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A Review of Selected Successful Energy-Efficiency Programs

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ABSTRACT

In industry, barriers may exist at various points in the decision making process, and in the implementation and management of measures to improve energy efficiency. Barriers may take many forms, and are determined by the business environment and include decision-making processes, energy prices, lack of information, a lack of confidence in the information, or high transaction costs for obtaining reliable information, as well as limited capital availability. Other barriers are the "invisibility" of energy efficiency measures and the difficulty of quantifying the impacts, and slow diffusion of innovative technology into markets while firms typically under-invest in R&D, despite the high pay-backs. Various programs try to reduce the barriers to improve the uptake of innovative technologies. A wide array of policies has been used and tested in the industrial sector in industrialized countries, with varying success rates. We review some new approaches to industrial energy efficiency improvement in industrialized countries, focusing on voluntary agreements.

INTRODUCTION

Under perfect market conditions, all additional needs for energy services are provided by the lowest cost measures, whether energy supply increases or energy demand reductions. There is considerable evidence that substantial energy efficiency investments that are lower in cost than marginal energy supply are not made in real markets, suggesting that market barriers exist. A study of the industrial electric motor market in France has demonstrated the existence of barriers due to decision-making practices, within an environment characterized by lack of information and split incentives (de Almeida, 1998). In this paper we will review the barriers for energy efficiency improvement in industry, followed by a discussion of innovative approaches for energy efficiency policy in industry, based on experiences in industrialized countries, including the United States. Learning from policy experiences is important for designing efficient and effective energy efficiency policies that support industry in a competitive environment by strengthening economic preformance and productivity, while at the same time pursuing the interests of the public for a clean environment. New policy approaches demonstrate the success of combining these goals when implemented in a sound way.

BARRIERS

Barriers may exist at various points in the diffusion process of measures to reduce energy use and/or GHG emissions. The diffusion process depends on many factors such as capital cost, operating cost savings, information availability, network connections, imitation effects and other factors (DeCanio and Laitner, 1997). All of these factors influence the probability of any given firm adopting any given technology at any particular moment in time. Barriers may take many forms in this process, and should be reviewed in the context of the industrial and business environment (e.g. multi-criteria optimization, firm size and structure, market structure, opportunity, information routes). While barriers exist, it is important to note that environmentally sound technologies and practices may also represent a strategic and competitive advantage through the development of new markets or new market opportunities, as shown by various authors (Porter and Van der Linde, 1995; Reinhardt, 1999). In this section we discuss the main categories of barriers found in the industrial sector.

<u>Decision-making processes</u> in firms are a function of its rules of procedure, business climate, corporate culture, managers' personalities and perception of the firm's energy efficiency (DeCanio, 1993; OTA, 1993) and perceived risks of the investment, stressing the importance of firm structure, organization and internal communication (Ramesohl, 1998). Energy awareness as a means to reduce production costs is not a high priority in many firms, despite a number of excellent examples in industry worldwide. For example, Nelson (1994) reports on a successful program at a major

chemical company in the U.S., which resulted in large energy savings with internal rates of return of over 100%. However, such programs are only reported in a relatively small number of plants. A recent analysis of the Green Lights program in the U.S. demonstrated the shortcomings in traditional decision-making processes, as investments in energy-efficient lighting showed much higher paybacks than other investments. (DeCanio, 1998). These analyses demonstrate the need for a better understanding of the decision making process, to be appropriately accounted in energy modeling and policy development.

Cost-effective energy efficiency measures are often not undertaken as a result of lack of information on the part of the consumer, a lack of confidence in the information, or high transaction costs for obtaining reliable information (Reddy, 1991; OTA, 1993; Levine et al., 1995; Sioshansi, 1991). Information collection and processing consumes time and resources, which is especially difficult for small firms (Gruber and Brand, 1991; Velthuijsen, 1995). The information gap concerns not only consumers of end-use equipment but all aspects of the market (Reddy, 1991). Many producers of end-use equipment have little knowledge of ways to make their products energy efficient, nor access to the technology for producing the improved products. Equipment suppliers may also lack the information, or ways to assess, evaluate or disseminate the information End-use providers are often unacquainted with efficient technology. In addition there is a focus on market and production expansion, which may be more effective than efficiency improvements, to generate profit maximization. Also, the lack of adequate management tools, techniques and procedures to account for economic benefits of efficiency improvements is an information barrier (see below). Finally, other policies and regulations may limit access to energy-efficient technologies.

Limited capital availability makes energy efficiency investments compete with other investment priorities and that many firms have high hurdle rates for energy efficiency investments. Capital rationing is often used within firms as an allocation means for investments, leading to even higher hurdle rates, especially for small projects with rates of return from 35 to 60%, much higher than the cost of capital (~15%) (Ross, 1986). In many developing countries cost of capital for domestic enterprises is generally in the range of up to 30-40%. Especially for small and medium sized enterprises (SMEs) capital availability may be a major hurdle in investing in energy efficiency improvement technologies due to limited access to banking and financing mechanisms. When energy prices do not reflect the real costs of energy (without subsidies or externalities), then consumers will necessarily underinvest in energy efficiency. Energy prices, and hence the profitability of an investment, are also subject to large fluctuations. The uncertainty about the energy price, especially in the short term, seems to be an important barrier (Velthuijsen, 1995). The uncertainties often lead to higher perceived risks, and therefore to more stringent investment criteria and a higher hurdle rate.

Lack of skilled personnel, especially for SMEs, leads to difficulties selecting and installing new energy-efficient equipment compared to the simplicity of buying energy (Reddy, 1991; Velthuijsen, 1995). In many firms (especially with the current development toward *lean* firms) there is often a shortage of trained technical personnel, as most personnel are busy maintaining production (OTA, 1993). Also the position within the company hierarchy of energy or environmental managers may lead to less attention to energy efficiency, and reduced availability of human resources to evaluate and implement new measures.

In addition to the problems identified above, other important barriers include (1) the "invisibility" of energy efficiency measures and the difficulty of demonstrating and quantifying their impacts; (2) lack of inclusion of external costs of energy production and use in the price of energy, (3) the often long life-time of energy-intensive industrial equipment, such as kilns and furnaces; and (4) slow diffusion of innovative technology into markets (Levine et al., 1994; Fisher and Rothkopf, 1989; Sanstad and Howarth, 1994). Regulation can contribute to more succesful innovation, but sometimes, indirectly, can be a barrier to implementation of low GHG emitting practices. A specific example is industrial cogeneration, which may be hindered by the lack of clear policies for buy-back of excess power, regulation for standby power, and wheeling of power to other users (Casten, 1998), as demonstrated in some of the deregulation schemes in the U.S. The existence of clear policies can be a driver for diffusion and expansion of industrial cogeneration, as is evidenced by the development of industrial cogeneration in The Netherlands (Blok, 1993). Finally, firms typically underinvest in R&D, despite the high paybacks (Nelson, 1982; Cohen and Noll, 1994). The under-investment is due to the risk of free-riders copying the results without the expenditures. Nevertheless, many studies have shown that R&D typically achieves high paybacks. Recent analyses seem to suggest that public and private R&D funding for sustainable energy technologies is decreasing in industrialized countries.

PROGRAMS AND POLICIES

Various programs try to reduce the barriers simultaneously in some steps. A wide array of policies reduce the barriers or the perception of barriers has been used and tested in the industrial sector in industrialized countries, with varying success rates. We will not discuss general programs and policies, but rather concentrate on specific examples in the industrial sector. With respect to technology diffusion policies there is no single instrument to reduce barriers; instead, an integrated policy accounting for the characteristics of technologies, stakeholders and regions addressed is needed.

Selection of technology is a crucial step in any technology adoption. Information programs are designed to assist energy consumers in understanding and employing technologies and practices to use energy more efficiently. Information needs are strongly determined by the situation of the actor. Therefore, successful programs should be tailored to meet these needs. Surveys in Western Germany (Gruber and Brand, 1991) and The Netherlands (Velthuijsen, 1995) showed that trade literature, personal information from equipment manufacturers and exchange between colleagues are important information sources. In the United Kingdom, the 'Best Practice' programme aims to improve information on energy-efficient technology, by demonstration projects and information dissemination. The program objective is to stimulate energy savings worth 5$ for every 1$ invested (Collingwood and Goult, 1998). Energy audit programs are a more targeted type of information transaction than simple advertising. Energy audit programs exist in numerous countries. An evaluation of programs in 11 different countries found that on average 56% of the recommended measures were implemented by audit recipients (Nadel et al., 1991). The Industrial Assessment Center program, sponsored by US DOE, is a well-known example of an audit program in the U.S. The program has performed well over 7000 audits in small and medium-sized enterprises in the U.S. Generally, about 42% of the suggested measures are implemented by these companies (Muller and Barnish, 1998).

Direct subsidies and tax credits or other favorable tax treatments have been a traditional approach for promoting activities that are socially desirable. An example of a financial incentive program that has had a large impact on energy efficiency is the energy conservation loan program that China instituted in 1980. This loan program was the largest energy efficiency investment program ever undertaken by any developing country, and commited 7% to 8% of total energy investment to efficiency, primarily in heavy industry. The program contributed to the remarkable decline in the energy intensity of China's economy. Between 1980 and the early 1990's energy consumption grew at an average rate of 4.8% per year (compared to 7.5% in the 1970s) while GDP grew twice as fast (9.5% per year), mainly due to falling industrial sector energy intensity. Of the apparent intensity drop in industry in the 1980s, about 10% can be attributed directly to the efficiency investment program (Sinton and Levine, 1994).

Programs or policies that promote or require reporting and benchmarking energy consumption have been implemented in some countries (Sun and Williamson, 1999). Reporting facility energy use has been shown as an effective means of raising management awareness of internal energy consumption trends while benchmarking energy use provides a means to compare the energy use of one company or plant to that of others producing the same products. Reporting and benchmarking programs have been established in Canada (Jago, 1999; Munroe, 1999), Norway (Finden, 1998; Helgerud and Mydski, 1999; Institute for Energy Technology, 1997), the U.K., and the U.S. (Martin et al., 1999; U.S. EPA, 1998). In addition to such national programs, specific industrial sectors such as the petroleum refining and ethylene industry have benchmarking programs (Solomon Associates, 1999).

New approaches to industrial energy efficiency improvement in industrialized countries include voluntary agreements (VAs). A VA generally is a contract between the government (or an other regulating agency) and a private company, association of companies or other institution. The content of the agreement may vary. The private partners may promise to attain certain energy efficiency improvement, emission reduction target, or at least try to do so. The government partner may promise to financially support this endeavor, or promise to refrain from other regulating activities. Many industrialized countries have adopted VAs directed at energy efficiency improvement or environmental pollution control (IEA,1997; EEA,1997; Börkey and Lévêque,1998; OECD,2000). There is a wide variety in VAs, ranging from public and consumer recognition for participation in a program (e.g. Energy Star Program in the U.S.) to legally binding negotiated agreements (e.g. the Long-Term Agreements in The Netherlands). Voluntary agreements can have some apparent advantages above regulation, in that they may be easier and faster to implement and may lead to more cost-effective solutions. Initial experiences with environmental VAs with respect to effectiveness and efficiency varied strongly, although only a few ex-post evaluations are available as most voluntary approaches are recent (EEA,1997; Worrell et al.,1997, Börkey and Lévêque,1998). In the next section we will discuss voluntary agreements more in depth.

VOLUNTARY AGREEMENTS

Agreements to meet specific energy use or energy efficiency targets are used widely in the industrial sector (Bertoldi, 1999; Chidiak, 1999; Hansen and Larson, 1999; Mazurek and Lehman, 1999; Newman, 1998). Such agreements, which are typically but not always voluntary, are defined as "agreements between government and industry to facilitate voluntary actions with desirable social outcomes, which are encouraged by the government, to be undertaken by the participants, based on the participants' self-interest" (Storey, 1996). An agreement can be formulated in various ways; two common methods are those based on specified energy efficiency improvement targets and those based on specific energy use or carbon emissions reduction commitments. Either an individual company or an industrial subsector, as represented by a party such as an industry association, can enter into such agreements.

Examples of industrial sector agreements and target programs include the following:

- Australia: Energy Smart Business Program (Cooper et al., 1999)
- Canada: Industry Program for Energy Conservation (CIPEC) (Jago, 1999; McKenzie, 1994)
- Denmark: Agreements on Industrial Energy Efficiency (Togeby et al., 1998; Togeby et al., 1999)
- France: Voluntary Agreements on CO2 Reductions
- Finland: Agreements on Industrial Energy Conservation Measures
- Germany: Declaration of German Industry on Global Warming Prevention (Ramesohl and Kristof, 1999)
- Japan: Keidanren Voluntary Action Plan on the Environment (Japan Federation of Economic Organizations, 1998)
- Netherlands: Long-Term Agreements on Energy Efficiency (Ministry of Economic Affairs, 1997; Nuijen, 1998; Rietbergen et al., 1998)
- Sweden: ECO-Energy
- U.K.: Energy Efficiency Best Practice Program (Miles, 1994), Make a Corporate Commitment Campaign (MCCC)
- U.K.: Energy-Intensive Industry Sector Efficiency Targets (Environmental News Service, 1999)
- U.S.: Voluntary Aluminum Industrial Partnership; PFC Emissions Reduction Partnership for the Semi-Conductor Industry

The level of commitment of the above voluntary programs varies widely. The effectiveness of voluntary agreements is still difficult to assess, due to the wide variety and as many are still underway. Ex-post evaluations are therefore limited. Voluntary industrial agreements in Japan and Germany are examples of self-commitments, without specific support measures provided by the government. Industries promised to improve energy efficiency by 0.6% to 1.5% per year in those countries (IEA, 1997). The VAs in The Netherlands aim at doubling the autonomous rate of energy efficiency improvement, i.e. improving energy efficiency by 20% between 1989 and 2000. Participants to VAs in The Netherlands have access to government programs for energy efficiency investments, are eligible for tax rebates, and have simplified procedures for environmental regulation compliance, e.g. permitting procedures. The voluntary agreements in The Netherlands were strongly encouraged by the government. They were also attractive to industry, as they allowed the development of a comprehensive approach, provided stability to the policy field, and were an alternative to future energy taxation (Van Ginkel and De Jong, 1995), or regulation through environmental permitting.

Experience with industrial sector voluntary agreements exists in the U.S. for the abatement of CFC and non-CO_2 GHG emissions. For example, eleven of twelve primary aluminum smelting industries in the U.S. have signed the Voluntary Aluminum Industrial Partnership (VAIP) with EPA to reduce perfluorocarbon (PFC) emissions from the electrolysis process by almost 40% by the year 2000. Similar programs exist with the chemical, magnesium and semi-conductor industries, as well as voluntary methane emission abatement programs with the coal, oil and natural gas industry. New voluntary efforts include landfill operators and agriculture. For more details on voluntary industrial agreements, see Newman (1998); Rietbergen et al., (1998); Nuijen (1998); Mazurek and Lehman (1999).

EVALUATING VA EXPERIENCES

A recent analysis of five voluntary agreements in Europe found significant differences between the structure of the agreements and the performance and effectiveness of the agreements. This analysis concluded that “the effectiveness of voluntary agreements can be seen as strongly dependent on the accompanying policy mix and the supporting framework which has to be adapted to the specific conditions of the target group envisaged” (Krarup and Ramesohl, 2000).

The Dutch long-term agreements on energy efficiency in industry have been evaluated favorably, and are expected to achieve the targets for most sectors (Universiteit Utrecht, 1997). The evaluation highlighted the need for more open and consistent mechanisms for reporting, target setting and supporting policies. Preliminary evaluations show that VAs are most suitable for pro-active industries, small number of participants, mature sectors with limited competition, and set a longer term target (EEA,1997). The evaluations also show that VAs are most effective if they include clear targets, includes a specified baseline, include a clear monitoring and reporting mechanism, and if there are technical solutions available with relatively limited compliance costs (EEA,1997).

Voluntary industrial agreements may be less effective in light industries, which typically have a large number of different companies. However, voluntary agreements may work well with some of the large companies that dominate production and energy use in these industries such as General Electric. In The Netherlands, Philips Electronics participates in an individual voluntary industrial agreement, since it solely dominates the electronics industry in The Netherlands.

INDUSTRY PARTICIPATION

Industries will participate in VAs for different reasons. While the voluntary declarations in Germany and Japan aimed to be a pre-emptive move to potential government policies aimed at climate change, in other countries VAs serve as a model to channel public-private partnerships. For example, in The Netherlands the VA was attractive to the steel industry because it made it possible to develop a comprehensive approach to energy and environmental issues. A VA is familiar to the industry (i.e. contract), provides stability to the policy field, and, last but not least, is an alternative to future energy taxation (Van Ginkel and De Jong, 1995). The VA for industry in The Netherlands excludes energy used as feedstock. For the steel industry this means that part of the coke and coal used in the blast furnace is excluded from the efficiency improvement goals, underlining the need for clear definitions of the baseline and targets. Generally, the VAs helped to increase awareness of energy efficiency and increase the implementation of practices and technologies. VAs are a flexible and cost-effective way to achieve the set goals, through reducing non-economic barriers to energy efficiency improvement (Nuijen, 1998). By 1998 the average energy efficiency improvement was 17.4% compared to the 1989 baseline. The steel industry in The Netherlands improved energy efficiency by 16% compared to the 1989-baseline (Ministry of Economic Affairs, 1999). This was mainly achieved by reducing material losses, increasing coal injection in the blast furnace, BOF-gas recovery, advanced cogeneration schemes, energy recovery, and good housekeeping and process control. Today, the integrated plant in The Netherlands is among the most energy-efficient and productive in the world.

In the U.S. the American Iron and Steel Institute (AISI) has proposed a voluntary plan for GHG emission reduction. This plan would aim at a gradual emission reduction through more effective utilization of materials, improving energy efficiency of processes, and introducing new processes (anom., 1997) The AISI views a VA as an incentive to steelmakers over agreements with “binding limits and mandated reductions” (anon., 1997). A VA, if based on the elements for success discussed above, could help to achieve the potentials for energy efficiency and productivity improvement (Worrell et al., 1999), while maintaining the needed flexibility to operate in a rapidly changing industrial environment.

LESSONS LEARNED

Based on the available evaluations of VAs several conclusions can be drawn and recommendations can be made.

<u>General</u>

In general to be effective, VAs should be part of larger, overall (energy) policy including supporting instruments and regulations. Stand-alone VAs not embedded in a set of policies and programs have generally less ambitious goals and are less effective, as demonstrated by the self-commitment style VAs of German industries.

Criteria, rules and procedures must be carefully prepared and negotiated prior to target setting, to level the playing field for all participants. This will also avoid a situation where individual companies may get out of the agreements at a later stage. Clarity will increase the participation rate and potential success of the VA.

Institutional capacity must be developed to support achievement of targets. The goal of VAs increases interest and information on energy efficiency opportunities and to make long-term changes in decision-making behavior in firms as well as public agencies. The lack of institutional capacity may reduce the long-term effectiveness of VAs. In Netherlands and in some German sectors (e.g. the cement industry),institutional capacity has grown through regular exchange of information on energy-efficient practices and technologies, contributing to considerable cost savings to achieve set targets.

Within a collective target, firms must undertake individual commitments to enable monitoring and evaluation of the VA and assess the contribution of all individual parties.

Target setting approaches are most suitable for mature industries with a limited number of companies (less than a few hundred) to enable clear monitoring procedures and evaluation of the contribution of individual participants (reducing the number of free-riders). The example of a VA with Philips in The Netherlands shows that alternative ways to negotiate a VA may be used in complex sectors with a multitude of small companies. In the U.S. firms like Johnson & Johnson and 3M have already made corporate commitments on various issues (e.g. waste prevention, energy efficiency) and implement plans and measures for the multitude of their facilities and plants.

Target Setting

Targets and the practice of target setting are important for providing credibility of the process to the public and participants, and are very important for the long-term effectiveness of a VA.

Target setting includes the determination of a baseline to assess progress compared to the "business-as-usual" developments. This gives credibility to the targets negotiated and the preferable treatment given to participants to VAs by public agencies.

Detailed analysis and preparation are required for ambitious targets. While some VAs (e.g. Japan) do not contain ambitious targets, others do (e.g. The Netherlands). The targets agreed on in The Netherlands (generally a doubling of the autonomous rate of improvement) are based on detailed analyses of the potential for efficiency improvement in the particular sector and audits of the main participating companies.

Targets must allow for inclusion of a wide-range of energy-saving activities. This provides flexibility for the industrial partners to achieve the targets in a manner that is cost-effective and efficient.

Targets must be differentiated by target groups, or industrial sectors, based on the economic potential for efficiency improvement in the particular sector. Hence, the targets should not be pre-defined for all sectors in a similar manner. This allows to realization of the full benefit of the flexibility of a VA. However, an overall policy target may be needed to calibrate the distribution of targets and to share the "burden" among sectors.

Targets should be set for the longer term (> 5 years) to allow flexibility and take advantage of business cycles and the often long lifetime of industrial energy-consuming equipment.

Target setting should be transparent to retain public credibility. A lack of credibility for the VAs may ultimately backfire on all participants, and lead to the need for other policies to achieve certain policy targets, which may not be beneficial to the partners.

Monitoring and Evaluation

Monitoring and evaluation are key to measure the success of a VA, as shown by examples in Germany and The Netherlands. In Germany an independent agency has been charged with the monitoring of the voluntary declaration of the German industry. Only one evaluation has been published in 1997, and the reliability of the data is often not of the quality to allow an in-depth evaluation (Ramesohl and Kristof, 1999). In contrast, in The Netherlands a detailed monitoring instrument has been set up for each sector using an energy efficiency index (EEI). This allows monitoring of the progress, while accounting for changes in product mix.

Project progress should be evaluated in a manner that can be used to adjust policies if necessary. This allows small adjustment of policies to help partners to achieve the targets, without disruptions of the VA process, increasing trust by all parties in the process.

A clear and transparent monitoring and reporting system is essential, as demonstrated in The Netherlands. It increases the credibility of the process for all partners and the public. A well-functioning monitoring system helps the industrial participants to evaluate the achievements in an independent manner.

Evaluation should be done by an independent third party, to increase public credibility of the VA process.

SUMMARY AND CONCLUSIONS

Barriers to energy-efficiency improvement may take many forms, and are determined by the business environment and include decision-making processes, energy prices, lack of information, a lack of confidence in the information, or high transaction costs for obtaining reliable information, as well as limited capital availability. Various programs try to reduce the barriers to improve the uptake of innovative technologies. A wide array of policies has been used and tested in the industrial sector in industrialized countries, with varying success rates. We review some new approaches to industrial energy efficiency improvement in industrialized countries, focusing on voluntary agreements. VAs provide a flexible and efficient instrument, if implemented properly. We discuss the main lessons learned from VAs in various industrialized with respect to target setting, monitoring and evaluation, as well as general structure.

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