to first emulations, confirms the program's objectives. As a consequence, in future projects it will not be necessary to fund the construction phases in the same way because the standards and methods of SolarBau are well accepted.

The present results, half-way through SolarBau's project period, exceed expectations by far and promise significantly reduced energy consumption of commercial buildings down to about one fifth of the present average value. However, it does not suffice to know how to construct such buildings. They have to be built, critically compared with conventional buildings, well-documented, the experiences made-use of in planning and building practices and, last but not least, disseminated in training and further-education programs for planners and architects.

GERMANY:
WIND POWER FOR GRID CONNECTION
"250 MW WIND“-PROGRAMME

Introduction

The German government has been promoting the deployment and development of wind energy for several decades. One of its most important strategic measures for the promotion of wind energy technology is the "250 MW Wind“-programme for Germany. The programme was started in 1989, the closing date is scheduled for 2006.

The "250 MW Wind" funding programme (initially the "100 MW Wind"-programme) was first published in the Bundesanzeiger in June 1989. Because of the great demand, and the reunification of Germany, the funding programme was expanded to a total of 250 MW in 1991. This figure refers to the standard power from wind turbines at a wind speed of 10 m/s. At the end of 1996, when the target total power of 250 MW had been reached, the contracting phase of the project was completed. The present total support capacity is in fact about 350 MW regarding the rated power given by each manufacturer as this usually corresponds to maximum power at higher wind-speeds. This capacity has been attained with a total of about 1,500 wind turbines included in the programme.

The "250 MW Wind“-programme is designed to acquire statistically relevant performance data concerning the practical operation of wind turbines in the Federal Republic of Germany. An outstanding feature of the programme is the accompanying measuring programme with the objective of acquiring and evaluating performance data from all wind turbines supported in the "250 MW Wind“-programme over a ten year period. The technological and scientific areas of this supportive measure WMEP11 are being implemented by ISET12 in Kassel.

Objectives of the Programme

According to the announcement in the Bundesanzeiger, the main policy objective of the "250 MW Wind“-programme was to increase the deployment of wind power in Germany and to obtain statistically verifiable data from the practical operation of wind turbines in the Federal Republic of Germany. Over a period of ten years, wind turbines from a large number of different manufacturers were to be funded and tested at various locations and for a variety

[11] WMEP: Wissenschaftliches Meß- und Evaluierungsprogramm – Scientific Measurement and Evaluation Programme

[12] ISET: Institut für Solare Energieversorgungstechnik – Institute for Solar Energy Supply Technology

of applications. The continuous evaluation and publication of the results of this programme would support the further development of wind energy technology and its integration in the German energy supply.

In combination with other governmental strategic plans and programmes the "250 MW - Wind“-programme can be seen as one module among many measures with the goals

- to conserve limited resources
- to improve the security of the German energy supply
- to protect the environment and the climate
- to increase the share of electricity generation from renewable energy sources in the national energy balance and
- to strengthen the position of the German energy technology industry in international competition.

However, the government did not specify targets to achieve a defined wind power capacity or share of electricity supply within a fixed time scale. The principle motivations and specific goals of the funding measure were

- the stimulation of commercial manufacturing facilities for the series production of wind turbines,
- the further development of turbine technology,
- the improvement of efficiency and economic aspects and
- the foundation of an inland wind energy market which did not exist before 1990.

Barriers addressed by the programme were the acceptance by the public of an increasing density of wind power installations in certain areas and the identification of possible environmental problems, such as land-use and noise.

Process of definition/design of the programme

In 1988 the "100 MW Wind“-programme started with the commissioning of the expert study “Experimental Programme Wind” by the former Federal Ministry for Research and Technology (BMFT) represented by the Research Centre Jülich – BEO –. The study was awarded to the German consultant “Fichtner Development Engineering”. The main objectives of this study were

- to verify the demand for a broad “Experimental programme wind energy” of the order of magnitude of 100 MW_{el} ,
- to examine whether such a programme could deliver findings for research and development to justify financing with funds of BMFT,
- to define targets for research and development,
- to define the strategies to reach the targets as quickly as possible,
- to propose administrative and organisational measures for the implementation and
- to make a rough estimate of the financial means which had to be provided.

This expert study recommended certain strategies for the implementation which were included in the final definition of the programme. These strategies refer to the:

- **assessment basis:** The promotion targets for an efficient and trouble-free operation of wind turbines based on the consideration of the combination of the amount of funding with the electricity produced. Since the operators have a strong motivation to maximise the energy yield they will carefully select efficient turbines and sites and will make an effort to achieve a trouble-free turbine operation. Since the annual fund transactions are designed as payment in arrears the operators obligation to report can be ensured over the whole term of validity of the promotion campaign.
- **quota of encouragement:** Based on model calculations of economic viability under relevant conditions regarding lifetime, interest rates, efficiency, O&M costs, and average electricity feed-in conditions, the promotion was decided to be 0.08 DEM/kWh as an operational cost grant for commercial operators. Non-commercial operators had a choice between the operational cost grant or a value-equivalent investment grant in order to minimise the risk of loss of one's livelihood and to stimulate an additional demand.
- **duration and general conditions:** The duration for observation was fixed to a ten year period in order to retrieve reliable information concerning lifetime, operational performance, and costs. The implementation phase was planned to spread over five years in order to allow for capacity limits of the manufacturers. The total running time of the programme thus resulted in 15 years. The general conditions which the turbines in the experimental programme had to meet were related to approval by authority, for instance statics and noise.

The Federal Ministry for Research and Technology advertised for bids for the experimental programme “100 MW Wind” on June 6th, 1989. As a result of the enormous response, BMBF increased the capacity from 100 to 250 MW in February 1991. Over the years, several modifications were made to adapt to changes in the relevant legislation, e. g. the Electricity Feed Law (EFL)[13]. The last amendment was published in February 1994. The deadline for bids was December 1995 and the last turbine started operation in 1998. Almost 1600 turbines with 350 MW rated power have been supported in the experimental programme "100/250 MW Wind“-programme.

Main actors and their roles

The implementation of the "250 MW Wind“-programme and its accompanying “Scientific Measurement and Evaluation Programme” was carried out by three major players, namely:

- The Federal Ministry for Research and Development (BMFT, 1989-1994) and its successors Federal Ministry for Education, Science, Research and Technology (BMBF 1994-1998) and the Federal Ministry of Economics and Technology (BMWi, since 1998),
- The Project Management Organisation BEO from Jülich Research Centre, and

[13] Stromeinspeisungsgesetz, in force from January 1st, 1991 until March 30th,2000

- the Institute for Solar Energy Supply Technology (ISET) in Kassel.

The other relevant players in the programme can be identified as

- investors and turbine operators e. g. private individuals, farmers, communities, commercial companies, utilities., as well as
- turbine manufacturers.

The experimental programme "100/250 MW Wind“ was implemented by the Project Management Organisation BEO (Jülich Research Centre) acting on behalf of the Federal Ministry of Economics and Technology and its predecessors. The “Scientific Measurement and Evaluation Programme” (WMEP)[14] is being carried out by ISET in a contract with the Jülich Research Centre. There is a strong interaction between operators and ISET which acts as an “interface” to the Research Centre Jülich and the Federal Ministry.

Policy mechanisms used

The aim of the policy measure was to implement a broad experimental programme which would supplement the existing demonstration programmes of the European Union, the German Ministry responsible for energy research and some federal states. The funding procedure was based on a combination of a broad and long term R&D-programme for new wind turbine installations, in order to solve the remaining problems concerning material fatigue, subsystem interactions etc., together with strategies aimed at bringing wind technology onto the market.

The main tactical implementation concepts were a combination of

- subsidies for operators instead of manufacturers,
- support for the energy produced instead of installed capacity,
- an obligation of the operators to report continually on operating results and to collaborate in the evaluation programme,
- motivation for a continuous participation in the complete evaluation process (10 years) by making the cash flow dependent on participation,
- general acceptance of the accumulation of different promotion sources such as additional state investment subsidies, and
- admittance of access of operators to special loans of the Deutsche Ausgleichsbank (DtA) with reduced interest rates for loans. The DtA is a “wholly-owned development agency of the German federal government” that, among other activities, supports environmental protection projects.

The financial support for the "250 MW Wind“-programme came from the Federal research budget. The actual subsidy for operators in the "250 MW Wind“-programme is DEM 0.06 or 0.08 per kilowatt-hour, depending on whether the electricity is fed into the grid or is being used by the owner of the wind turbines himself. The grants are limited to a maximum of 25 percent of the turbine costs. Alternatively non-commercial operators had the option to choose an investment subsidy limited to a maximum of 90,000 DEM. The support of the

[14] WMEP: Wissenschaftliches Meß- und Evaluierungsprogramm

"250 MW Wind“-programme is granted in addition to the tariffs paid by the utilities under the Electricity Feed Law (January 1991 until March 2000, table) or the Renewable Energy Law (since April 2000).

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
EFL-tariff [DEM/kWh]	0.1661	0.1653	0.1657	0.1693	0.1728	0.1721	0.1715	0.1679	0.1652	0.1613

Table: Annual rates of the EFL from 1991 until March 2000

The Renewable Energy Law which fixes the initial compensation rate to 0.178 DEM/kWh for a five year minimum period has been in force since April, 1st 2000. A prolongation of the initial compensation rate will depend on each turbine individually according to a turbine specific reference yield at a reference site.

The funding measure was limited to a total installation capacity of 250 MW, related to a wind speed of 10 m/sec. This corresponds to a total rated capacity of 360 MW. The amount of financial appropriation is estimated to total about 320 million DEM to be spent by the Federal Government before 2006. This does not include the costs for the additional measurement programme WMEP of about 50 million DEM.

The "250 MW Wind“-programme can be considered as an important element of the wind energy success story in Germany. As a result of the subsidies granted in the frame of the programme and the national Electricity Feed Law, the total specific investment costs of wind turbines could be lowered to about 1,700 DEM/kW in the year 2000. The specific electricity generation from wind has increased to an annual mean value of about 2000 full load hours (kWh/kW).

Expectations have been surpassed almost by a factor of four with regard to the capacity installed in 1996, to the market stimulation achieved, and with respect to the total electricity contribution of wind power to the demand of the whole country. Meanwhile the inland trade of wind turbines is developing completely independently of the "250 MW Wind“-programme. The installed wind power capacity in Germany surpassed the 5,000 MW level in June 2000 and contributes with approximately 10 TWh per year. The overall availability of the turbines exceeds 98 %. The Electricity Feed Law has contributed significantly to this success and is now in its revised form – the Renewable Energy Law (EEG) – a driving force for investors.

Wind electricity generation has increased from about 0 % in 1989 to almost 2 percent of the net electricity consumption of Germany in 2000. Regionally, for instance in the Federal state of Schleswig-Holstein, the share of wind energy is about 15 percent of the electricity demand with an overall aim to reach 25 percent contribution by 2010. This impressive development was achieved as a result of the stimulation of wind power deployment by the "250 MW Wind“-programme, the competition between several manufacturers on the market and the fact that wind turbines can be operated profitably. The export of wind turbines from German manufacturers has increased continuously to about 10 percent as a result of its success on the domestic market as well as the good reputation of these proven technologies. The deployment of wind energy in Germany is also having an impressive effect on

employment. The "250 MW Wind“-programme has helped to create jobs. It is estimated that today the wind power industry accounts for about 15,000 jobs in Germany.

However, with increasing deployment of wind turbines in Germany, the awareness of environmental effects such as land use, noise and effects on the landscape has increased in parts of the population. Thus the acceptance of new projects is inhibited in areas of already high market penetration.

Monitoring and evaluation process

The "250 MW Wind“-programme is designed to acquire statistically relevant data concerning the practical operation of wind turbines in Germany. Therefore an intensive evaluation programme was prepared during the planning phase of the main programme. The technological and scientific areas of this supportive measure, the “Wissenschaftliche Meß- und Evaluierungsprogramm” (WMEP), are being implemented by the Institut für Solare Energie-versorgungstechnik (ISET) in Kassel. The WMEP is collecting and evaluating performance data from all funded wind turbines over a ten year period. The following areas are the main focal points of this evaluation:

- wind resources, e.g. local and regional distribution of wind resources in Germany, wind conditions at specific sites,
- turbine performance, e.g. energy production and consumption of wind turbines, periods of grid interconnection, periods of full and partial load, performance characteristics,
- reliability, e.g. technical availability, causes of faults, bad performance, component breakdowns, and
- economic aspects, e.g. income through the operation of the WT, costs related to maintenance, repair and insurance.

As a funding condition, participants in the programme are required to keep a log book for each funded turbine and to record information on:

- basic technical data concerning each turbine, method of grid connection, topography of the site etc.,
- energy production and consumption, the acquisition of monthly figures through regular readings of calibrated electricity meters,
- malfunctions, repair and maintenance: these are reported on form sheets which are submitted to the central processing division after each occurrence,
- operating costs: fixed costs for maintenance contracts, insurance and other costs are documented.

The main actors in the monitoring and evaluation process are ISET and the Research Centre Jülich. The amount of administrative work required, the recording equipment used and the long distances between plant sites in Germany, make the support of local contractors necessary. The success of the project is being helped by four institutes acting as subcontractors with their expertise in the field of wind energy. They supervise the on-site installation and operation of the measuring equipment and help the operators to keep their log books. They are:

- Deutsches Windenergie-Institut GmbH, Wilhelmshaven, in Lower-Saxony and Bremen,
- Wind-consult GmbH, Bargeshagen, in the eastern states,
- Windtest Kaiser-Wilhelm-Koog GmbH, Kaiser-Wilhelm-Koog, in Hamburg and Schleswig-Holstein and
- Institut für Elektrische Energietechnik, Universität Gesamthochschule Kassel, in the remaining states.

There is intensive and continuous communication between all partners involved in the project during all phases.

The installation phase is supervised by ISET and its subcontractors in order to verify that the proposer has installed exactly the turbines for which he had made an application and which have been approved with regard to site, type of machine, rated power, rotor diameter and hub height as well as the correct installation of the necessary additional equipment such as calibrated electricity meters and stipulated interfaces for the measuring equipment. ISET reports regularly on the process.

ISET controls the delivery of quarterly reports. If necessary ISET admonishes belated operators with their liability to submit documents.

The subcontractors verify sporadically the meter readings of the operators. The Research Centre Jülich crosschecks with ISET the accuracy of statements from the operators prior to authorisation of the payments of subsidies to the operators.

Discussion of results

The accompanying measurement programme is a very helpful tool for the evaluation of the results of the programme. The following major results have been observed:

- an overall improvement of the state of the art in wind energy technology,
- an increase of the availability of wind turbines in Germany up to 98%,
- a gain of relevant know-how on maintenance and operating hours,
- the issue of public acceptance could be discussed “on site”,
- the programme made a major contribution to the international break-through of wind power.

In addition, the Electricity Feed Law, garanteeing specific minimum prices for electricity generated from renewable energy including wind power, was very helpful towards the success of the programme.

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CS 8

Photovoltaic Power Generation Systems (from R&D to deployment)

Introduction

Japan has been implementing Research and Development (R&D) and Deployment Programs of Photovoltaic (PV) Power Generation Systems. The R&D Program initially started in 1974 as a part of the "Sunshine Project," launched to develop oil-alternative energy after the oil crisis in 1973. It has been under the direction of the "New Sunshine Program (NSS)" since 1993 and continues today as PV systems have arisen as a solution for global environmental issues.
The R&D Program has resulted in reducing PV system cost, consequently, contributing to the Deployment Program for full-scale promotion early on. Legal preparations, technological standards preparations and subsidy programs establishment are under way.
So far, the Programs have taken Japan to the largest PV installed capacity in the world. Therefore, the Programs should be included here as a lesson for other countries which aspire to the same mission.

Objectives of the program

Japan's energy supply such as crude oil and coal depends largely on imports from abroad. The supply of crude oil is actually 100% imported. Our objective of new and clean energy development and deployment is to reduce these dependencies and to diversify energy resources as well as to solve global environmental issues.
Japan has revised "The Long-term Energy Supply/Demand Outlook" in June 1998, which set a target for new energy installed capacity with the target for PV of 5000MW by the end of 2010.

The major barrier to PV diffusion is the high cost. The generation cost of PV systems for residences, the major market, is approximately JY81/kWh, three times as expensive as that of electric power companies at approximately JY24/kWh. Therefore, in order to achieve mass production, PV cost needs to be at least competitive with conventional electric power cost by developing technology and establishing large markets in parallel.

Process of definition/design of the program

Since the R&D and Deployment Programs are under the direction of separate agencies, each Program's targets and processes are separated as follows:

1) Overall target

The overall target of the Programs is to install PV capacity of 5000MW by 2010. This target was set in the Long-term Energy Supply/Demand Outlook and the Oil-alternative Energy Supply in June 1998, by the Advisory Committee for Energy, a Minister's advisory

committee consisting of representatives from academia, research institutes, mass media, energy-related organizations and consumers.

2) R&D Program

The target of the core R&D project called “Development of Technology for Practical Application of Photovoltaic Power Generation Systems” is to realize PV prime cost of JY140/W (at 100MW production) by the end of FY2000. This target was set in the Master Plan by the Industrial Technology Council, a Minister’s advisory committee consisting of representatives from academia, research institutes, mass media and energy-related organizations.

3) Deployment Program

The target of the Deployment Program is the establishment of a new PV market and demonstration of system endurance. Projects are planned and designed following a formal hearing involving the suppliers such as solar cell manufacturers, housing manufacturers and related organizations. While carrying out the project, requests and opinions from consumers such as individuals, private companies and local governments are fed back, following which the project is flexibly modified.

Main actors and their roles

The chief director of the Programs is the Ministry of International Trade and Industry (MITI) of Japan, which conducts national energy policy and industrial technology policy. The main actors and their roles for each Program are as follows:

1) R&D Program

The New Sunshine Program Headquarters in the Agency of Industrial Science and Technology is in charge of long-term planning, budget compilation and overall coordination of R&D. R&D affairs are actually conducted by the New Energy and Industrial Technology Development Organization (NEDO), which consigns projects to the private sector and cooperates with universities and research institutes. The private sector has organized the Photovoltaic Power Generation Technology Research Association (PVTEC) to carry out cooperative R&D. The national research institutes conduct basic and applied technology R&D.

2) Deployment Program

The New Energy Policy Division, Coal and New Energy Department of the Agency of Natural Resources and Energy, is in charge of promotional policy, budget compilation and overall coordination of deployment. The New Energy Foundation (NEF) carries out subsidy programs for residences, the major deployment field, while NEDO conducts various model projects and field test programs for industries and local governments. Solar cell

manufacturers and housing manufacturers have organized the Japan Photovoltaic Energy Association (JPEA) to carry out public relations and dissemination in cooperation with the government.

Policy mechanisms used

1) Overall policies

i. The Advisory Committee for Energy, a Minister's advisory committee, compiles "The Long-term Energy Supply/Demand Outlook". The present outlook was revised in June 1998 and agreed in Cabinet Council in September 1998. It targets PV installed capacity by the end of 2010 to be 5000MW.

ii. "The Law Concerning Promotion of the Development and Introduction of Alternative Energy" sets targets of oil-alternative energy installed capacity. The present target of 5000MW PV installed capacity was agreed in Cabinet Council in September 1998, following the revision of the "Long-term Energy Supply/Demand Outlook."

iii. "The Law Concerning Promotion of the Use of New Energy" was enacted in June 1997. It prescribes the basic policies on new energy use including PV, the guideline on new energy utilization, and the financial support measures for businesses, which use new energy.

iv. "The Guideline for Promotion of Efforts to Prevent Global Warming" was devised in June 1998 following COP3. It considers PV as an urgent energy supply/demand provision for the 2010 target of CO_2 emissions reduction.

2) R&D Program

The R&D program budget is 100% borne by the government (private expenses are exceptional). The government provides official subsidies to NEDO for its expenses, while NEDO conducts and consigns the R&D operations to the private sector and universities.

i. Development of Technology for Practical Application of Photovoltaic Power Generation Systems (since FY1974-, covered 100% by official budget, BJY7.28 for FY2000)

Objectives:

For solar cell manufacturing technology, in order to reduce solar cell cost, thin-film solar cells (amorphous silicon, CdTe, CIS, thin-film polycrystalline silicon solar cells, etc.) have been under development. Target for manufacturing prime cost by FY2000 is JY140/W (at

100MW production). In parallel with this, for system technology, hardware such as architecturally-integrated PV modules, as well as software such as solar cell and system evaluation technology, and grid-connection technology for mass production is also under development.

ii. Development of a Low-energy Consumption Manufacturing Process for Solar Grade Silicon (FY1997-FY2000, 2/3 official budget and 1/3 private budget, BJY0.53 for FY2000)

Objectives:

In order to reduce the cost of Solar Grade Silicon (SOG--the raw material of thin-film polycrystalline silicon solar cells), the main product in the present market, manufacturing technology has been under development. The target by the end of FY2000 is less than JY2300/KG for feedstock and less than JY300/KG for ingot production cost by electromagnetic casting.

iii. Development of Practical Technology for High-efficiency Multicrystalline Silicon Solar Cells (FY1999-FY2002, 100% official budget, BJY0.56 for FY2000)

Objectives:

In order to increase the conversion efficiency and to reduce the cost of thin-film polycrystalline silicon solar cells, the main product in the present market, manufacturing technology has been under development. Target manufacturing prime cost by the end of FY2002 is less than JY147/W (at 100MW production). Target efficiency is more than 20%.

iv. Development of Advanced Manufacturing Technology for Photovoltaic Power Generation Systems (FY2000-FY2004, 50% official budget, BJY1.24 for FY2000)

Objectives:

In order to firm up all developed manufacturing technology for further cost reduction and mass production, collaborative projects are being carried out between private companies and NEDO with expenses shared.

3) Deployment Program

i. Field Test Project on Photovoltaic Power Generation Systems for Industrial and other Applications (since FY1998-, covered 50% by official budget, BJY4.0 for FY2000)

Objectives:

In order to demonstrate the efficacy of PV systems and to standardize and adapt the PV systems for full-scale and diverse promotion, collaborative demonstration projects between

private companies, local governments and other organizations' PV owners and NEDO have been carried out with expenses (1/2 respectively) shared.

ii. Subsidy Program for Residential Photovoltaic Power Generation Systems (FY1997-, JY180,000/kW official budget since September 2000, with the remainder borne by the applicant, BJY14.5 for FY2000)

Objectives:

In order to promote PV systems full-scale, to reduce cost further and to establish a sustainable PV market, the subsidy program for individual PV owners is conducted intensively over a fixed period by NEF.

iii. Local Introduction of New Energy Promotion Project (FY1997-, 50% official budget—out of a total FY2000 budget of BJY6.43 for renewable energy)

Objectives:

In order to accelerate the promotion of the use of new energy-saving technology, the subsidy project is conducted by NEDO for local governments which carry out such activities.

vi. New Energy Enterprises Support Project (FY1997-, 33% official budget-out of a total FY2000 budget of BJY11.49 for renewable energy)

Objectives:

In order to support enterprises which use new energies, NEDO subsidizes 33% of its expenses.

Monitoring and evaluation process

1) R&D Program

i. Monitoring process

The Master Plan for the R&D Program under the Agency of Industrial Science and Technology is scheduled and evaluated by the Industrial Technology Council.

For example, the "Development of Technology for Practical Application of Photovoltaic Power Generation Systems" experiences interim evaluations every three or four years. The results are evaluated and the ensuing schedule is revised if necessary.

On the other hand, it has been a trend for governmental programs to go through rigid evaluation. Consequently, no longer does the Industrial Technology Council direct both scheduling and evaluations, an evaluation council has recently been established especially for evaluations. Under the evaluation council, Subcommittees consisting of neutral experts from academia, the technological field and the mass media are organized for each project. The final evaluation of the results and a decision on project

continuation are made. In the case of continuation, the Master Plan is rescheduled based on their remarks.

ii. Evaluation contents

Evaluations are made on the following items:

A. Project design and operation

- Objective
  - adequacy of the technology research items for project policy
  - flexibility of the project depending on the national/international situation
  - accuracy of the possibility of technological application
  - accuracy of understanding of related technology trends
- Target
  - validity of the target index
  - adequacy of the target (including budget, duration)
- Schedule
  - adequacy of the schedule, investigation
  - adequacy of R&D items to achieve the target
  - flexibility of schedule modification
- Necessity for governmental participation
  - clarification of reasons why the government needs to participate
- R&D operation structure
  - sufficiency of the cooperative structure among industry, academia and the government
  - leadership ability of project leaders

B. Project results

Evaluations of the project on the whole and each elemental technology are made on the following items:

- Specific achievements
  - sufficiency of the achievement in the context of the objective/aim and the target
  - significance of the achievement (world leader, international contribution, originality, etc.)
- Application, promotion, public relations

- adequacy of the application outlook after the project is concluded
- clear technical target for application
- potentiality for ripple effect on various fields
- pending patents
- sufficiency of public relations (to experts and the general public)

2) Deployment Program

Mainly the Agency of Natural Resources and Energy and the Advisory Committee for Energy conduct the Deployment Program. Until recently, new energy programs were evaluated in general, not in details of each energy category or project. However, as environmental issues pose elusive solutions such as at COP3, and new energies including PV face great anticipation, the New Energy Committee was organized in December 1998 under the Advisory Committee for Energy. It counsels on promotional trends in each new energy, policy streams, future policies, international positions and so on. At present, it provides counseling on promotional policies, including previous situations and effects, from which it will form future policies by the summer of FY2001.

Discussion of results

1) Overall discussion

The overall target of the R&D and Deployment Programs in Japan is PV installed capacity of 5000MW by the end of FY2010. Therefore, the final results will not be apparent till that time. Currently, installed capacity seems to be growing every year.

The significant feature of the Programs is not the prominent amount of the official budget, but the preparation for future mass deployment following achievement of the target. Approximately 200MW was installed by the end of FY1999. Especially in the residential market field, over ten thousand units have been installed annually with the help of subsidies. It is not impossible to see that residential PV systems will someday become conventional.

Participation of the average citizen, who has seemed to be quite passive towards energy issues, will be a great force in other new energy projects, too. In addition, cooperation among the government, solar cell manufacturers, housing manufacturers and electric power companies is indispensable in deploying PV systems. Their teamwork is one of the key factors of achievements in Japan.

The target of 5000MW PV installed capacity is not the goal but a target in the process. It still does not compare when converted to oil supply (1220kl) nor CO_2-emissions reduction (1600t). Further deployment of several more MW will be targeted in the future. Although the official target capacity has not yet been published, the government has been taking into consideration future perspectives and projects.

2) Program discussion

i. R&D Program

The R&D Program, including “Development of Technology for Practical Application of Photovoltaic Power Generation Systems” and others, has been achieving world-leading results. The factors of this success are:

- as the government plans and directs the long-term R&D scheme continuously and consistently, the talents from the private sector, universities and national institutes can be gathered to engage in their respective research
- a sufficient official budget (largest in the world) covers the R&D projects
- projects are evaluated appropriately, and flexibly modified

Not every project has been successful. The factors of failures include:

- several technologies were adapted to develop one solar cell, which were too advanced or improbable (inadequacy of the technology theme)
- some companies and researchers could not maintain their motivation in the long-term scheme (lack of motivation)

Since the R&D Program is now being contributing to the Deployment Program, private sector participants are facing the decision whether or not they should adopt PV technology for future business. Some of them have decided to withdraw. Consequently, the government has taken into consideration maximizing the adequacy of both the technology scheme selection as well as the budgetary focus.

Moreover, present technology is applicable to residences (competitive generation cost for residential purchase), but not advanced enough for industries and the electric power business. Therefore, in order to be applied to the electric power business, innovative and low-cost solar cells are to be developed in the future.

ii. Deployment Program

The most successful Deployment Program in Japan is the “Residential Photovoltaic Power Generation System Monitoring Program,” which reflects the characteristics of Japan’s Programs.

In Japan where electricity is distributed throughout the country and supplied steadily while a blackout is rare, the determinant of electricity selection is the price. Therefore, at the first stage of the Deployment Program when support was essential to encourage such expensive PV systems be deployed, subsidy programs were the means to establish the new market.

The “Residential Photovoltaic Power Generation System Monitoring Program” materialized in FY1994. Since then, PV installed capacity has increased rapidly, and 17 thousand applicants were accepted in FY1999. The factors of its success are:

- economies of scale; private companies increased their production, the PV system price decreased, the market was expanded (JY3.6M/kW approx. in FY1993 →JY0.93M/kW in FY1999)
- surplus electricity purchase system by electric power companies with equivalent surplus and demand power prices materialized

- increased awareness of environmental issues; expense is still high even with subsidies for general consumers
- architecturally-integrated PV modules have been licensed as architectural materials by the Building Standard Law, facilitating sales by housing manufacturers

On the other hand, the drawbacks of this program are:

- the businesses by solar cell manufacturers and housing manufacturers have been assured by subsidies, resulting in a market size that depends on the amount of the subsidies
- the amount of subsidy was fixed during the first stage, and the system price bottomed-out as a result (subsidy is now at a fixed rate per kW)

In this fiscal year, the number of applicants for this program exceeded the number of prospects. This program will end in FY2002. A sustainable residential PV market without subsidies is the key issue to further deployment.

Deployment of High Efficiency Heat Recovery for Domestic Ventilation in the Netherlands

1. Introduction

Dwellings represent about 25-30% of all energy used in OECD countries. Energy losses due to ventilation will increase in the near future up to 10% of the total energy use (lit 1). In energy efficient dwellings energy losses for ventilation, infiltration and support energy (fans etc.) can account for more than 40% of the total energy use of dwellings. New innovative energy efficient ventilation technologies could give an important contribution to decrease energy use in the residential sector. To realise the Dutch governments policies on energy use in the built environment the Energy Performance Standard (EPN; NEN 5128, lit 2) is introduced in 1995. This standard concerns the integral energy-efficiency of buildings, including energy use for heating, DHW, fans, cooling, lighting and humidification. As ventilation and air tight building have a substantial influence in the EPN it is expected that Mechanical Ventilation with Heat Recovery (MVHR) will play a major role in energy-efficiency concepts for houses, complying with the required Energy Performance Coefficient. Application of MVHR was not only expected to give a contribution in decreasing (mechanical) ventilation losses. It is also a prerequisite for increasing the air tightness of dwellings as MVHR ensures a continuously ventilation.

In order to achieve a substantial market penetration as well as a market acceptation a strategy plan was drawn up by Novem for a broad implementation program for MVHR. This strategy led to an increase of the market penetration of MVHR from less then 1% in 1995 to 10% in 1999 (new built houses). For 2000 a market share is expected of at least 15%.

2. Objectives of the program

2.1. Background

The introduction of MVHR for the residential sector in the Netherlands took place in the early eighties. The first step was a research, followed by a report, on the application of MVHR in Dutch houses. NEOM (the formal Netherlands Organisation for Energy and the Environment, now Novem), started a large scale market introduction in the mid-eighties, accompanied by several demonstration projects, monitoring and supporting researches. Despite these efforts the market penetration of MVHR still was less then 1%. In 1993 a market survey took place on the decision making of application of domestic ventilation systems and, particularly, the application of MVHR (lit. 3).
In general, the main conclusions of this market survey were:

- MVHR has a bad image, due to problems caused by lack of quality. This lack of quality and the absence of a market acceptation were the main barriers for a larger market introduction of MVHR. Lack of quality displays on several aspects: design, execution, quality of components, maintenance etc.
- Building regulations and (initial) costs are dominant decision factors for the selection of ventilation systems.

2.2. Strategy plan and objectives

To encounter these problems and barriers for further application and market acceptation Novem drew up a strategy plan in 1995. This plan included:

- strategies and actions for quality improvement:
  - on process level
  - on component level
- embedding of MVHR in building regulations i.e. in the Energy Performance Standard
- promotion and information to market parties (principals, builders, installers, consumers)

In table 1 a summary is given of the strategy plan with objectives for a number of identified barriers, distributed in three general actions.

General Actions ⇒ **Barriers ⇓**	**1. Dissemination**	**2. Quality Improvement**	**3. Embedding**
1. Building regulations	1.1 Emphasising role of MVHR in Building reg's	1.2 Stimulation of developments for further limiation of energy use for ventilation: - development of high efficiency heat recovery - deployment of DC	1.3 Review of NEN 5128: 1995 on rewarding heat recovery Linking limiting air tightness with MVHR Release of NEN 5138
2. Bad image and (lack of) aquintance with MVHR	2.1 Foundation for High Effiency Ventilation (Stichting HR-ventilatie) Release of brochure with MVHR success storiezs Occupants instructions	2.2 QA document ISSO 61: Quality requirements for domestic ventilation systems Certification of installers	
3. Costs	3.1 Costs for ventilation expressed as LCC: task in IEA Annex 27	3.2 Fixed prices	3.3 Grants for MVHR

3. Design of the program

3.1. Dissemination

Promotion and information to market parties

One of the most important actions in the Novem strategy plan was the streamlining of information and promotion activities by the founding of the "Stichting HR-Ventilatie" (Foundation for High-Efficiency Ventilation). In the chapter 4 their role is further explained. (action 2.1)

Expressing costs for ventilation as LCC

Initial costs are a dominant decision factor for the selection of ventilation systems. However life cycle costs, including operating, energy and maintenance costs have a much bigger influence in the total costs during the lifetime of a building. Within IEA Annex 27 "Demonstration and Evaluation of Domestic Ventilation Systems a model to establish life cycle costs has been developed. In this model LCC is linked with a model for determining the reliability of ventilation systems as function of the basic quality and level of maintenance. It also includes costs for non-scheduled maintenance due to ventilation related damage to the building (lit. 5). (action 3.1)

Fixed prices

Although this was one of the objectives in the strategy plans and supporting activities in this field are organised (certification of installers, foundation for high efficiency ventilation) no

progress was made in this field. This objective was not adopted by the supply side of the market. (action 3.2)

Grants
In 2000 grants are given for high efficiency MVHR in existing dwellings (HFL 400,-- per unit, including 2 DC fans). For new dwellings MVHR is an important measure and a well-accepted technology to realise the demanded Energy Performance Coefficient. For that reason grants are considered not to be necessary to stimulate a further market introduction. (action 3.3)

3.2. Quality improvement

Quality improvement on process level
To improve and to ensure the total quality of ventilation systems a method is developed (Model quality Assurance - MQA) to realise and guard this total process. The primary objective of the process of realisation of a ventilation system (or a climate installation in general) is to build an installation that meets the Terms of Reference with respect to indoor climate, energy consumption and cost. To this effect design guidelines will have to be followed and tests will have to be carried out.
The model quality Assurance (MQA) system makes it possible to obtain a clear cut view of a climate installation during the process of realisation, so that it becomes clear what requirements will have to be met and which design guidelines, communication and tests will have to be carried out. Figure 1. schematically represents the MQA.

Management Aspect	**Realisation process climate installation**				
	1. programme	2. design	3. work out	4 realisation	5 management
0. general					
1. organisation					
2. communication					
3. requirements					
4. means					
5. buy					
6 time					
7. financial					
8. realisation					
9. experience					

This MQA is developed for ventilation systems in a publication (ISSO 61; lit.3) and is used by the Dutch Installers Branch (VNI) for process certification (action 2.2).

Quality improvement on component level

Development and introduction of counter flow heat exchangers:

In 1996 the Dutch ventilation industry started to develop a new type of MVHR units. These heat recovery units were based on the application of counter flow heat exchangers. In general from a thermodynamic point of view a laminar heat exchange is the best solution for heat exchangers (Bejan 1982). One stipulation is that the distance of the flux is small. The distance between the heart of the warm and cold flow must be as small as possible either the contact surface area must be maximal. Triangular or rectangular parallel canals with a counter flow cope with these conditions. In relation to turbulent flows as in cross flow heat exchangers the efficiency of laminar flows is much higher. Theoretically an efficiency of 100 % is possible. The laminar canal heat exchanger has the distinction with other types of laminar exchangers that the canals for both media have the same shape and that every canal wall for one medium is also the wall for the other medium. The ratio wall to canal volume is maximal.

One of the main difficulties was the connection of the canals with the collection canals. This problem is solved by making the connection in two steps:

1. Re-organising canals by replacing every uneven column one canal-height vertically thus introducing rows with alternating supply and exhaust flows;
2. Omitting the walls closing the flow direction left and for the other right and so on.

By applying this principle it is possible to produce laminar counter flow heat exchangers in mass production at relative low costs.

Application of counter flow heat recovery is not only initiated because of the energy benefits. The efficiency of 90% results in a relatively high supply temperature (17^0C at outdoor temperature of -10^0C). This gives an improvement of the thermal comfort and reheating of the supplied air is not necessary. This also means that low induction inlet grilles can be used. This prevents problems with noise and dust deposit. The first prototype laminar counter flow heat exchanger was introduced in 1996 in a configuration with DC fans to minimise the electric support energy for fans. In 1998 the Dutch Ventilation Industry launched the counter flow heat recovery units on the market. (action 2.1)

Deployment of DC fans:

Not only ventilation losses have to be taken into account also the support energy, needed for fans, is important. DC fans have a higher efficiency then the traditional AC fans especially in cases of lowering the air flows. In general electricity use for fans can be reduced by 50% using DC fans instead of AC fans. Although the principle of DC technology for fans was known for years application for domestic ventilation was not common because of the extra costs for DC fans. Now the Dutch EPN also takes into account fan energy (and DC fans are rewarded in the calculations) DC fans are introduced for domestic application. All High Efficiency MVHR units have DC fans, not only for minimising electricity use but also for improved controllability of fans. (action 2.1)

3.3. Embedding

Embedding of MVHR in building regulations

MVHR is rewarded in the Dutch Energy Performance Standard NEN 5128: 1998.

To enable standardised measurements for heat recovery efficiency and total energy performances of heat recovery units Dutch Standard NEN 5138 is released. This standard is comparable with EN 308.

In chapter 5 this is further explained. (action 3.1.)

4. Main actors and their roles

The main actor for the implementation of high efficiency heat recovery in the Netherlands was Novem. In the eighties Novem (then under the name NEOM) conducted demonstration programmes and several supporting researches. In 1995 Novem initiated a strategy plan for a further market introduction and market acceptation. In 1996 the Foundation for High efficiency ventilation was established, initiated by Novem and the Dutch Ventilation Industry. The objectives and mission of the foundation is to promote a good and healthy indoor environment as well as energy efficiency by the use of balanced ventilation with heat recovery. The foundation tries to achieve this goal by giving independent and objective information, development and stimulation of market introduction of energy efficient ventilation systems.

The benefits of this foundation is that all information about MVHR is streamlined and objective. There is one organisation as counterpart for policymakers, standardisation bodies, other market parties etc. Beside six industrial parties also Novem, the Dutch Installers Branch Organisation (VNI), Gasunie and Intechnium (educational institute for installers) are members of the Foundation.

Since their establishment all major activities for communication, dissemination, quality improvement and product development are co-ordinated by the Foundation for High Efficiency Ventilation. The annual budget is approximately 200 kEuro.

5. Policy mechanisms used

MVHR in building regulations:

Building regulations in the Netherlands are given in the so-called Building Decree. The Building Decree has four parts:

- Safety
- Health
- Usefulness
- Energy

Every regulation must “fit in” in one these starting points. Two very important aspects of the Building Decree are:

- Every demand or regulation is given as a performance criteria: this means there are **no** prescriptions about what kind of materials should be used or thickness of etc. etc.
- One is free to arrange or divide a building or dwelling: this means that the performance criteria are given in such a way that they are independent of arrangement of rooms in

building. This also means that you can rearrange rooms in a building without getting into conflict with the building regulations.

In the chapter energy only three regulations are given. For dwellings is this in:

art. 70: Limitation of transmission losses

art. 71: Limitation of air permeability of the building envelope

art. 71a: Energy Performance of a building

Regulations on energy only apply for **new** buildings (not for existing buildings).

Most important is art. 71a Energy Performance. The energy performance is a one-number value in which the total energy performance of a building is expressed. This is called the Energy Performance Coefficient (EPC). The EPC is calculated by the so called Energy Performance Standard (NEN 5128 and NEN 2916). It contains:

- Energy use for heating, including:
    - Transmission losses
    - Ventilation and infiltration losses
    - Passive and active solar gains, internal gains
    - Efficiency and support energy for heat generation
- Energy use for DHW
- Energy use for fans
- Energy use for lighting (only non residential buildings)
- Energy use for cooling (mostly non residential buildings)
- Energy use for humidification (mostly non residential buildings)

In the building decree the demands on the Energy Performance Coefficient for all kinds of building types (residential and non residential) are given. You are free to select your own set of energy efficiency measures to cope with the required EPC. In other words you can compensate less thermal insulation with energy efficient installations (heat pumps, heat recovery) and/or sustainable energy. The energy performance standard was introduced in 1995. Ever since the EPC was sharpened in 1998 and, next, in 2000.

Energy use for ventilation is taken into account in energy use for heating (i.e. ventilation losses) and energy use for fans. Ventilation losses include three parts: infiltration, mechanical ventilation and use of ventilation provisions (grilles and windows). The mechanical air flow can be reduced by multiplying with a factor (1 – the energy efficiency). For conventional cross flow heat exchangers the energy efficiency is 65%. For cross flow heat exchangers the default value for energy efficiency is 75%. However, if the energy efficiency is determined by measurements according to standard NEN 5138 the measured efficiency can be applied. For most of the high efficiency MVHR this measured energy efficiency is 90 to 95%.

Application of MVHR allows also an increase of air tightness resulting in lower air flows due to infiltration.

Energy use of fans is taken into account separately. The default value for DC fans lead to 40% less energy use compared with AC fans. However, if you select more energy efficient DC fans, you can calculate with the real input power. This can result in 50 to 60% less energy use in the energy performance calculations.

6 Monitoring and evaluation process

6.1. Background

As the requirements on energy efficiency, reflected in the Energy Performance Coefficient, rapidly increases in the Netherlands, discussions arose on indoor environment in energy efficient houses. There is an awareness of the role of ventilation, and as a result the possible contradiction between IAQ, thermal comfort and energy use for ventilation losses. In 1999 and 2000 a programme is carried out to investigate indoor air and ventilation quality in new built energy efficient homes (i.e. complying with the latest Dutch Energy Performance Standard) with different types of ventilation systems and especially focussing on high efficiency heat recovery. One of the goals of this programme is to study the impact of strengthening the national requirements on energy efficiency on the indoor environment regarding IAQ, ventilation and thermal comfort. In this programme several parties will co-operate like Novem, several regional health care organisations, the Dutch ventilation industry and Gasunie. The Foundation for High Efficiency Ventilation is responsible for researching the performances on IAQ, ventilation and energy use of the counter flow heat exchangers in practice. Therefor in 1999 in six low energy houses a measurement and evaluation program was carried out. A next project has followed in 2000. This case study will focus on the results of the first project.

6.2. Energy performances of counter flow heat recovery units

The energy performance of heat recovery units can be measured by the Dutch standard NEN 5138: Heat Recovery in Residential Buildings - Determination method. This method is more or less similar to the European standard EN 308 but is in its boundary conditions more suitable for measuring domestic ventilation units. In NEN 5138 a standardised method is given for measuring the energy efficiency and the Performance Factor of domestic heat recovery units. The Performance Factor is defined as the yearly (useful) saved energy divided by the needed electrical input for fans. In table 2 the measured energy performances under laboratory conditions are given.

Table 2. Energy performance (laboratory conditions – NEN 5138)

Manufacturer/type	**Energy efficiency (%)**	**Electrical input (W)**	**Performance Factor (-)**
Brink Renovent HR	96	46	9.8
Itho Ecofan HRU	97	40	10.4
J.E. Stork Air WHR 90	96	48	8.6

In six demonstration houses counter flow heat recovery units of manufacturer Brink were applied. The energy performances in practice were determined by real time measuring the in and outgoing temperatures of the air flows. For correcting temperature efficiency to energy efficiency the in and outgoing mass flows were also measured. The average measured energy efficiency in practice is 85%. This is less then the measured energy efficiency under laboratory conditions. The difference is caused by the instability of the measurements, especially the fluctuations of the in and outgoing air flows and the accuracy of temperature measurements. The gas savings vary from 210 to 290 m^3 nat. gas/year. The average electricity consumption for fans was 200 kWh/year. By using flow controlled DC fans the problem of instability is solved now. Measurements in the second project (using flow controlled fans) show that the average efficiency in practice is 92%.

Ventilation performances and air flows

The total ventilation as well as the separate ventilation components were measured as follows:

- Total average air change rates during 8 weeks by passive tracer gas method (PFT)
- Air tightness of building envelope by Dutch standard NEN 2686: Air Leakage of Buildings - Method of Measurements.
- Monitoring use of fans by datalogging.
- Inventory of use of other ventilation provisions by questionnaires.

Total air change rates were measured in habitable and service rooms (figure 2) as well as for the whole building (figure 3). These total air change rates include mechanical air flows (MVHR-unit), infiltration of air through the building envelope and window airing. The air leakages of the dwellings are measured by pressurisation tests (blower doors). The air tightness is expressed as the airflow through the building envelope at a pressure difference over the envelope of 10 Pa ($q_{v;10}$). The $q_{v;10}$ values of most dwellings were between 60 and 80 dm^3/s. This corresponds with n50 value of 1.6 to 2.2. The measured $q_{v;10}$ values are given in figure 4

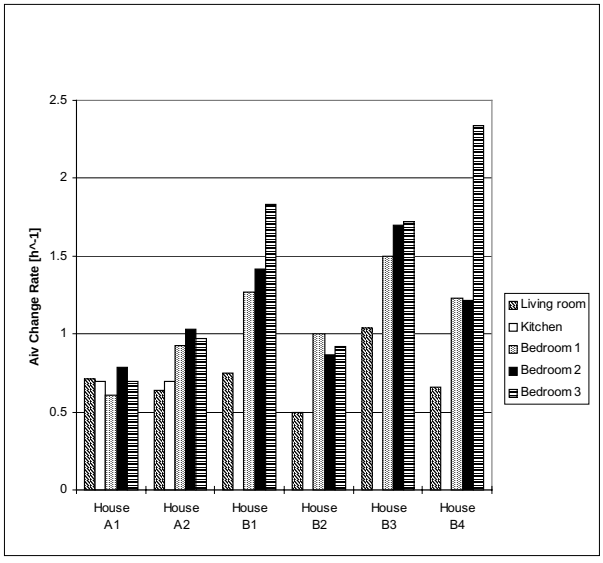

Figure 2. Measured air change rates in rooms

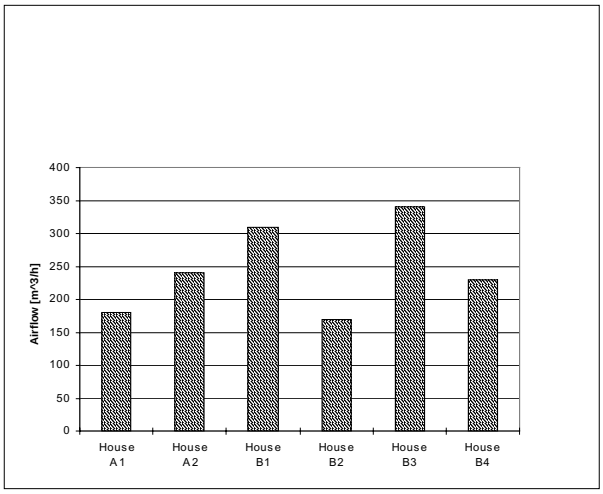

Figure 3. Total air flow rates in dwellings

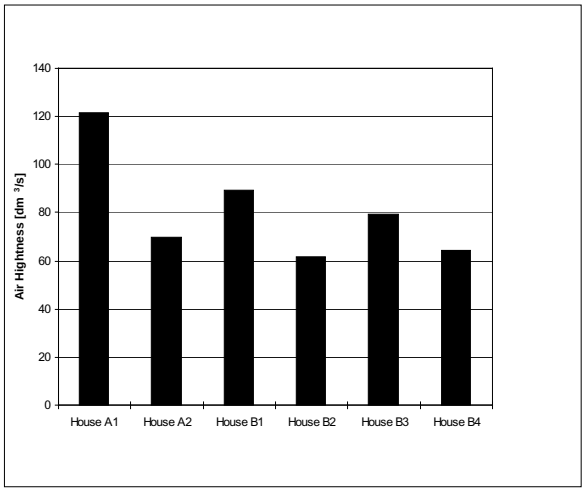

Figure 4. Measured air leakage at 10 Pa

Indoor air quality

In figures 5 to 8 the measured concentrations CO_2, CO, TVOC (related to CH_4), as well as the relative humidity are given. These concentrations were measured real time during one week. In figure 9 and 10 measured concentrations of NO_2 and Radon are given.

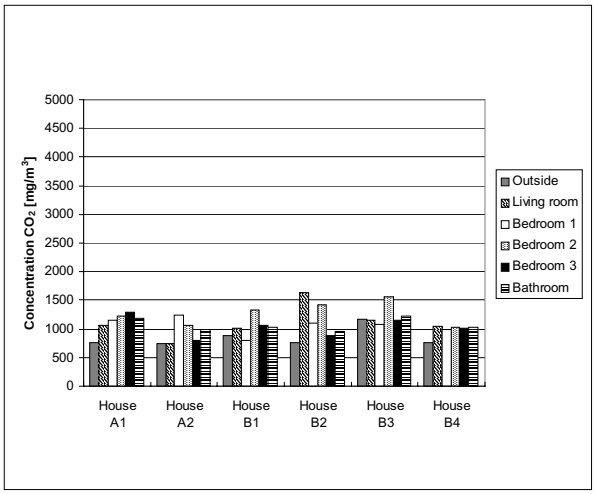

Figure 5. Measured CO_2 concentration

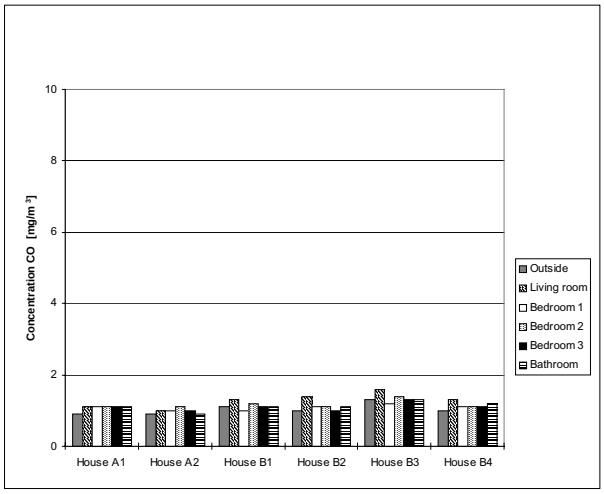

Figure 6. Measured CO concentration

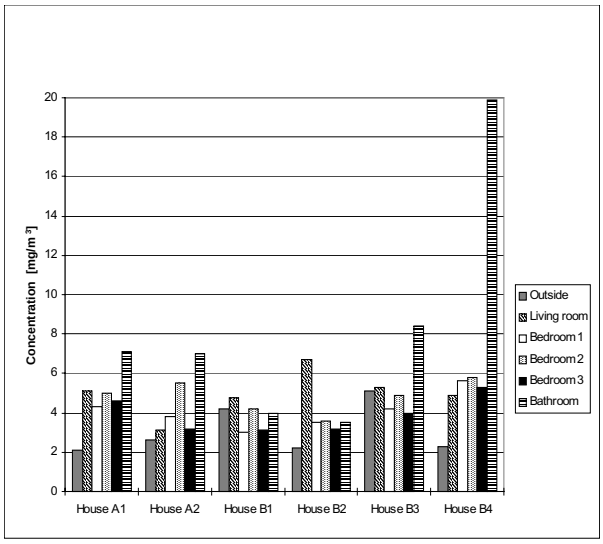

Figure7. Measured TVOC concentration

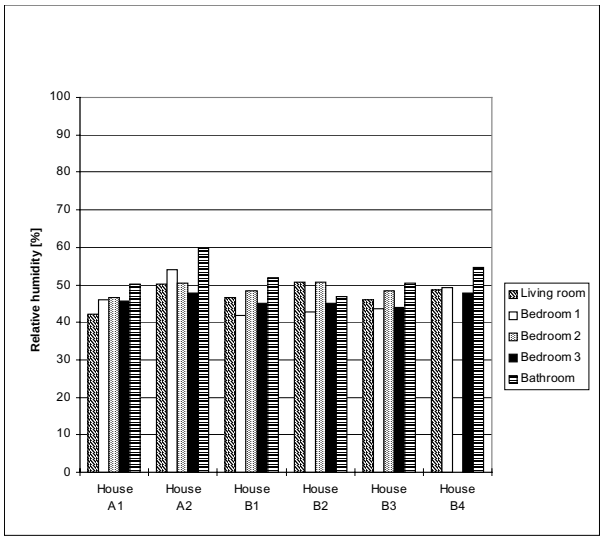

Figure 8. Measured relative humidity

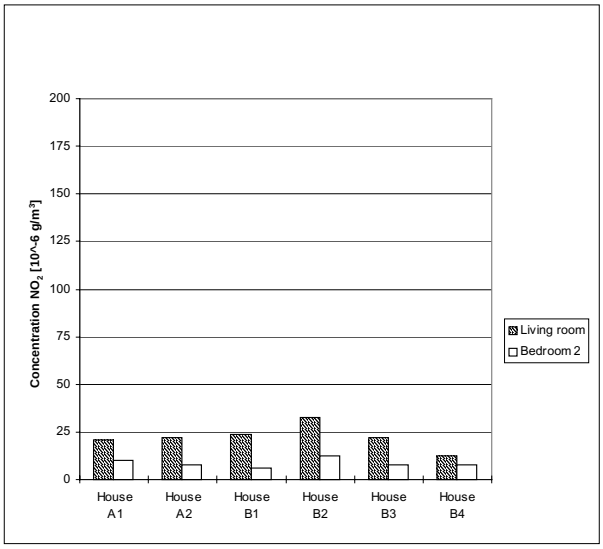

Figure 9. Measured NO_2 concentration

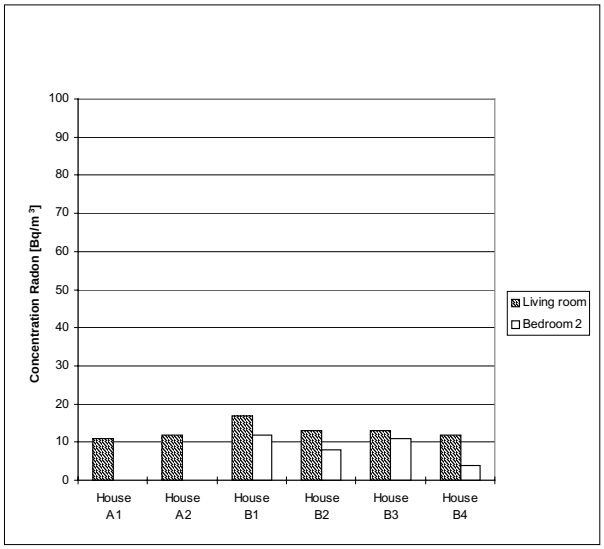

Figure 10. Measured Radon concentration

Thermal comfort and noise

Thermal comfort and noise (i.e. the absence of noise) are two of the most important parameters for occupants to assess the quality and appreciation of ventilation systems. Thermal comfort is measured in the middle of the living room at 0.1 m and 1.1 m. Local thermal comfort is evaluated on draught. Figure 11 shows the PD values calculated from measured air velocity, air temperature and turbulence.

System noise was measured in the middle of the living room and in one of the bedrooms. The fans were switched to the middle position, corresponding with the nominal air flows according to the Dutch building regulations. Figure 12 shows measured A-weighted noise levels.

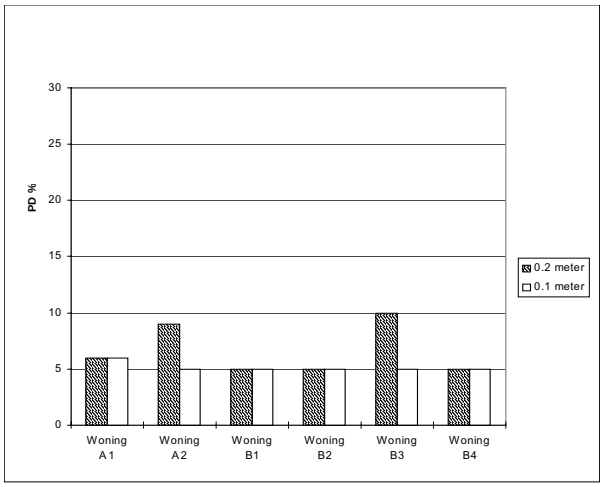

Figure 11. Measured PD value in living room

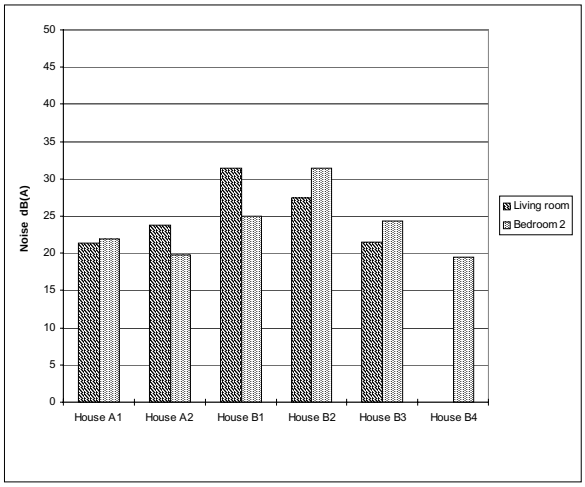

Figure 12. Measured noise levels

7 Discussion of results

7.1. Measurements

Indoor air quality

Average CO_2 levels did not exceed the hygienic guideline level of 1800 mg/m^3. However, during nighttime in a number of houses this level was frequently exceeded in bedrooms. This is mainly caused by the fact that occupants use the low position of the fans, without using additional ventilation provisions. Using the middle position of the fans or opening windows lead to a much lower CO_2 concentration in bedrooms. CO and NO_2 concentrations appear to be far below the guideline values. This is due to the fact that there are no or limited sources within the houses. All houses have gas stoves for cooking. In two houses occasionally higher CO levels were measured, caused by tobacco smoke. In most of the bathrooms TVOC concentration show high peaks in the morning, caused by use of cosmetics and cleaning. The ventilation systems were able to lower these peaks to normal concentrations within an hour.

Thermal comfort and noise

Counter flow heat recovery units are developed to realise a healthy and comfortable indoor environment combined with extreme low energy use for ventilation losses.

The overall conclusion is that counter flow heat recovery units can provide an indoor environment that meets the guidelines concerning indoor air quality, thermal comfort and noise levels. Thermal comfort is realised under all weather conditions without the necessity of applying reheaters; the (thermal) efficiency of approximately 95% is enough to secure a supply temperature of just a few degrees under room conditions. Noise levels caused by the ventilation system vary from 20 to 30 dB(A). These levels do not exceed the guideline values for system noise.

Use of the ventilation system

Questionnaires as well as monitoring switching times of fans show that occupants do not have an optimal use of the ventilation provisions. It was not clear if this is caused by lack of information, indifference or that occupants are well conscious of not using the ventilation provisions. Despite this observation it is remarkable that performances on both energy, indoor air quality and thermal comfort were very good. Although occupants behaviour is dominant in the total air change rates the minimum ventilation performance of the systems is sufficient to provide a healthy indoor environment in an air tight dwelling.

7.2. Market penetration

In table 3 a summary is given of the residential building volume in the Netherlands, the development of the Energy Performance coefficient, and the market share of MVHR. The numbers of MVHR units from 1997 to 1999 are based on sales data of the Dutch ventilation industry. The number for 2000 is a prognosis, based on the first half-year sales data. The data for 2001 and further are market prognoses from the Foundation of High Efficiency Ventilation (lit 6).

Table 3. Development of market penetration

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
number of new dwellings	97000	90000	85000	78000	70000	66500	?	?	?
EPC	1.4	1.2	1.2	1.0	1.0	1.0	1.0	?	?
number of MVHR	2900	5400	8500	12500	17500	20000	?	?	?
market % MVHR	3	6	10	16	25	30	35	40	?
absolute saving MVHR HRwtw referred to nat. supply/mech. exhaust (TJ)	25.6	47.5	74.8	110.0	154.0	176.0			
	monitored				prognosis				

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CS 10

First Draft

The PV-Covenant in the Netherlands

Case Study for the IEA/CERT project on

"Lessons learned and best practices in energy technology deployment"

I. Introduction

In this case study the *PV Covenant in The Netherlands* [1] will be illustrated. The technology involved is *photovoltaic solar energy* (PV) *for the built environment*. The formal starting date of the Dutch PV Covenant was the 14th of April 1997 and it will be closed in December 2000.

This Dutch PV Covenant is an interesting program because:

1. It is a joint approach by the demand- and supply side of the Dutch PV market in co-operation with the government and Novem, The Netherlands Agency for Energy and the Environment. All partners in the PV Covenant deliver a specific fixed contribution.
2. The Covenant is based on consensus on joint efforts towards price reduction in relation to goals for phased installation of grid connected PV power.
3. The implementation of PV systems in the built environment is tuned on National PV programme executed by Novem, also partner in the Covenant.
4. The goals of the PV Covenant are based on a solid plan: *"PV Introduction plan"*; annex of the Covenant.

II. Objectives of the PV Covenant

Policy objective:

The aim of the PV-Covenant is: *"To direct and guide the initial market introduction of PV-systems in the built environment."* The quantitative target is to realise **7,7 MWp** of cumulative grid connected solar PV in the built environment in the year 2000[15].

Strategic goals:

To deliver an effective contribution to the development of PV as sustainable energy source for the large scale application in the Dutch energy supply of the next century. More specific:

[15] This goal has already been reached

a. Realisation of the number of PV systems in the built environment is necessary, according to the PV introduction Plan, to build up the needed experience for a sound future

b. A phased development of the installed PV power, according to the *"PV Introduction Plan"* [2]

c. To contribute to the improvement of the price performance ratio of grid connected PV systems and to build on the competitiveness of PV as energy source in the Dutch energy supply

d. To improve and widen the awareness of PV of industry, institutions and the society, enabling future large scale introduction of PV in The Netherlands, using the common vision of *The PV Introduction Plan*.

Specific Goals:

The specific goals of the PV Covenant are related to the contributions of the partners which signed the Covenant.
The **Ministry of Economic affairs** will do its best to make available in the period 1997-2000:

A. an average amount of 13 million Dutch Guilders per year for:
    1) research and development of solar cells;
    2) R&D of components for grid-connected application
    3) Product and market development of autonomous PV systems in The Netherlands and for export.

B. an average amount of 20 million Dutch Guilders per year (including personnel) for:
    1) realisation of pilot projects to fill in Dutch PV Programme "PV in the built environment"

The **Energy Distribution Companies** (EDC) will strive for the realisation of 7,7 MWp cumulative installed grid connected PV power in 2000. This matches with 0,1 PJ of saved fossil energy. Each EDC will strive to realise her share of this goal related to her market share of the nation wide electricity sales.

The PV companies, **manufacturers of PV** cells and modules will strive to substantially reduce the price of PV systems in accordance with the figures of *The PV Introduction Plan*, which are based on expected market volumes.

The **building industry** will strive to take all necessary actions to realise the 7,7 MWp on roofs and buildings, possibly constructional adjustments, cost savings for roof tiles and supporting 'green financing schemes'. Each building company will strive to contribute to the 7,7 MWp at least according to their related market share.

R&D institutions (ECN) will bring in their expertise and facilities to support the realisation of the targets for price reduction and reliability by implementation of R&D results and evaluation of realised projects. Her own R&D program will be matched with the goals of the PV Covenant.

Novem will execute the National Research Program for PV and will take all necessary actions for realisation of the goal of 7,7 MWp in 2000. Furthermore Novem will initiate

publicity campaigns with the partners for further PV stimulation, monitor the development and execute the secretariat of the Covenant.

What specific barrier(s) to technology diffusion was addressed ?

In order to achieve the goals for PV set by the Ministry, a commonly shared strategy needed to be developed and important parties needed to be committed to this plan. Only a joint strategy of the supply and demand side of the market could guarantee the market volume needed for the required cost reductions. Furthermore the Covenant intended to create sufficient awareness and commitment for grid connected building integrated PV by the large market players and emphasise the opportunities as stakeholder related to the inevitable development of PV in The Netherlands and world wide.

III. Process of Definition/Design of the Program

In the initial phase towards the covenant the Ministry of Economic Affairs initiated the so called PV-Platform, consisting of key players in the pv area. This Platform developed the concept covenant starting in 1994.

Meetings of the Platform were organised regularly on a bimonthly basis besides bilateral meetings. On April 14th of 1997 the PV Covenant was officially signed by 15 organisations.

The Covenant is aiming for PV application in the built environment and preparing the way for large scale application. The PV Covenant is based on a detailed strategy report “PV Introduction Plan”, written in co-operation by ECN (as R&D institute) and the Dutch PV industry (Shell Solar). ECN is one of the main executors of the Dutch R&D activities in the field of PV.

IV. Main Actors Involved in the Implementation of the policy

The PV-Covenant was signed in 1997 by 15 parties: ECN, R&S (the later Shell Solar Energy), the Ministry of Economic Affairs, several Energy Utilities (Energy Distribution Companies) and their branch organisation (EnergieNed), several project developers (building industry), and Novem. In the course of 1998 and 1999, 13 more parties co-signed the Covenant, (more utilities, other PV-manufacturers and suppliers, and municipalities). The chairperson of the PV Platform is an independent person, which turned out te bean important binding factor .

Main actors:

- **Novem** is executing the Dutch National PV Programme "NOZ-PV" on behalf of the Ministry of Economic Affairs. Therefor Novem is a 'spider in the web' of activities in the field of PV. Novem provides subsidies for PV (demonstration) projects.
- The **Ministry of Economic Affairs** is providing the funds for the execution of the NOZ-PV programme and sets the goals for PV introduction in The Netherlands.
- The **Energy Distribution Compa**nies (EDC's) played a leading role initiating PV-projects at the time the Covenant started, due to their position in the energy market. They have investment subsidies available for PV projects in their 'B-MAP programme'. At present EDC's are focused more on the aspects of market liberalisation. Initiatives with the development of new products and services including 'green energy' products have started. Some of the EDC's have build PV-systems to cover a small part of the needed green electricity by PV power. Furthermore all Dutch EDC's have agreed on the production of 3,2% Renewable Energy by the year 2000.
- **ECN** with over 30 PV experts in different R&D areas played an important role in the support of the development and up scaling of the Dutch Shell Solar production lines for cells and modules.
- The **Building industry (mainly project developers)** evaluated PV-application opportunities in many new housing projects. The large scale new housing programme in The Netherlands (500.000 new houses till 2007) offers good opportunities for (smaller) PV systems. Their interest in PV was stimulated by the prosperous market situation with large demand and good economic circumstances and the growing awareness for sustainable building.
- **Shell Solar** as cell and module manufacturer increased their production capacity and started initiatives in product development ('Sunpower'). As market leader the played a leading role in the targeted cost price reduction. Most of their initiatives were taken in co-operation with other Covenant partners such as an inverter manufacturer, EDC's and the building industry. Furthermore Shell Solar and above mentioned and other organisations contributed to the initiatives for large scale projects like the 1 MWp housing project in Amersfoort.
- Due to his former experience (as a politician) and position, the **independent chairman** with his extensive network was able to bind the heterogeneous group of Covenant partners, each with their own interests. In co-operation with the secretary (the independent and experienced PV consultant) they form a team which is able to operate independently.

V. Policy mechanism used

Right after signature the PV Platform was reformed to a forum with all the organisations which signed the PV Covenant. From this forum of 28 people a smaller PV Steering Group was formed with representatives of each line of business. The PV Steering Group, which meets every two months is represented by one person of the Energy Distribution Companies, two on behalf of the Manufacturers, one on behalf of the building industry, one on behalf of

the knowledge institutes, a representative on behalf of Novem, one of the Ministry and the independent chairman assisted by an independent consultant for the secretariat.

Tasks of the Steering Group were to control and monitor the execution of the PV Covenant and the expansion with new organisations.

Furthermore, since 1999, the Steering Group plays an initiating role in formulating and preparing a new PV Covenant for the period after 2000.

The Covenant was and still is a basis for the National PV Program (NOZ PV) executed by Novem and funded by the Ministry of Economic Affairs. The **subsidy programme (NOZ PV)** is therefor tuned to the goals of the Covenant. During the Covenant subsidies were available for demonstration projects in the built environment, for more experimental projects where new (technical) issues were demonstrated, for market introduction projects and for R&D projects on cells, modules or BOS/components. Also a specified budget is available for autonomous and export projects. The total amount of money of this program directly related to the Covenant is about 35 million Dutch Guilders per year.

The ministry furthermore stimulated PV financially by adding PV on the list of environmental measures and equipment were tax paying companies can get **fiscal advantages** like the option to depreciate an investment in one year (in stead of the usual more years) and extra tax deductions on the investment.

In the mean time the **Energy Distribution Companies** (EDC's) which signed the Covenant also made some additional **generic subsidies** (average: 3 NLG/Wp) for PV projects available. These investment subsidies were financed by their Environmental Action Plan ("B-MAP"), which is financed by a small environmental tax all consumers are due to pay till 2000 on every kWh and every cubic meter of gas.

In the "PV introduction Plan", annex of the Covenant, expected **cost schemes** were formulated based on the expected market volumes per year and cumulative during the Covenant period. These cost schemes served as a reference for the judgement of project proposals submitted for subsidy in the Novem NOZ-PV program. Only with good reason higher prices were accepted in projects. The cost schemes therefor served also as reference in the market.

Tasks of Novem's NOZ PV program is also the execution of an PR and **information campaign**. Some special brochures and flyers were made specifically for the development and progress of the PV Covenant. For all the specific activities related to the PV Covenant as mentioned above Novem has a budget available. From this budget also the secretary (an independent PV consultant) and the chairman were paid (together some 30.000 EURO per year), as well as costs for meetings (rooms).

As a result of the PV Covenant some additional **voluntary agreements** were put up for specific projects by some of the partners. For instance one of the EDC's based in Rotterdam, made and signed a 'Solar electricity Covenant' with some near municipalities: Den Haag and Rotterdam. The last city also signed the PV Covenant, while in Den Haag the headquarters of the EDC is located. Aim of this specific Covenant is the realisation and installation of small and larger PV systems in order to fulfil their obligation of the PV Covenant. Also in other large projects more forms of co-operation like a Covenant can been seen. The last years

Covenants have proven to be an effective instrument achieving various environmental targets in The Netherlands.

VI. Monitoring and evaluation process

The main actors monitoring the progress of the implementation of the PV Covenant, are the PV Steering Group, the PV Platform and Novem.

PV Platform

At least twice a year the PV platform meets and discusses the latest topics by having presentations by its own members or specialists on other fields (for example marketing). Furthermore presentations with data are given on the progress made with the Covenant targets. Some market figures are gathered or available at Novem, other are collected by a simple questionnaire between all partners by the secretary. The agenda of a meeting is made by the secretary in co-operation with the chairman. Being an independent PV consultant the secretary has a good overview over the (international) market developments.

PV Steering Group

The PV steering group meets about every two months. News, new developments from partners and projects and (international) market developments etc. are discussed. The independent secretary and chairman play an important role in judging the relevance of topics for the meetings.
Since the Steering Group contains the most experienced people in the field of PV in The Netherlands, discussions take place at a very high level. Difficult matters are prepared in the Steering Group and subsequently proposed to the PV Platform. Of all PV Steering Group meetings a report is being made, which after correction by the Steering Group is spread also towards the partners in the PV platform.

Monitoring report

In a Monitoring Procedure, annex of the PV Covenant, is written how the monitoring should be executed. An overview of aspects to be addressed in the (yearly) report is also provided.

Novem is executing a market survey every year in order to create a market overview of PV systems. Based on the market data Novem will interpret trends and developments. The data are being collected by questionnaires send to all manufacturers and suppliers of PV systems and components. Novem is purposed to produce a report every year, which then can be spread towards the partners of the Covenant. Since 1997 one monitoring report has been produced and it seems that additional reports are not being missed, due to the overkill of information partner organisations are receiving.

The monitoring report covers all items addressed in the monitoring procedure, which is based on the international guidelines of the IEA PVPS program [5].It is the intention of the PV Steering Group to produce at least one final evaluation report on the ending PV Covenant.

New PV Covenant

In the middle of 1999 the PV steering Group was urged to start with the preparation of a new PV Covenant for the period after 2000, since the present Covenant is ending per 31st of December. The experiences with the present Covenant and the increased goal (parties talk about 250 MWp in 2007!) make it preferable to attract new organisations to join a new PV Covenant. An example is the National Association of Installers (VNI), since (the PV experience of) installers are becoming more and more crucial for large scale market introduction. Other important organisations are associations of various consumer groups such as housing associations and the National Business Association.

VII Discussion of results

Overall evaluation of objectives

The acceptance of grid connected PV-systems as a part of both the built environment and of the national energy supply has developed in a very positive way in the Netherlands. Many parties consider building integrated PV-systems as an attractive and viable option and are actively participating in demonstration projects and market developments. A wealth of experience has been built up with the application of PV-systems as a building product in many different types of buildings and new housing projects. New products have been developed (Sunpower) and forms of co-operation between various partners have been started in order to manage larger building integrated PV projects, such as an one MegaWatt project in Amersfoort and the currently under preparation 5 MWp project in the province of the North of Holland.
The market for PV-systems is developing well, and the aim of 7.7 MWp by the end of 2000 will most probably be achieved. In relation to this the targeted price development mentioned in the “PV Introduction Plan” [2] has been realised.
The PV Steering Group, as representation of the PV-Platform, is working hard on an updated strategy document and a new PV Covenant for the years 2001-2007, with the aim to contribute effectively to the realisation of around 250 MWp (cumulative) by the year 2007.

It is difficult to specify the role and importance of the PV Covenant in this process. However, several parties involved in the PV-Platform claim that it is not only the actual signing of the Covenant which is important, but also that the process of writing and discussing the PV-Covenant and the underlying Introduction plan stimulates discussion on important, sometimes controversial subjects. Also, it is a good way of getting the actual expectations and aims of parties out in the open. Moreover, the PV-Platform constitutes an important network, in which parties can meet and exchange information and have an opportunity to state their case and try to influence national policy. Also, considering the eagerness of parties to co-sign the Covenant (14 additional partners of various background signed after the initial 15 in two shifts during last one and a half year), being part of the PV-Platform is important for all parties who feel they have something at stake in the development of PV-systems in the Netherlands.

Which were the key elements of success ?

Important elements of success are the fact that quantified goals in terms of installed power were formulated, and that there was a budget for realising projects. The PV Platform

constitutes an important platform for open discussions and exchange of opinions, thus enlarging the support by organisations involved in the government goals . Furthermore the PV platform turns out to be an excellent forum to exchange the latest information and newest developments from key note persons from the Dutch PV market, the government and Novem. Although the participants all have very few time available, the attendance of the meetings was very good which underlines the importance.

The status and image of the Covenant increased the added value for organisations to join. The grown common interest of large scale PV application has a positive influence on politics. The signed agreement is used in several ways for extra publicity and status in obtaining projects and sales activities.

Also important is the strategy document 'PV Introduction Plan' [2], because it outlines a vision and strategy which is also supported by the central authorities. All partners can refer to it and justify internally according to the development of their own company strategy. Finally, the PV Steering Group as representation of the PV Platform, and with the national experts around the table, greatly enhances efficiency of operations and the level of discussions.

Which were the main sources of problems ?

In the initial phase, large efforts had to be made to create a Covenant text that was acceptable to the important players. Parties involved felt that they were in the platform in order to state and protect their particular positions and not to help the development of the PV market in general.

For long term strategy implementation it can be recommended to monitor closely the harmonisation of a (new) national PV program with the Covenant goals.

With the growing importance of strategic subjects discussed in the PV steering Group some Platform partners wanted to get more information. A conflict of interest can occur between the Steering Group wanting to discuss freely, without getting confidential information in reports 'out on the street', and partners in the PV Platform aiming for more details. This is more specific the case when the market is growing and partners are becoming more and more competitive. Therefor in the last meeting of the PV Platform it was agreed that an extra representative of another module manufacturer would take part in the PV steering Group.

Important and hard to maintain is the detailed monitoring of the PV Covenant. Checking and controlling if the efforts by partners are related to their market share and specified contributions in the Covenant needs continuous attention by a specialised organisation.

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CS 11

Deployment of Renewable Energy in a liberalised energy market by Fiscal Instruments in the Netherlands

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Introduction

To achieve a place for renewable energy the Government of the Netherlands has followed a *supply oriented* policy approach during the past decade. In view of the rapidly emerging liberalized energy market government is changing its focus from support to producers to a demand-driven approach.

Key elements of the Dutch policy for the promotion of renewable energy over the past decade were:

- the energy tax on the use of electricity and natural gas
- fiscal instruments to lower investment costs
- voluntary agreements with the energy sector and industry (based on tradable Greenlabels)
- various subsidy schemes to increase the attractiveness of new initiatives.

In view of the upcoming, liberalized energy market 2 major instruments will be added in 2001: (i) a fully liberalized market for green electricity with free consumer choice; (ii) a legally based tradable certificate for renewable energy. The lay-out of the Dutch policy for renewable energy, with its focus on the demand side, has a rather unique position within Europe. Firstly, because of its focus on the demand side, and, secondly, because of its emphasis on voluntary action.

This paper evaluates the market development over the last 4 years and for the future.

Objectives

Renewable energy policies are driven by the well-recognised need for a sustainable society. Within Dutch government policies, targets for renewable energy are addressed in environmental programmes, white papers on energy and on climate change.

The Dutch government aims in its Third White Paper on Energy (1995) at 2 major goals for 2020:

- 33% improvement of the efficiency with which energy is used by continuing energy savings and use of more efficient technologies (with this efficiency target total energy consumption should remain effectively at the 1990 level despite economic growth)
- 10% of all energy used should be provided from renewable sources.

Currently, around 35 PJ (1.2 %) of the Netherlands energy consumption is delivered from renewable sources. For 2020, the target of 10% renewable energy represents a supply of 380 PJ based on the most recent projections of long-term economic growth and energy consumption.

In the Energy Report from 1999 the governments presents its policies in view of a liberalised market:

- A consumer driven approach in the renewable energy market
- Voluntary agreements with specific sectors in the market
- Greening the fiscal system by increasing the energy tax
- Encouraging research and development through specific programs.

Recently, our government published its Action Plan on Climate Policy. This plan contains the actions which are required to comply with the reduction targets of the Kyoto Protocol. By the end of the Kyoto budget period, the emissions of greenhouse gases should be 6% lower than in 1990 (according to the EU agreement on the burden sharing of the Kyoto target over its member states).

Based on projections of greenhouse emissions a reduction of about 50 million tons of CO_2 is required. Domestic measures should cover 25 million tons of the total reduction (the remaining 25 million tons will come from Joint Implementation, CDM-projects and emission trading). Renewable energy forms part of the domestic measures to reduce CO_2. To implement this reduction, a firm target for 2010 has been set at a share of 5% by renewables to the total energy consumption (180 PJ). In terms of CO_2 reduction, this target should reduce 4 million tons of CO_2.

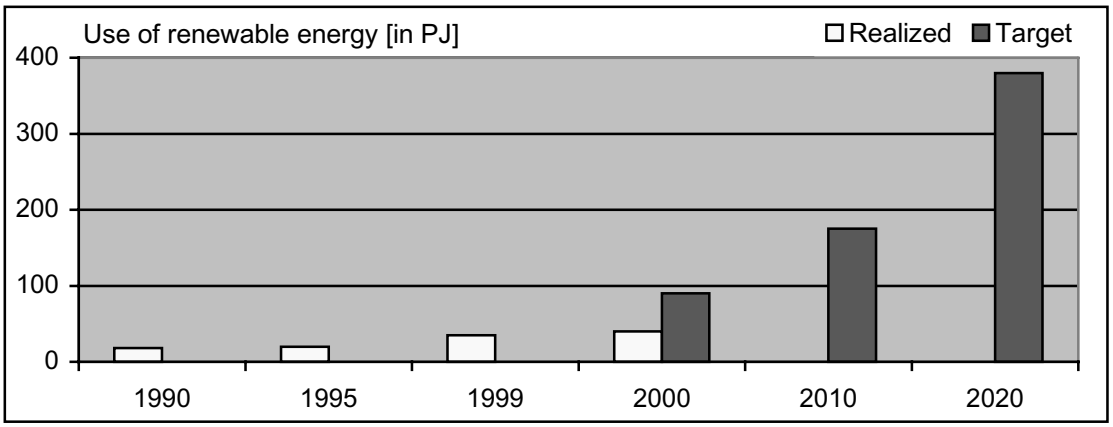


Figure 1 Targets for renewable energy in the Netherlands according to government policy

Policy design

Following the publication of the Third White Paper on Energy Policy in 1995, Government recognized that its subsidy schemes and fiscal instruments to decrease investment costs of renewables were insufficient to achieve its intermediate target for 2000. Also, the level of investment and subsidies from the energy distribution sector up to 1995 would be inadequate to reach this target. The actions of the energy sector formed part of a voluntary agreement with the Minister of Economic Affairs on the implementation of an environmental action plan *(Milieu Actie Plan, MAP)*. This agreement was up for renewal in 1996. Considering the intermediate target for renewables in 2000, government and the energy sector agreed on including a specific goal for renewable energy as part of the new voluntary agreement. During the negotiations this goal was finally set at 1.700 GWh of renewable electricity which the distributors would supply to their customers in 2000.

The new target created a significant challenge for the energy distribution sector. In 1996, approximately 2.300 GWh of renewable electricity was produced, of which about 1.600 GWh was from waste incineration or from auto-producers and not delivered to the public grid. However, both sources are excluded from the agreement. The objective was to specifically increase the deployment of “new” renewables, such as wind energy and biomass. Achieving the target of 1.700 GWh required major investments in the service areas of each distributor, by either the companies themselves or by private investors. However, the opportunities and possibilites for implementing for instance wind energy vary widely between these service areas.

The sector realized that if they maintained their usual policy of subsidizing in their own service area only, the costs of reaching the target would vary substantially between the distributors. For customers this would mean that environmental levies they paid as part of the energy tariffs to cover the environmental action plans would also vary. To overcome these differences, the energy sector investigated the possibilities of burden sharing systems. Mid 1997 the energy sector concluded that a tradable certificate system for renewable energy would be the best option. Subsequently, two decisions were taken by EnergieNed, the branch organisation: (i) a binding set of targets for each electricity distribution company with a penalty for not complying, and (ii) the introduction of a tradable certificate for renewable

energy, the so-called Greenlabel. The system was fully implemented and operational by January 1998.

The Greenlabel represents a tradable certificate which is issued for each unit of 10.000 kWh of renewable energy which has been delivered to the grid. Producers of renewable energy receive this Greenlabel in addition to a regular price for their electricity and the benefits provided by the government. By selling Greenlabels the producer can achieve a profitable exploitation of his installation.

The Greenlabel system brings benefits to both buyers and sellers of renewable energy:

- lower costs for distribution companies in comparison with the usual subsidy system, because they are able to buy from outside their own service area on a larger market
- a better price for producers of renewables, because they are able to search for the highest bid and not bound anymore to the distribution company in the service area where their installation is connected to the public grid.

Following the introduction of the energy tax in 1996, one distribution company (PNEM, now part of Essent) started with selling green electricity *("Groene Stroom")* to its customers. The exemption of the energy tax for green electricity helped to lower the higher price of this product (see section 5.2). Although still more expensive than "regular" electricity, a niche market appeared to exist with customers willing to pay extra for a green product. Given the success of the first product, other distributors followed with their own products.

In 1999 the Minister of Economic Affairs evaluated the position of renewable energy in a liberalized market. The energy sector had made it clear, in a position paper called Energy and Enviroment in the 21st Century, that it wasn't prepared to renew any voluntary agreement after 2000. The sector feared that if they would take on voluntary agreements, new entrants in the market would not follow this example, but instead go for market share and lower price. According to the position paper, energy saving and renewable energy are considered important, but only at the specific request of customers. The further introduction of renewable energy should, in the opinion of the energy sector, be based on selling products like green electricity.

Government recognized the implications of the liberalized energy market. In the Energy Report of 1999, the Minister of Economic Affairs lays down the approach for the coming years. The most crucial step is opening a fully competitive green market in 2001. This market opening with free consumer choice is ahead of the market opening for mid-sized and small consumers (in 2002 and 2004 respectively). To facilitate the market, a legally based certificate system will be put in place. These certificates are issued for renewable production and receive their value on the market place as they are eligible for tax exemption when used to sell green electricity to consumers. As a third step, the tariffs of the energy tax are increased substantially, while the exemption for green electricity remains in tact. With the tax

levels of 2001, green products can become cheaper in price than regular electricity despite the extra costs of renewable energy.

Main actors and their role

The changes in policy from more or less a supply based support over the past decade to a demand side based approach in the coming years will change the involvement and roles of the main actors. New actors (such as traders and brokers) will step in the field, while producers, retailers and consumers will operate in different settings. New actors and major changes in the role of existing actors are highlighted in the table below.

actor	role	
	past decade	future (from 2001)
Ministry of Economic Affairs	develop policies close voluntary agreements	develop policies set rules free green energy market close voluntary agreements
Tax Service	approve tax credits approve exemption energy tax	approve tax credits approve exemption energy tax
Energy distribution sector	provide subsidy to producers (upto 1997) buy for voluntary agreement (through Greenlabels from 1998)	retail selling green energy
Issuing Body	did not exist officially	issue certificates monitor & oversee market
Traders & brokers	no role	buy & sell green energy (mainly wholesale market)
Consumers	pay levy to distributors	buy green energy
Producers	invest on subsidy	invest on market based demand
Novem Senter	support implementation provide subsidies	support implementation provide subsidies

Policy Mechanisms

The shift to a sustainable and prosperous society can be supported by “greening” the fiscal system. Within this context, in the Netherlands the Regulated Energy Tax was introduced since 1996. The energy tax encourages energy conservation and the use of renewable energy by making fossil energy much more expensive. The reduction in the energy tax and the zero tariff for ‘green’ electricity, provide a strong incentive to use renewable energy. In addition the tax system focuses on supporting investments with specific fiscal instruments.

Support for Investments

Investment support in the Netherlands is entirely based on fiscal measures. The following schemes to improve the profitability of renewable energy are available:

a) *Green Funds:* Investors in “green projects” (such as renewable energy) can obtain loans at a lower interest rate (about 1.5 percentage point) from Green Funds. These Funds are created by savings

by private persons, who are exempted from paying income tax on the interest received. About 2.000 million Dutch guilders are available in green funds.

b) *Accelerated Depreciation*: The VAMIL scheme offers entrepreneurs a financial advantage because accelerated depreciation is permitted on equipment which is included in the VAMIL list. The accelerated depreciation reduces tax payments on company profit

c) *Tax Credit*: The EIA scheme makes it possible that investments in technologies on the EIA list may be offset against taxable profit. The tax credit offered varies from 52.5% to 40% (depending on the size of the investment).

From these three instruments EIA provides the strongest investment support. The combination of Green funds, Vamil and EIA equals a subsidy on the investment of about 25 - 35 %, depending on the profit and fiscal situation of the company. Banks now offer lease constructions on renewable energy equipment where these fiscal measures are incorporated, making financing easy and also available to parties who are not fully able to use these instruments.

Higher payment for electricity from renewables

Households and Small and Middle-sized Enterprises (SMEs) pay an energy tax on electricity and natural gas. These consumers pay their energy tax –as part of the energy bill– to their supplier, who in turn pass the revenues on to the taxation authorities (Ministry of Finance).

The Environmental Taxes Law which forms the basis of the energy tax includes two special provisions on renewable energy:

- producers from renewable energy which is delivered to the public grid are eligible for a support payment from the proceeds of the energy tax
- consumers who buy "green energy" under a contract with a supplier are exempted from paying the energy tax.

The following sources qualify as "renewable" according to the energy tax: wind energy, small hydro, biomass[16], biogas and PV. Other sources (in particular energy from municipal waste incineration) does not qualify as renewable or green energy according to the definitions of the energy tax.

Since the introduction in 1996, the energy tax has been increased substantially for small consumers (see Table 2). By January 1999, the government introduced a tax exemption for green energy. This exemption of the energy tax has created a strong incentive to buy green for the group of small end-users. The level of support payment to renewable producers follows the tariff for mid-sized end-users. Since the introduction of the energy tax, these

[16] Only energy from 100% biomass qualifies as renewable. Mixtures with plastics or other materials from fossil resources do not qualify.

tariffs have increased as well, but not as progressive as for small consumers. The total payment from the energy tax to producers will reach about 23 million Euro in 2000, which is less than 1% of the total revenues collected. In addition, about 25 million Euro will flow to renewable producers from green tariffs (enabled by the tax exemption of green energy).

Table 2 Tariffs of the Energy Tax in the Netherlands (in €ct / kWh)

Year	1996	1997	1998	1999	2000	2001
Electricity use						
0 – 10.000 kWh	1.34	1.34	1.34	2.25	3.72	5.83
10.000 – 50.000 kWh (*)	1.34	1.34	1.34	1.47	1.61	1.94
50.000 – 10.000.000 kWh	-	-	-	0.1	0.22	0.59
above 10.000.000 kWh	-	-	-	-	-	-
Natural gas						
0 – 5.000 m³	1.45	2.9	4.32	7.25	9.45	12.03
5.000 – 170.000 m³ (*)	1.45	2.9	4.32	4.74	5.19	5.62
170.000 – 1.000.000 m³	-	-	-	0.32	0.7	1.04
above 1.000.000 m^3	-	-	-	-	-	-

(*) Producers of renewable energy receive a support payment from the proceeds of the Energy Tax according to this tariff rate

Agreement with utilities on a mandated share for renewables

In the Netherlands the government has made an agreement with the energy sector in 1996 concerning CO_2 reduction and market introduction of renewable energy, with a specific target for the end of the year 2000 (Environmental Action Plan 2000). Within this agreement the energy distribution companies will have to sell a quantified amount renewable electricity of 1.700 GWhe by the end of year 2000.

To cover the expenditures of the Environmental Action Plans, distributors charge consumers a levy as part of energy tariffs for gas and electricity. The maximum rate allowed by the *Energy Distribution Act* is 2.5%; in practice, environmental levies are lower. Rates are approximately 0.2 €ct per kWh. In total the revenue received for the Environmental Action Plans is around 100 million Euro a year. A significant part of these revenues (approx. 40 million Euro) is used for investing in renewable energy or buying Greenlabels.

To fulfill the target of 1.700 GWh in an economically efficient way, the energy sector introduced in 1998 the Greenlabel system of tradable certificates. Producers receive such a certificate for each unit of 10.000 kWh delivered to the public grid. They can sell the certificate on the market which consists mainly of energy distribution companies. Since the

start of the system in 1998, prices for Greenlabels have increased, from around 2.5 €ct / kWh to 3.0 €ct / kWh for recent contracts. The price rise is caused by a shortage of certificates on the market to cover the target of 1.700 GWh.

Free consumers of green energy

In addition to the supply based approach, another part of the Dutch energy policy focuses on increasing the demand side. Consumers can choose for the green electricity programme of their energy supplier. They pay an additional tariff when they buy “green electricity”, but in return are exempted from paying the energy tax. Currently, tariffs vary between 2.7 and 4.5 €ct / kWh (see table below). Depending on the supplier, green electricity is cheaper or about as expensive as regular electricity (for which the tariff includes the energy tax). On average, green electricity is sold at a premium rate of about 3.6 €ct (excl. VAT) above the normal price. The additional tariff is used to pay the producers of renewable electricity about 2.7 €ct, and the remaining 1 €ct is used for administration, marketing and profit.

supplier	tariff * [in ? ct/kWh]	indication of share in green market	indication households reached in service area
Essent	2.7	✻✻✻	☆☆☆
Eneco	3.7	✻	☆
NRE	3.9	✻✻	☆☆☆☆
Delta	4.3	✻	☆
Delfland	4.5	✻	☆☆
REMU	4.5	✻	☆
NUON	4.5	✻✻	☆☆

Legend market share

✻ 0 - 5%
✻✻ 5 - 30%
✻✻✻ > 30%

Legend households reached

☆ 0 - 1%
☆☆ 1 - 2%
☆☆☆ 2 - 4%
☆☆☆☆ > 10%

* Excluding VAT and energy tax exemption
(3.7 ? ct/kWh for use up to 10,000 kWh in 2000)
(5,87 ? ct/kWh for use up to 10,000 kWh in 2000)

The conditions and composition of “green electricity” vary between suppliers. In 2000, about 650 GWh of green electricity will be sold to households, services and industry (total renewable production –electricity from municipal waste not included- was around 1.150 GWh in 1999). Due to the structure of the green pricing programmes and its short history, it is difficult to estimate how much new capacity has been or will be installed through these programmes. In participation, they are, however, a success. Some active suppliers have succeeded last year in achieving more than 10% of their customer base (the average is around 3%).

The number of consumers has increased considerably over the last 4 years (fig. 5) and reaches around 155.000 at the moment. The largest difficulty encountered by suppliers is not to attract customers for their programmes. Some have even opted to stop their marketing. The largest obstacle at the moment is the increase the generation of renewables and installation of new capacity due to a whole range of difficulties in obtaining permits.

Reducing cost price and increasing green payment

The mixture of Dutch policy instruments to strengthen the competitiveness of renewables works in two directions: (i) reducing the cost price of producers and (ii) increasing the ability to pay for renewables by end-users. A schematic representation how all instruments work together is given in fig. 2.

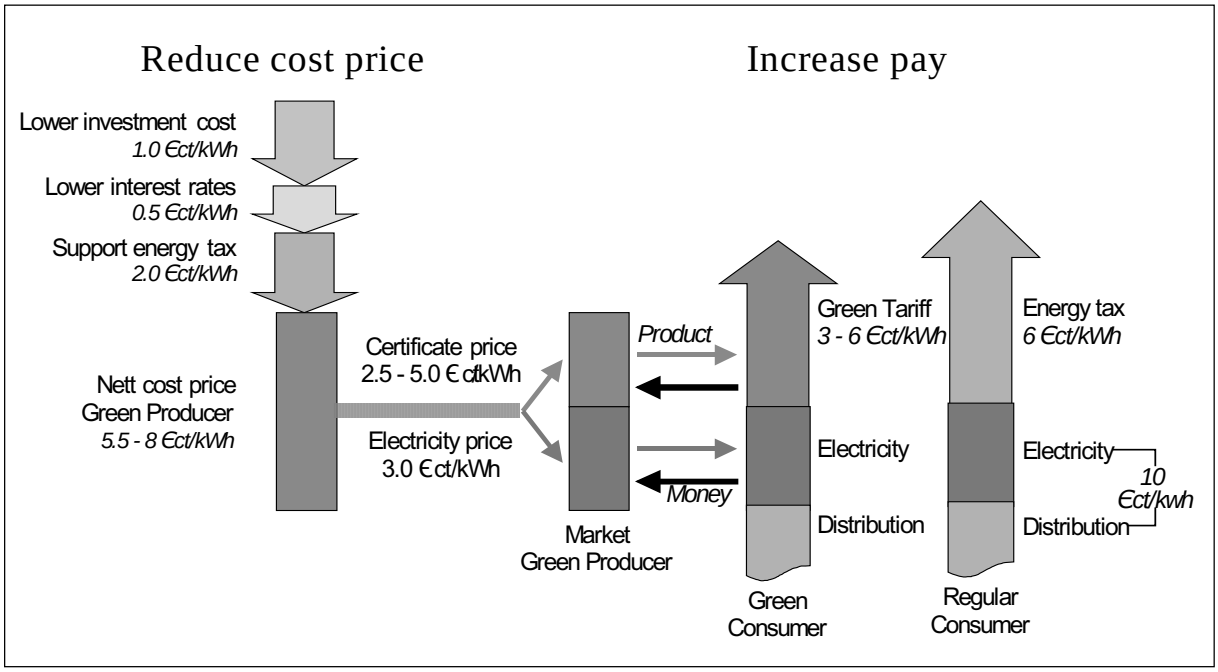


Figure 2 A schematic diagram how Dutch policy instruments achieve competing prices for renewable energy. On the supply side, instruments help to lower the cost price of renewables and allow competitive prices for electricity. The tradable certificate a producer receives can be sold on a separate market. Fair prices are possible through the demand side instrument of green tariffs and the energy tax.

Money flows in the following way in the system:

– *cost price reduction by 2.5 – 4 Eurocents per kWh*
  - all fiscal instruments relating to the investment lower the production costs of an installation with about 1 – 2 Eurocents per kWh
  - the support payment from the energy tax for each renewable kWh produced lowers the cost price with 1.5 – 2 Eurocents per kWh

competitive prices on electricity and certificate markets
  - the producer can now offer his electricity for regular prices on the "fossil" electricity market
  - in addition, he receives a tradable certificate which can be sold on a separate market

increase the ability to pay for green by 6 Eurocents per kWh
  - the exemption of the energy tax for small consumers allows a tariff of around 6 Eurocents per kWh for "green electricity" which is competitive with "regular" electricity
  - with these revenues suppliers can buy green certificates on the market from producers or traders.

Monitoring and evaluation of policy instruments

The success of Dutch policy instruments in the deployment of renewable energy sources can be measured in several respects:

- the market penetration of renewables
- the competitiveness of renewables with fossil based generation
- the use of financial resources provided by government instruments
- the market share of green pricing programmes and consumer involvement
- the "user-friendlyness" of policy instruments for investors.

The monitoring of the deployment of renewables is carried out by a number of organisations. Novem monitors for the government together with the Central Bureau of Statistics (CBS) the market penetration of renewable energy. The issuing and use of the tradable Greenlabels is registered and monitored by KEMA on behalf of EnergieNed[17]. EnergieNed also monitors the market share of green pricing programmes. The Ministries of Finance and of Economic Affairs undertake regular evaluations how financial resources from government instruments are used. These evaluations also consider the efficiency and success of these instruments.

Market penetration of renewables

During the last 4 years, the production of renewable electricity increased from around 600 GWh in 1996 to an expected amount of 1.400 GWh in 2000. In relative terms this represents a a large increase. However, despite the doubling in volume, market penetration is still well below government targets. In comparison with other countries (such as Denmark and Germany), the introduction of "new" renewables proceeds substantially slower. In this respect, current policies fail in promoting the market share of renewables.

The main reason for not meeting targets (and a slower increase than in neighbouring countries) is the shortfall in wind energy projects which come online. Although surveys of investment plans show a large volume of potential production, difficulties in obtaining planning approvals and building permits prevent a rapid implementation. The current portfolio of investment plans covers around 4.000 GWh of wind capacity; however, the annual increase is in the order of approximately 100 GWh.

A promising signal, however, is that the renewable energy market reacts to the delays which wind projects encounter. Because of the lack of wind energy deployment, investors switch to bio-energy and this source takes over in the free market.

[17] For the legally based tradable Green Certificate System which will start in 2001, this task will reside with the Issuing Body for these certificates.

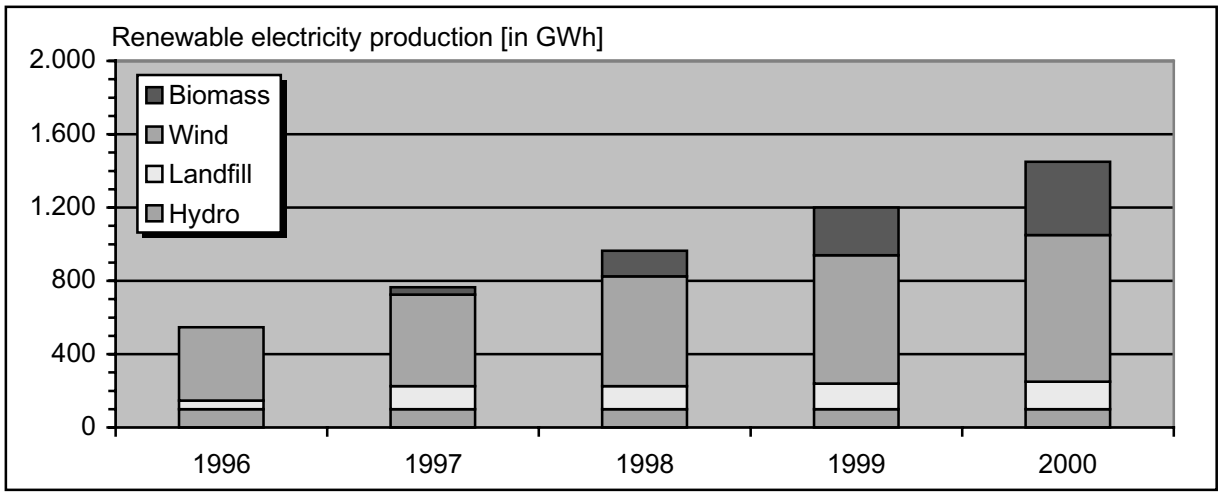


Figure 3 The increase of renewable electricity production in the Netherlands. Due to a lack of wind energy deployment, bio-energy is taking over the lead in the market.

Competitiveness with fossil based generation

Government support of producers with direct fiscal measures is for some options only sufficient to make them competitive with fossil based generation. The sales price for sources like wind energy is slightly above current market prices for electricity when these direct support measures are taken into account (see Table 3). To achieve market penetration of these sources, additional measures are required.

Until 2000, this additional support is given either through the purchase of “Greenlabels” or by revenues from green pricing programmes. From 2001 onwards, sales revenues from green pricing programmes will be the main source of support. For sources such as wind energy and biomass CHP, certificate prices of around 0.5 – 3.5 €ct/kWh are required to achieve competitive market prices. Taking the exemption of the energy tax as a benchmark for the maximum certificate price, retailers can offer up to 5.8 €ct/kWh to producers (in addition to the regular electricity price and other fiscal support of the government).

The combination of direct support to producers and the revenues of green pricing (enabled by the exemption of the energy tax) create competitive prices with fossil based generation for nearly all Dutch renewable energy sources.

The total financial value of the Dutch renewable energy market amounts to 130 million Euro in 2000. Approximately, 75% of this money flow is covered by support mechanisms for renewables (see fig. 4).

Table 3 An indication how competetive renewables on the “fossil” and “green” electricity markets based on sales prices (including government support)

	electricity sales price (in €ct/kWh)			green tariff price (in €ct/kWh)		
	without support	after direct government support *	competitive with fossil electricity (~ 3.5 €ct/kWh)	indicative price for a green certificate	competitive with energy tax exemption	
					tax 2000 (3.5 €ct/kWh)	tax 2001 (5.8 €ct/kWh)
hydro	12-15	8-12	no	4-8	no	some
wind	6-8	4-6	no	1-2	yes	yes
landfill	3-4	1-2	yes	< 0	yes	yes
biomass cofiring	5-6	3-4	yes	< 0	yes	yes
biomass CHP	8-10	5-8	no	2-4	some	yes

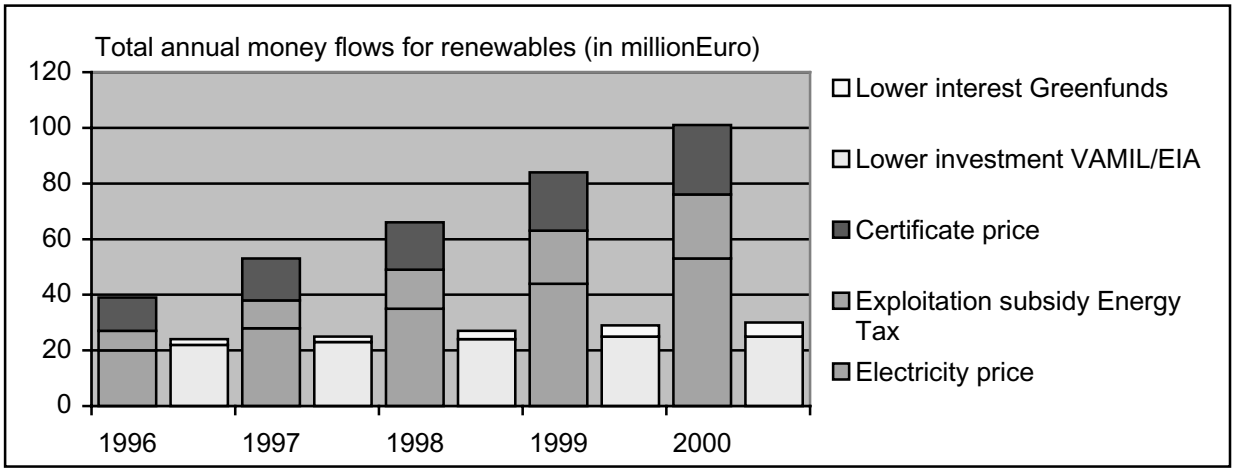


Figure 4 Total annual flow of money to renewable energy in the Netherlands from electricity sales and support instruments. The left column for each year shows the payment which are based on electricity output. The right column shows the support based on investment costs.

Market share of green pricing programmes and consumer involvement

Dutch Green Pricing schemes have attracted within a short period of time on average 3.5% of all households. Some active suppliers have succeeded last year in achieving more than 10% of their customer base. The number of consumers has increased considerably over the last 4 years and reaches around 155.000 at the moment. As a result, a significant portion of all renewables produced is now sold under green pricing programmes to households, services and industry.

Suppliers find a large interest among customers for their programmes even with little marketing efforts. The largest obstacle they face at the moment is the increase the generation of renewables and installation of new capacity due to a whole range of difficulties in obtaining permits. Some have therefore even opted to stop their marketing of green energy, because supply is limited.

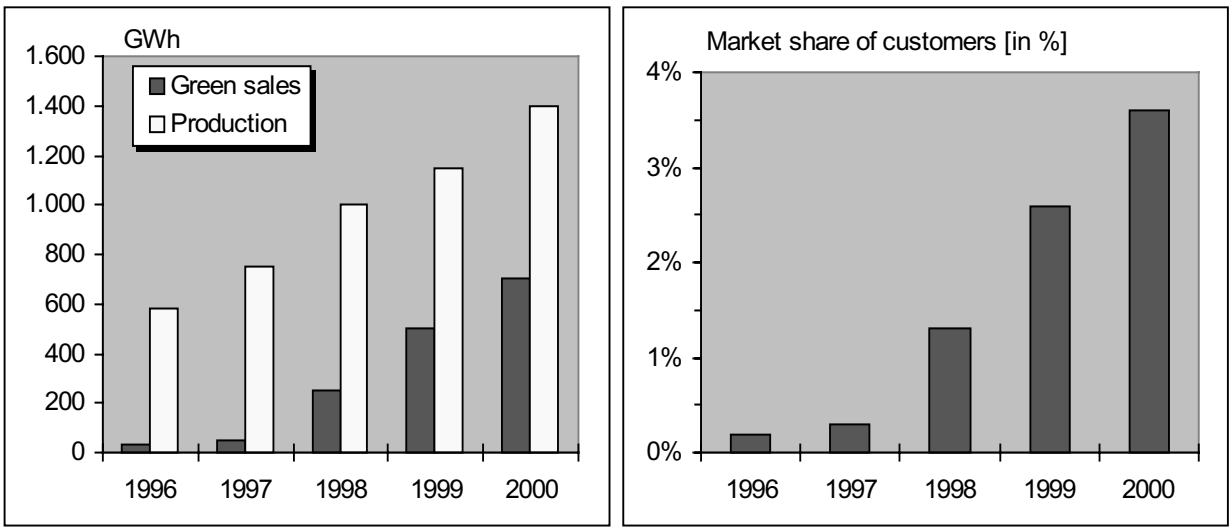


Figure 5 Annual sales and production of "green" electricity in the Netherlands (left) and market share reached by green pricing programmes of the total customer base (right)

"User-friendlyness" of policy instruments for investors

In comparison with other European countries, the Netherlands have the broadest and most diverse use of support mechanisms for renewable energy (see Table 4).

Having the broadest range of policy instruments does not necessarily mean it creates the most effective approach. For instance, countries as Denmark, Spain and Germany reach faster growing levels of renewables than the Netherlands through their policies of feed-in tariffs[18]. The Netherlands have decided not to use this approach for 2 reasons:

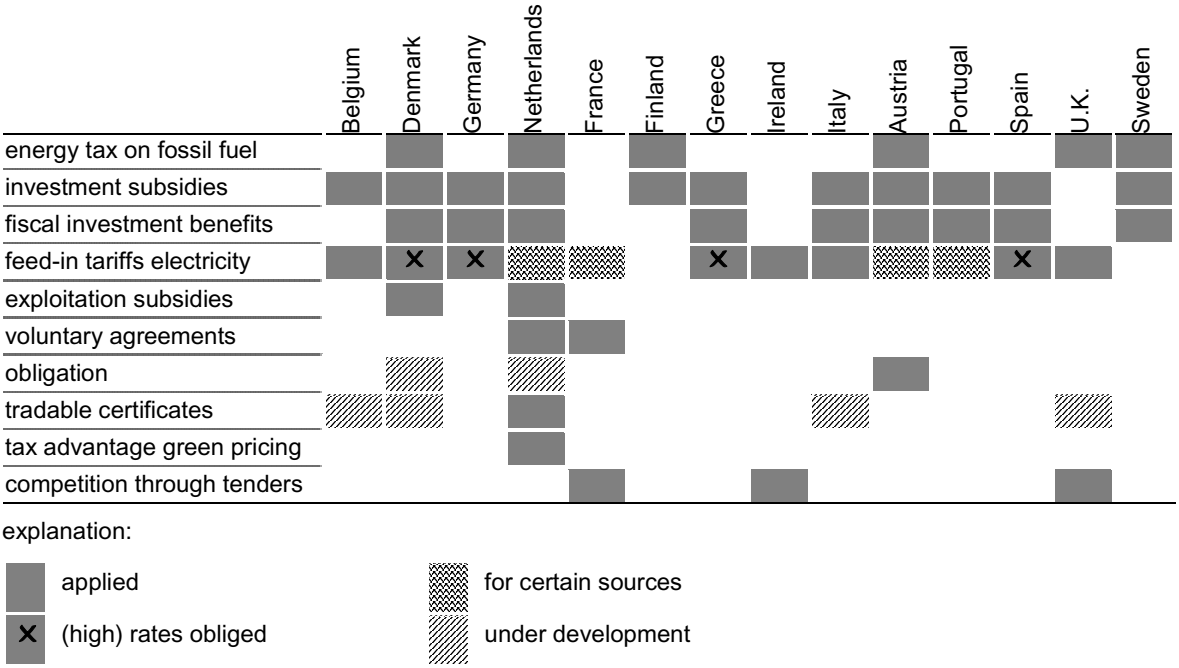
- fixed buying rates for grid operators do not fit well within the structure of a liberalised energy market
- fixed rates do not provide an incentive for innovation, competition and reduction of production prices of renewable energy.

The lay-out of the Dutch policy for renewable energy has a rather unique position within Europe: it focuses on strengthening the demand side and places a strong emphasis on voluntary action. The advantages of this approach are a better "fit" with the new setting of the liberalised market with full competition and free consumer choice. On the other hand, the approach is vulnerable. The deployment of renewable energy strongly depends on market conditions and reactions. There are no guarentees that targets will be met.

From the perspective of the investor, the current Dutch policy instruments are complex and sometimes confusing. To overcome these complexities, investors usually need (and use) consultants and financial advisors to assess the implications for their investment case.

[18] A feed-in tariff is an obliged, fixed (high) tariff for which grid operators have to buy electricity from specific sources, such as renewable energy or combined heat and power production.

Table 4 Use of policy instruments for deploying renewable energy in EU member states



LESSONS FROM THE DUTCH APPROACH

We draw the following lessons from the Dutch policy approach to deploy more renewable energy:

- a trading system based on certificates provides a market based solution for the deployment of renewable energy and fits within the liberalised market:
  - the Ducth market has shown that is capable to react rapidly to changing market conditions (e.g. the lack of wind energy deployment is countered by more investments in bio-energy)
  - trading promotes the deployment of the most cost-effective options
  - the system provides the opportunity for a transparent market of green energy with consumer choice and full accountability (because products can be verified independently)
- this trading scheme can work with several demand policies such as an obligation or voluntary demand by consumers through green pricing programmes;
  - when green pricing is the main drive for demand, the price difference between renewable and “regular” energy plays a dominant role to achieve sufficient demand
  - an energy tax on “regular” electricity (in combination with a lower or absent tax on renewables) provides a market based solution to support the switch to green energy
- current policy approaches to support the market introduction of renewables are usually complex and diverse (not only in the Netherlands, but other countries as well);

  - the complex situation regarding support mechanisms provides sometimes a barrier for investors; simpler mechanisms could be more effective and would certainly be more transparent
  - when an open, internal European market for renewables emerges, differences in support mechanisms between countries may distort market development
- the rapid market penetration of green energy in the Netherlands (and some other countries as well) suffers from long lead times in project development
  - financial support instruments cannot solve these issues; other policy instruments and actions are required to shorten these lead times.

CS 12

Market Transformation on Lighting (Sweden)

Introduction

Technology procurement of high-frequency (HF) electronic ballasts was carried out in 1991 and 1992. The competition was announced in September 1991 and concluded in March 1992. The purchaser group guaranteed a direct purchase of 26 000 HF electronic ballasts, with an option on a further 26 000. In comparison with the sales of HF lighting in Sweden prior to 1992, which had amounted to about 5 000 units, this represented a significant marketing opportunity for the manufacturers.

HF electronic ballasts replace the traditional mains-frequency iron-cored choke ballasts in fluorescent lights. HF lighting has many advantages: an improved light quality, better controllability and longer life. Taken together, these mean that lighting fittings designed for use with HF ballasts can result in electricity savings of 20-25%, with a 20% longer life. Savings of up to 70% can be expected if HF lighting systems are combined with other lighting improvements such as new luminaire designs and effective control.

Objectives of the program

As the installation of HF lighting systems is generally linked to the replacement of the luminaires, NUTEK's incentive agreements have specified a maximum specific installed lighting power of 10 W/square metre, which should be compared with the typical present-day value of 20-25 W/square metre.

The performance specifications for HF lighting systems that were drafted in 1991 were successful, considering not only the present-day market but also future requirements. Today, several manufacturers offer products in this field.

The market for HF lighting systems has grown rapidly during the last four years, so that it today accounts for about 60-70% of new luminaires. Over 600 000 were sold in 1995, and HF lighting can be said to have become a standard. The rate of take-up seems to be close to that estimated by NUTEK. In comparison with the situation prior to NUTEK's involvement, annual sales of HF lighting systems are now 20 times higher.

Based on the assumption that each HF lighting fitting saves 19.6 kW/year (1 700 hours x 14 W per lighting fitting = 19.6 kWh/year), the total energy saving to date is assessed to amount to over 71 GWh, of which 33 GWh were saved in 1995. Of this, NUTEK's share amounts to at least 80%. As the installation of such systems is generally associated with the replacement of older lighting systems and can often account for savings of up to 70% in terms of the nominal lighting power per square metre, the upper limit for energy saving, resulting from the lighting fittings themselves, lower lighting power and improved control systems, amounts to over 200 GWh in total, or 100 GWh during 1995 alone.

Process of definition/design of the program

The ballast manufacturers' commitment was established by the technology procurement programme through the buyers' groups order of 26 000 HF-ballasts, which was approximately five time greater than the yearly sales of the HF-ballasts prior to the procurement. The winning manufacturer was the one with the best solution for future product development (Stillesjö 1991). The buyers' group was

composed of the leading purchasers whose choice of technology strongly affects other purchasers and actors on the market, that is, opinion leaders. In order to increase the level of knowledge about HF-ballast among the purchasers/buyers and

the influential actors, several actions were taken. The concurrent demonstration project "Light Corridors" was carried out in several phases and thereby had several additional goals. The project demonstrated installations with a wide geographic coverage. The local utilities were given the option of

obtaining a demonstration installation featuring HF-lighting for office rooms and a corridor (Ottosson& Wibom 1997; Pertola & Bångens 1995).

The most important results from this demonstration project were the development of programme requirements for lighting power density. These requirements are 10 W/sqm installed in office rooms and 5 W/sqm in corridors. The programme requirements do not only involve energy efficiency, they also

contain requirements for visual comfort. After some time they became the common standards among many lighting consultants and electrical installation contractors. (NUTEK programkrav ("program design requirement") 1994; Ottosson & Wibom 1997; Pertola & Bångens 1995)

The other result from the "Light Corridors" demonstration project was the development of a testing method for the program requirements, which enabled all manufactures to test their product. Studies on HF-lighting's effects on health and visual comfort were also included in the "Light Corridors project." Moreover, this project also showed the economical results obtained when the initial investment

costs were compared to the lifetime operating and maintenance cost. Life-cycle costing information was introduced as part of the lighting programme.

Eventually, the lighting luminaire manufacturers began to show a considerable commitment to this. The first published collection of examples of high quality, energy-efficient office lighting with luminaires and installation that met the requirements included 34 examples from 15 different manufacturers (NUTEK 1994-11). The latest edition from October 1997 had 61 examples, 15 of them with new,

high-efficiency fluorescent strip lighting, T5's. A total of 14 manufacturers had their products tested. (NUTEK 1997-10).

All the information produced by the “Light Corridors project” was widely disseminated by targeted informational material and education, as well as by the participants in the project installations. However, these efforts were not enough to get the property owners and administrators to invest in HF-lighting, partly because of the severe recession in the economy in the early 1990s, which had a large effect on the building sector. To tackle this obstacle, NUTEK created incentive agreements whereby the property owners were given a subsidy of SEK 1,5 (~US$ 0.2) per each kWh saved in the first year. This money covered only a part of the incremental cost involved when investing in energy-efficient lighting. In order to get this subsidy, the programme requirements of 10 and 5 W/sqm installed had to be met, which was achievable only when HF-lighting was installed. About one hundred incentive agreements were signed. A survey three years later among those who have had incentive agreements showed that 72% continued to adhere to the programme requirements and thereby the HF-lighting systems.

The luminaires with HF-ballast are generally more efficient and give a higher lumen output from the luminaire. Consequently, the number of luminaires per room can be diminished. The HF-lighting is most cost effective when the reduction in operating and maintenance costs is taken into account. This information is not always easy to communicate convincingly if the operating costs and the investment cost are not assessed to the same budget, i.e., those who pay for the efficiency don’t benefit from the operational savings. A guidebook and seminars, ENEU 94, on how to succeed in purchasing energy-efficient technology was created in co-operation with the Association of Swedish Engineering Industries. The key information for success is to gather at an early stage all those who might be affected by both the technology and the resultant decision, and to jointly derive the required specifications. Later, when the bids come in, they are to be compared according to life-cycle analyses (ENEU 94).

The buyers’ group for the technology procurement programme for HF-ballast was composed of industry leading purchasers, whose choice of technology strongly affects other purchasers and actors on the market. In 1991, NUTEK’s lighting programme, consisting of buyers’ groups and incentive agreements, had reached 30% of the total floor area in commercial premises. This high level of commitment among the property owners and purchasers was achieved through networking, active and dedicated project management at NUTEK.

The yearly energy savings by 2010 from the NUTEK’s lighting programme are approximately 390 GWh.(Figure 2). The direct effects are those from the incentive agreements. The saving from these are only 8.6 GWh yearly, beginning from 1992. and represent only 2.2% of the total effect over the time span considered. (Lighting installations have a 20-year life span, and are included in Figure 2 under the heading ”incentive agreements indirect” as a part of each year’s saving distributed over 20 years time.), The most important effects of the incentive agreements and the “Light Corridors ” project are however the four ripple effects that they have resulted:

- an indirect effect among those involved in the agreements

- a ripple effect among those who have heard about the programme requirements and the agreements
- a ripple effect resulting from electrical consultants (in Figure2: “Spin-off 2”) who have been in direct contact with the incentive agreement parties or who have themselves been involved in the 'Light Corridors' project. The ripple effect is due to their continuing to recommend new lighting technology while working for other clients
- a ripple effect resulting from electrical installation contractors (in Figure 2: “Spin-off 3”) who have been in direct contact with the incentive agreement parties or who have themselves been involved in the 'Light Corridors' project. The ripple effect is due to their continuing to re-commend new lighting technology when working for other clients.

The aggregated, the direct, indirect and ripple effects of the incentive agreements amount to an annual electrical saving of 390 GWh over 20 years. This corresponds to a market penetration rate of approximately 40% each year after 1998. (NUTEK 1996; Suvilehto, Alopaeus Sandberg, Nilsson, and Persson 1997).

The total cost for the NUTEK’s lighting programme is estimated at SEK 37 M (~US$ 5.3 M) NUTEK’s cost per saved kWh is however only SEK 0.008 (~US$ 0.0011). (NUTEK 1996). This price per saved kWh was arrived at by dividing the cost equally for the 20 years over the equipment’s life-time using the fixed annual instalment method, with a 6% interest rate.

Main actors and Policy mechanisms used

The early energy-efficiency programmes within the public and commercial sectors have focused on two main end-uses, lighting and ventilation. The lighting programme started with a technology procurement for electronic high frequency ballast (HF) for fluorescent lighting. It began by understanding the market and its participants, figure 1. Purchases in this market are made by relatively few professional buyers and/or decision makers. The main influential actors on the market are electric consultants and electric installation contractors. The more cautious actors in the early stages of the programme were the lighting luminaire manufacturers.

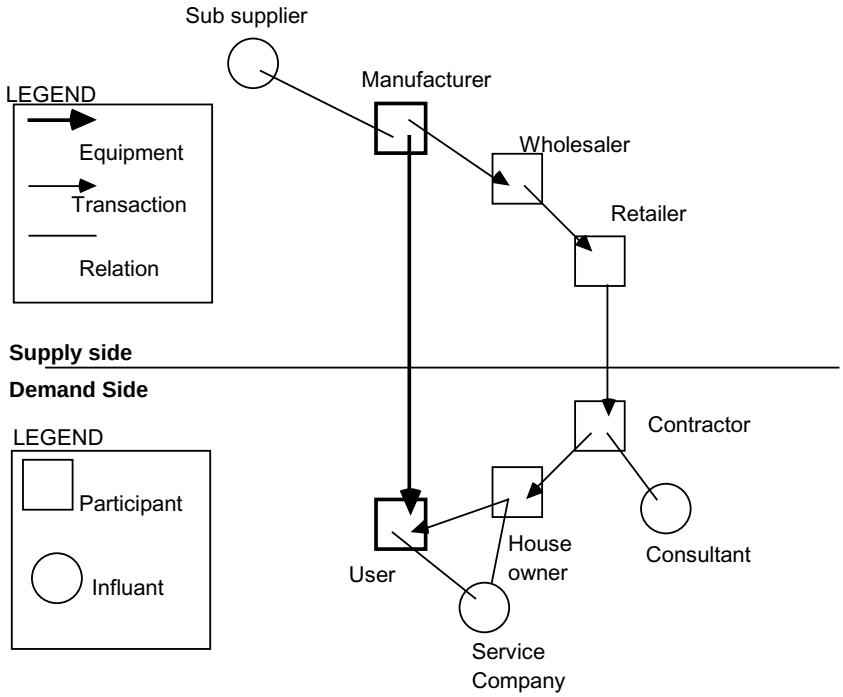


Figure 1. Market Structure for The Procured Products. Source Nilsson 1996.

A technology procurement (or co-ordinated procurement) scheme was used, in the following way: the buyers group ordered 26 000 pieces of electronic ballast which was approximately five times greater than the yearly sales prior to the procurement. This first trail batch was given a subsidy. The procurement was combined with several co-ordinated market activities. There was e.g. a concurrent demonstration project “Light corridors” were the local utilities were given an option to demonstrate the technology in practice whereby the programme was given a wide geographical spread. 0

The market transformation programme for lighting focused also on the design phase of the lighting installation. The programme developed design requirements for lighting power density together with visual requirements . The leading words for the programme were good performance with less energy. Power density levels were 10W/sqm in an office room and 5 W/sqm in corridors. These levels have become a standard among the lighting consultants and electrical installations contractors. However before developing such a levels a testing method for lighting was needed and developed as one of main phases in the project. The tested lighting systems were made known for the market with separate collections of good examples. Programme was also combined with education of the market actors e.g. designer and electric installations contractors as well as luminaire manufacturers. The programme tested and informed about how the the energy efficient lighting systems effected peoples health. . Today main focus is on the purchasing process. The efforts are set on the economical evaluations used in purchasing. STEM provides market with a tool to purchase according to the installations life cycle costs.

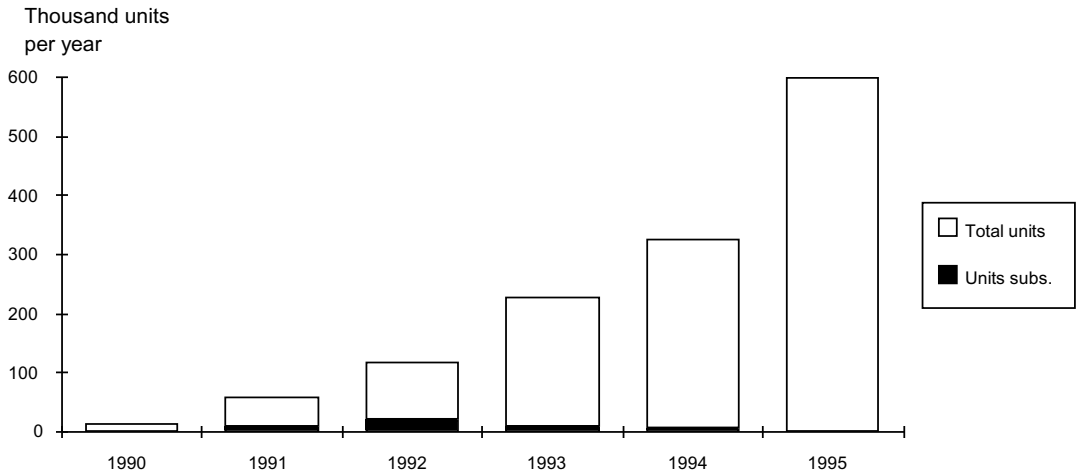
Monitoring and evaluation process

HF lighting pays best when it can be installed from the start in a new building project or for renovation projects when an existing lighting system is replaced by HF lighting in its entirety.

Profitability depends on investment costs, maintenance costs and product value. HF lighting has many benefits that are not shown in Table 4.3. When assessing profitability, it is impossible to give an average figure as it is always the user who sets the values to be assigned to the product characteristics.

The payoff time for HF lighting varies widely, depending on the installed lighting system. It is used mostly in schools, shops, swimming baths, offices, industries and the health care sector. It can also be used as outdoor lighting or lighting of parking places: in Hässleholm, Kristianstad, Perstorp, Östra Göringe and Simrishamn, for example, it has been used in various commercial premises. A straight payoff time varies between 3.6 and 12 years. However, a 12-year payoff time is unusually long: this is because it was the first major installation in the town (Energy efficiency improvement measures in Kristianstad, 1995).

The energy savings justify installation of HF lighting. However, energy saving is not the only reason: there are many other, and perhaps more important, benefits such as flicker-free lighting, reduction in power demand, the use of occupation sensing control, daylight control etc.



The effects of the programme on energy use consist of the direct effects, the indirect effects and the take-up effect. The direct effect resulting from the participation of the purchaser group amounts to about 1 %, the indirect effect resulting from incentive agreements amounts to about 15 %, and the remaining proportion of the 80 % is due to spontaneous take-up. We are of the opinion that HF lighting systems have entered the self-sustaining take-up phase, and that energy savings resulting from this take-up will increase relative to the other market influence mechanisms over the coming years.

At the present rate of growth, HF lighting systems will entirely take over the relevant market segment by the end of the century, which also indicates that the energy savings will be permanent and will increase in the future (see also Chapter 7). Several empirical investigations indicate that 'behavioural' changes, to the benefit of HF lighting systems, are significant among relevant target groups who influence purchasing, as shown in Table (Dovelius, 1996). It is interesting to note that the market share of HF lighting (60-70 %) is in good agreement with the shares indicated by installation contractors (68 %) and purchasers (71 %) when interviewed on the use of HF lighting.

Awareness changes in respect of HF lighting

Target group	1994	1996	Capacity
Installation contractors	39 %	68 %	Install the systems
Electrical consultants	64 %	94 %	Recommend the systems
Purchasers	25 %	71 %	Purchase the systems

There are, in other words, clear learning effects which, as a result of significant market growth, have resulted in the price fall as shown in Figure 3.6. The price of HF lighting units has fallen by about 25 % between 1992 and 1995, and is expected to fall further. After, and as a result of, NUTEK's technology procurement programme, the European market has also grown, particularly in countries having higher electricity prices. This growing foreign market has a beneficial effect on prices. The overall Swedish lighting market has also improved as a result of the project and of other lighting projects.

The replacement of entire luminaires by HF luminaires involves system costs that vary from case to case, although the price of the actual HF lighting unit is the same. A recent survey (Dovelius, 1996) shows that installation of HF lighting involves an additional cost of about SEK 200-300 per luminaire. Nevertheless, despite this additional cost, the market for HF lighting systems is growing rapidly, which indicates that a high value is attached to their benefits in the form of lower running costs, reduced energy bills, flicker-free lighting etc. This is a case in which the market is prepared to pay an additional cost for the benefits of the technology.

Factors that affect the economy: HF lighting

	Positive effect	Negative effect	Reported
Investment:			
1. Cost increase due to the equipment		1	*
2. Cost increase due to associated measures		2	
3. Cost savings in other measures	3		*
4. Maintenance costs (not energy)	4		*
Energy saving:			
5. In the lighting equipment itself.	5		*
6. Elsewhere, as a result of use of the equipment.	6		*
7. Higher energy use elsewhere.		7	*
8. Energy price changes.	8		*
9. Reduction in power demand.	9		*
10. Life time	10		*
11. Real rate of interest			
Value factors:			
12. Thermal comfort.	12		*
13. Indoor climate quality.			*
14. Appearance	14		*
15. Noise.			
16. Risks	16		*
17. Safety of use.			
18. Maintenance-free	18		*
19. Health	19		*
20. Environmental aspects			

1: HF lighting costs approximately SEK 200 more per luminaire. It is best to replace the entire lighting system in order to obtain full benefit of HF lighting.

2: Additional costs for occupation sensing and daylight control.

3: There are various potentials for saving if the entire lighting system is replaced. The energy saving amounts to about 20-25 %.

4: Reduction in the number of light sources.

5: Most efficient lamp operation and limitation of the ON time.

6: Reduced heat load, reduced cooling requirements, ability to provide occupation and daylight control.

9: Reduced power demand.

10: 90 000 hours (15-25 years?) per ballast, with extended tube life.

12: Flicker-free lighting.

18: Reduction in the number of light sources.

19: Reduced risk of accidents, better working conditions, good occupational hygiene and good work environment.

Discussion of results

Discussions with HF lighting manufacturers indicate that NUTEK's action has played a considerable part in introducing HF lighting to the market. It is estimated that development has been brought forward by five to seven years, and has also encouraged development of improved products. Based on manufacturers' data, NUTEK's contribution today accounts for at least 80% of the market.

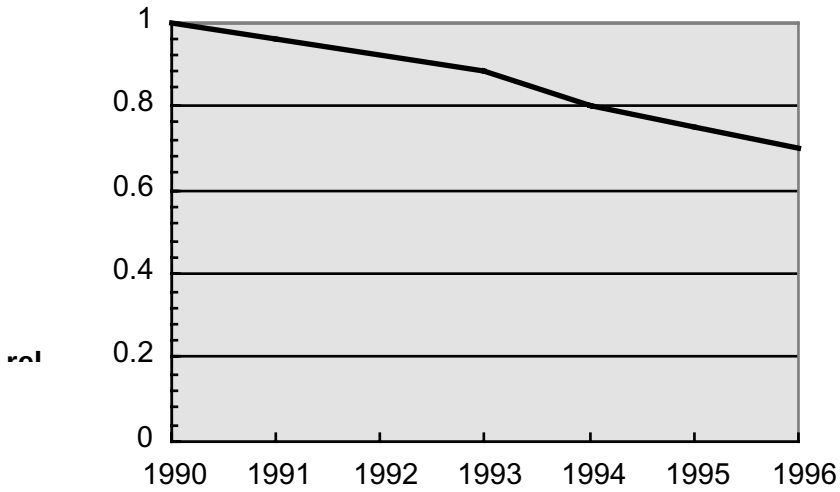
The HF lighting technology procurement project has been very successful. Several factors and events have assisted this: perhaps the most important were the right choice of time and an understanding of the market's current, hidden and future needs. Incentive agreements, the programme requirements, performance requirements and plentiful information on lighting have all been the correct operative instruments.

The HF lighting technology procurement project has been highly successful, resulting in rapid take-up of HF lighting systems and an improved quality of lighting. Several factors and events have assisted this: perhaps the most important were the right choice of time and an understanding of the market's current, hidden and future needs. Incentive agreements, the programme requirements, performance requirements and plentiful information on lighting have all been the correct operative instruments.

HF electronic ballasts as such are of less interest, although they are the key technological component in larger lighting renovation schemes. NUTEK was successful in concentrating attention on the greater whole of lighting and sparking improvements in the lighting environment. The effects would probably have been less impressive if NUTEK had concentrated its efforts on HF electronic ballasts alone, simply because the name is less comprehensible than is lighting. In addition, NUTEK also considered users' requirements, and not simply the energy savings, when disseminating information on HF lighting.

It could be claimed that the market was ready for change. At the same time, the concept of 'lighting culture' was growing in Sweden, accompanied by an unconscious acceptance of light. The fact that the market for these types of lighting systems consists almost exclusively of commercial premises, and that purchasing decisions are made by companies and not by individual consumers, is by no means unimportant. During the 1990s, companies have attached increasing importance to the productivity of their employees and have, for example, attempted to improve working conditions. There is a clear link between the quality of lighting and productivity, i.e. better lighting often results in higher productivity. The wages costs of those working in the premises is one of the major cost items, while energy as such is not. A few days' increase in productivity (e.g. through reduced absence, improved working conditions and general satisfaction) pays for the additional costs of better lighting.

Through its incentive agreements, NUTEK succeeded in creating sufficient demand for this lighting to encourage the manufacturers to take the competition seriously. The competition was important for the winning manufacturer, as its main business is in lighting technology and lighting control systems. The company had been developing this technology since the beginning of the 1980s, but had not commercialised it as the market was too small. At the same time, the competition and its after-effects presented a substantial business opportunity, as HF lighting was strategically close to the company's main business areas. One of the effects of winning the competition was that the manufacturer strongly stepped up further development. This, together with growth of the market, has resulted in noticeable price reductions.



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CS 13

Market Transformation on Heat pumps (Sweden)

Introduction

NUTEK has arranged three technology procurement projects in the heat pump sector. The first two, which were more in the nature of market surveys and smaller demonstration projects, were operated between 1990 and the beginning of 1993, but were not particularly successful in market terms. The third project ran from December 1993 until September 1995. Its objective was to encourage the development of reliable, cheaper and improved heat pumps for detached houses. The purchaser group consisted of a mixture of potential buyers, which also included members from the other Nordic countries. In addition to helping to draft the performance specification, the purchaser group guaranteed purchase of at least 2 000 units of the winning model.

The new heat pumps have now been on the market since the end of 1995. In less than a year, sales have exceeded the target of 2 000 units, and appear to have reached 4 000-5 000 units at the end of 1996. In addition, there has been a significant growth in interest in the Swedish heat pumps from other countries, with about 30% of the output of the larger manufacturers being exported to Europe.

Objectives of the program

The NUTEK technology procurement was finished in 1996. It provided an energy-efficient heatpump (efficiency factor 2.8 to 3.8) for a low cost (30% cheaper) for the small power classes. The heating

energy savings from the heat pump was at least 8 000 kWh per year. All proposed systems were tested and market pricing, as well as pump efficiency, was carefully followed.

Market characterisation: Fifteen manufacturers have a combined market share of approximately 90% of the market for heat pumps in the small power class suitable for single family homes. The other actors in the market are the utilities, heating, water and sanitary consultants, and installation companies. The purchasers are single-family house owners. Approximately 1/3 of all the single-family houses have direct electric heating, and a total of 250 000 houses were built in the 1970s, and should be renovated soon.

Process of definition/design of the program

The technology procurement in 1993 for small, brine-water heat pumps was started as a market transformation programme for domestic heating. The heat pumps are a fairly well known product in Sweden. Unfortunately, there were some poorly performing pumps in the mid 1980s and these low-quality pumps and peoples' bad experiences with them made the total market for heat pumps collapse.

In the beginning of the 1990s there were very few heat pumps for small single family houses with a floor area of 140 sqm, and an electricity need for both heating and hot water in the range of 20 000 kWh.

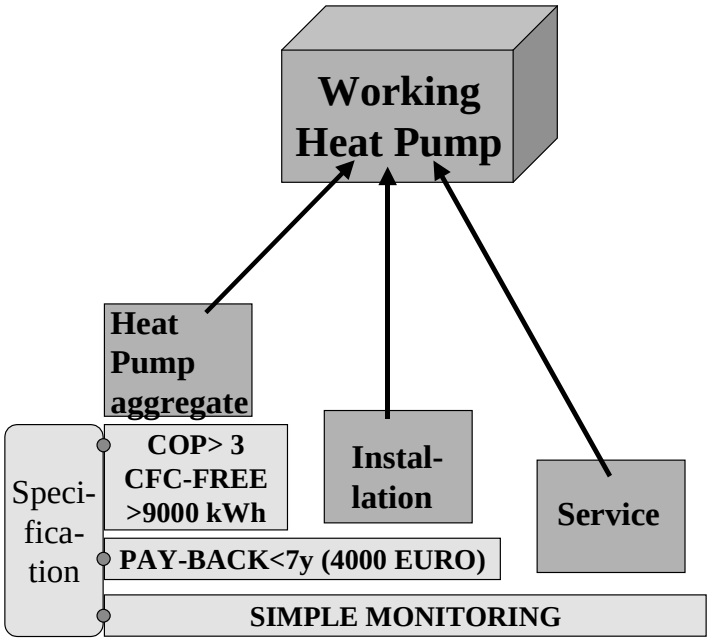
As far as the manufacturers were concerned, the performance specification was demanding. Manufacturers who produced prototypes had them tested cost-free. Six manufacturers met the performance requirements. The two winning heat pumps were over 30% more efficient and 30% cheaper than heat pumps prior to the competition. In practice, NUTEK's efforts succeeded in bringing forward a new generation of heat pumps.

Main actors and Policy mechanisms used

A technology procurement scheme was used, in the following way: potential purchasers of heat pumps were put together with energy experts in a working group to draft the required energy efficient performance parameters together with the other requirements for the heat pumps to be developed and a competition for heat pumps with those characteristics was announced to manufacturers willing to participate. In addition to helping to draft the performance specification, the purchaser group guaranteed the purchase of at least 2 000 units of the winning model.

Procurement demands

- Module size (3*600)
- Installations should faciltate service
- Specialist competence for service not required
- Chlorine-free refrigerants
- Low noise level
- COP > 3
- Electricity use to be lowered > 8 MWh per year
- Price for complete installation
- Pay-back < 7 years for installation
- Pay-back < 3 years for pump module



The procurement programme was combined with a "package" of activities supporting the market penetration of the winning models. Methods used were subsidy for the first trial batch, positive labelling, campaigns on national, regional and local level, education of professionals as well of consumers by telephone consumer advice, information material and trade exhibitions [19].

NUTEK's package of activities supporting the market penetration consists of regional and local campaigns involving targeted informational folders for consumers, positive labelling for identification of products that met the requirements, telephone consumer advice (a consumer hot-line), education, trade exhibitions, and subsidies for the first trial batch. The most essential elements for the improvement in market position have been the highly committed procurement winner and the trade association for heat pumps. The active and committed project leadership at NUTEK and the consumer hot line were also important.

An important reason for the success to date has been the sound knowledge of the heat pump sector within NUTEK and long-term consolidation of knowledge within the sector. These two factors have enabled the right arguments to be found for activating the latent technology and getting out on to the market. NUTEK has also provided by no means insignificant technical support.

NUTEK also made a considerable effort to stimulate the heat pump market. Important signals have been given, and the reputation of the heat pump, which was perhaps one of the most critical factors against it, was restored and even improved.

The size of the initial guaranteed purchase was equivalent to about a whole year's sales in Sweden, which must also have encouraged the manufacturers to participate. This is a sector in which heat pumps are often manufacturers' main product, which gives them a greater

[19] Swedish Procurement and Market Activities. American Council for Energy Efficient Economy, ACEEE Summer study 1998, 7.317, Heini-Marja Suvilehto & Egil Öfverholm

incentive to bring out improved products. The new heat pump does not directly compete with existing products: instead, its superior performance simply replaces the older range.

Increased sales on the domestic market, and favourable export prospects, have resulted in significant optimism and openness among the manufacturers, thus strongly powering further development. Although it now seems unlikely that much additional procurement incentives will be required for small waterborne heat pumps, NUTEK should continue to monitor the trend and be ready to take steps to ensure that they favourable market continues and any impediments are eliminated.

If we compare the price and performance of heat pumps in the European market, it can justifiably be claimed that, after this technology procurement project, Sweden is the leading country in respect of small liquid/water heat pumps.

Monitoring and evaluation process

The total sales of the heat pumps with a brine-water system have increased heavily after the NUTEK's technology procurement programme (Figure 3). According to the heat pump manufacturers' trade association, NUTEK's procurement programme restored the credibility of heat pumps in the market and established heat pumps among the options for home owners (Lund et al. 1996).

The increased sales volume has meant that economies of scale are beginning to appear in production, thus opening the way to reducing the prices. In addition, economies of distribution and reduced sub-contractor prices have also occurred. Together, the manufacturers estimate that these factors should enable the price of heat pumps to be reduced by about 25 % over the next few years.

One year after conclusion of the programme, the energy savings resulting from it are estimated as amounting to about 30-40 GWh/year. The market is growing and also includes increased exports to the other Nordic countries, to Switzerland and to Holland. Some manufacturers have reported an increase of over 100 % in turnover, with even the smallest increase amounting to 30 %. This has resulted in new investment in additional production capacity and a substantial increase in employment within the companies concerned.

There are many different arrangements for heat pump systems, depending on where the heat source is, how the heat is distributed in the house and how the maximum output power of the heat pump compares with the maximum power demand of the house. A heat pump either saves electricity or replaces the use of other energy carriers by electricity.

An earth heat pump affects the profitability of all conservation measures intended to save heating energy in the house. It is therefore not sufficient merely to investigate the heat

pump; instead, the investigation/analysis should also cover any other conservation measures.

Factors that affect the economy Heat pumps for waterborne (previously electric) heating systems

	Positive effect	Negative effect	Reported
Investment:			
1. Cost increase due to the equipment		1	*
2. Cost increase due to associated measures		2	
3. Cost savings in other measures			
4. Maintenance costs (not energy)			
Energy saving:			
5. In the heat pump itself.	5		*
6. Elsewhere, as a result of use of the heat pump.			
7. Higher energy use elsewhere.			
8. Energy price changes.	8		*
9. Reduction in power demand.	9		
10. Life time	10		
11. Real rate of interest			
Value factors:			
12. Thermal comfort.			
13. Indoor climate quality.			
14. Appearance			
15. Noise.			
16. Risks			
17. Safety of use.			
18. Maintenance-free			
19. Health			
20. Environmental aspects	20	20	

1: The source publications have given costs for new heat pumps: the price of the heat pump (SEK 15 440 - SEK 20 800) + the cost of the collector + installation; total, SEK 35 700 - SEK 40 000. There are major differences in the costs of the piping system for the collector.

2: Laying the pipes causes damage to gardens (of existing houses), and can give rise to extra costs and value losses.

5: In general, the energy savings resulting from new heat pumps have been estimated as amounting to about 9000 kWh/year. The heat distribution system affects ..... ? ..... ? ..... ? ..... In a low-temperature heating system, the savings are greater than when heating with conventional radiators.

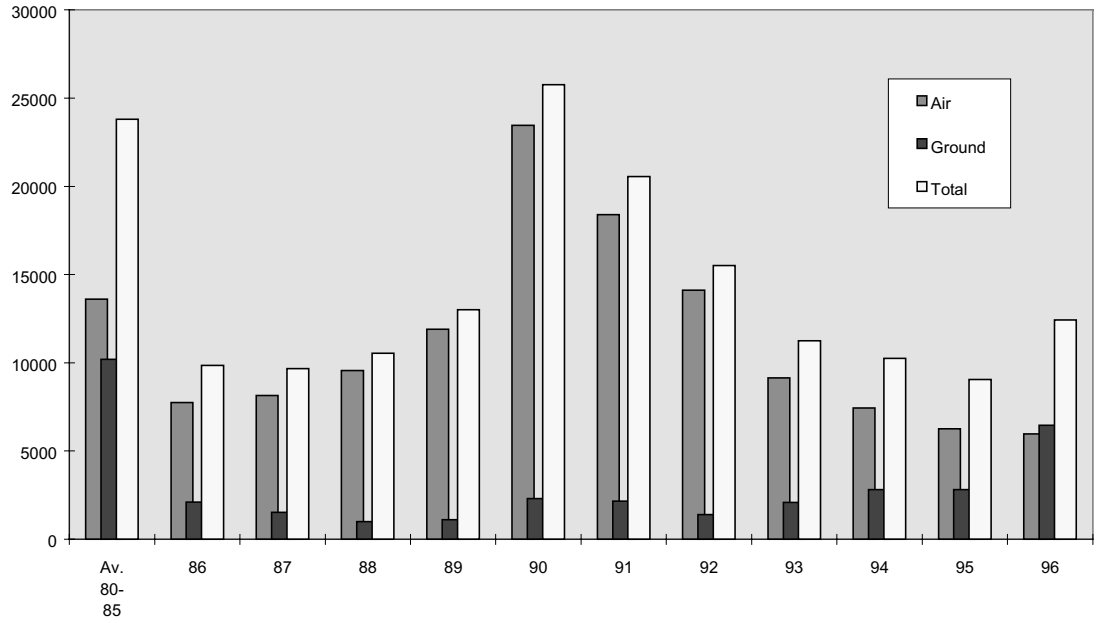
8: The energy price depends on the electricity tariffs, which can vary widely in Sweden.

9: The power saving, relative to the energy saving, is small in the case of a heat pump, amounting roughly to about 30 % of the house's power demand. However, this enables the supply fuse rating to be reduced, thus reducing the standing charge for electricity. (One of the factors determining the fixed charge element of Swedish electricity tariffs is the supply fuse rating.)

10: A 20-year life has been used as a basis for the budget calculations.

20: Installing a heat pump increases the taxable value of the house. On the other hand, the value of the house-owner's capital increases.

Figure: Heat pump sales in Sweden.



The technology procurement programme has succeeded in transforming the heat pump market. The total yearly sales of heat pumps are approximately 25 000 pieces, before 1995 the yearly sales were approximately 12 000 pieces. The sales are now focused on the ground coupled heat pumps which are more efficient and suit better the Swedish climate. The same efficiency level as in the procurement can today be provided by most of the producers. More over 75 percentage of the new residential buildings today, both multifamily houses and detached houses, are equipped with a heat pump[20].

Discussion of results

Several reasons can be identified for the rapid success and market spread. Heat pumps were already relatively well known in Sweden, although they had acquired a poor reputation during the 1980s with regard to quality. In the 1990s, it was price and lack of confidence in them that were the main problems for the heat pump market. NUTEK's competition forced the manufacturers to produce a marketable product and played a central part in re-establishing the reputation of heat pumps on the market. In combination with good products, this resulted in rapid take-up.

One year after conclusion of the programme, the energy savings resulting from it were estimated at about 30-40 GWh/year. The market is growing and also includes increased exports to the other Nordic countries, to Switzerland and the Netherlands. Some manufacturers have reported an increase of over 100% in turnover with even the smallest increase amounting to 30%. This has resulted in new investment in additional production capacity and a substantial increase in employment within the companies concerned.

To control costs one must first of all bear in mind that we are not talking about "overnight" potentials but a release over a certain time when the situation changes and can be changed.

1. Timing is important. Changes should not be forced but opportunities for a change not be lost. Most energy using equipment will be changed during the next 25 years. If all those opportunities are used there will be tremendous change. Policy target is education and routines for design and purchasing.
2. Technology use has to be directed towards improvement and implementation of the improved products. Policy target is the redirection of the purchasing power and the dialogue between important customers and manufacturers.
3. Volumes for the technology have to be enlarged to ensure that costs for improvements can be distributed and that competition bring forward new solutions. The effects are mostly captured in the "learning curve". A forced growth in volume will make these effects arrive sooner. Such force is at hand when procurement is made by central purchasers or by a group of co-operating local purchasers.
4. Actors will have to develop improved concepts as the business environment changes. Utilities might adopt the energy service concept on the deregulated market. Third party financing might be more common. Energy Service Companies (ESCOs) might turn global etc etc. The more the interest is turned to the service and the lesson the "raw" kWh the better.

[20] Peter Rohlin, Swedish National Energy Administration, July 2000.

5. Distributional evolution is necessary. Retailers and consultants will be more important as advisers to sustain the trends towards improvements. Promotional systems, labelling, improved design instruments, new routines for purchasing etc, are all instruments to develop in order to guide customers better and to ensure profits for the actors taking part in distribution of goods.
6. Systems design that takes better care of multiple aspects of technology shifts, as described earlier.

	POTENTIAL	ACCEPTANCE
TIMING	+	
TECHNOLOGY	+	
VOLUME	+	+
ACTORS		+
DISTRIBUTION		+
SYSTEMS DESIGN	+	+

The Swedish Government Programme for an Environmentally Adapted Energy System (EAES)

Introduction

1. During late autumn 1992 and spring 1993 the Swedish Government, in connection with the ratification of the UN Framework Convention on Climate Change, initiated an international climate related programme, which is mostly known as the EAES Programme, the Swedish Programme for an Environmentally Adapted Energy System. This programme is primarily directed towards projects in Baltic Region and Eastern Europe (Estonia, Latvia, Lithuania, Poland and Russia). It is aiming at an improvement of energy systems through energy efficiency measures and increased use of renewable energy sources for energy.

2. In June 1997 all the implemented and ongoing projects in the Baltic States were reported to the UN Climate Secretariat in Bonn in accordance with the Uniform Reporting Format which was finally adopted by the COP working groups at their meeting in March 1997. The reports had the form of joint reports endorsed by Sweden and the respective Baltic country.

3. The Baltic Sea Region has been one of the supreme testing grounds for the AIJ process. On the UNFCCC AIJ-list there are 96 projects of which 76 concern Energy Efficiency and Renewable Energy. Out of these 76 there are 52 registered in the Baltic Sea Region. That means that an overwhelming majority of the knowledge that the AIJ projects where supposed to create, in terms of how barriers can be overcome, is first-hand knowledge in this particular region.[21]

4. The energy systems built up during the earlier planned economy systems in Central and Eastern Europe were almost totally based on fossil fuels, mainly oil and coal and to some extent natural gas. Usually these fuels were imported at prices far below those on the world market or there were correspondingly low internal prices for domestic fossil fuels. Energy efficient technology and technology for environment protection were not particularly called for in this context and were not a natural choice at any phase in the production or the consumption of energy. The low energy prices simply did not motivate the application of such technologies.

5. The main activities are directed towards a reduction of emissions, hazardous to the climate and the environment, from oil or coal-fired energy production plants.

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[21] See also *Activities Implemented Jointly. Partnerships for Climate and Development*. IEA/OECD, Paris 1997 p.57 ff

- **Conversion of heat production plants to the use of biofuels:**

  The existing boilers have been equipped with a prefurnace and simple fuel, ash and flue gas systems in order to keep costs down.

- **Reduction of heat losses in district heating systems**:

  The district heating systems have been complemented with water treatment facilities and substations in order to stop corrosion an to improve temperature control in the houses. In some cases pipes have been added or replaced and small, inefficient boiler houses closed down. Labour intensive methods have been used to keep investment costs at a minimum.

- **Energy efficiency in buildings**

  The windows have been weather-stripped, the attics insulated and the internal heat distribution systems adjusted to adapt to the best practices of the 70s

6. The cases are typical for the potential in Markets in Transition and development all over the world. The success in finding and releasing such projects as done in the EAES project could be copied widely.

Objectives of the program

7. Studies have shown that around 90 % of the energy systems in the Baltic States and Eastern Europe are based on fossil fuels, in particular in the district heating systems which are relatively well developed but often in a very bad shape due to lack of maintenance etc. All the more important in this context was of course the introduction of world market prices for oil and other fossil fuels, which for the Baltic States meant drastic price increases. Increased fuel prices have heavily affected heating costs in all parts of the system and have resulted in stronger demands for subsidies from the state budget and/or municipal budgets and a worsened financial situation for the production plants and distribution companies. As for consumers, at present their heating costs represent 50 % or more of their total housing costs.

8. The annual emission of CO_2 per capita in 1989 in Central and Eastern Europe was 16.8 tonnes, which was almost twice that in the EFTA/EU countries, 8.5 tonnes. The corresponding figure for Sweden in 1989 was 7.3 tonnes. Besides CO_2 emissions from the energy sector it has been stated that the sulphur emissions, which adversely affect the southern parts of Sweden in particular, emanate to a very large extent from Eastern Europe. Since 1990 a decrease in sulphur dioxide emissions has been observed, however, the degree of pollution is still considerable and there are signs that these emissions are beginning to increase once again.

9. The situation in the Baltic Sea Region is a “microcosm” of the development trends on the energy markets and the prerequisites for creating sustainable systems. The development in the energy sector in the 1990´s in the Baltic States is partly of a similar nature, partly following different paths. Two of the countries Estonia and Lithuania are net exporters of electricity, in the case of Estonia electricity production is mainly based on domestic oil-shale and in the case of Lithuania based on nuclear power, while Latvia imports a large part of its main supply of electricity. In all the countries natural gas plays an increasing role for heat production. At the same time all the countries have vast and still un-exploited domestic energy resources of biomass mainly from forest wastes, which is a highly suitable fuel for district heating, and in the future also for co-generation. Other possible renewable sources are biogas and wind. The Russian Federation and Poland both have domestic fossil resources but also, in particular the Russian Federation, vast possibilities

of using biofuels. There is now a growing interest in both these countries for the use of biofuels for heat production.

10. During the last 5-6 years the use of domestic biofuels has increased, in particular in the Baltic States. Starting from a rather low part of the total energy balance of 2-3 % the increase sometimes has been 100-200 %, but still biofuels does not contribute to more than 8-10 % of the total energy supply. In this context it can also be noted that during this period an export market for biofuels has been developed in these countries and now represents an important part of income from exports. Increased export opportunities have, however, resulted in increased prices of biofuels on the domestic market. Although increased access to, and competition from, natural gas as a result of extended networks there is still an interest for using biofuels where the prices for biofuels have a competitive advantage. This is of particular interest in areas where natural gas is not accessible. There is also an interest for diversification as regards fuels for heat and electricity production both for increased security of supply and sometimes for competitive procurement reasons.

11. As regards energy efficiency the situation is similar in all the countries and is characterised by low technical and performance standards in production plants, distribution and end-use, due to lack of contemporary know-how and inadequate legislative and institutional framework. The often unclear legal status as regards ownership of residential buildings is an obstacle for obtaining financing for energy efficiency measures.

12. Another barrier is lack of financial resources for investment in the energy sector and insufficient capabilities in preparation and implementation of new investment projects.

13. Still, in some cases, due to lack of financial resources, municipal heating companies which have possibilities to use biofuels are forced to buy imported fossil fuel from the big local or international oil and gas companies which can offer deliveries on long-term credits, rather than the more cheap domestic biofuels which often are provided by small local companies.

14. There is still also a lack of policies for environmental protection measures directed towards the energy sector which is one of the most important sources of emission hazardous to climate and environment. There are no, or still too few, incentives from environmental point of view to promote increased use of renewable energy sources. The ongoing process in many of the countries towards adaptation and adjustment to the EU policies of the respective national policies as regards environment and energy and the increased regional co-operation in the Baltic Region will be of great importance for the future development.

Process of definition/design of the program

15. The point of departure for the EAES Programme was to make use of the good experiences of the improvements of the climate and the environmental conditions in Sweden, which are the results of the programmes for energy efficiency and increased use of renewable fuels, not least in the district heating sector, during the years since the international oil crises in the 1970's. A decisive factor was also that the preconditions for the use of waste from forestry works and wood-working industries in all the countries concerned were of the same magnitude as in Sweden. The programme was primarily directed towards small and medium-sized projects which until then had generally been considered as administratively too cost-demanding for implementation within programmes introduced by international financing institutions. The direction towards municipalities and municipal heating companies was also an area where the barriers for obtaining financing at reasonable conditions were the greatest.

16. In the more detailed conditions for the projects elaborated by the programme management there were no explicit demand for state guarantees in other cases but when the plant in question was owned by a state entity. To begin with the guarantees for the loans often were provided and decided upon by municipal authorities, later on when the municipal companies were included in the legislation for private companies in the respective Baltic states the securities usually have the form of registered mortgages or pledge agreements. Only in a very few cases state guarantees have been provided. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years and at a rate that is low but market-adapted (STIBOR+). The idea was furthermore that the projects to be implemented generally should have a pay-off period of less than 10 years.

17. The basic strategies for the projects are defined by the following key words/phrases:
    - **Quick** implementation, standard solutions
    - **Affordable** investments on favourable, but commercial, terms
    - **Reliable**, proven and sustainable technology

18. The fact that the financing of the projects were to be provided though loans a clear combination of cost-efficiency and substantial results in the form of climate and environmental improvements and clear economic advantage were imperative. Furthermore it was important to be able to offer implementation solutions which were based on well-established and sustainable technology and a short implementation time. Thus, there was no incentive for implementing projects that were not profitable within a reasonable time-frame. The main direction was therefore on. projects which otherwise were not to be implemented due to barriers such as scarcity of capital, high capital costs, lack of information, inadequate access to economic or technical expertise etc.

19. At the beginning of the programme the loans from the EAES Programme very often were the very first any of the municipalities or the municipal heating companies had ever been engaged in. Therefore, it has always been a special assignment for the Swedish side to explain thoroughly the conditions for the loans and the economy of the projects. An important role in this context is played by the local legal advisers that are assisting the management of the EAES Programme and the borrowers in the process of arranging loan agreements and securities for the loans so that these documents are always in line with the legislation in each country and that they follow the rules set out by the respective governments for loans from abroad. This work is all the more important as the EAES Programme has a possibility to provide loans without guarantees from the respective governments.

20. Already before the EAES Programme started there were a good knowledge on the high technical skills in the countries in Central and Eastern Europe within the Swedish agencies dealing with energy, industrial and technical cooperation both on a bilateral basis as wells in international cooperation activities. However, for obvious reasons, the acquaintance with market economic principles was weak in these countries. It was therefore important that the plant-owner and the local project manager were to be directly involved in all parts of the implementation process in what could be characterised as a "learning-by-doing" process. Swedish consultants was assigned to assist the local management in this process until the project was commissioned. In addition, local technical experts were assigned as advisers and to follow the implementation and commissioning and making independent evaluations of the projects.

21. Partly this process was chosen as the resources for a more extensive and comprehensive training activities was not foreseen in the programme. Looking back, it can be said that this working method has been beneficial for both sides as it has provided the local partner with knowledge of market economy including i.a. experience of procurement in open competition, loan handling etc. The Swedish side in turn has gained in-depth and detailed knowledge of the specific problems and the possibilities in each country and has also created a good environment for long-standing cooperation and relations. Over the years this experience and knowledge have contributed to a refinement of the programme and the implementation process. The success of this working method has also been verified in a number of local, Swedish and international evaluations.

Main actors and policy mechanisms used

22. As a result of the Government Bill on Energy adopted by the Riksdag (Parliament) in June 1997 a new Government agency, the Swedish National Energy Administration (Statens Energimyndighet, STEM) entered into operation as of 1 January, 1998. The main part of the new agency consists of the departments dealing with energy matter which were transferred from NUTEK. The Swedish National Energy Administration has the central role of implementing the Government's policy aiming at transforming the Swedish energy sector to sustainability and to be less dependent of both fossil fuels and nuclear energy, where emphasis is laid on energy efficiency and further increased use of renewable fuels for both heat and electricity production.

23. The loan is given by the Swedish Administration. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years during which the interest accumulates. The interest rate is set to STIBOR + x% where x is depending on the type of project and the borrower. Security is given by local municipality guarantees or by mortgage.

24. Implementation

Projects are normally divided into the following stages:

- Expression of interest from a municipality
- Visit and assessment by NUTEK representatives
- Letter of intent
- Small feasibility study, Business plan
- Design of a simple call for tender
- Loan contract, Guarantee, Security, Mortgage
- Open competition
- Evaluation of tenders
- Signing of main contract
- Project management, On-site meetings, Support and Supervision
- Commissioning, Final inspection
- Operation and maintenance
- Emission measurements
- Follow-up programme

The project management is done by the local staff, having a local budget and using local labour and material as much as practically possible. Therefore, the local management is one of the main factors to be evaluated before a project is initiated. The local project management is, however, guided through the entire process by NUTEK representatives.

25. One important assignment for the Swedish consultants when a potential project was located, either through direct search activities or through proposals from central authorities, was to get an overview of the real costs and the consumption of fuels, production demand etc. In the earlier situation fuel was provided for a central supply facility, salaries to the staff from another budget and the settling of tariffs and collection fees for the heat by other authorities and organisations. There was no clear demand for total cost coverage and very often over-capacity was installed and - at the same time - the losses in distribution and end-use were, and are still, often considerable. Another important issue was to find out about the real base-load requirement, i.e. in practice, the status quo (or ex-ante) baseline. In the calculations of the cost-efficiency of a boiler conversion project the base-load was a decisive factor for the new capacity to be installed in order to avoid installation of over-capacity.

26. An important feature of the EAES Programme is the fact that all procurement are made in open competition where Swedish companies, companies in the other Nordic countries as well as local companies in the respective recipient countries can participate provided they can offer equipment and services of the required technical standard.

27. Through the projects Swedish companies have gained experiences of the working conditions in the respective countries and a fruitful long-standing cooperation have been developed between Swedish and local companies of benefit for both sides. Local companies get increased possibilities to adapt their technological standards to international requirements and thereby improved export possibilities. Swedish companies increase their competitiveness, including on third markets, through such cooperation. In this context the special small boiler production project in Latvia could be mentioned. In short this project was based on Swedish technology procurement experiences and resulted in local production of small biofuel boilers in the size of 1.5-2 MW following a technical concept elaborated by Swedish consultants. A number of such boilers have been installed in EAES projects in Latvia and in neighbouring countries.

28. It has many times been verified from the participating Swedish companies, which often are small or medium-sized, that the EAES Programme has opened up market possibilities which they otherwise had not been able to exploit due to lack of knowledge and/or that such activities would have been considered too risky. Through the EAES Programme these companies, together with their local partners, have got good reference plants which have rendered them a number of other customers in the respective countries, i.a. forest industries and wood-working industries.

29. For the plant-owners and local suppliers the projects have provided a possibility to get practical learning-by-doing experience of market economic conditions. It often happens nowadays that the local Baltic company takes the role of main contractor and the Swedish company participates as sub-contractor. Over the years an increasing cooperation between local experts and consultants and Swedish consultants have been developed. Today, very often local consultants are engaged as sub-consultants to the Swedish firms engaged.

Monitoring and evaluation process (see also appendix)

30. Today the programme comprises around 60 projects, some 50 of which have been fully implemented or are in their very final stages of implementation, and another 10 are ongoing. About half of the projects concern boiler conversions, where environmental effects are more obvious and directly measurable. However, to increase the efficiency of a boiler conversion it is often advisable to implement efficiency measures in the distribution network. This may, for example, include water treatment for the system as well as measures affecting buildings thereby also increasing the efficiency in the entire heat supply system. Improvements to the distribution networks can thus result in the closing down of fossil fuel fired boilers, while measures in buildings result in higher comfort. Besides energy savings of some 20-25 % in heat consumption, further savings can be obtained as the residents no longer have to use electric radiators to compensate for unsatisfactory heat and hot water deliveries. The indirect merits of energy efficiency measures in distribution and end-use are also that they might mean savings in the form of avoided costs in respect of new heat production plants.

31. The investments, financed by loans to the plant owners for a total of more than 60 projects, (see appendix) represent about SEK 225 million (approx. US$ 25 million). In addition to these costs, NUTEK has provided consultancy support for around SEK 40 million (US$ 4.3 million). Additional costs for the projects consist of administration, evaluation and follow-up activities, as well as information and seminars The directly measurable reductions in environmentally hazardous emissions resulting from the implementation of the projects in the enclosed list, are estimated at:
    - CO_2 300,000 tonnes/year
    - SO_2 3,100 tonnes/year
    - NO_x 170 tonnes/year

32. Results from implemented conversion projects that have operational experience from 1-3 heating seasons show that the fuel costs for heat production in the converted boilers have been reduced by an average of 40 % compared with the costs for the same production level based on fossil fuels. At the same time, job opportunities have been created in the extraction and production of biofuels sector and it has been possible to make use of waste from wood-working industries that otherwise is subject to dumping fees. The low prices for e.g. sawdust contribute to the reduction in the total biofuel price.

33. The average investment costs per installed MW in boiler conversion projects are less than SEK 1 million, including civil works. In the small boiler projects in Latvia, where the boilers have been produced locally, based on a Swedish concept, the average cost per installed MW is around SEK 0.65 million. However, such figures are less important than the annual plant production figures. So far those plants which have been in operation for two or more heating seasons show good capacity utilisation records. The investments for boiler conversions, counted as per tonne of reduced CO_2 emissions, are around SEK 545 (US$ 57), counted over one year only, while the lifetime of a converted boiler is estimated to be 15-20 years.[22] The specific investment cost for other types of projects is highly variable. The grant part, including administration, evaluations etc. is estimated at around SEK 80/tonne CO_2. International expertise recommends the accounting of a risk cost of 20 % for defaults in loan repayments. NUTEK has estimated this cost factor to be equal to the grant part, i.e. SEK 80/tonne CO_2.

34. It should also be noted that in some cases the borrowers have refrained from making full use of the offered two year grace period and have already started their repayments on

[22] See also paragraph 36 below. The investments are recovered fully in the profitable projects.

the loans. So far no real defaults in repayments have been registered although in one case a delay has occurred. In general, the borrowers show great concern in honouring their obligations under the loan agreements. Up to the end of 1996, repayments, interest and instalments of around SEK 6 million (US$ 0.850 million) have been made. For 1997 the expected repayments are estimated to amount to some SEK 11 million (US$ 1,5 million). The repayments are reallocated to the Programme for financing further projects.

Discussion of results

35. The EAES Programme has provided Sweden with at lot of knowledge on the particular problems in the respective countries where projects are implemented. The working method - close contacts and cooperation with local experts during the whole implementation phase, during commissioning and in the follow-up activities - have created an ever increasing and widespread network which now includes central authorities, universities, energy institutes, municipalities, energy companies etc. This network plays an important role for transfer of knowledge, for preparation, translation and adaptation of information to be disseminated in the different countries and for contributions and participation in other projects, i.a. in different twinning projects initiated by the European Union and international organisations.

36. Due to the fact that the projects are financed through loans to the plant owner the major part of the EAES are of "no-regret" character, i.e. projects that are attractive to the host mainly on the basis of economic profitability but they do often go un-exploited due to a number of different barriers, such as scarcity of capital, too high capital costs and availability of long-term borrowing on the local market, lack of information, inadequate access to technical expertise. As joint implementation projects, such activities require a foreign partner to make relatively small investments in order to reduce such market barriers that enable the local partners to take actions that are already cost-effective, as is described in the report by IEA, 1997 "Activities Implemented Jointly - Partnerships for Climate and Development". Such small projects are usually difficult to finance through international financing organisations as the incremental costs often are too high and the bureaucracy too time consuming. It has also been stated that the strategy chosen by the EAES Programme recognises that there is a great potential for lowering barriers to existing no-regret options and that it initiates a process of market transformation for further activities of climate improvements beyond the joint implementation project.

EAES Programme - Projects implemented and ongoing in terms of year of commissioning, country and project types

Year of comissioning / Country / Type of projects	Number of projects	Invest-ment[23] Costs MSEK	Consult-ancy[24] Costs MSEK	Total Costs MSEK	Saved/ converted Energy MWh/år	CO_2 reductions Annually tonnes	CO_2 reductions Accumulated tonnes	Cost for reduction of CO_2, öre/kg: Investment	Investment accum.	Consultancy	Consultancy accum.	Total	Total accum.
1993	3	11	3	14	72 000	25 600	384 000	42	3	12	1	55	4
1994	7	30	5	35	134 800	48 120	891 800	221	12	54	3	275	15
1995	7	20	4	23	86 700	30 400	436 500	87	6	26	2	113	8
1996	17	63	12	75	273 450	90 345	1 381 175	194	13	51	4	245	17
1997	13	28	6	35	73 070	26 090	481 350	130	8	40	3	170	11
1998	13	35	7	41	105 810	36 575	741 625	215	13	89	6	304	18
Ongoing	6	36	4	41	72 700	25 800	520 350	167	9	23	1	190	11
Estonia	21	75	13	87	302 770	100 260	1 635 900	182	12	48	3	230	15
Latvia	22	63	11	74	246 850	85 875	1 567 125	186	11	38	2	223	13

[23] Loan to the project

[24] Covered by grant

Lithuania	9	44	6	50	191 000	62 750	1 016 250	103	6	18	1	122	7
Russian Federation	13	42	11	53	77 910	34 045	617 525	155	10	90	6	245	16
Poland	1	2	1	3	500	2 200	55 000	88	4	34	1	122	5
Boiler conversion projects	27	105	18	123	562 500	192 270	3 128 550	65	4	16	1	80	6
Distric Heating Distribution	15	30	6	36	58 270	21 990	350 200	189	11	46	3	235	13
Energy Eff. in end-use	11	17	6	23	13 860	4 840	72 600	431	29	164	11	595	40
Combined projects	13	74	12	85	184 400	66 030	1 340 450	124	6	22	1	147	8
Total resp.	**66**	**225**	**42**	**267**	**819 030**	**285 130**	**4 891 800**						
Average CO_2 cost/invest.								**79**	**5**	**15**	**1**	**94**	**2**
Total resp.	**66**	**225**	**42**	**267**	**819 030**	**285 130**	**4 891 800**						
Average CO_2 cost/project								**166**	**10**	**49**	**3**	**214**	**14**

1 SEK = 100 öre = 0.11 Euro

CS 15

Energy Efficiency Best Practice Programme Case Study

Introduction

The UK Energy Efficiency Best Practice Programme (EEBPP) was launched in April 1989, to stimulate energy savings in industry, buildings and the business use of transport energy. The Programme involves an integrated set of activities to develop & research current best practice, disseminate relevant, impartial information and support the development of new energy efficient technologies and techniques. To ensure sufficient programme coverage, the EEBPP comprises two components, industrial (including transport use) and buildings, that run in parallel, but with appropriate knowledge-sharing.

Since its launch, the Programme has evolved, working with the various business, commercial and public sectors to meet its objectives. The Programme uses input from relevant trade and professional associations and industry experts, together with feedback from impact assessment, to direct changes and set strategies. As a key Department of the Environment, Transport and the Regions (DETR) initiative, the Programme gives priority to major departmental policy concerns. Under the Kyoto Protocol, the UK is committed to reducing greenhouse gas emissions to 12.5% below the 1990 levels by 2008-1012; in addition, the Government has set a domestic goal to reduce carbon dioxide emissions to 20% below 1990 levels by 2010. The Programme plays an important role in UK Government programme of action to deliver these emission reduction targets, working in synergy with other policies and measures. It also features strongly in the DETR's efforts to promote sustainable development. The EEBPP continues to evolve as a major player in the Climate Change Strategy set by the UK Government's and the Devolved Administrations.

The EEBPP is a comprehensive technology transfer information dissemination programme that has successfully and cost-effectively addressed the information/market barrier. The achievements of the Programme have been quantified and the targets set have been met. Indeed, the target for savings by the year 2000 was increased when it became clear that the original one would be exceeded.

Objectives of the programme

In the UK, industry and buildings account for some two-thirds of total energy consumption, making a substantial contribution to national carbon dioxide emissions. Energy use in these areas could be reduced by some 20-30% using currently available, proven cost-effective energy efficient technologies and management practices. The EEBPP sets out to address gap between what is currently achieved and what could be achieved with best practice, by promoting technology and management practices. The Programme works alongside other policies and measures to encourage energy efficiency. For example, consultants under the Site Specific Advice initiative have access to all EEBPP information, and the Climate Change Levy has had much help from the EEBPP to enable businesses to meet their Negotiated Agreements, or simply to reduce their energy bills.

Targets for the EEBPP are set with the overall strategic goals of lessening the climate change impact of UK industry and the national building stock, improving industrial competitiveness and promoting energy security. The overall objective of the EEBPP is to

stimulate energy savings worth £800 million/year (1990 prices), equivalent to carbon savings of about 5 million tonnes/year.

Energy savings must also be made cost-effectively. The Programme is designed to help organisations cut energy bills by 10-20%, by providing the independent advice and assistance needed to persuade them to use cost-effective technologies and management techniques. It must provide a cost benefit of at least £5/year of energy savings for every £1 of tax payer's money used to fund the Programme. Further details on the objectives of the EEBPP can be found in the Climate Change Strategy[25].

The EEBPP continues to address significant barriers to the take up of energy efficient technologies and techniques. The Programme offers impartial information and advice, targeted to individual queries, tackling the seemingly conflicting barriers of too much information and insufficient unbiased information. Through promotion of results from successful demonstration projects, the Programme aims to stimulate senior management commitment, and to overcome resistance arising from the perceived risk of investment in new technology. Training initiatives aim to involve all the workforce, overcoming the human barrier to improving energy efficiency, mainly resulting from a fear of change. It also offers support for research and development of new energy efficient technologies and techniques, and uses the considerable management and technical skills within the Programme to identify and address gaps in knowledge.

Process of definition/design of the programme

As a strategy-based programme, the EEBPP is managed for the benefit of business, with its direction decided in consultation with business. Strategies are evolved in close collaboration with representative bodies, trade and professional associations and other relevant parties.

Sectoral and cross-sectoral strategies are set up in response to perceived needs or changes within particular areas. Each strategy defines a coherent set of issues, identifies the actors concerned and outlines the ways in which the issues will be addressed. The Programme's management teams have established close working relationships with relevant sectoral and cross-sectoral organisations, and these links are exploited as part of the information gathering process for each proposed new strategy. The strategy development process involves identifying barriers to energy efficiency, prioritising areas for action, and generating a portfolio of possible project and promotional activities. The process is designed to identify the most cost-effective areas for action.

Draft strategy documents are then presented to the Energy Efficiency Programme Committee (EEPC), which advises the DETR on the potential savings, cost-effectiveness and so on. The EEPC comprises up to 12 independent members drawn from industry, commerce, the buildings sector and academia, and as such offers valuable, expert advice and makes a significant contribution to the content and direction of the programme.

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[25] The UK Government's Climate Change Strategy, published in November 2000, is available on the Department of the Environment, Transport and the Regions (DETR) web site, at www.detr.gov.uk/climatechange.

Main actors and their roles

At the time of writing, the EEBPP is managed on behalf of the DETR by two contractors, ETSU (part of AEA Technology plc) and BRECSU (part of BRE Ltd), who act in agency roles. After 1 April 2001, the Programme will be run through Carbon Trust[26].and subsequently management of the different Programme elements will be put out to tender.

The industrial component is managed by ETSU and currently covers all the main industry sectors, the industrial utilities and commercial and fleet transport. It also encompasses cross-sectoral areas like compressed air, small and medium-sized enterprises (SMEs), combined heat and power (CHP) and management techniques. The buildings component is managed by BRECSU and addresses domestic housing, public sector buildings and commercial and industrial premises. Again, this component also encompasses cross-sectoral areas like insulation, lighting, SMEs, CHP and management techniques. Where there is a potential overlap in areas of responsibility, ETSU and BRECSU consciously work together to co-ordinate their activities, sharing knowledge to benefit the Programme. While recognising the need to work in different ways appropriate to the diverse energy use sectors, constant liaison and comparison of Programme management methodologies ensures maximum efficiency of the EEBPP.

Both contractors adopt the sector approach, with sector managers responsible for particular areas, such as chemicals, non-ferrous metals, housing and schools. On the technology side, sector managers work with equipment manufacturers and users to generate, collate and disseminate authoritative, information to relevant parties. Technical projects, such as New Practice and Good Practice Case Studies, are monitored independently by contractors appointed by ETSU and BRECSU. With non-technology areas, such as management techniques, it is important to involve everyone in the workforce, so sector managers work with, for example, the Chartered Institute of Management and trades unions. Again, any results are verified independently by appointed contractors. The close working relationships with other relevant organisations are a cornerstone of the Programme's success.

The Energy Efficiency Programme Committee (EEPC) also plays a major role in the EEBPP. The 12 independent members mainly have industrial/commercial/building concerns, or come from academia. The committee also has also a representative from the Department of Trade and Industry (DTI) and an observer from the Energy Saving Trust. Through their review of each strategy, members of the EEPC make a significant contribution to the quality and success of the Programme, and to ensuring value for money.

Policy mechanisms used

As the UK Government's principal energy efficiency information, advice and research programme for organisations in the public and private sectors, the EEBPP works in synergy with other Government policy measures, particularly negotiated agreements.

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[26] The Carbon Trust is the provisional name assigned to a UK governmental body, being set up to run an integrated programme to accelerate the take up of existing low carbon technologies and other measures that support a low carbon economy.

The core output of the Programme is a portfolio of descriptive or prescriptive publications, which range from detailed technical reports to simple leaflets. The majority of publications fall into four categories:

- Energy Consumption Guides that benchmark energy performance in specific sectors of industry and building stock, and show patterns of energy consumption to enable readers to establish their relative energy efficiency performance, with suggestions of ways to improve it;
- Good Practice Case Studies and Guides that describe the application of proven energy-saving measures and techniques;
- New Practice Case Studies and Reports that detail independent monitoring of the first application of innovative energy efficiency techniques and practices;
- Future Practice Profiles and Reports that describe the R&D projects supported by the Programme, with the aim of developing tomorrow's solutions.

In addition, information is made available on CD-ROM and in other multimedia formats. Printed literature is distributed at events or by mail in direct response to specific requests.

Information and assistance available from international programmes, such as the International Energy Agency's (IEA) CADDET programme and the European Community (EC) SAVE and Framework R&D programmes, is also integrated into the EEBPP where it is cost-effective to do so. When the proposed European Best Practice Initiative (which draws on EEBPP experience) is launched, it will also be integrated into the Programme.

Increasingly, electronic dissemination techniques are being used, with much material now available on the Programme web site at http://www.energy-efficiency.gov.uk/eebpp. Relevant information is also disseminated via articles in the trade and technical press. All publications and independent advice can be obtained through the Environment and Energy Helpline, a freephone service available throughout the UK.

Under the EEBPP, ETSU and BRECSU have an extensive programme of events - workshops, site visits, seminars, conferences, exhibitions, and so on - for every sector that is active. All events are carefully tailored to specific audiences and energy efficiency messages. Many of the events are hosted or co-sponsored by other organisations, such as professional or trade associations, which not only shares the costs, but also encourages outside organisations to endorse the Programme message, thereby enhancing its credibility. Events prove an effective means of information dissemination, providing participants with well-targeted practical information and advice on energy efficiency as it relates to their situation.

Funding for the EEBPP comes from the DETR, as part of its research strategy. The DETR sets the level of funding and determines the Programme direction. The funding is split between the service costs for the principal agencies, ETSU and BRECSU, and for contracts let by these agencies for the independent monitoring of energy efficiency projects, the commissioning of scoping studies to develop sectoral and cross-sectoral strategies, marketing support services and so on. Regular reports are made to the DETR on both expenditure and progress towards energy saving targets. Funding for 2000/2001 is set at £19.804 million. Further details on funding can be found on the DETR web site at http://www.research.detr.gov.uk.

Monitoring and evaluation process

Impact assessment is an integral part of the EEBPP, with feedback playing an important role in the evolution of the Programme. Two types of impact assessment are used:

- **Follow-up studies**

These generally take the form of questionnaires, handed out at specific events for later completion. The questionnaires are designed to identify how EEBPP advice has been applied to make changes and whether these changes have resulted in energy savings. The responses are analysed by the relevant project team, with help from the ETSU or BRECSU impact assessment unit as appropriate. These studies enable the project teams to gauge the uptake of energy efficiency measures, which gives some indication of the effectiveness of the event, and the advice and literature handed out. These data are used to modify future Programme output as necessary. Following up an event also helps to build close working relationships between the Programme and its target audience.

- **Market research**

A top-down assessment, usually carried out by specialised market research contractors, is used to monitor the moves towards energy efficiency and the dynamics of energy efficiency practices, as well as the extent to which respondents have found the EEBPP useful. The relevant project teams, together with the ETSU and BRECSU impact assessment units, play a key role in deriving the study methodology and research plan. Data from these studies prove invaluable when revising or developing strategies. They also enable project teams to detect changes in sector benchmarks.

As part of an on-going improvement programme, advice on possible modifications to the assessment methodology is sought from external consultants and further work is planned to assess the extent to which energy savings are maintained over time.

The results of impact assessment enable the Programme managers and the DETR to identify new areas for activity and also areas in which work can be scaled down. For example, in recent years, the potential for major energy savings in business transport and in SMEs has been identified, and increased resources have been assigned to these areas. On the other hand, if a sector is identified where the rate of return on investment in promoting energy efficiency has reduced, it may indicate that work can be scaled down; a watching brief in the UK and abroad will reveal if, and when, the EEBPP should step up activity in such a sector.

While ETSU and BRECSU have developed monitoring and evaluation processes suited to their own areas, the processes themselves are subject to independent assessment by contractor appointed by the DETR. This verifies results and provides a platform for input to improve the methodologies used.

In addition, the performance of the Programme as a whole is also monitored independently of the agencies. For example, in 1995, the Policy Research in Engineering, Science and Technology (PREST) was appointed to carry out a comprehensive review of the programme, including its impact assessment techniques.[27] Studies of this kind enable the DETR to

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[27] A summary of the findings of the PREST review is available, and a copy can be ordered through the Energy Efficiency Best Practice Programme web site .

monitor value for money, modify Programme direction, expand research interests, develop links with other DETR research programmes, other Government initiatives and overseas programmes, and also to determine future research partners.

Discussion of results

Based on independent studies, by 1999 the Energy Efficiency Best Practice Programme had stimulated energy savings in excess of £650 million/year (where £ is the UK pound), equivalent to over 4 million tonnes/year of carbon savings. These savings are in line with those projected and agree with those derived from impact assessment studies, and show that the Programme is on line to achieve its overall target of £800 million/year, equivalent to 5 million tonnes/year of carbon savings. Indeed, savings resulting from the Programme have exceeded expectations, with the result that the target for the year 2000 was increased in 1994, when it became evident that the original one would be met with ease. Analysis shows that the EEBPP produces savings at a cost of around £20-30/tonne of carbon savings, making it a highly cost-effective programme.

The energy saving results are quantified through the results of follow-up studies and other impact assessment. The Programme repeats sector benchmarking, for example by collating data for Energy Consumption Guides, and uses the data to determine the shift in energy performance. To-date, each revisit has reported lower energy use, costs and therefore lower energy costs, improved competitiveness and reduced greenhouse gas emissions, showing that the messages are not only getting through, but being acted upon.

In recognition of the success of the EEBPP, it remains a key component of the UK Government's Climate Change Strategy, under which the Programme will broaden to help deliver the UK Government's emission reduction targets. In July 2000, the Environment Minister announced a new initiative, the Carbon Trust, in line with proposals from the Advisory Committee on Business and the Environment (ACBE) [28]. The Trust will take on the management and commercial development of the business (including business transport) elements of the EEBPP, enabling it to deliver tailored information and advice direct to business, carry out on-site energy audits and provide support to fund to development of low carbon technologies.

As the Programme has evolved, it has been increasingly important to develop and maintain links with other programmes, within the UK and overseas. These programmes form useful sources of information, as well as providing outlets for energy efficiency messages. Maintaining links has proved key to the success and evolution of the EEBPP, minimising duplication of effort and maximising spread of the messages. Partners include the IEA's CADDET programme and the EC SAVE and Framework R&D programmes. Where programme objectives coincide and there is scope for synergy, the EEBPP co-funds projects and encourages UK organisations to apply to these programmes for funding. Links have also been established with the UK Environment Agency on the energy efficiency aspects of the Integrated Pollution Prevention and Control Directive, and there is on-going liaison with the Energy Saving Trust. In addition, the Programme contractors liaise with the UK research

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[28] Details of the proposed Carbon Trust can be found through the DETR press release web page http://www.press.detr.gov.uk and through its environmental initiatives web page http://www.detr.gov.uk/environment.

councils, particularly the EPSRC (Engineering and Physical Sciences Research Council) and the Department of Trade and Industry (DTI) is kept informed of work relevant to its sectors.

The EEBPP has also been instrumental in promoting the use of CHP, working with the Government to help it achieve its target of 10,000 MWe installed by 2010. The EEBPP has setting up and running the CHP Club, designed to help CHP users exploit the new, positive opportunities to develop CHP schemes. It is also closely involved with CHPQA, a self-assessment and certification scheme to help CHP users to capitalise on enhanced capital allowances and exemption from the Climate Change Levy, due to come into force in April 2001.

Independent evaluation of the EEBPP has proved very favourable, and has adjudged it to have a comprehensive coverage of UK industry and buildings. Where these evaluations have identified any weaknesses, the Programme has develop means of overcoming them. New approaches to information dissemination will continue to be exploited, to ensure the target audience is met and that energy efficiency information is readily available to all. As sectors become more energy efficient, Programme initiatives are held at a maintenance level until new issues arise that justify a greater level of activity. This maintenance ensures that energy consumption data remain current and evaluation techniques must be improved to enable monitoring of savings over time.

The Energy Efficiency Best Practice Programme is clearly effective in generating energy savings, and has proven good programme management skills that allow it to identify and exploit energy-saving opportunities within and across the various industry and buildings sectors. Key to its success have been organisational learning and experimentation, resulting in the use of initiatives derived for one area being applied elsewhere, increasing the energy-saving potential of individual sectoral activities. Regular review of strategies ensures that programme activities are continually refined and updated, and therefore remain appropriate. It also ensures that any market or technological changes are addressed by the programme.

The success of the EEBPP is well-documented, with the initiative being taken up in other countries, and by the European Community programmes.

UNCONVENTIONAL NATURAL GAS E&P

EXECUTIVE SUMMARY

The gloomy, almost crisis-like outlook for the future of domestic natural gas in the late 1970's set in motion a set of national-level energy initiatives for adding new gas supplies. Two of the most valuable of these were: (1) the joint government/industry R&D programs in tight gas, gas shales and coalbed methane by the Department of Energy's Office of Fossil Energy (DOE/FE) and the Gas Research Institute (GRI) that established the essential exploration and production technology; and, (2) the unconventional gas economic incentives (Section 29 tax credits) that buffered the economic risks faced by the early set of unconventional gas developers and helped attract scarce investment capital to this emerging resource.

Now, twenty years later, unconventional gas offers one of the impressive technology success stories. A poorly understood, high cost energy resource is now providing major volumes of annual gas supplies and helping meet the growing domestic demand for natural gas.

- Unconventional natural gas provided 4,500 Bcf of supply in 1998, up threefold from about 1,500 Bcf twenty years ago.
- Proved reserves of unconventional gas are 52 Tcf, up from less than 20 Tcf when the R&D and incentive programs started.
- Assessed recoverable resources of unconventional gas are now estimated at 370 to 500 Tcf, providing confidence that with a continuing pace of technology progress the contribution of unconventional gas will continue to grow.

Behind these spectacular numbers are a host of dedicated activities, occasional failures and many successes, all underlain by substantial investments in R&D and technology. Tight gas, the flagship of unconventional gas, is now pursued routinely by independents and majors alike in over a dozen major domestic basins. Gas shales development has expanded from the Appalachian Basin to new basins in Michigan (Antrim) and North Texas (Barnett). Coalbed methane, a resource once labeled "moonbeam gas", has been converted from a mining hazard to a low cost source of new gas reserves. Ironically, geopressured methane, the resource holding "a 1,000 years of gas", came up short once the bright, hot light of serious scientific inquiring was turned on.

With the benefits of hindsight and history, it is also possible set forth key "lessons that have been learned" from this case study in energy technology development. While the "lessons learned" are many, four stand out:

- When rigorously planned and managed, joint government/industry R&D can be highly successful, providing significant benefits to the domestic economy.

- A critical mass of funding and sufficient time are essential for ensuring success, particularly for ambitious, break-through types of R&D initiatives.
- Special purpose performance based economic incentives can greatly accelerate industry's adoption of technology, by helping attract capital and rewarding success.
- Disseminating technology and building a base of support requires a comprehensive effort, ranging from publications for the informed layman to high visibility, "flagship" field demonstrations.

UNCONVENTIONAL NATURAL GAS E&P

INTRODUCTION

The topic of this case study in U.S. energy technology policy and deployment is *unconventional natural gas exploration and production.* The case study starts with two national-level initiatives established in 1978 -- a comprehensive, multi-year R&D program and a set of price and tax incentives for unconventional gas. While many of these technology policy initiatives ended in the early 1990's, some are still in effect, including a portion of the technology based Department of Energy R&D program in unconventional gas.

The case study provides a rich set of "lessons learned". These "lessons" demonstrate that combining a well managed joint government/industry R&D technology program with performance based incentives for early application of new technology can be highly successful, providing significant economic benefits to the U.S. economy.

Historical Context. After decades of plentiful supplies, low costs and public indifference, natural gas finally moved to the center of national attention. The winter of 1975-76 saw worrisome curtailments in natural gas supplies leading to closing of schools and public facilities. In the following winter the problems of supply curtailments grew worse, leading to Congressional hearings and a scramble for explanations.

While numerous reasons were posed for the cause of the problem, the one set of answers that gained broad public and political acceptance was that "the nation was rapidly running out of natural gas supplies." Prominent in the winning debate were two dominating figures, M. King Hubbert and the Federal Power Commission, both who saw a pessimistic, depleting future:

- King Hubbert, who had gained considerable credibility among energy policy and Congressional staff by correctly forecasting the peak and subsequent decline in domestic oil production, applied his same forecasting methods to natural gas. In widely followed Congressional testimony, he set forth a future of limited natural gas resources and a pending crisis in gas supplies. Hubbert viewed a low domestic natural gas resource base of 1,050 Tcf of which nearly one-half had already been produced. He predicted that the peak in natural gas productions would occur shortly (in 1977) followed by a dramatic decline.

- The Federal Power Commission, responsible for regulating the price and profitability of natural gas production, defended its stance for continued price controls by stating -- why deregulate natural gas when there is so little left to find?

Search for New Resources. The bleak, uncertain outlook for natural gas set the stage for ground breaking legislation -- phased removal of wellhead price controls, incentives

for new natural gas development, and restrictions on gas use for electric generation (NGPA, Public Law 95-621). The concern over future gas supplies also set in motion a search for new sources of natural gas, in settings that had been previously overlooked:

- A Federal Power Commissions task force identified that 600 Tcf of gas in place existed in three large Western basins. These gas resources were held in geologically complex, extremely low permeability ("tight") reservoirs where existing technologies were insufficient for ensuring economical production.

- The Bureau of Mines identified that considerable volumes of methane (pure natural gas) were being vented for safety reasons from coal mines, wasting a valuable resource.

- Gas bearing Devonian-age shales were judged to hold several thousand Tcf of gas in the Appalachian Basin, "one of the least defined domestic gas producing regions."

- And, public interest was stirred by major articles in Fortune and The Wall Street Journal that a new natural gas resource -- geopressured aquifers -- could provide gas for 1,000 years.

Numerous special purpose studies and narrowly focused R&D efforts were initiated to further understand and pursue these large, little understood natural gas resources.

Foundation for a Coordinated R&D Program. Faced with a growing body of new, sometimes promotional information on unconventional natural gas, the Energy Research and Development Administration (ERDA) commissioned a comprehensive study of these resources. Advanced Resources International, then called Lewin and Associates, with Mr. Vello Kuuskraa as Study Director, was contracted to perform this broadly scoped, landmark study. The introductory page of this study, "Enhanced Recovery of Unconventional Gas (Volumes I, II, and III)," February 1978, pointedly set forth the challenge:

"As conventional domestic natural gas supplies dwindle, the nation must seek ways to slow these trends and obtain new supplies. The choices faced are controversial, costly and risky. They entail difficult balancing among higher prices, accelerated development, reliance on imports and new technology. This study has been conducted to assist public decision-makers select among these many choices by addressing two questions:

- How severe is the need for additional future supplies of natural gas?

- What is the economic potential of providing a portion of future supply through enhanced recovery from unconventional natural gas resources?"

As important, the study set forth the framework for an aggressive, coordinated program of research and development on unconventional natural gas -- "Beyond the analysis of these two questions, the study serves to assist the Department of Energy (the successor to ERDA) design a cost-effective research and development program to stimulate industry to recover this unconventional gas and to produce it sooner."

OBJECTIVES, DESIGN AND IMPLEMENTATION OF THE PROGRAM

The Department of Energy's unconventional gas R&D/incentives program has had many political twists and policy turns during its twenty years of existence. The outline and objectives of the original Enhanced Gas Recovery Program, that responded to the supply crisis atmosphere of the late 1970's, was set forth in the FY 1978 Congressional Budget Request. Subsequent administrations, reflecting their own National priorities and energy strategies, shaped and modified this program continuously. The Gas Research Institute's R&D program in unconventional gas, formulated in 1982, faced a somewhat similar experience in its later years.

Original DOE R&D Program Objectives. The strategic policy goal was to develop and stimulate the deployment of advanced exploration, development and production technologies for recovering new gas supplies from the massive but complex unconventional gas resources -- tight gas, coalbed methane, gas shales and geopressured methane. The technical objectives were to increase per well gas recovery efficiencies and lower unit development costs while providing incentives (through tax credits) for prompt, orderly development of the nation's gas resources.

In addition, two quantitative, national-level natural gas supply goals were set forth for the Enhanced Gas Recovery Program:

- *Increase gas production by an incremental 3 billion cubic feet per day by 1986, and*
- *Add 10 Tcf of producible reserves by 1985.*

Changing Horses in Mid-Stream. Even before the results were in, the political winds and market conditions shifted. The Reagan administration, in 1980, first scaled back the R&D program and then pushed to eliminate government involvement in short-term gas supply R&D, citing (with little foundation) that "the private sector has the financial and technical resources to develop the technology needed for new unconventional gas resources." Congressional intervention maintained the program, although only at a life-support level.

In 1991/92, with the publication of the administration's National Energy Strategy and the growing R&D role of the Gas Research Institute in unconventional gas, much of the remaining DOE R&D program was eliminated, with only the low permeability ("tight sands") area surviving. When, in 1994, the Gas Research Institute also shifted its priorities, terminating its focus on unconventional gas in favor of a more generic technology-based R&D program, for all practical purposes public R&D on unconventional gas came to an end. With subsequent loss of focus and declining public and industry support, the Gas Research Institute's generic R&D program on gas supplies is now also being phased out.

Program Definition, Design and Implementation. The original DOE R&D program had its roots in Volume III of the study -- "Enhanced Recovery of Unconventional Gas (1978) -- and was shaped considerably by industry and outside technical input. Unfortunately, in subsequent years the political process rather than science and analysis shaped much of program design. In contrast, the GRI R&D program on unconventional gas was able to stay, at least during its formative years, outside the political process. The definition and design of the GRI program relied greatly on the priorities of industry-based advisory committees and a FERC imposed benefits calculation methodology. The two R&D programs complemented each other, with the DOE program often conducting the exploratory, fundamental science and the GRI program providing the applied science and technology transfer.

Each organization relied greatly on outside technical experts, research organizations and industry to perform and commercialize its R&D. This helped to bring valuable cost-efficiency and cost-sharing to the program, particularly during the field documentations stages. The

supporting Appendices to this paper provide additional details on the budgets and technical accomplishments of the DOE R&D program.

Supporting Policy Mechanisms

Two separate economic incentives were set forth in Congressional legislation to encourage the development of unconventional gas - - incentive pricing and tax credits.

Incentive Pricing Under NGPA. The first set of economic incentives for encouraging exploration and development of unconventional gas were set forth in the Natural Gas Policy Act of November, 1978. Section 107 of this act deregulated the well-head sales price of natural gas from Dervonian-age gas shales, coal seams and geopressured brines. Section 102 of this Act enabled tight gas to become eligible for the highest ceiling price within the NGPA regulated categories, providing this resource with modest economic incentives.

Section 29 Tax Credit. A separate set of economic incentives for unconventional gas were placed into The Crude Oil Windfall Profits Tax Act of 1980. Section 29 of this act provided tax credits to qualified unconventional gas wells and formations. While producers needed to select which set of incentives to use, the deregulation of natural gas in 1981 made this choice moot. With amendments, the Section 29 tax credit qualifying period for new unconventional gas wells lasted until the end of 1992, with tax credits provided for gas produced through 2002.

The incentive provisions of the Section 29 tax credit were designed to reward efficient unconventional gas development and performance. And they did. During a time when national average wellhead natural gas prices were between $1.50 and $2.50 per Mcf, the tax credit for tight gas was about $0.50 per Mcf and for gas shales and was on the order of $1.00 per Mcf for coalbed methane, adding considerable economic value to the efficient production of these resources.

Response to Incentives. Not surprisingly, industry's development and production of unconventional natural gas responded strongly to these incentives:

- The production of Section 29 "legally eligible" tight gas, a resource with many undeveloped basins and readily available technology, grew from 240 Bcf in 1980 to 1,180 Bcf in 1986, plateauing thereafter. Overall production from this resource, including "legally" and "geologically" defined tight gas, was considerably higher as numerous low permeability areas and pre-existing tight gas production remained unapproved by FERC or a FERC-designated State agency.

- Lacking a sufficient base of technology, coalbed methane had little opportunity to use the tax credits until the end of the 1980's. Even with this late start, by the end of the qualifying period over 5,000 CBM wells were drilled and completed before the tax credits expired.

- Drilling for gas shales increased substantially in the Appalachian Basin and with R&D opening up the Michigan Basin drilling boomed, averaging over 1,200 wells per year in the last six years of tax credits.

Post Tax Incentive Activity. A most significant outcome of the tax incentive program was that unconventional gas well drilling and completions stayed strong after the expiration of the tax credits:

- After a brief lull, tight gas well completions rebounded to 3,000 wells per year.
- Coalbed methane well completions slumped somewhat in the mid-1990's but now have reached new highs with the strong activity in the Powder River Basin.
- Gas shale well drilling has averaged 900 wells per year for the six years since the expiration of the tax credits, only somewhat less than the 1,200 wells per year prior.

The reason for the strong post tax incentive activity was that unconventional gas exploration and development technology had progressed sufficiently such that the industry remained economic and could attract capital without the need for further incentives or subsidies.

MONITORING AND EVALUATION

The initial DOE and GRI unconventional gas R&D programs placed considerable effort toward establishing reliable, efficient monitoring and evaluation systems. Explicit supply enhancement goals, detailed R&D program plans, annual budget justifications and benefit to cost analyses were used. However, as the gas supply conditions moved from shortage to surplus and the political support for public R&D waned, the rules of the game and the measures of success changed.

The DOE R&D Program. The initial DOE R&D program's monitoring and evaluation process, involving independent outside technical experts, served the program well. As new information was collected and compared with expectations, a series of significant shifts in the program occurred. For example, the geopressured methane program, having found to be geologically flawed, was terminated. At the same time, other priorities and budget shifts occurred with increases for tight gas and coalbed methane and decreases for gas shales, bringing the individual technology area budgets into closer line with their resource potential.

However after a few years, as the gas shortage turned into a gas surplus, much of the national level evaluations and mid-course adjustments became politically driven rather than analytically founded. The coalbed methane R&D program was essentially shut down. The gas shale R&D program stayed on life support only due to Appalachian Basin political support. Subsequently the program was terminated in 1992. Tight gas R&D survived, but at a dramatically reduced level.

In recent years, DOE's R&D monitoring and evaluation process has again become much more analytical and rigorous. While no sense of urgency has yet emerged for using R&D or incentives to stimulate additional natural gas production (even though natural gas prices are at an all time high and concerns exist again about winter gas curtailments), several important management steps have been taken. A Strategic Center for Natural Gas has been established at the National Energy Technology Laboratory and a National Research Council/National Academy of Sciences evaluation of the accomplishments and benefits of each of the unconventional gas technology areas is underway.

The GRI R&D Program. From its inception, the Gas Research Institute was mandated by the Federal Energy Regulatory Administration (FERC) to perform extensive cost-benefit analyses, set forth rigorous budget justifications, and hold several levels of advisory board review. This process and clear focus on unconventional gas served GRI and its R&D program well. In 1994, however, GRI switched from a resource based program addressing unconventional gas to a generic E&P technology based program. At that point, GRI began to look like any other industrial R&D shop, lost its national gas supply mandate, and found difficulties justifying its program costs and benefits to industry.

DISCUSSION OF RESULTS

Unconventional gas offers one of the great success stories of national benefits and progress in technology. A poorly understood, high cost energy resource, one that the U.S. Geological Survey had not even included in its national appraisals of future gas resources (until their most recent 1995 assessment), is now providing major volumes of annual gas supplies and helping meet growing domestic natural gas demand.

- Unconventional natural gas provided 4,500 Bcf of supply in 1998, up from 1,500 Bcf twenty years ago.
- Proved reserves of unconventional gas are 52 Tcf, up from less than 20 Tcf twenty years ago; remaining recoverable resources of unconventional gas are estimated at 370 Tcf to 500 Tcf.

Looking ahead, based on projections by DOE/EIA's National Energy Modeling System (in AEO 2000), considerable further development of this resource base is expected, assuming a continuing strong pace of technology progress. By 2010, annual unconventional gas production is expected to reach 5,700 Bcf. The recent National Petroleum Council (NPC) Natural Gas Study expects even more from unconventional gas, estimating 6,800 Bcf of supply in 2010 from these resources. (The NPC tight gas study includes certain gas plays, such as the Austin Chalk with 400 Bcf of annual production, that are counted as conventional gas in the DOE/EIA model.)

The NPC study explicitly states, "This study assumes that technology improvements will continue at an aggressive pace." Recent cutbacks in industrial R&D, the small size of DOE's gas supply program, and the termination of the Gas Research Institute's public R&D on unconventional gas raise serious concerns on the future pace of technology progress. The NPC Study highlights its concerns by stating, "However, recent (declining) trends in research and development spending raises concerns regarding this (aggressive pace of technology improvement) assumption."

1. Tight Gas Sands. By the mid-1970's, industry knew that large quantities of natural gas resources existed in tight (low permeability) formations. However, the flow and production of gas from most of these tight formations was too low to support economic recovery. A handful of independents explored for areas where nature had sufficiently fractured this tight rock to make it productive, but generally with a poor record of success.

At the start of the R&D and incentives program, annual production from tight gas sands was low, with most of the naturally fractured "sweet spots" in these tight gas basins having been deemed found and developed. Significant advances in exploration, well drilling and stimulation technology were required to further pursue this large, complex gas resource.

The combined DOE, GRI and industry R&D programs, plus a set of modest tax incentives, unlocked the gas resource held in these tight rocks. The gas play, born in the Appalachian and San Juan basins, expanded rapidly into the major Rocky Mountain gas basins and more recently into Texas and the Mid-continent. By 1998, annual tight gas production was 2,920 Bcf, up from 1,400 Bcf in the mid 1970's. Proved tight gas reserves were 35 Tcf from a cumulative of 46,000 producing wells (not including the numerous older low producing tight gas wells in the Appalachian Basin), with nearly 48 Tcf of tight gas having been produced since the initiating of the R&D program.

2. Gas Shales. At the start of the R&D Program, the Appalachian Basin gas shales were a small, declining resource providing 70 Bcf per year. Annual new well drilling averaged only 200 wells and proved reserves were about 1 Tcf. Wells were being completed open hole, with little definition of productive pay zones, and were being stimulated with nitroglycerine (a remnant of early 1900's technology). Much of the activity was centered in the Big Sandy area of eastern Kentucky. Little understanding existed on key gas storage and production mechanisms nor about geologically similar gas shale plays in other parts of the country.

By 1998, annual gas shale production had reached 360 Bcf. Proved reserves were 5 Tcf, with another 4 Tcf having been produced in the twenty years from 1978 to 1998. Stimulated by Section 29 tax credits and the expansion into new gas shale basins in Michigan and North Texas, well drilling climbed sharply. Over 16,000 productive gas shales wells were drilled from 1978 to 1998 with a peak of 1,700 gas shale wells completed in 1992, the last year wells could qualify for tax credits.

3. Coalbed Methane. The combination of building a scientific base of knowledge, fostering appropriate technology and providing economic incentives launched the birth of a new natural gas industry -- coalbed methane -- now with nearly $10 billion of capital investment. Much of the early development was by independent production companies such as Devon Energy, Meridian Oil and Taurus Energy, who saw their gas production, reserve holdings and market capitalization rise sharply.

Coalbed methane production climbed from essentially zero at the start of the R&D program to 1,200 Bcf in 1998, from three significant basins. Proved reserves were 12 Tcf from over 6,000 producing wells, with another 7 Tcf having already been produced. The introduction and continuing adaptation of technology enabled the industry to remain profitable and vigorous, even after the 1992 expiration of Section 29 tax credits. Today, several new coalbed methane basins and plays are being actively developed, including the Powder River (Wyoming), Raton (Colorado), and Uinta (Utah), providing a base for continued growth.

4. Geopressured Methane. While considerable geologic and reservoir knowledge was gained, no commercial natural gas production was established for this resource. Still, the R&D program in geopressured methane helped bring a strong dose of reality and understanding on the viability, or lack of, for this gas resource and helped dispel the speculation that "a 1,000 years of natural gas" was at hand.

LESSONS LEARNED

Twenty years have passed since the DOE R&D and incentive programs were launched in unconventional natural gas. What lessons and insights might one be able to draw from this rich base of experience that would be relevant to other existing and emerging R&D programs such as Carbon Sequestration? Among the many "lessons learned," ten stand out:

1. When rigorously planned and managed, government supported R&D can be highly successful, providing significant benefits to the domestic economy. The DOE and GRI R&D programs introduced knowledge and hardware that turned a low productivity, high cost resource into a reliable source of new natural gas reserves and supply. Using a value of $0.50 per Mcf of additional natural gas production and reserves due to advances in technology and economic incentives, the national economic benefits of unconventional gas are $46 billion, not counting future development.

2. Establishing a scientifically-based knowledge base "the intellectual foundation," is an essential first step. Much of the negative outlook and low R&D support for coalbed methane stemmed from an ill-advised and unsuccessful "drill and hope" field demonstration project (separate from DOE's R&D program) before a scientific foundation had been established. The series of dry holes that followed severely set back and almost condemned what is now a vigorous industry.

3. Joint industry/government partnerships and implementation help leverage R&D resources and bring commercial practicality to the program. The GRI unconventional gas program regularly benefited from industry cost share and advice. DOE began to realize similar values when it increasingly turned to industry/government partnerships rather than relying solely on the internal R&D programs of its National Laboratories for implementing tight gas and gas shales R&D.

4. A critical mass of funding and sufficient time are essential for achieving success, particularly for ambition, breakthrough efforts. The timely and efficient development of the coalbed methane resource had a major setback when it was prematurely terminated. Fortunately, GRI picked up the R&D on this resource and made it one of its high priorities, enabling the technology to mature, to be rigorously field tested and to achieve success.

5. Independent evaluation of fundamental assumptions, data and results, while often unwelcomed by research investigations and proponents, is essential for avoiding wasting scarce R&D resources. The independent review of the geology and science of geopressured methane (while initially roundly criticized by its proponents) helped close down a large R&D program targeting this geologically flawed and economically non-viable resource.

6. Cost reductions and efficiency improvements in geologically based technologies rely as much on adapting the technology to the geologic setting as on fundamental breakthroughs. Successful results in the various coalbed methane and gas shale basins required substantially adapting technology rather than blindly applying methods that worked in other geologic settings or requiring totally new technology. As such, reliable and accessible geologic and reservoir data on the high potential basins need to be a priority for R&D.

7. Efficiently disseminating technology to industry requires a comprehensive program of technology transfer ranging from publications for the informed layman to high visibility "flagship" field demonstrations. GRI's publication of the "Quarterly Review of Methane from Coal Seams Technology," the numerous articles prepared by its technical contractors and the major field laboratory at Rock Creek greatly reduced the time for technology penetration and use by industry.

8. Economic and tax incentives can greatly accelerate industry's adoption of technology by helping assemble capital, by lowering economic risk and by challenging the financial community's imagination. The tremendous boost in new investment and well drilling, seen by all three of the unconventional gas resources, is a testament to the power of properly structured economic and tax incentives.

9. Special purpose "performance based" rather than broadly structured or "input based" economic incentives are a key to success. The highly focused Section 29 tax credits available to the unconventional gas industry had considerably larger impacts than the general purpose R&D tax credit available to all industry.

10. For maximum effectiveness, the incentives need to be sufficiently attractive and long lasting but also have a "sunset provision." Section 29 tax credits significantly improved project economics during the initial risky phase of unconventional gas development. As the technology and resource understanding matured, these risk premiums became less, enabling the unconventional gas industry to compete for project approval and capital without the need for continued incentives.

TECHNOLOGY DEPLOYMENT CASE STUDY
U.S. DEPARTMENT OF ENERGY'S SUB-CFL PROGRAM

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Introduction

In early 1998 the U.S. Department of Energy (DOE) launched a program designed to speed the market introduction in the United States of a new generation of smaller, brighter, and less expensive compact fluorescent lamps (CFLs). The program, called the DOE Sub-CFL Program, emphasized the small size of the lamps, intending to overcome one of the primary market barriers to wider market acceptance of this technology. CFLs often do not fit into lighting fixtures designed for typical incandescent lamps. It was developed primarily in cooperation with the multi-family housing industry, the primary target market sector, but also encouraged participation by other high volume buyers and market intermediaries, such as electric utilities, universities, government agencies, lighting retailers, public housing authorities, and hotel/motel companies.

The program used a technology procurement to induce manufacturers to develop and sell new products meeting technical specifications developed in cooperation with the multi-family housing industry. After extensive interaction with the multi-family housing industry, DOE's Pacific Northwest National Laboratory (PNNL) issued a request for proposals (RFP) to lighting suppliers, soliciting bids to supply sub-CFLs meeting minimum technical specifications. Winning suppliers were selected based on price, the extent to which bid product was smaller than the maximum size requirements, and the quality of the warranty offered.

The program offers an interesting case study for three primary reasons: 1) it successfully introduced 16 new lamp models into the U.S. market; 2) it achieved this aggressive response from the lighting industry without advanced guaranteed purchases, which are typical in technology procurement programs, and; 3) it exceeded its program sales goal of one million lamps by more than 50%.

Program Objectives

The Sub-CFL Program was developed in response to the Energy Policy Act of 1992, Sections 127 and 128 which required DOE to study and propose plans for developing and commercialising more efficient appliances (including lighting equipment). The legislation did not contain specific goals other than the general goal, "to improve energy efficiency." No specific energy use or carbon emission reduction goals were stated in the legislation, nor were any specific energy efficiency goals described.

In addition to the Energy Policy Act goal of improving energy efficiency, the Sub-CFL Program had several specific goals and objectives. The long-term goal of the program was to expand the market for CFLs by inducing manufacturers to develop and sell new CFLs that are shorter and lower cost than most CFLs then in the market. The medium term objectives of the program were to:

1) induce at least two manufacturers to commercialise new, smaller CFLs;
2) induce the commercialisation of a low-cost, 15 W integral CFL less than 5 inches (127mm) in length;
3) implement a program that offered CFLs at prices substantially below the then prevailing market price of $15-$22, and;
4) achieve sales of at least one million units.

These goals were based on the results of market research aimed at identifying the market barriers to wider use of CFLs in the multi-family housing sector. That research identified several barriers, by far the most important were price and size. Less important market barriers identified were low levels of luminous flux (light output), and ability to start in cold temperatures (for outdoor use). Accordingly, a program was designed addressing these barriers. Technical specifications were developed for the procurement setting maximum size requirements for each lamp wattage category in the program, minimum luminous efficacy, and a minimum starting temperature.

Process of Definition/Design of the Program

Based on its experience in working with the public multi-family housing sector on the Super-Efficient Apartment Size Refrigerator Program[29], DOE began working with private multi-family

[29] The Super-Efficient Apartment Size Refrigerator Program was a technology procurement jointly developed and implemented by U.S. DOE, the New York Power Authority, and the Consortium for Energy Efficiency. It led to the market introduction and substantial sales of a refrigerator exceeding U.S. DOE minimum refrigerator standards by 30%.

housing owners and operators, seeking opportunities to help them purchase more energy-efficient appliances, including dishwashers, refrigerators and clothes washers. DOE engaged a wide range of companies throughout the U.S., both large and small, in an effort to more fully understand their business and the decisions that affect the energy use of their multi-family buildings. In addition, DOE engaged several national and regional trade associations representing multi-family owners and operators.

Multi-family housing companies initially expressed strong interest in the idea of organizing projects to test the rental market response to the use of more efficient appliances. But the very substantial incremental cost of efficient appliances, relative to the cost of appliances that were typically installed by the companies, proved to be a formidable obstacle. The multi-family owners and operators were unwilling to stray from their long-run practice of purchasing the lowest cost appliances available, regardless of their energy consumption.

As a result, DOE began to explore technology improvements requiring less capital outlay and suggested a program to encourage owner/operators to consider purchase of Energy Star® lighting fixtures, specifically, dedicated CFL fixtures (lighting fixtures using pin-based CFLs) for outdoor and common areas. The owner/operators, however, stated that the expense of retrofitting fixtures in existing buildings made them an unattractive candidate for a joint project with DOE. The investment conservatism of the industry proved to be an even more formidable obstacle to the organization of a collaborative project than DOE had previously estimated.

DOE then proposed integral CFLs, a low-cost technology, hoping that successful completion of a low-cost, low-risk project would help make the industry more comfortable working with DOE and make possible future projects involving higher capital outlays by the industry. The suggestion was well received, but the discussions with the industry identified two major market barriers to widespread use of CFLs: price and size. Multi-family owners and operators emphasized most CFLs were too expensive and too long to fit into most of the existing lighting fixtures in their buildings.

After consideration of the substantial amount of information and feedback received from the multi-family industry, DOE decided a technology procurement, aimed at bringing low-cost, very small CFLs into the market was an appropriate means of engaging the multi-family housing sector in an effort to use more efficient technology. A technology procurement program was thus developed.

The decision to use a technology procurement approach was based on several factors:

1) New products were needed in the marketplace to address the identified market need.

2) Aggressive pricing was needed to make the new products attractive to the identified market. Technology procurement offered an opportunity to use competition among bidders to drive prices down.

3) The technical change needed in CFLs to meet the size requirements developed with the multi-family housing industry was modest; a common trait for products brought to market through successful technology procurements.

4) The multi-family industry expressed strong interest in the proposed approach.

A technology procurement program was designed to maximize the chance of success. The key design elements, and a short justification for each follow.

1) Two-phase approach

The program was implemented in two phases, with the first lasting five months, and the second lasting 24 months. The purpose of the first phase was to test the logistical operation of the program and to test the market reaction to products offered. Furthermore, the first phase was designed to attract bids based on products already available in the market, while the second phase was designed to attract newly developed products. The time consumed by phase I was intended to allow manufacturers more time to develop the new-to-market products expected in the second phase.

2) Web-based ordering

To keep implementation costs down, a newly developed web site was used as the primary channel for distributing information about the program, as well as for ordering products made available through the program

3) Strong warranty

Knowing of the multi-family industry's dissatisfaction with previously available CFLs, and of their hesitancy to purchase products with which they were not familiar, the program required manufacturers to offer an unconditional one-year warranty, which essentially eliminated risks of participation by multi-family owners and operators.

4) Cold start capability

Most lighting costs in multi-family property are billed directly to tenants. However, common area lighting, a large fraction of which is located outdoors in climates that experience low winter temperatures, is billed to the property owners. Since the program was targeting the property owners/operators, a specification was adopted which required bidders to offer products that would start and produce acceptable lighting levels in very cold temperatures.

5) *Emphasis on size*

Recognizing the importance of small size in overcoming market resistance to purchase CFLs, the program emphasized size reductions by not only setting difficult-to-meet size requirements[30], but by also awarding extra evaluation points to bidders by the extent to which they reduced size beyond the minimum requirements.

6) *Multiple suppliers*

Given DOE's previous experience with technology procurement, the program was designed to increase the chance that more than one bidder would be awarded an agreement to supply products through the program. Multiple suppliers allow program implementers to drop suppliers for performance or product quality reasons without having to suspend the program or issue a new RFP because other suppliers are available to continue supplying products.

7) *Participation by buyers outside of the multi-family housing sector*

While the target market sector was the multi-family housing industry, the program was designed to allow participation by utilities, government agencies, schools, and retailers. Program designers believed potential product demand by these other sectors would increase the number and aggressiveness of bids submitted by CFL manufacturers, without appreciably increasing program costs or complexity (since no subsidies were involved).

Main Actors and Their Roles

The main actors involved in the implementation of this program and their roles were:

1) *Private multi-family housing owners and operators*

As described previously, these companies were heavily consulted in the development and design of the program. They were used to identify the key market barriers to wider spread use of CFLs, and their guidance was used to design a program that met their needs. This sector was also the primary market target for the program.

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[2] The program's technical specifications restricted participation to those lamps meeting the following maximum length requirements: 15-16W (133mm); 18-20W (140mm); 23-28W (152mm); 30+W (178mm). A typical general service incandescent lamp of 60 - 100W is 113mm long.

2) Multi-family housing trade associations

During program design, discussions were held with several trade associations for the purpose of soliciting their guidance and their assistance in communicating and promoting the program to their members. At a national level, both the National Multi-Family Housing Council and the National Apartment Association were engaged. Both provided valuable guidance and agreed to alert their membership to the program opportunity.

3) CFL manufacturers

Extensive discussions were held with a large number of CFL manufacturers that were considered to be potential bidders. Meetings were held in the corporate offices of all three major lighting manufacturers (GE, Osram, and Philips), as well as a substantial number of smaller manufacturers and manufacturers' representatives (TCP, Lights of America, Link USA, Sun Park, Planet Mirth, Duro-Test and others). These meetings were used to alert the manufacturers to the program, to solicit their interest, and to seek their review and critique of both the program design and technical specifications. These meetings proved invaluable in shaping the technical specifications and in building interest in bid submission.

4) Utilities

While individual utilities were not engaged in the development and design of the program, program designers believe this was an oversight. Given the important role they've played in using and promoting the program, their involvement at an earlier stage would probably have produced a program better suited to their use. Nonetheless, a number of utilities -- especially large California-based utilities – have either directly purchased large number of lamps for use in their programs, or promoted use of the lamps to their customers. And interestingly, publicly-owned utilities, such as the Los Angeles Department of Water and Power, found the program especially useful given it had used government purchasing procedures to arrange the ordering agreements with the winning program CFL suppliers. That allowed publicly owned utilities to purchase the lamps without having to implement their own government-regulated procurements, which tend to be expensive and time consuming.

Utilities designed a number of programs around the sub-CFL program, including a low-income weatherization program providing the sub-CFLs free of charge to low-income customers, a green power program giving sub-CFLs to customers willing to sign up for green power, a multi-family housing program promoting volume purchases of sub-CFLs by multi-family owners and operators, and a program that signed up retailers to purchase and resell sub-CFLs in exchange for utility-paid advertising directing customers to participating retailers.

5) *Consortium for Energy Efficiency (CEE) and Northwest Energy Efficiency Alliance (NEEA)*

Both of these organizations are market transformation organizations[31]. CEE is a national organization, whose membership is primarily energy utilities engaged in market transformation programs. CEE played an important role in regularly communicating program information to its membership during the program's implementation. NEEA is a regional organization whose members include utilities, companies and other organizations involved in market transformation programs in the Pacific Northwest. NEEA not only modified their existing CFL program to promote use of sub-CFLs available through the DOE program, they voted in the Spring of 2000 to assume leadership of the Sub-CFL program (with co-funding from DOE), and to launch a special effort aimed at increasing the presence of sub-CFLs in Northwest retail stores.

6) *Retailers*

Based on the assumption that the majority of program sub-CFL sales would be sales directly from manufacturers to large volume buyers, such as multi-family housing companies, retailers were not asked to participate in program design. However, once sub-CFLs were made available through the program, the new products and prices were attractive enough to spur significant involvement by retailers, particularly cooperatives that buy products for the thousands of small, independently owned hardware stores in the U.S.

Policy Mechanisms Used

The policy mechanism used for this program is a technology procurement. Technology procurement is a method to pull new technologies and products into the marketplace through competitive procurements backed by large volume buyers. Generally, it involves a multi-step process requiring:

- Organization of target large volume buyers and market influencers (such as utilities);
- Interaction with those buyers to understand their business and technology needs in detail;

[3] Market transformation program is a term used in the U.S. to describe a new generation of conservation programs that are more carefully designed to exploit market forces than the previous generation of utility-sponsored conservation programs, and that are designed to have their market effects be self sustaining after cessation of the programs.

- Definition of their technology needs in the form of technical specifications, and acquisition of their commitments or intentions to purchase new products meeting those specifications;
- Dissemination of those specifications for expert appraisal by potential manufacturers of the newly defined product;
- Issuance of a competitive solicitation to potential suppliers, requesting bids for new products meetings those specifications, as well as the price at which they are willing to offer the products;
- Selection of one or more winners from those bids;
- Completion of agreements with the winning bidders establishing the terms and prices by which third party purchasers might purchase of the target products;
- Implementation of promotion/ marketing programs to maximize the purchase of the newly available products.

By working closely with potential buyers, technology procurement greatly increases the likelihood that products brought to market will be well received by buyers. And by organizing large volume buyers for new products, technology procurement reduces the risks to manufacturers of new product introduction, and allows them to introduce products at more competitive prices.

The Sub-CFL technology procurement followed the steps described above, with few exceptions. The key exception was that utilities were not significantly involved in the development of the program, more by oversight than by design. However, after the program was developed, utilities became important program partners by helping their customers purchase the newly available lamps.

The RFP attracted bids from seven companies in Phase I, from which three were awarded basic ordering agreements (BOAs). The Phase II RFP brought in eight bids, from which five were awarded BOAs. DOE did not subsidize the lamps, yet because the lamps could be purchased in large quantities directly from manufacturers or their representatives, prices of the new products were kept very low, ranging from a delivered price of $4.95 to $8.30 each, depending on order quantity and destination.

The program then launched a modest effort to announce the availability of the lamps. A website was developed to provide information on the program and products (www.pnl.gov/cfl). Other popular energy and multi-family housing websites were contacted and requests were made to install links to the program on their websites. Program staff made presentations at conferences, wrote articles for multi-family housing newsletters and other publications, and encouraged utilities to develop programs to take advantage of the new lamps.

As of October of 2000, the program is entering a new stage, in which DOE will be relinquishing its leadership of the program, and turning it over to the Northwest Energy Efficiency Alliance (NEEA). DOE's role was focused on market introduction of sub-CFLs,

and given its success in achieving that goal, it sought to transition the program to another organization interested in continuing promotional efforts for the lamps. In agreeing to assume leadership for the program, NEEA declared its intention to focus its efforts on getting sub-CFLs into the retail market sector in the Pacific Northwest, particularly independently owned retail stores that generally do not have the resources to easily access new products. To promote the new products, NEEA's program will use a combination of a completely redesigned website, with special features of value to retail store purchasing, and circuit riders, specially trained individuals who make site visits to hundreds of retail stores and offer information and assistance in purchasing new energy-efficient products for resale. NEEA has committed to operate the program in such a way as to allow utilities and purchasers outside of the Pacific Northwest to continue accessing program information and products in the same way they previously had (although no effort will be made to promote the products outside of the Northwest). Furthermore, they plan to sponsor issuance of new RFPs that will expand the range of Sub-CFL lamps included in the program, such as adding dimmable and reflector-type lamps.

For the 2-½ year operation of the program, total DOE expenditures amounted to $342,000. This budget covered technical research, market research, interaction with potential buyers and manufacturers, development of technical specifications, RFP development and issuance, award evaluation, CFL performance testing, promotion, and other miscellaneous program tasks. Expenditures by utilities who have operated programs to promote use of sub-CFLs are unknown, but are believed to exceed $1 million. Planned expenditures by utilities are also unknown, but are estimated to exceed $3 million.

Monitoring and Evaluation Process

DOE did not adopt a third party monitoring and evaluation process. However, DOE implemented a modest internal monitoring and evaluation process, using one contractor directly involved in the program's implementation, and one contractor who was not.

Approximately nine months after products were first made available to buyers through the program, buyers were surveyed on a range of issues, including:

- Reason for purchase
- Satisfaction with purchase
- Problems with performance
- Speed and accuracy of order fulfillment
- Warranty claims
- Where installed

Results from the survey revealed a high level of satisfaction, insignificant problems with performance, limited order fulfillment problems, and prompt handling of warranty claims. In addition to this survey, program staff regularly solicited and received customer feedback on the above issues. This feedback identified problems with two suppliers, both of which were subsequently disqualified from the program.

In addition to this type of program monitoring, DOE had program suppliers provide monthly sales reports. Those reports showed a steady upward trend in lamp sales.

DOE also implemented an effort to measure market impact from the program, relying on its implementation contractor for this information. Pre-program baseline observation measurements were made for a number of market impact indicators, including:

- Number of sub-CFLs introduced to the market
- Number of retailers selling sub-CFLs
- Evidence of influence on standards or specification setting organizations
- Sub-CFL prices
- Sub-CFL sizes
- Sub-CFL sales
- Number of utilities specifically promoting sub-CFLs

Measurements and observations for each of these indicators were taken in August and September of 2000, indicating significant market impact, several of which are discussed in the following section on results.[32]

Discussion of Results

Information collected in the above-described measurement of market impact, as well as other available program information, indicated the program achieved all of its medium-term objectives. It is still too soon to judge whether it has met its long-term goal of expanding the market for CFLs, but there is substantial evidence indicating the program has had an important market impact.

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[4] Readers should note these measurements and observations were not conducted within a rigorous, externally reviewed evaluation framework. They were collected as part of a modest effort intended to serve internal program management needs, and thus should not be interpreted or used in the same way a third party, more rigorous evaluation would.

The medium-term program objectives are repeated here, followed by a brief discussion of observed or measured results:

1) *induce at least two manufacturers to commercialize new, smaller CFLs*

   The program induced five manufacturers to commercialize new products. Lights of America (LOA), Sunpark Electronics, Link USA, JKRL, and Surya/PMI all developed and introduced new products in the U.S. market in response to the program. LOA introduced two products (15 and 20 watts); Sunpark six products (15, 20 and 23 watts, each in a mid- or high-power factor versions); Link three products (15, 20 and 26 watts); JKRL four products (15, 20, 23 and 26 watts); and Surya/PMI one product (15 watts). Some of these products reflected modest changes in what the manufacturer had previously offered, such as small size reductions, increased luminous efficacy, and better cold temperature starting and operation (Sunpark, Link, and JKRL); while others reflected all new lamp designs (LOA and Surya/PMI).

2) *induce the commercialization of a low-cost 15 W integral CFL less than 5 inches (127mm) in length*

   The program succeeded in inducing commercialization of two 15 watt, low-cost products that were less than five inches (127mm) in length. LOA introduced model # 2415, a spiral tube lamp whose tubes are attached to the base at an acute angle (as opposed to the right angles typically used by spiral lamp manufacturers). The lamp is 4.69 inches (119 mm) in length, and sold through the program for $6.75 to $7.25, depending on order quantity. Surya/PMI introduced model # PMIET15, which uses four u-tubes mounted in a compact base. The lamp is 4.56 inches long (116 mm), and sold through the program for $4.95 to $6.25, depending on order quantity and destination.

3) *implement a program that offered CFLs at prices substantially below the then prevailing market price of $15-$22*

   Products offered through the program were priced aggressively. As of September 2000, delivered prices for the various products ranged from $4.95 to a high of $8.20, depending on lamp model, order size, and destination.

4) *achieve sales of at least one million units*

   Reported sales in the program surpassed 1.5 million units in August 2000..

In addition to the results associated with the program objectives, the following results were observed:

1) The number of retailers offering sub-CFLs appeared to increase. Prior to launch of the program, the only lamps known to meet sub-CFL size requirements, and known to have significant retail presence, were Philips Earthlight Universals. As of August 2000, there are now numerous sub-CFL models widely available in the retail sector, including lamps sold through the program, and sub-CFLs brought to market by other

manufacturers. Numerous national, regional, and independent retailers now offer sub-CFLs.

2) The program had an observed impact on specifications setting organizations, most noticeably with regard to power quality specifications. The program's draft specifications on power quality touched off an intensive set of discussions among utilities, EPA Energy Star staff, and manufacturers over the high-power quality requirements that utilities and EPA had imposed on CFLs and residential lighting fixture programs. In less than a year, these programs had almost universally backed off on these requirements, and adopted the power quality requirements of the sub-CFL program.[33]

3) CFLs meeting the sub-CFL size requirements continued to enter the market after the launch of the program. In addition to the many lamps introduced by small manufacturers, GE brought two new models to market meeting sub-CFL size requirements, including a spiral lamp that is selling for as low as $6.67 at a major regional retailer. A sales-weighted average size of CFLs sold in the U.S. is unavailable, but a growing selection of sub-CFL lamps is now clearly available.

4) Prior to launch of the sub-CFL program, no utilities were promoting sub-CFLs. (Numerous utilities were promoting CFLs, but they had no size requirements or efforts aimed at sub-CFLs.) As of August 2000, numerous utilities were promoting sub-CFLs, all of which are in the western region of the U.S. Almost all of the major California utilities are specifically promoting sub-CFLs, and as discussed before, the Northwest Energy Efficiency Alliance, in cooperation with northwest utilities, is implementing a new region-wide program to promote sub-CFLs.

Key Elements of Success

The single most important element contributing to the success of the program was the careful evaluation of a market sector that led to the discovery of a very important market barrier to CFLs (size) which had been overlooked by previous CFL programs. The second most important element of success was the careful evaluation and identification of technical means for overcoming this barrier. Together, these elements positioned this program to develop a good technical solution for a prominent market problem.

Another key contribution to program success was selection of the right policy tool, technology procurement, for the set of circumstances faced by DOE. A clearly defined and widespread need that could be addressed with modest technical improvements in existing technology made technology procurement an attractive candidate. Making it all the more attractive was its ability to use competitive processes to drive down prices (another important market barrier) without the use of subsidies.

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[5] The Sub-CFL Program specified a power factor of 0.5, and had no requirement on total harmonic distortion (THD) for current. These specifications were in marked contrast to power quality specifications in widespread use at the time, which required a power factor of at least 0.9, and THD of no more than 33%. Most companies and organizations sponsoring programs with these specifications were finally persuaded that the high power quality requirements offered little or no benefit to their electric systems, and unnecessarily made the cost of CFLs higher. They subsequently dropped the THD requirement, and adopted the 0.5 power factor requirement.

Selection of multiple winners, which prevented absolute dependence on a single supplier, and utility involvement, which proved to be very important partners for moving product into the marketplace, were also key contributors to success.

Main Sources of Problems and Failures

A significant source of problems was the program's decision to work with small manufacturers (and their representatives). While these small companies proved willing to challenge the status quo, and willing to price their product very aggressively, several nonetheless suffered from their logistical ability to handle large volume orders. Substantial time and effort were expended to resolve these problems.

A second important source of problems was the perception by some companies in the retail and wholesale lighting business that DOE was attempting to compete with them. They saw DOE operating a website directing potential buyers to a select group of suppliers, and interpreted that as an inappropriate use of government funds. Almost all of these problems were resolved by explaining that DOE's purpose for operating this program was to introduce new products to the market, and then provide *short-term* assistance in getting those products established in the market.

Another program shortcoming was its oversight of the important role utilities could play in helping bring these products to market. As described earlier, utility partnerships were not developed until after the program was underway. While they nonetheless became very important partners, the extent of their role and the effectiveness of the program probably would have been greatly enhanced had they been involved in early program design.

Lessons Learned
The United States Clean Coal Technology Demonstration Program

Introduction

Launched in 1985, the Clean Coal Technology Demonstration Program (CCT Program) is an ongoing unique, cost-shared, technology development effort supported jointly by the United States Department of Energy (DOE) and the private sector. In its implementation, many precedent setting actions were taken and a sense of mutual responsibility for the end product was developed. The program's success to date is a tribute to the innovations used by both the public and private sectors to overcome procedural issues, create new management systems and controls, and move toward accomplishing shared objectives. The program has an exceptional success record. Over half of the 40 projects in 18 states have reached successful completion.

The technological successes are evident. SO_2 and NO_x control technologies emerging from the CCT Program have moved into the utility and industrial marketplace and now provide cost effective regulatory compliance. A new generation of advanced coal-based power systems has been placed in commercial service that represents an enormous leap forward in terms of efficiency and environmental performance. These advanced power system projects will provide a springboard for widespread, global deployment. This in turn will contribute greatly to reductions in greenhouse gas emissions.

The principles of the CCT Program evolved from many of the experiences - positive and negative of earlier U.S. DOE demonstration programs. As a result, the program has accommodated changing political and economic environments. The CCT program serves as a model for other government programs aimed at introducing new technologies into the commercial marketplace.

Objectives

The CCT Program was established to demonstrate the commercial feasibility of CCTs to respond to a growing demand for a new generation of advanced coal-based technologies characterized by enhanced operational, economic, and environmental performance. Clean coal technologies being demonstrated under the CCT Program are establishing a technology base that will enable the U.S. to meet more stringent energy and environmental goals.

Coal Technologies for Environmental Performance

The CCT Program is cognizant of concerns about global climate change. Clean coal technologies (such as IGCC) being demonstrated in the CCT Program offer utilities an option to reduce greenhouse gases (GHG) by as much as 25 percent with first generation systems through enhanced efficiency. Commercialization of atmospheric fluidized-bed (AFBC) and pressurized fluidized-bed combustion will also serve to reduce GHGs.

Coal Technologies for Competitive Performance

As the electric generation market moves from a regulated industry to a free market, the CCT Program has kept pace with the changes. Whether the changes are brought about by the federal government through existing or new legislation or by state governments, the CCT Program is demonstrating the first generation of many technologies that will be needed in a competitive power generation market. These new technologies will be far more efficient than existing plants and environmentally benign.

Coal Technologies to Sustain Economic Growth

The CCT Program is contributing to the maintenance of a diverse energy mix in the U.S. by developing and deploying a technology that enhances the efficient use of the United States' abundant coal resource while simultaneously achieving important environmental goals. The advancements in coal use technology resulting from the CCT Program will reduce dependence on foreign energy resources and create an international market for these new technologies. The Worldwide market for power generation technologies could be as high as $80 billion between 1995 and 2020.

Process of Definition/Design of the Program

The projects are selected via a competitive solicitation process administered by the U.S. DOE. The U.S. Congress sets the goals for each solicitation. The Department of Energy translates the congressional guidance into performance-based criteria and developed approaches to address "lessons learned" from previous solicitations. The criteria and solicitation procedures are offered for public comment and presented at pre-proposal conferences.

The CCT Program implementation principles are:

Strong and stable financial commitment for the life of the project, including full funding of the government's share of the costs;

Multiple solicitations spread over a number of years, enabling the CCT Program to address a broad range of national needs with a portfolio of evolving technologies;

Demonstrations conducted at commercial scale in actual user environments, allowing clear assessment of the technology's commercial potential;

A technical agenda established by industry, not the government, enhancing commercialization potential;

Clearly defined roles of government and industry, reflecting the degree of cost-sharing required;

A requirement for at least 50 percent cost-sharing throughout all project phases, enhancing participant's commitment;

An allowance for cost growth, but with a ceiling and cost-sharing, recognizing demonstration risk providing an important check-and-balance to the program;

Industry retention of real and intellectual property rights, enhancing commercialization potential;

A requirement for industry to commit to commercialize the technology, reflecting commercialization goals; and

A requirement for repayment up to the government's cost-share upon successful commercialization of the technology being demonstrated.

Main Actors and Their Roles

Public and private sector involvement is integral to the CCT Program process and is crucial to the program's success. The CCT Program was created as a joint government-industry initiative. It is a partnership in which the federal government sets performance objectives, founded in national environmental concerns, and asks industry to respond with technical solutions. After the U.S. DOE selects the projects most suited to accomplish solicitation objectives and establishes performance measures, industry takes the lead in project management and assumes responsibility for commercialization. In this cooperative effort, industry retains its rights to the real and intellectual property generated through the development and commercialization of the technology in return for assuming at least 50 percent of the project costs.

To date CCT Program participants include:

ABB Combustion Engineering, Inc., and CQ Inc.

ABB Environmental Systems

Air Products Liquid Phase Conversion Company, L.P.

AirPol, Inc.

Alaska Industrial Development and Export Authority

Arthur D. Little, Inc.

Babcock & Wilcox Company

Bechtel Corporation

Bethlehem Steel Corporation

Coal Tech Corporation

CPICOR™ Management Company, L.L.C.

Custom Coals International

ENCOAL Corporation

Energy and Environmental Research Corporation

JEA

Kentucky Pioneer Energy, L.L.C.

Lakeland Electric, City of Lakeland

LIFAC-North America

McDermott Technology, Inc.

New York State Electric & Gas Corporation

NOXSO Corporation

Ohio Power Company

Passamaquoddy Tribe

Public Service Company of Colorado

Pure Air on the Lake, L.P.

Sierra Pacific Power Company

Southern Company Services, Inc.

Tampa Electric Company

ThermoChem, Inc.

Tri-State Generation and Transmission Association, Inc.

Wabash River Coal Gasification Repowering Project Joint Venture

Western SynCoal, LLP

Policy Mechanisms Used

The CCT Program is implemented through competitive solicitations. Five competitive solicitations sponsored by the U.S. Department of Energy resulted in selection of the most advanced coal-based technology concepts available anywhere in the world. Federal funding was leveraged twofold through partnerships encompassing utilities, state governments, technology developers, and research organizations. To date more than $5.6 billion has been expended, with industry and states investing two dollars for every one from the federal government.

The first solicitation (CCT-I) for clean coal projects resulted in a broad range of projects being selected in four major product markets:

I. Advanced electric power generation

II. Environmental control devices

III. Coal processing for clean fuels

IV. Industrial applications.

The second round of solicitations (CCT-II) became the centerpiece for satisfying the recommendations contained in the Joint Report of the Special Envoys on Acid Rain (1986). The goal was to demonstrate technologies that could achieve significant reductions in the emissions of precursors of acid rain, namely SO_2 and NO_x. The third round of solicitations (CCT-III) furthered the goal of the CCT-II and added technologies that could produce clean fuel from run-of-mine coal.

The fourth and fifth solicitations (CCT-IV and CCT-V, respectively) recognized emerging energy and environmental issues, such as global climate change and capping SO_2 emissions, and thus focused on technologies that were capable of addressing these issues. CCT-IV called for energy efficient, economically competitive technologies capable of retrofitting, repowering, or replacing existing facilities, while at the same time significantly reducing SO_2 and NO_x emissions. CCT-V focused on technologies applicable to new or existing facilities that could significantly improve efficiency and environmental performance.

Monitoring and Evaluation Process

In 1989, the Secretary of Energy issued directives to establish a Clean Coal Technology Executive Board to be chaired by the U.S. DOE Assistant Secretary for Fossil Energy (ASFE) and to establish a CCT Review Panel. The purpose of the directives was to streamline the review and approval process for clean coal technology projects. The Executive Board responsibilities include:

> Monitor progress on each project negotiation and implementation against an agreed upon schedule, and report to the Secretary of Energy on the overall progress of the CCT Program on a regular basis
>
> Resolve issues referred to the executive Board by the Review Panel(s), or for which the ASFE's office desires the viewpoint of the Executive Board members.
>
> Approve and forward to the Secretary of Energy Comprehensive Reports to congress on negotiated projects that have been accepted by the Review Panel and forwarded to the Executive Board by the ASFE.
>
> Provide a final control, where necessary, on the timeliness and quality of documents generated and actions taken by U.S. DOE staff to comply with the Clean Coal Program management objectives.

However, projects are managed by the participants, not the government. To protect the public interest, safeguards are implemented to track and monitor project progress and direction. The U.S. DOE interacts with the project at key negotiated decision points (budget periods) to approve or disapprove continuance of the project. Also, any changes to cost or other major project changes require U.S. DOE approval. In addition to formal project reporting requirements, an outreach program was instituted to make project information available to customers and stakeholders.

List of References and Documentation

Public Law 98-473; Initiation of CCT Program; informational solicitation

World Wide Web Home Page: (http://www.fe.doe.gov)

Fossil Energy TechLine: +01 202-586-4300

Computer Bulletin Board via modem: +01 202-586-6495

CCT Compendium: (http://www.lanl.cov/projects/cctc)

The following documents are available through the U.S. DOE, Office of Coal and Power Systems, Washington, DC 20585, +01 301-903-2624.

Clean Coal Technology: The New Coal Era

Clean Coal Technology Demonstration Program: Program Update

Clean Coal Technology Demonstration Program: Project Fact Sheets

Clean Coal Today

Topical Reports

Project Performance Summaries

Annual Clean Coal Technology Conference

CCT Program Bibliography of Publications, Papers and Presentations

Clean Coal Technology Program: Lessons Learned

Clean Coal Technology Export Markets and Financing Mechanisms

Foreign Markets for U.S. Clean Coal Technologies

Discussion of Results

The number and magnitude of demonstration projects put in place by the CCT Program is unprecedented, as is the extent of industry cost-sharing. The investment has resulted in 40 projects in 18 states. Over half of the projects have already reached successful completion. Now almost a decade-and-a half after the CCT program's inception and within its original Federal funding target, the program has achieved and expanded its objectives.

Below are listed several success stories of the DOE Coal R&D and Clean Coal Technology (CCT) programs. The CCT successes -- mostly demonstrations of pre-commercial, new technologies -- could not have occurred without earlier DOE R&D. R&D successes that culminated in CCT demonstrations include:

I. Low NO_x burners: Far less expensive than preceding technology for removing NO_x (oxides of nitrogen, precursors of smog) emissions, about ½ of US coal-fired capacity today has these burners. Sales to date are about $1.5 billion.

II. Atmospheric Fluidized Bed (AFBC) power plants: DOE/industry investments in this clean technology have resulted to date in at least $9 billion in domestic and foreign sales ($6.2 B domestic, $2.8 foreign) and 75,000 domestic jobs.

III. Advanced Scrubbers: Three advanced scrubbers have been demonstrated by DOE, one of which earned *Power* magazine's *1993 Power Plant of the Year* award.

IV. Tomorrow's Power Plants (*Integrated Gasification Combined Cycle*, or IGCC and *Pressurized Fluidized Bed*, or PFBC): These pre-commercial, virtually pollution-free plants have the potential of far higher efficiencies (thus 20% to 40% lower CO_2 levels).

V. The Rosebud SynCoal ™ and Encoal ™ processes are two different ways to upgrade low-rank coals to cleaner, more efficient fuels. Both processes are being marketed worldwide.

The success of the CCT Program is attributable, in part, to lessons learned from prior experiences and early involvement of the private sector in shaping the program. DOE has learned from its experiences during the program's implementation and has been able to make improvements. A feature of the CCT Program is that there been a series of procurement actions, spread over a number of years. Allowing time between solicitations has made it possible to meet changing national needs, to make adjustments in program implementation, and to allow time for private sector to develop projects.

<u>Coal for the Future</u>

The investment in the CCT Program is forming a solid foundation upon which to build a responsible future for fossil energy while addressing growing global and regional environmental concerns and providing low cost energy. The U.S. DOE's Office of Coal & Power Systems (OC&PS) has identified specific program areas to build upon the success of the CCT Program and provide a solid foundation upon which to progress toward Vision 21. Vision 21 is a long-term strategic concept which integrates OC&PS program goals to develop the full potential of the nation's abundant fossil fuel resources while addressing regional and global environmental concerns. Vision 21 plants would comprise a portfolio of fuel-flexible systems and modules capable of producing a varied slate of high value commodities, such as clean fuels, chemical, and electricity, tailored to meet market demands in the 2010-2015 time frame.

Country expert on this deployment program/policy:

Expert's name: Mrs. Barbara N. McKee

U.S. Department of Energy, Office of Fossil Energy

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Industrial Assessment Centers Program: Deployment Policy Case-Study

Program Manager: Chuck Glaser; e-mail charles.glaser@ee.doe.gov phone: (202) 586-1298

Support Staff: Andrew Gluck; e-mail: agluck@idsonline.com phone: (703) 715-3009

Filename: IEA_IAC(FD)

Introduction

The Industrial Assessment Center Program (IAC) is run by the Office of Industrial Technologies within the United States Department of Energy's Office of Renewable Energy and Energy Efficiency. The IAC program (formerly called the Energy Analysis and Diagnostic Centers (EADC) program) has been training university engineering students in energy efficiency practices for small and medium-sized manufacturing plants (SICs 20 □ 39) since 1976. The name of the program was changed to reflect the broader range of the services offered which now include a waste and productivity assessment along with the traditional energy audit. The primary teaching mechanism has been a paper analysis of a plant's energy bills, physical layout, and short description of operations followed by a one-day hands-on walk-through of the plant. Students are taught to ask analytical questions and make first-hand observations that will aid them in preparing a written summary of recommendations for improvement. The program offers students a unique opportunity to gain actual plant floor experience which has translated into better job offers and has established a cadre of engineers loyal to their energy efficiency roots who continue to espouse energy efficiency practices and technologies throughout their careers. Plants managers typically implement 50% of the recommendations for immediate savings, and adopt an awareness of energy, material, and labor inefficiencies that allows them to continue to make similar improvements, over time, both at the original plant where the assessment took place, as well as at other company locations.

Objectives of the program

The strategic goals of the IAC program reflect the strategic goals of the Office of Industrial Technologies (OIT). The following is the goal statement of OIT:

"By partnering with the industry, OIT will motivate and will assist industry develop technology solutions to critical energy and environmental challenges that will produce important national

benefits per unit of Gross National Product. Major goals of the Office of Industrial Technologies are:

A 25 percent improvement in energy efficiency and 30 percent reduction in emissions for the vision industries by 2010. A 35 percent improvement in energy efficiency and 50 percent reduction in emissions for the vision industries by 2020.

The Office of Industrial Technologies, through partnerships with industry, government, and non-government organizations, develops and delivers advanced technologies and practices to assist industry in meeting challenging goals in the areas of energy efficiency, and global competitiveness."

Process of definition/design of the program

Legislation authorizing the creation of the federal energy administration was drafted soon after the United States felt the effects of OPEC's tightening of oil supply. In the United States of America, a considerable number of laws and regulations have been promulgated concerning energy policy, energy conservation policy and energy efficiency promotion. In terms of history of energy conservation laws, the "Energy Policy and Conservation Act of 1975" was the among the first laws which were established with a view to regulate and possibly curb energy consumption and limit the related dependence on imported oil. Over the past two decades, the initial act has been amended several times. The EADC program and the current IAC program are outgrowths of that original legislation.

Main actors and their roles

Teams of engineering faculty and students from the centers, currently located at 29 universities around the country, annually conduct roughly 25 energy audits or industrial assessments and provide recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. These teams of engineering students led by university professors form the core of the technology diffusion mechanism. There are two field managers who oversee 15 schools each. These field managers, also associated with universities, serve both an administrative and a supervisory function. The U.S. Department of Energy funds the program, oversees the field managers and conducts an annual "Directors' Meeting" where a cross-pollination of best practices takes place. The IAC program, the field managers, and many of the schools also maintain websites. Self-help material downloadable from these websites has also proved to be of great benefit for many industrial manufacturers and consultants who might not otherwise be eligible to receive an assessment.

Policy mechanisms used

The IAC program is fundamentally an information dissemination program. Congressional appropriations in recent years have been about eight million dollars U.S. annually. These funds cover all administrative expenses incurred both by DOE headquarters and its two field managers. In addition, each of the thirty universities receives a stipend to conduct in-house training of faculty and students in preparation for the in-plant assessments. Each of the students who conduct the assessments is paid by the IAC (with DOE funds) on an hourly basis for their involvement in the assessments. The Industrial Assessment Centers program enables eligible small and

medium-sized manufacturers to have comprehensive industrial assessments performed at no cost to the manufacturer. The manufacturers, however, do bear the cost of implementing any of the recommendations they decide to adopt. The free assessment serves an important contributory role (whether it be the initial raising of awareness, or the final input into a decision-making process already begun) in each plant's decision to implement energy savings recommendations.

Monitoring and evaluation process

There are at least four levels of monitoring and evaluation that help influence the self-correcting mechanism guiding the IAC program.

First, results of the assessments are quantified through phone interviews conducted by the engineering team six to nine months after the site visit. The results of these interviews are reported to the field manager at Rutgers University where plant specific information as well as recommendation and implementation results are housed in a database. Anyone with a computer and a modem can download these results over the internet. Once a year an annual report is compiled by Rutgers in which the assessment results are analyzed and discussed. The field managers are in regular communication with the DOE headquarters program manager who monitors performance results and discusses immediate concerns and long-term trends with the field managers who are expected to take corrective action when necessary.

Second, The U.S. Department of Energy conducts an annual "Directors' Meeting" where a cross-pollination of best practices takes place. This once a year three-day event is an opportunity for all 30 schools, two field managers, and DOE personnel to share thoughts and perspectives on goals and objectives...and which activities were most fruitful in helping to achieve those goals and objectives. The report of the annual Directors' Meeting is a major ingredient in helping to shape new program directions during the course of the next fiscal year.

Third, each year, each of the programs within OIT undergoes a program review. During these sessions, program managers are called upon to report program accomplishments in

the year gone by, and to develop future plans. These meetings are internal OIT meetings peer reviewed by other DOE program managers. From time to time a more intensive look at each program is conducted to ensure that program goals and objectives are coordinated with OIT goals and objectives...and that program is pursuing the right activities in the most efficient manner. This more intensive investigation is called a "critical program review." The IAC program is in the process of implementing some recommendations that were the result of a year-long "critical program review". The team that conducted the review consisted of DOE and National Laboratory employees. During the course of the year, the critical review team interviewed over 100 respondents, asking for opinions, observations, suggestions, criticism, and praise. These respondents included members of industry and consumer organizations, as well as universities and state energy offices. The full spectrum of stakeholders was consulted before the critical review team issued its final report with recommendations for program definition/design improvement. The annual program review and occasional "Critical Review" referred to above help gain an even broader outside perspective on program effectiveness and efficiency.

Finally, Oak Ridge National Laboratory is conducting an on-going evaluation of the assessments and various other pathways to energy savings. Some interesting preliminary findings suggest that, in addition to the documented direct initial effects of the assessments on the plants, alumni of the program continue to have a substantial long-term impact on energy savings throughout their careers. Also, we are just beginning to understand that the reach and result of technical assistance downloaded from IAC web sites is quite substantial. More definitive results will be announced when the evaluation is completed.

Discussion of results

According to the Industrial Assessment Center Program Impact Evaluation conducted by Oak Ridge National Laboratory, "It is concluded that appreciable energy and cost savings may be attributed to the IAC Program and that the IAC Program has resulted in more active and improved energy-efficiency decision making by industrial firms." The following discussion quantifies this assertion.

The program uses a well-established database (http://oipea-www.rutgers.edu/database/db_f.html) to track savings resulting from recommendations generated during IAC site assessments. As a result of the 734 assessments conducted in 1999, over 2.5 trillion btus are saved annually. Energy dollar savings of over $9.7 million annually are augmented by $6.6 million in waste savings and over $24 million in productivity savings. Total annual savings from 1999 assessments tallied $40,684,908, or $55,429 per assessment. Since the entire IAC budget was $8.3 million, these savings equate to a 4.9 to 1 benefit/cost ratio for year one alone. These savings will continue to accrue annually for many years to come.

This discussion does not include the cost of the implementations that is born by the plants themselves. This investment by industry can be seen as the leveraging effect of the IAC

investment. Since, historically, the average payback period has been about 1 year, it can be assumed that industry spent about $40 million to achieve the $40 million in cost savings in 1999. When the lifetime benefits of 1999 implementations are compared against the sum of federal and private sector outlay we see an aggregate benefit / cost ratio of 8.1 to 1 ($397,491,551 / $48,984,908).

These numbers do not tell the whole story since there are additional benefits that are not quantified in the current database. These include energy, waste, and productivity savings through: 1) replication of implementations at other plants, 2) implementation of recommendations that occur after the initial call-back (and are therefore not captured in the database), 3) the efforts of program alumni who find jobs in industry where they can continue to use their IAC training, 4) the dissemination of technical information found at the IAC headquarters', field managers' and IAC universities' websites. These other "pathways" to energy savings magnify the direct energy savings from the assessments themselves. The initial findings of the Oak Ridge National Laboratory program evaluation suggests that alumni savings are significantly larger than direct impacts from assessments.

From 1981 through the end of 1999, 9,075 assessments were performed by over 1,550 engineering students trained by the IACs. To put the total program effect into perspective consider that a cumulative federal investment of about $80 million dollars (in nominal dollars) has engendered activity that has saved industry over $2.4 billion (in constant 1998 dollars) from 1981 through the end of 1999. {Maria – please note that these numbers must undergo some additional scrutiny}

One example of the long-term effect of IAC alumni are the substantial number of program alumni who serve in positions of influence for Energy Service Companies that are dedicated to finding and implementing long-term energy savings solutions for industry. This subset of the alumni population accounts for trillions of btus saved per year. Substantial projects undertaken by these alumni include the building of co-generation facilities for energy-intensive industrial users that promise to save enormous amounts of energy for the next 20 to 30 years.

But, the intent of the program is not to gain a one-time quick fix, but rather to facilitate a long-term change in awareness, attitude and behavior that will ensure energy savings, waste savings, and productivity gains on a permanent basis. So it is the change in the human decision-makers and advisors that is perhaps the most interesting and long-lasting effect of the IAC program. As part of the IAC program evaluation, Oak Ridge National Laboratory conducted a study that modeled industrial energy-efficiency decision-making before and after one of three IAC interventions: direct energy assessment, the employment of an alumnus of the IAC program, or use of the information from an IAC Website. In all three cases, affected firms were seen to move toward permanently institutionalizing an energy-efficiency awareness and approach in their internal corporate investment strategy.

The key elements of the IAC program's success are: 1) well-trained faculty at the participating universities; 2) mentor/protégé relationship among students; 3) small team size (8 - 10 students); 4) real world hands-on approach to teaching; 5) polite and humble attitude of students toward their industrial hosts; and 6) practical solutions with proven payback (nothing exotic) to real problems. It was surprising to find that two indirect pathways to energy savings had such significant impacts: alumni influence on future decisions, and website dissemination of best practices, are also substantial key elements of the IAC's program success.

Some schools can fall into a "cookie-cutter" approach to problem solving, recommending the same solutions, even if more pressing problems with different possible solutions also exist. Other failures of the program that are now being addressed were the lack of student input and feedback to DOE headquarters to help program managers revamp less than adequate aspects of program delivery. A student forum website has been created to encourage students to communicate among the schools in the program and with DOE headquarters directly (if desired). Also, each student is given the opportunity to respond to an annual questionnaire regarding program performance. Finally, there was a danger that each IAC could operate as an island unto itself. Greater integration of the IACs with each other and with other beneficial programs and initiatives of the Office of Industrial Technologies is being sought. A committee comprised of four center directors has been formed to investigate channels for greater interaction and integration with other OIT programs. A number of initiatives have been started to incorporate IACs with the Industries of the Future approach that is the hallmark of OIT. That means that rather than concentrating exclusively on small and medium-sized facilities, IACs are now venturing into larger plants that are common to the nine energy-intensive "Vision Industries" that comprise the "Industries of the Future" (Agriculture, Aluminum, Chemicals, Forest Products, Glass, Metalcasting, Mining, Petroleum.

CS 20

United States Department of Energy's Motor challenge and BestPractices Programs

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INTRODUCTION

Beginning in 1992, US DOE Office of Industrial Technologies (OIT) sought to design a program that promoted increased energy efficiency of motor systems and was responsive to industry needs. The Motor Challenge program began as the result of an industry roundtable discussion and evolved through a series of events that presented industrial end-users and the companies that serve them with a unique opportunity to share in and help shape the program. The result is a program "designed with industry for industry" that relies extensively on existing market forces to bring program messages to the industrial end-users

The program was initiated in 1993-94 with three initial offerings: showcase demonstrations, MotorMaster software, and the Information Clearinghouse. As additional program offerings were developed and the ongoing dialogue with industry matured, a program structure emerged to deliver the program message within existing market mechanisms.

By 1996, a primary feature of the Motor Challenge program model was its reliance on partnerships with industry both to develop new program materials and to deliver this information to industrial customers. Two additional programs, Compressed Air Challenge and Steam Challenge, subsequently emerged based on elements of this program design.

By 1999, other sectors, such as process heating, had expressed interest in developing their own program initiatives. Rather than continuing to create separate new programs, OIT moved to integrate all existing and proposed program initiatives of this type under the program heading of BestPractices. Like Motor Challenge, BestPractices offers tools to improve a plant's energy efficiency, enhance its environmental performance, and increase its

productivity. The BestPractices team is comprised of all the resources, tools, and expertise that previously made up the OITs' Challenge programs - Motor Challenge, Steam Challenge, Compressed Air Challenge, and the Industrial Assessment Centers. The team applies a plant-wide systems approach in identifying opportunities to help industries increase energy efficiency, reduce waste, and boost productivity.

The BestPractices Program provides technical assistance by delivering energy-saving products, services, and technologies to the nine Industries of the Future (IOF): agriculture, aluminum, chemicals, forest products, glass, metalcasting, mining, petroleum, and steel industries. Plant-wide assessments, Showcase Demonstrations, technical assistance, and workshops all occur within the United States. Self-help tools and information are downloaded internationally from the program's website at http://www.oit.doe.gov/bestpractices/.

This case study will focus primarily on the experience with the Motor Challenge Program because it is the most mature and has been the subject of a formal evaluation.

PROGRAM OBJECTIVES & BARRIERS

The policy objective of the BestPractices program is to facilitate a transformation in the way the nine IOF energy-intensive manufacturing industries consider and manage their power demand from motors, steam, compressed air, and process heat systems plant wide. Through BestPractices, OIT aims to provide industry with better near-term and long-term technological solutions to improve energy efficiency, enhance environmental performance, and improve productivity for their total manufacturing plant operations. BestPractices takes an integrated systems approach to analyzing ways in which energy needs can be minimized.

Existing industrial equipment and services markets (both supply and demand) traditionally focus on components rather than systems. This piecemeal approach to industrial motor-driven and steam systems in the US typically results in less than optimal system operation, reliability, and efficiency. Motor Challenge, and now BestPractices, pursues an objective to develop best practice information and tools in cooperation with industry associations and energy efficiency organizations. These information and tools are then distributed either directly by the Programs, or through Allied Partners (vendors, utility companies, and others) to end users of motor systems to promote a systems approach in the way these systems are managed, maintained, upgraded and improved. The program goal has been and continues to be improving awareness of the benefits of a systems approach in US industry.

The main barrier to the program has been the industry's failure to focus on energy efficiency, since energy is relatively cheap. Furthermore, manufacturers are reluctant to tamper with tried and true production systems to pursue what they believe to be small percentages of energy savings. Management has tended to emphasize production quotas as opposed to efficiency gains. This program seeks to underscore the positive effect on the bottom line from addressing energy inefficiency in a systematic way. Through printed materials, software decision-making tools, training, Showcase Demonstrations, case studies, and third-party

independent performance validations, BestPractices removes the perceived financial and technical risk of undertaking major energy savings projects. From the start, the program faced the challenge of changing ingrained business and engineering practices among end-users and vendors without the use grants, rebates or other direct financial incentives.

PROGRAM DESIGN AND STRUCTURE

The BestPractices program has used an approach that can be described as "*developed by industry for industry.*" The overall program design evolved over several years with substantial input from the industrial community. Throughout the development of the BestPractices program, program managers have been guided by the following technical and program design principles:

- Promote a "systems" approach
  Industrial engineers have long known that careful matching of the elements of a plant system (in the case of motor systems – motors, controls, couplings, and process machinery) to the work to be performed yields far more savings than upgrading just the individual components. The Motor System Market Assessment found that over 71 percent of total potential savings came from systems-level measures such as improving the configuration and control schemes in pump, fan, and compressor systems. The practical procedures and the benefits of the system approach are stressed in program tools, publications, and case studies.

- Harness the business motivations of end-users, manufacturers, and vendors in disseminating technical information and promoting energy efficiency

  The BestPractices program has and continues to emphasize not only the energy savings associated with improved system efficiency, but other benefits of efficiency improvements such as increased control over production processes, reduced waste, and an improved production environment for workers. BestPractices also works with manufacturers and vendors to identify and exploit competitive advantages associated with promoting efficient systems and the benefits of life cycle costing. A recent evaluation of the Motor Challenge program found that 67% of all savings resulting from program activities during the period from program inception through 1998 could be attributed to the actions of Allied Partners- equipment vendors, utilities, equipment manufacturers, state governments and others who partnered with Motor Challenge to deliver the systems message to their industrial customers. This is particularly remarkable given that the Allied Partner activity was only launched in 1996.

MAIN ACTORS AND THEIR ROLES

The US DOE, OIT employees have formed the administrative backbone of the program, with technical support being provided by the Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the National Renewable Energy Laboratory. In addition, Washington State University provided technical support in development of software tools and staffing of the information clearinghouse.

As referenced above, the Motor Challenge program began developing partnerships with key industrial trade associations shortly after the program was launched. Partnerships were developed with the American Water Works Association, Compressed Air & Gas Institute,

Electrical Apparatus Service Association, Hydraulic Institute, Technical Association of the Pulp & Paper Industries (TAPPI), Consortium for Energy Efficiency, and several regional utility groups. These partnerships enabled the program to develop a very broad reach to industry with a modest level of support from USDOE.

The Motor Challenge program also established the Allied Partner initiative that includes over 225 companies and organizations nationwide. The Allied Partners cooperate with the program in promoting energy efficient motor systems through distribution of information materials, technical tools, and sponsoring technical training and workshop events. Allied Partners are companies and organizations that provide products and services to industry through the course of regular business contacts. Allied Partners are not paid to use program offerings or to promote more energy efficient motor-driven systems; they choose to participate based solely on sound business reasons.

POLICY MECHANISMS USED

The policy mechanisms used successfully by Motor Challenge to implement the program fall into two main categories: 1) information and decision-making tool development and dissemination, and 2) development of strategic partnership networks with industrial trade associations and industrial supplier companies.

n Information and Decision-Making Tools

Motor Challenge developed and offer a wide variety of information materials including decision-making software, training programs, case studies, showcase demonstrations, plant assessments, technical tips and fact sheets, and information services.

Decision-Making Software

1. *MotorMaster+ Motor Selection and Management Software.* MotorMaster+ contains a database of efficiency, price, and other catalog information for more than 25,000 three phase, integral horsepower electric motors produced by major manufacturers. Using this database, the algorithms contained in the program, and information on motors currently in use, vendors and end-users can identify specific models which will provide the most cost-effective replacement for failed motors. The program can also be used to analyze the benefits of replacing versus repairing a failed motor. Other modules support motor inventory management. To date, over 23,000 copies of MotorMaster+ have been distributed to end-users and vendors.
2. *Pump System Assessment Tool - PSAT*. PSAT estimates pump system efficiency based on a limited number of on-site measurements. It can be used to assess the overall efficiency of a pump system relative to its optimal

performance. It can be used to determine if further engineering analysis is justified to improve the pump itself and its system components and controls.

3. *ASDMaster*. ASDMaster is a software program that assesses the feasibility and cost-effectiveness of adding Adjustable Speed Drive controls to a motor system. This product was developed under the auspices of the Electric Power Research Institute (EPRI). Motor Challenge licensed this software from EPRI and sponsors training in its use and distributes the software to trainees.
4. *AirMaster*. AirMaster provides an assessment of a compressed air system. Its primary purpose is to estimate compressed air system energy use and load profile based on a guided set of on-site observations and measurements.

Training Programs

Motor Challenge technical training sessions cover a wide range of plant system topics including: use of MotorMaster+ and motor selection; basic pump system efficiency topics and use of PSAT software; basic Adjustable Speed Drive operations and use of ASDMaster.

4,536 individuals representing an estimated 2,923 establishments have registered for these courses. Additionally, an estimated 2,500 to 5,000 individuals have received training through participating Allied Partners (suppliers and others) but have not registered with the Program.

Showcase Demonstration Case Studies

Showcase Demonstration Case Studies develop information on the field performance of energy efficient motor systems and design practices. In exchange for technical assistance from the Program's technical experts, customers arrange for monitoring and verification of energy savings associated with various system efficiency measures. Motor Challenge used the documentation of the Showcases to develop case studies which facility managers could use to assess the applicability of similar measures to their own facilities. To date, 16 technical case studies have been developed.

Technical Tip Sheets, Fact Sheets, Sourcebooks

Motor Challenge offers a wide range of technical information on motor system topics that identify industry best practices and key performance improvement opportunities.

Information Services

The Motor Challenge program Information Clearinghouse provided answers to technical questions over the phone, and compiles and disseminates technical information on a wide variety of topics. The program also developed and maintained a frequently visited internet web site and a bi-monthly newsletter (Energy Matters) distributed to over 25,000 individuals, and through an Allied Partner network (see below).

n **Strategic Partnerships with Trade Associations and Industrial Supply Companies**

As discussed earlier, Motor Challenge program pursued two approaches to deliver its message and its services. Each has its advantages and disadvantages, but it is clear that strategic partnership with industrial trade associations and industrial suppliers provided a significantly larger impact with less program resources than the direct contact approach.

Motor Challenge developed partnerships with trade associations representing important groups of end-users, manufacturers, and vendors in the industrial markets. The basic partnership approach has been to harness OIT's technical resources to address plant-related technical issues and opportunities that affect a broad range of the associations' members. These industry partnerships have also served as the main vehicle to develop new types of information, tools and training offerings. Examples of these partnerships include the following:

1. *The Compressed Air Challenge.* A focus on compressed air systems started with an industry partnership between Motor Challenge and the Compressed Air & Gas Institute (CAGI), a trade organization of 45 manufacturers of compressed air system equipment. The Compressed Air Challenge (CAC) developed from a dialogue with CAGI and 13 other organizations nationwide. The collaboration includes CAGI, DOE, equipment manufacturers and distributors, government agencies, non-government organizations, and utilities. In all the CAC counts 15 separate organizations as sponsoring members, all of which contribute both funding and time to the collaborative efforts. The CAC's first program initiative was to develop an introductory training program on compressed air system efficiency.

2. *Pump System Initiative*. The Hydraulic Institute (HI), a trade organization of approximately 70 pump manufacturers, has marketed a video training program entitled "Energy Reduction in Pumps and Pumping Systems" with student and instructor workbooks. HI has formed a "Life Cycle Costing" committee with DOE's facilitation assistance that will be developing products to assist end users address life cycle cost factors in managing and maintaining their pump systems.

3. *Pulp and Paper Industry Initiative.* TAPPI became an Allied Partner and distributed over 400 copies of MotorMaster+ to pulp and paper mills across the country. TAPPI has 33,000 members and provides Motor Challenge tools and information to them mostly free of charge.

4. *Electrical Apparatus Service Association (EASA) Initiative*. EASA became an Allied Partner and it has worked with the program to develop technical information materials that benefit its member service organizations and for the motor system end user. It also distributes the Energy Matters newsletter and other program materials to their members under the organization's auspices.

The Motor Challenge Allied Partnership also grew out of a need to more effectively reach industrial customers on a limited program budget. The Allied Partnership approach has since become a key delivery mechanism of Motor Challenge tools and services to the different actors in the targeted markets. It combines the concepts of "one to many" and "many to many" for maximizing the outreach with the limited resources available to the program. The purpose of Allied Partnership activities can be captured as follows:

- Create a broad network of program support;
- Highly leverage development and deployment activities;

- Provide opportunities for market players to work with each other in a neutral setting; and
- Create opportunities to spotlight other OIT-sponsored programs and technologies.

Motor Challenge has recruited a number of Allied Partner organizations (private, public, not-for-profit) to help disseminate its materials and services to end-users. Among vendors, Allied Partners are primarily manufacturers, equipment distributors, service providers, and industrial consultants who perceive a value in providing their own customers with information on how to increase the energy efficiency of their manufacturing facilities.

State government agencies and utilities with an interest in industrial energy efficiency also became Allied Partners. These organizations use the technical resources available from Motor Challenge to help structure their own programs to promote energy efficiency of industrial systems. They also distribute tools and information to vendors and end users that participate in state and local utility programs.

MONITORING AND EVALUATION PROCESS

The US DOE contracted Xenergy Inc. to independently conduct an evaluation of the Motor Challenge Program. The primary objective of the evaluation was to estimate the energy savings that can be attributed to the Motor Challenge activities. In the course of gathering and analyzing the data needed to estimate energy savings, Xenergy also compiled information on the program's effects on the markets for industrial motor systems and on participants' response to the various program offerings. Some energy savings estimates and selected findings on market impacts are presented below.

The evaluation research and analysis activities were designed to answer three basic questions:

- How many industrial facilities and vendors used Motor Challenge materials and tools to make changes in motor system purchase, management, and design practices?
- What portion of reported changes in motor system practices were attributable to Motor Challenge?
- How much energy did those changes save?

It is important to note that estimated savings associated with Motor Challenge participants upgrading the efficiency of replacement motors are incremental to savings realized as a result of the promulgation of regulations to implement new efficiency standards for some integral horsepower polyphase motors contained in the Energy Policy Act (EPAct) of 1992. In October 1997, federal regulations went into effect which required all general purpose integral horsepower motors up to 200 horsepower sold in the United States to meet efficiency standards developed by the National Electrical Manufacturers Association. In this evaluation, the program is only credited with savings associated with the purchase of new premium efficiency motors (higher efficiency than the EPAct standards), where the upgrade from EPAct standards can be attributed to the program. Also, the evaluation credits the Motor Challenge program influence on end users to replace a higher percentage of failed standard

motors rather than repairing them relative to what the users would have done in the absence of the program.

The primary objective of the evaluation was to estimate energy savings attributed to the Program. Therefore, it was decided to focus evaluation resources on program components that met the following criteria:

- Established energy program evaluation methods could be used to quantify energy savings; and,
- Established methods could be used to demonstrate a plausible link between program activities and actions taken by end users to save energy.

DISCUSSION OF RESULTS

The independent evaluation conducted in 1999 found that the Motor Challenge is responsible for US$24.9 million in annual energy savings, is highly cost-effective, and has just begun to reach US industrial end users. The evaluation attributed approximately 67% of program savings to the Allied Partnerships and 33% to direct program efforts. Training produced the greatest benefit, followed by use of MotorMaster+ software.

Given below are some of the results of the evaluation:

- The energy savings attributable to the program totaled 498 GWh per year. Table 1 shows the distribution of these energy savings attributable to different program components. The monetary value of these savings is estimated at $24.5million as of end of FY1998.

Table 1
Summary of Energy Savings
Attributable to the Motor Challenge Program (as of end of FY1998)

Component	Net Program Energy Savings (MWh/year)	Net Program Energy Savings ($/year)
End-Users		
MM+	246,112	11,813,362
Showcase Demos.	22,861	1,630,073
Training Attendees		
ASD Training	24,758	1,188,375
Pump Training	30,199	1,445,695
Allied Partners		
Vendor & Consultants	80,597	3,868,639
Utilities & Government	59,674	2,864,323
Subtotal	*464,121*	*22,810,467*
Other		
Energy Matters (newsletter)	27,284	1,309,620
Teleconference	6,857	329,143
Total	***498,262***	***24,449,230***

- On average, the registered MotorMaster+ users are large industrial facilities. Xenergy estimated that they use roughly 20 times as much motor system energy as the average manufacturing plant. Altogether, MotorMaster+ users consumed 155,000 GWh/year in electricity versus 1.1 million GWh/year for industrial users as a whole. Thus, even though registered MotorMaster+ users represent less than one percent of all industrial facilities, they account for 14 percent of total industrial electricity use and a comparable portion of motor system energy.

- Between 5,600 and 9,500 end-user facilities received information materials, tools, and training directly from the program. 3,510 of the facilities are registered MotorMaster+ users. An additional 10,000 end-users received Motor Challenge tools and materials from vendor and utility Allied Partners. It is not clear how much these end-users overlap with those that received materials directly from the program.

- Among registered MotorMaster+ users, between 10 and 15 percent undertook changes to motor system design, purchase, and maintenance practices that they said would not have been made in the absence of the program. These changes included upgrading efficiency of replacement motors; opting to replace rather than repair failed motors; improvements in motor system maintenance practices; and installation of ASDs.

- At least 3,000 motor system vendors and consultants received information, tools, and training from the program.

- Among a group of the 104 vendors and consultants participating in the program as Allied Partners, about half reported that they had used Motor Challenge materials to influence customers to purchase energy efficient motor equipment and to make changes in their practices regarding motor system design, specification.

- 96 electric utilities, industry associations, and government agencies used MC materials and tools to structure or enhance their own programs to increase motor system efficiency for their customers and constituents. Over 10,000 customers were reached through these programs.

Some other evaluation results in context include:

- *Over the life of the program, Motor Challenge has established communication channels with technical and management decision-makers that represent a large portion of US motor system consumption.*

  At a minimum, Motor Challenge has identified technical and management personnel (registered MotorMaster+ users) in 3,510 facilities that account for 14 percent of total industrial motor system energy use, or roughly 95,000 GWh per year. In addition to these end-users, the program has identified potential decision-makers in 2,000 to 4,000 facilities through its Information Clearinghouse, and training activities. The customer identification records that support these operations are a key resource in advancing the mission of the program.

The results can also be understood in the context of the market for motors.

- MotorMaster+ users attributed the purchase of 10,170 premium efficient motors to the influence of the program (instead of purchasing EPACT qualifying motors). This is roughly 6 percent of the number of units of all premium efficient motors sold in 1998 to the industrial sector.

- MotorMaster+ users reported that they replaced 20,500 failed motors, instead of repairing them. Those 20,500 motors were almost entirely in the 5 horsepower and over range, and have a retail value of about $38 million. They account for over 4 percent of the number and dollar sales, respectively, of all polyphase induction motor sold in those horsepower categories in 1998. Based on the results of the end-user survey, Xenergy concludes that facilities that use Motor Challenge tools have used them extensively to guide decisions regarding replacement versus repair of failed motors.

To summarize, Motor Challenge has barely scratched the surface in terms of helping end-users realize system-level energy savings. Between MotorMaster+ users, training session attendees, and users of various information services, Motor Challenge can account for about 6,000 to 8,000 end-use facilities. As mentioned above, MotorMaster+ users are very large facilities in terms of motor energy usage. For purposes of this analysis, it was assumed that Motor Challenge participants who are *not* MotorMaster+ users are significantly smaller, that is, closer in size to the average industrial facility. Using this assumption, it was estimated that all end-users that have participated in Motor Challenge use between 110,000 and 150,000 GWh per year in motor system energy. Applying the *Market Assessment* finding that system-level improvements can reduce motor system energy use by 10.5 percent, potential savings from system related measures for these firms' ranges from 11,000 to 16,000 GWh per year. Xenergy's best estimate suggests that end-users represented in the various evaluation surveys undertook projects that yielded a maximum of 550 GWh per year in savings. This is no more than 5 percent of the potential savings.

Motor Challenge changed and adapted over the years. Some of the problems or weaknesses that led to the modifications are mentioned below. These were endemic to the "Challenge" programs that preceded the BestPractices Program:

- Initial attempts to sign up Partners were met with some resistance. Reporting data on energy consumption and production was seen as one possible explanation.
- There was more demand for inclusion in the Allied Partner program than DOE resources allocated could support. Therefore, an effort to broaden the reach of the Allied Partner program by signing hundreds of new companies and organizations was curtailed. The Allied Partnership remains open to any interested domestic company or organization. However, current program strategies now favor strategic Allied Partnerships with key national and regional trade associations, national equipment manufacturers and distributors, industrial consulting firms, utilities with large industrial loads, along with state agencies and non-government organizations who work directly with industry.
- Separate "Challenge" programs were set up to specialize in different technology areas. This was not the most efficient way to work with or deliver a broad range of information and assistance to industry. As a result, OIT initiated BestPractices, which integrates all of the previous "Challenge" programs.

<u>BestPractices Program</u>

The BestPractices program is building on the successes and lessons learned from Motor Challenge and the other Challenge programs, while expanding new efforts into the area of emerging technologies. BestPractices is integrating the delivery of energy-saving products, services, and technologies to the nine OIT, Industries of the Future: agriculture, aluminum, chemicals, forest products, glass, metalcasting, mining, petroleum, and steel industries. In

coordination with the industry-specific and industry-wide programs of OIT, BestPractices continues to provide technical assistance to help these industries increase energy efficiency, reduce waste, and boost productivity. The BestPractices team includes representatives of the IOF partnerships, Industrial Assessment Centers (IACs), and OIT's former Challenge programs for motors, steam, and compressed air. The team promotes a plant-wide systems approach in identifying immediate cost-saving opportunities, productivity improvements, and opportunities for application of emerging technologies.

BestPractice offers the same types of information and services as were offered through the Challenge programs such as information materials and services on industrial equipment and systems, decision-making tools, technical training, and other resources. In addition, BestPractices now offers assistance for assessing plant operations, including:

- Free, one-day assessments of small- to mid-sized plants by university-based OIT Industrial Assessment Centers
- Cost shared plant-wide assessments to help IOF manufacturing plants develop a comprehensive strategy to increase efficiency, reduce emissions, and boost productivity. Up to $100,000 in matching funds are available to IOF plants through a competitive solicitation process.

Advanced technologies developed with OIT support are regularly emerging from research and development and are ready for demonstration and use. BestPractices offers expanded support to help deliver these solutions to industry through showcase demonstrations and technology implementation.

- Showcase Demonstrations held at manufacturing sites; provide the public opportunities to understand the benefits of emerging technologies by seeing them applied in real-use conditions. The effort includes an independent third party to validate technology performance and costs in comparison to baseline practice; each technology with validated performance benefits will receive an OIT Certificate of Recognition.

- To validate performance and reduce the perceived risks associated with emerging technologies, BestPractices offers cost-sharing support to facilitate technology adoption. OIT Technologies eligible for implementation assistance must have completed the full-scale demonstration phase.

References:

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Energy + - a pan-European procurement project for refrigerator-freezers

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Introduction

The pilot project named *energy* + ran from January 1999 until June 2001 and sought to facilitate an increased market penetration of energy efficient refrigerator-freezers on the European market by making the best existing units (by the time of the project's start) available from more manufacturers throughout the Union, and by making these models the choice of more customers. The project *also* intended to contribute to earlier commercialisation of units that are even *more energy efficient* than the best existing ones through a technology competition.

Ten European countries participated in the project (Austria, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal Sweden, and the U.K), which used a method often referred to as procurement. It is simple in principle: The project group gathered strong, influential purchasers from the whole Union and, together with them, drew up specifications for a refrigerator-freezer with good energy and environmental qualities that is also user friendly. These specifications were then presented to manufacturers to show them that there is a market for these highly efficient products and to point out what features the buyers are looking for. By doing so the project intended to spur manufacturers to develop or make such units available on a larger scale.

The first pan-European procurement project

Before the start of the project, processes of this kind had only to a limited extent been used in the European Union and in other international co-operations. Those initiatives had shown that such aggregation of buyers is possible and also effective within one country, or among a limited number of countries. The Energy + project is interesting to study since it extended the concept by embracing the whole European Union and Norway. By working on a pan-European scale a strong market pull could be created which enabled a market transformation where a buyer group from one country alone would not have been strong enough. However, extending the concept also meant new challenges since the countries in Europe are rather different not only in terms of climate and culture (with different product preferences and

usage patterns as the consequence), but also in terms of market structures and political aspects, making the process complex.

Objectives of the program

The project was preceded by a one-year study[34] investigating the possibilities and the potential for procurement activities at European level. The study concluded that the instrument is feasible as well as promising for common European actions. One of the main barriers at European level was identified as the lack of experience and therefore confidence in the process as such. To gain such experience was one of the main objectives of the project. Refrigerator-freezers were found to meet the criteria necessary for such an activity as they are fairly standardised products sold on a highly international market. Being the most common cold appliance sold in Europe, with approx. 45% of total annual cold appliance sales of 18-19 million units, they also represent a significant energy saving potential. Further, production of such highly efficient units was not considered to imply any major technical problem for manufacturers. The main barrier to the large diffusion of already existing efficient units seemed to be the high sales price, which appeared to be the result more of branding and marketing policies than expensive technical components.

The action was timed in line with the political agenda at European level: It was built upon the well established energy labelling system and plays an important role to help identify efficient cold products during the period between the introduction of the minimum energy performance standards (September 1999) and the up-coming revision of the energy label thresholds. When the European Union introduced its labelling scheme for refrigerator-freezers only a few appliances qualified for the most stringent level “A”. A quick evolution of the energy efficiency of products available on the market has, however, made it necessary to revise the criteria (the levels and principles for which has been proposed by the *Cold II* study presented in Spring 2001). Since it will take a few years for the new requirements to come into force, the e*nergy*+ project has had and continues to have an important role in giving visibility to the most efficient products available and helping the manufacturers and buyers distinguish them from the “normal” A-rated units.

The project further constitutes a good means for the European countries to work together towards the common green house gas (GHG) reduction commitments under the Kyoto Protocol35, as domestic refrigerators and freezers are responsible for and 6% of Europe’s final electricity use meaning about 2% of Europe’s GHG emissions related to human activities.

Process of definition/design of the program

The project was based on a previous one-year study carried out under the SAVE programme (see earlier reference). Nine countries participated in the study under which national teams

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[34] “Procurement for Market Transformation for Energy-Efficient Products – a study under the SAVE programme”, 1998, Swedish National Energy Administration (STEM) report ER 15:1998

[35] “Kyoto Protocol to the United Nations Frame work Convention on Climate Change”, 1997 FCCC/CP/L.7/Add.1

carried out a total of 36 market studies regarding four different products: electric motors, solar-energy systems for water heating, office lighting systems, and refrigerator-freezers. These market studies included interviews and discussions with a wide range of market actors and policy makers. Refrigerator-freezers were found to be the best candidate for a pilot action.

Once the broad product category – refrigerator-freezers – had been decided upon, the pilot project undertook a more detailed feasibility study on this specific market. This study set out to investigate a number of questions, such as market relevance, market structure, supply chain patterns (e.g., the paths from supplier to end-user), how retailers market their products, pricing structures, the distribution of products on the market according to the European energy label classification in various countries, and the technical scope for improvements. All relevant market actors including retailers, manufacturers, trade unions, consumer associations, policy makers and research institutes were consulted. During the whole project a close contact has been kept with these actors who have been actively involved at all stages.

Main actors

Buyers and supporters

The term “buyer group” has been defined in a broad sense, since the role of the *energy+* buyer group was different from similar groups used in more traditional procurement projects. This was mainly due to the important role of retailers in a European context. Thus, the “buyer group” included retailers, institutional buyers (such as housing companies and holiday resorts), and supporters (such as national and regional energy agencies, and environmental NGOs who in their daily work inform about and push for energy efficient products). These actors were important collaborators when defining the technical and functional specifications presented to manufacturers.

All of the buyers and supporters have signed a declaration where they state their intent to buy and/or promote e*nergy+* appliances. The declaration is non-binding, but it nevertheless represents an effort on behalf of the signatory to penetrate and acknowledge the technical requirements, and an important moral commitment to the process.

Manufacturers

Manufacturers were invited to present products that would qualify to enter the *energy+* lists by meeting a set of strict but simple technical and functional specifications defined by the buyers and supporters in co-operation with the project management. The specifications did not prescribe any technical solution: manufacturers were free to present any solution as long as its performance and functions met the specifications.

Consumer associations and recognised testing institutes

These actors where involved to test the performance of the appliances presented by the manufacturers.

Policy mechanisms used

The policy mechanism used, often referred to as procurement, is simple in principle: The project group gathered strong, influential purchasers from the whole Union and, together with them, drew up specifications for a refrigerator-freezer with good energy and environmental qualities. These specifications were then presented to manufacturers to show them that there is a market for these highly efficient products and to point out what features the buyers are looking for. By doing so the project intended to spur manufacturers to develop or make such units available on a larger scale.

Energy+ contained the following five main phases of work:

Phase 1 Feasibility study (more detailed studies focusing on refrigerator-freezers and their market specifics).

Phase 2 Definition of process (i.e. letter of intent, *energy+* lists, updates), aggregation of buyers, development of mandatory specifications and optional requirements.

Phase 3 Results and follow up of Round 1, Publication of Round 2 specifications, publication of requirements for the *energy+* award competition.

Phase 4 Tender/development period, aggregation of additional buyers and supporters for Round 2.

Phase 5 Evaluation and selection of *European energy+ Award* winners, additional marketing, testing and follow up of the project.

Dissemination activities were part of all the five phases above.

It is not possible to draw clear cuts between these steps or phases of the *energy+* project, or of any procurement activity. The whole process requires a great deal of flexibility and openness to adjust to new inputs and experiences during the course of the project. For instance, the feasibility study was not only an activity that served to verify a given, planned procedure; it also played a role in starting to build up important relations with market actors who would eventually come to participate in the project's buyer group. During the feasibility study, important experience was achieved and used as input when the technical requirements for the products were developed. Thus, the feasibility study itself also served as an initial step of the market transformation activity for the project.

Similarly to the feasibility study, it is also difficult to draw clear division lines between the phases of building up a buyer group and developing the technical requirements. The buyer group's views on the requirements were actively solicited, and the requirements were amended several times based on input from buyers, technical experts and the project team's views before they were finalised.

A project was carried out in two rounds.

For the first round, a list of units that met the *energy+* mandatory specifications and that were available on the market by December 2000 was compiled and published. This first round list was updated once in September 2000 to include new entrants.

The second round was dedicated to *energy+* appliances available in 2001 when new lists of units were compiled and promoted. The publication of the second round lists was also co-ordinated with the announcement of the winners of the *energy+* award competition

The European energy+ Award competition

As an additional incentive for innovation and increased energy efficiency, the *European energy+ Award* competition was launched in February 2000 when the results of the first round were presented. The competition was based on the mandatory specifications, together with optional requirements of importance to the buyers. The mandatory specifications and the optional requirements together may best be described as set of specifications aimed at guiding the manufacturers in the development of products. These optional requirements include even better energy efficiency (than the mandatory specifications), refrigerants and foaming agents with low environmental impact, low noise, clear (external) temperature displays, reasonable price, and user friendliness. A formula based on the relative importance of the various optional requirements was developed to guide manufacturers in developing their submissions, and to help evaluate the entries. (Mandatory specifications as well as optional requirements are available from the project's web site, www.energy-plus.org.)

The competition was open to units in three separate classes: one-door models, two-door models and prototypes. The winning products were presented at a public award ceremony at Domotechnica trade fair in Cologne, Germany, in March 2001.

Cost and funding

The total budget of the project amounted to approx. one million Euro of which the SAVE programme's share was 35%. The rest came from the participating organisations, often national agencies or research institutes and universities in co-operation with such. Considering the impact of the project and the fact that it involved ten countries during 2,5 years the project does not appear expensive.

As for the direct *project-related* costs and impacts it should be noted that part of the costs are to be seen as investments that will lower the costs of continued *energy+* project(s) (costs for logo, web site and network build-up are to a large extent investments).

Monitoring and evaluation process

In what respects the technical results of the project an independent jury composed of internationally recognised experts in the fields of energy efficiency, technological aspects and consumer issues evaluated and selected the winner of the award competition. To verify the information in the testing protocols sent in by manufacturers, random testing of the appliances in all classes was performed at the internationally recognised TNO testing laboratory in The Netherlands using standardised testing methods.

An evaluation of the actual project and its impacts is included in the project programme. In the beginning of the project information was gathered on a number of key factors like market availability of efficient units, price, sales data and also an evaluation of attitudes and awareness. Some of these key factors were evaluated once again after the finalisation of the

project, and some of them are still to be evaluated. It is for example far too early to observe real market impacts as the project just came to its end. The already tight budget does not admit any third party evaluation, that would have been desirable.

Discussion of results

The contents of the lists or qualifying units and participating demand side actors far exceed the project team's expectations by the time of the project start. Approximately 100 organisations joined as institutional buyers, retailers or supporters. These organisations together represent more than 15.000 retail outlets and manage a total of more than one million dwellings. By the time of the last update of the lists (April 2001) four manufacturers had submitted 16 qualifying products to be included in the lists. Two of these products were *European energy+ Award* winners. These units are the most energy efficient on the European market today and have values believed to come close to, if not conform with, the most stringent minimum level for class A under the revised European cold appliance energy label. One can thus draw the conclusion the project has contributed to an earlier introduction of highly efficient units on the European market.

The project has contributed to rise the awareness of energy efficient refrigerators among actors within each country, and it established a contact network that did not exist before the project implementation and that can be used in future projects.

In the light of the successes in terms of listed energy+ products, manufacturers enthusiasm and overall positive feedback from retailers, it is sometimes easy to forget that an important aim of the project was to test the methodology. Does co-operative procurement on a pan-European basis work? The results were not the results of a traditional policy instrument simply scaled up to a European level. They were the results of a new approach to market transformation never tried before on a pan-European level. The methodology was tried and found to function.

Key factors of success

The strong demand side with retailers, institutional buyers and numerous supporters φρομ αλλ οῶερ Ευροπε ωασ α κεψ φαχτορ φορ συχχεσσ. Τηε χονχεντρατιον ον μαρκετινγ issues and recognition for the participants by the creation of a graphical profile, a logotype, a promotion CD-rom for the participants, a web-site and the production of promotion material is believed to have played a major role for the actor's interest to participate.

Main sources of problems

The main problem was the difficulty to match the administrative rigidity of the energy agencies and public bodies involved in the project with the flexibility demanded in different phases of a procurement program. Another problem, that was to some extent overcome, was the fact that the biggest buyers were not end-users but retailers who have an interest in high range products with a high mark-up, something that hampers diffusion and therefore is in contradiction with the aim of the project.

Another important problem is related to the difficulties and limitations to work with limited funding which is insecure in the long-term. To provide continuity and security for the market actors a long-term budget must be secured if this kind of actions are to continue.

More information about the project and its results is available on the project website www.energy-plus.org**.**

The IEA-SOLARPACES START Missions a deployment policy case-study

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Introduction to the START Mission Instrument of IEA SolarPACES

Since 1977, IEA/SolarPACES has pursued a focused program of research and development in the field of concentrating solar power and chemical energy systems. Systematic development of three concentrating solar power (CSP) technologies—troughs, towers, and dishes—has led to the ever-increasing ability of these technologies to concentrate and harness solar energy for electricity production and other uses with efficiency, reliability, and cost effectiveness. Our vision within the IEA/SolarPACES community is that by 2010, CSP technologies will be making a significant contribution to the delivery of clean, sustainable energy services in the world's sunbelt.

The goal of the SolarPACES START Missions (Solar Thermal Analysis, Review and Training) is to help nations and their power sector to develop a rational approach to the deployment of solar thermal electric systems and to improve the competitiveness of solar thermal technologies. The objectives shall be achieved by supporting the market development and expand the awareness of the potential of solar thermal to address the energy and environmental problems that the world faces. Each Mission means the concentrated joint effort of an international team of SolarPACES experts and representatives from their respective country, and may include analyses of appropriate solar thermal power technologies, review of specific sites for solar thermal power projects, review of the terms of reference for detailed feasibility studies, development of a concept of financial engineering based on the applicable law, identification of potential funding sources and options for specific projects, comparison of power generation costs in the country.

The first step in realizing grand market-introduction plans is to develop initial project opportunities. SolarPACES is helping identify the most promising projects by sending experts to selected sunbelt countries. To date, START teams and other SolarPACES experts have been instrumental in launching and/or supporting project feasibility studies for India [6d], Egypt, Spain [9a,9b], Crete [9c], Morocco, South Africa, Mexico, Australia [6a,6e], and Brazil. IPP-type projects employing solar trough and tower technology are in an advanced stage of development in at least 6 countries.

How the START Mission has become a uniquely successful tool of deployment policy will be shown here on the example of the first START Mission to Egypt, which has culminated now in the implementation of the 130MW Hybrid Fossil Solar Thermal (HFST) Power plant project at Kuraymat with private participation and a 50Mio USD support grant of the Global Environmental Facility (GEF)

Objectives of the IEA SolarPACES program

Our vision within the IEA/SolarPACES community is that by 2010, solar thermal power technologies will make a significant contribution to the delivery of clean, sustainable energy services in the world's sun-belt.

Recognizing both the environmental and climatic hazards we face in the coming years and the continued depletion of the world's most valuable fossil energy resources, high temperature solar thermal technologies can provide crucial solutions to energy problems within a short time-frame.

Electric power production from solar thermal plants is nearing cost-effectiveness and will be among the early opportunities for the technology to enter the market place. We expect that success in entering this market will reduce costs and help pave the way for more advanced solar thermal technologies and processes capable of producing gaseous and liquid fuels and chemicals to penetrate a much broader range of markets, including the transportation and chemical sectors of the world economy.

The following three objectives to help us achieve those objectives, are planned to expand our IEA/SolarPACES role from one which has been focused largely on technology development to one addressing the full range of activities necessary to overcome barriers to large-scale adoption of solar thermal technology.

1. Support TECHNOLOGY development by leveraging national resources for research and development through international cooperation.These core SolarPACES activities remain of utmost importance to improving the competitiveness of solar thermal technologies.
2. Support MARKET development to reduce financial, political, market and institutional hurdles to commercialization of solar thermal technology.
3. Expand AWARENESS of the potential of solar thermal technologies (including long term fuel supply and the potential for solar chemistry) to address the energy and environmental problems that the world faces.

In addition to the technical hurdles we have focused on for the past two decades, we are facing numerous non-technology-related barriers to solar thermal's achieving wide spread contributions to sustainable energy and a cleaner environment. To achieve our vision we must overcome obstacles and threats, and we must meet a number of critical challenges.

Obstacles and threats:

- Energy market deregulation and low energy prices, including a market-push toward use of the least-cost power option, while ignoring the cost of external environmental impacts of competing technologies.
- Uncertainty about cost, performance, and reliability.
- Perceived risks of high capital-cost projects.
- Intellectual property protection issues.
- Funding decreases in national solar thermal R&D programs.

Challenges:

- Establishing appropriate market entry incentives, including equitable taxation relative to conventional energy products, carbon taxes or renewable energy tax credits
- Removing legislative and regulatory barriers to the supply of CSP to the grid.

- Increasing support for the development of effective tools for assessing the true value of renewable technologies including externalities.
- Improving the attractiveness of investment opportunities in CSP technologies

Process of Definition/Design of the START Mission Instrument

In October, 1995, the concept of the START Mission was developed. The goal of these Missions is to help nations in the above mentioned regions develop a rational approach to the deployment of solar thermal electric systems within their country.

Each Mission means the concentrated joint effort of an international team of SolarPACES experts and representatives of the respective country, and may include

- analysis of appropriate solar thermal power technologies
- review of specific sites for solar thermal power projects
- review of the terms of reference for detailed feasibility and implementation studies
- development of a concept of financial engineering based on the applicable law
- identification of potential funding sources and options for specific projects
- comparison of power generation costs in the country.

The START missions have proven to be instrumental in linking the various national solar thermal R&D policies of the fourteen SolarPACES member states represented by the SolarPACES Executive Committee with the needs of the host countries, the capacity of the involved industry and the financial support schemes of multilateral development agencies.

The Roles of the START Mission Team and its Host

The main actors of the START missions and their roles are discribed in detail in the START Mission Procedures endorsed by the SolarPACES Executive Committee and included in the Annex A to this case study. A summary is given here:

Organization's from a country's energy and electricity sector, interested in the development of solar thermal projects may formulate a proposal to host a SolarPACES START Mission to the SolarPACES Executive Committee via its Secretariate. Such proposal must discribe

- the host organization's interest and expectations in the field of solar thermal technologies
- the host organization's role in the host country's energy policy making and energy project implementation process
- the specific solar thermal project opportunities, that the host organization would like to analyze and review in a START mission
- the solar thermal technologies, in which the host organization would like to receive information and training

In case the proposal is accepted by the SolarPACES Executive Committee, the host organization will be requested to fill out a preparatory START Mission Questionaire for efficient execution of the missions as included in the Annex B to this case study.

The START Mission experts are selected by the START Mission Coordinator and the interested host organization according to the expertise profiles required for the respective mission from an expert shortlist. Funding of the expert's time spent in the preparation, conduction and reporting of the Mission will be provided in kind by the SolarPACES member

that has nominated the expert. The participation of additional experts from industry, electric utilities and financing institutions may be decided by the START Mission Coordinator on a case by case basis. The final report of each START Mission will be edited by the Mission Head with the active support of the participating experts in English language. It will include the information provided by the host organization in the host country questionaires, the findings of the mission and an executive summary.

Policy Mechanisms used in the START Missions

As part of the preparatory phase of a START mission, the START Mission Head identifies together with the Host the policy mechanisms and support instruments for which the host country may be eligible and reviews such policies and instruments during the mission itself for applicability to the identified solar thermal project opportunities.

The conducted START missions to Egypt, Jordan, Brazil and Mexico have identified the Operational Programs of the Global Environmental Facility (GEF) as the principal support instrument for the market deployment of solar thermal technologies in these developing countries within the sunbelt.

As the objective of the solar thermal project opportunities identified and analyzed by the START Mission Team is to reduce GHG emissions, they falls into the main area of the GEF's Climate Change Operational Programs, which are:

Operational Program No.5 (GEF-OP5)	Removing barriers to energy conservation and energy efficiency
Operational Program No.6 (GEF-OP6)	Promoting the adoption of renewable energy by removing barriers and reducing implementation costs
Operational Program No.7 (GEF-OP7)	Reducing the long-term costs of low greenhouse gas-emitting energy technologies

During the START missions, it must be determined to what extent the project opportunities in the Host country fulfill the eligibility criteria and terms of reference of GEF Operational Programs 6 and 7. GEF-OP6 seeks to reduce GHG emissions associated with energy consumption and production through increased use of already commercially viable Renewable Energy Technologies (RET). The objectives of GEF-OP6 are to:

- remove the barriers to the use of commercial or nearly commercial RETs; and
- reduce any additional implementation costs for RETs that result from a lack of practical experience, initial low volume markets, or from the dispersed nature of applications, such that profitable "win-win" transactions and activities increase from the deployment of RET's

The program, however, will be flexible in the consideration of new applications as the range of commercial applications increases with time and the technologies become more economical. A successful result is one in which a particular least-cost, win-win renewable technology has become financially sustainable in the market of a recipient country. The output of a GEF-OP6 project is the removal of a barrier to a particular renewable energy application, possibly a barrier resulting from high cost of implementation.

The objective of GEF-OP7 is to reduce anthropogenic greenhouse gas emissions by increasing the market share of those low GHG energy technologies for specific applications

which are not yet widespread least-cost alternatives in the recipient countries. Meeting this objective depends on two assumptions:

1. that the assisted technologies will be implemented once their cost has become competitive with fossil-fuel technologies and
2. many of the promising renewable energy technologies will achieve successful results

Technologies “graduating” from GEF-OP7 may need some additional support from GEF-OP6 in countries with barriers.

GEF-OP7 activities would initially focus on those technologies that have been commercially proven or demonstrated, but have not impacted significantly on the market because of the high costs of technology transfer and replication, or associated commercial risks in new operating environments. For cost effectiveness, the scope of GEF-OP7 should be limited to those technologies which are expected to become more economical with the economies of scale of manufacturing and widespread application.

There are two main types of project results:

1. the direct results of the low GHG emitting technology project are the amount of energy generated, the amount of GHG emissions avoided, etc.
2. The indirect result, of greater interest to the program, is the reduction in cost of future procurement

There are three key assumptions for cost reduction leading to increased competitiveness and market share, i.e. that

1. cost reduction will in fact be passed on
2. cost reduction is industry-wide and not limited to the businesses receiving GEF financing
3. there are no countervailing reductions in international prices of competing fossil fuels and alternative technologies

GEF-OP7 will finance activities, including project preparation, on an incremental cost basis. The types of activities that can be financed include targeted activities in research, capacity buildup, technical assistance and investments.

Preparing, Monitoring and Reporting START Missions

The most important ex-ante evaluation tool of the START missions is the START Mission Questionaire as included in the Annex B to this case study, that has to be filled out by the Host country before the START mission. The data provided in this Questionaire are the basis for preliminary screening of suitable solar thermal project concepts- For this purpose, the experts of the START mission team design suitable technology configurations, estimate their annual performance with the provided solar resource data, estimate the levelized electricity cost with the provided economic data and estimate financial feasibility on the basis of the provided revenue schemes. With such preparation, the START team experts focus during their mission on the independent presentation of the technologies, the review of the resource data, the inspection of the proposed project sites and the discussion of the eco-financial assumptions. In an final conclusion round table, a consensus recommendation to the Host country on the further implementation plan of the identified solar thermal project opportunities is elaborated jointly between the START experts and the involved Host country decision makers. These START Mission findings are documented together with the results of the preparaqtory analysis in a final START mission report.

Best “checkpoints” or feedback systems for monitoring or evaluating the successful implementation of the solar thermal projects proposed jointly by the START Team and the Host country are the common milestones of power project implementation:

- Conceptual Design Completed and Technical Feasibility Proven
- Project Site Identified and Secured
- Financing Concept Completed and Ecomic Feasibility Proven
- Consultancy for Preparing the Projects Request for Proposal Contracted
- RFP Published
- Winning Bid Selected
- BOOx or EPC Contract Assigned
- Plant Committed and Start of Operation

Discussion of START Mission Results

The tangible results of the IEA SolarPACES START missions to Egypt, Jordan, Brazil and Mexico can be summarized as follows:

START Mission to Egypt in February 1996:

In Egypt, the START Mission was requested by the hosting New and Renewable Energy Agency (NREA) and the Egyptian Electric Authority (EEA) of the Government of Egypt, to

provide information exchange by independent experts on solar thermal technologies applicable in Egypt

1. review three specific sites planned and previously evaluated by the NREA
2. discuss the Terms of Reference (TOR) for detailed feasibility and implementation study: Bulk Renewable Electricity and Energy Production (BREEP)

The START Mission recommendations served as the information basis and independent expert evaluation for Egypt’s subsequent application to the Global Environmental Facility, to support the identified 130MW Hybrid Fossil Solar Thermal (HFST) Power plant project at Kuraymat with private participation with a 50Mio USD support grant under GEF-OP7. The milestones of success have been:

- NREA’s submission of a longterm solar thermal implementation program to the Egyptian cabinet and parliament, aiming at the implementation of … MW of CSP plants until 2020; this program has been fully endorsed by cabinet and parliament in 1997.
- Award of a 1000kUSD GEF grant to NREA for project identification and feasibility analysis and preparation of the terms of reference for international project bidding in 1998.
- Request for Pre-Qualification of private developer consortia, interested in implementing the 130MW HSFT Kuraymat plant as a BOOT project. Over twenty international prime developers submitted their statement of interest by May 2000.

Publication of the RFP for Kuraymat is scheduled for early 2000; award of BOOT contract for end 2000; after a 18-24 month construction period, the Kuraymat hybrid fossil solar power

plant shall start operation in 2004. Planning of two subsequent 300MW hybrid fossil solar thermal power plants has just started to be on grid in 2007 and 2009 respectively.

Basic key to this success was the absolute engagement of NREA and the support of EEA and the Egyptian Ministry for Energy for this project: Prior to this first START Mission to Egypt, NREA had very successfully conducted a series of activities investigating the national solar thermal potential, national technological capacity and industrial resources and their implications for the national energy plan, as a means of gaining the support of the Egyptian Electrical Energy Agency and Ministry of Energy as well as international development agencies. In this case, through a series of preliminary studies and selection processes, the host organization, NREA, had already focused its prime interest on natural-gas-fired hybrid fossil-solar power plants with proven parabolic-trough collector technology, particularly gas and steam turbine combined-cycle plants. While GEF-OP7 is an excellent instrument for the support of such projects, the application procedures and negotiation interfaces have still be designed in the era of public utilities with government owned power projects in mind and can hardly keep pace with the dynamics of modern private sector power project development.

START Mission to Jordan in March 1997:

In March 1997 a START team composed of IEA/SolarPACES representatives from Egypt, Germany, Israel, Spain, Switzerland and the US, with guest observers from the European Union, visited Jordan. The Mission host was the Jordanian National Electric Power Company, NEPCO, located in Amman. The purpose of the START mission was to brief NEPCO, the Ministry of Energy and Mineral Resources and the Royal Scientific Society on the current techno-economic status of solar thermal technologies and discuss the next steps in building Jordan's first large solar thermal power plant.

Jordan's solar potential and land resources are optimal for the implementation of solar thermal power technologies. Most regions in Jordan offer direct normal insolation above 2000 kWh/m²yr. The best sites, in the southern part of the country, exceed 2500 kWh/m²yr. It is estimated that within 50 km from required infrastructure (roads, grid) accessible sites have huge potential far in excess of present consumption. The START team recommended that the collection of direct radiation data be continued and that more direct normal radiation stations be setup.

For a first solar thermal IPP, the START team recommended the integration of a parabolic trough or solar tower system in a base-load 130-MW fuel-oil-fired steam plant as a booster or fuel saver be considered. Further progress towards implementation of a solar thermal project lost focus and priority in NEPCO, who was entirely absorbed by the new challenges imposed by the privatization and deregulation of the Jordanian power market. Now, that a series of conventional private IPP's have been successfully bidded and implemented in Jordan, newly emerged "green" investment funds and project developers have revived the solar thermal proposals of the START mission team and resumed recently negotiations with NEPCO and the Jordanian Ministry of Energy on a solar thermal BOOT project.

START Mission to Brazil in May 1997:

During the week of May 5th, 1997, a START Team composed of IEA/SolarPACES representatives from the US, Germany, Spain and Israel visited Brazil. The host of the mission was Centro de Pesquisas de Energia Elétrica (CEPEL) located in Rio de Janeiro, an

institution similar to USA's Electric Power Research Institute. The purpose of the team's visit was to brief research centers, electric utilities, and the energy ministry regarding the techno-economic status of solar thermal technologies and to explore the possibility of building a solar thermal power plant.

The START Team visited two proposed solar sites, reviewed the associated insolation data, and performed a first-cut systems analysis based on this data. CEPEL organized an International Solar Thermal Workshop to take place during the START Mission, which included START Team presentations on technology, economics, proposed plants, and the analyses of Brazilian meteorological data, and possible solar sites. Brazilian researchers and officials presented information on energy demand, financing, private and government markets, and past studies of solar thermal development. The team met with CEMIG (the electric company of the state of Minas Gerais who historically has expressed the greatest interest among Brazilian utilities in developing solar thermal electric power) to exchange information on energy resources and options, and demonstrated various software tools to researchers at CEPEL's laboratories in Rio de Janeiro.

Brazil's aggressive power sector expansion program seeks to increase the installed generating capacity by building natural gas pipelines and power plants, since many restrictions have been placed on tapping the remaining hydro potential. CEPEL and others in Brazil have studied the CO2 avoidance impact of concentrating solar power. The greatest success of this START Mission has been in providing IEA's support for CEPEL's efforts at reducing the long-term costs of greenhouse gas-reducing solar electric generating stations. Without IEA's participation, the Brazilian Government might not have continued this particular greenhouse gas reduction effort.

The START Mission was able to bring expertise and tools to Brazil for studying and designing solar power plants. The ability to exchange information is invaluable: Brazil needs access to the current status of the technology, while the international concentrating solar power community needs to understand the policy and cultural barriers facing the technologies.

Perhaps a weakness of the START Mission was its lack of outreach to international development organizations, such as The US Agency for International Development (USAID) and The Interamerican Development Bank (BID). Concentrating solar power rarely surfaces on these organizations' vistas, leaving a broad gap in medium- to large-scale renewable power options for developing countries.

Prior to this START Mission, Brazil had applied for a grant from the GEF for the purpose of building a solar power tower with methane reforming storage technology. The GEF requested that Brazil first prepare an assessment of the available concentrating solar power (CSP) technologies in order to show the merit of the proposed system. Funding for this technology assessment has been granted through the GEF and the study will soon begin under the direction of CEPEL. The current plan of work, in addition to the technology evaluation, includes market analyses, further international technical collaborations, and formulation of cost-reduction strategies. IEA/SolarPACES assistance has been requested for all phases of the study.

Dissemination Mission to Mexico in October 1998:

A solar thermal dissemination mission was conducted in October 1998 in Mexico City on "Solar Thermal Concentrating Technologies", at the Technology Museum in Mexico City and cosponsored by IEA SolarPACES and Institute for Electrical Investigations of the Comisión Federal de Electricidad (CFE-IIE).

The dissemination mission was attended by 31 experts from Europe, Mexico and the United States. CFE had invited high level representatives from the Mexican Energy Ministry, CFE, industrial firms and the Mexican solar energy research community.

The North Western part of Mexico offers excellent solar radiation potential (2500kWh/m² and higher) and the load demand curves are similar to the load demand curves in California with peaks in summer afternoons due to the increasing load of air conditioning. The radiation values were mostly estimated from satellite cloud coverage data; the ground data base is rather poor. There are various research groups active in solar thermal covering the subjects of parabolic trough technology, direct steam generation, dish technology and solar chemistry. Such activities, however, have been conducted in a rather isolated manner without the interchange with the solar thermal work carried out in Europe. It was agreed to establish a closer working relationship with the European and U.S. solar thermal research community.

The Mexican Ministry for Energy reported about the successful implementation of gas fired independent power projects in the North of Mexico and expressed the interest of the Mexican government in the presented solar thermal technologies and the will of the ministry, to support CFE and private developers in obtaining a Worldbank/GEF grant for the realization of a privately financed solar thermal power project. The Ministry also affirmed, that the national law for independent power producers would allow private developers to implement a solar thermal plant at Mexico's border with the US and to export solar electricity to the US, where it may be sold for green power tariffs.

CFE reported that it had reestablished negotiations with the Worldbank/GEF on the funding of a solar thermal feasibility study and the obtainment of a grant for a solar thermal project in the order of 50 million USD. A mission of the Worldbank was expected for the week after our mission to Mexico, where the next steps should be clarified.

Since this mission in 1998, CFE has received a grant from GEF to complete the feasibility study on the economic viability and technical feasibility of integrating a solar parabolic trough systems with a Combined Cycle Gas Turbine (CCGT) at the Cerro Prieto, Baja Norte site owned by CFE with world class solar insolation at 2665 kWh/m²-year. CFE is committed to complete the terms of reference for bidding this solar thermal project by the end of 2000. The recent change of the Mexican government, however, may also imply changes in composition and structure of the governmentally owned CFE, which actually may delay project progress. The dependence of governmentally owned national utilities on changes in government is a common weakness of many projects in developing countries and has paralized the progress of a similar solar thermal project in India for more than a decade.

Conclusions from the START Missions

The SolarPACES START missions have proven to become an extremely time and cost effective instrument of the SolarPACES community, to help achieve the objectives of supporting MARKET deployment of solar thermal technologies and of expanding

AWARENESS of the potential of solar thermal technologies. Their major success so far has been the support of the 130MW Hybrid Solar Thermal Plant at Kuraymat in Egypt, that has been promised a 50Mio USD grant by the GEF and for which over 21 international consortia have stated their interest, to develop, finance and operate it as a BOOT project.

While the cost of the START missions have been minimal (a few thousand USD travel budget provided by SolarPACES and a few person months of inkind expert contributions from the participating SolarPACES member organizations) the real ingredients for success may be summarized as follows:

- High interest and local pushers in the host countries, including an excellent, voluntary preparation of the START mission by the involved host organizations
- Informal approval of the START Mission Requests by the SolarPACES ExCo and informal agreement on the objectives and agenda of the START Missions between SolarPACES and the Host organizations
- High personal motivation and dedication of all experts from the START Mission team and the Host countries to achieve the objectives with their inkind contribution without any buraucratic or administrative hurdles.

In this way, the START mission serves as a catalyst for condensing available transnational expertise, industrial technologies, international financing support elements and an existing political will in the host countries into a feasible solar thermal project proposal.