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POLICIES AND PROGRAMS FOR PROMOTING ENERGY CONSERVATION IN THE RESIDENTIAL SECTOR: LESSONS FROM FIVE OECD COUNTRIES

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June 1989

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POLICIES AND PROGRAMS
FOR PROMOTING ENERGY CONSERVATION IN THE RESIDENTIAL SECTOR: LESSONS FROM FIVE OECD COUNTRIES

INTRODUCTION

Purpose and Method

This report is the product of a study of national residential energy conservation policies and programs in five OECD (Organization for Economic Cooperation and Development) countries: Denmark, France, Japan, Sweden, and West Germany. We chose these countries because, in each, different contextual aspects affected the development and the impacts of energy conservation policies and programs. By "contextual aspects" we mean all of the characteristics of the countries before each of the programs was put into place. Contextual aspects, therefore, include institutions, the economy, politics, culture, physical characteristics (such as the size and condition of the housing stock), climate, energy supply, and energy demand. The countries were also chosen because, within each of them, important positive examples of the use of policy and programs to reduce residential energy consumption have been demonstrated.

In this report we describe national residential energy conservation policies and programs in the five countries listed above. Within supply and demand contexts, we describe the governments' stated energy policies, the structure of and relationships among the various institutions responsible for establishing and implementing those policies, and the programs they developed. This information is presented country by country, in what we call "country reports." In addition, we refer to national residential energy conservation programs in the United States.† The purpose of this is to establish the setting in which our work is expected to be used; the reader can use this information in order make his/her own comparisons with the five countries listed above.

Governments' objectives and goals determine of the types programs that they choose to implement. We have established a typology based on the "tools" that governments use in programs. In the countries studied here, the tools available for meeting policy objectives are

† For detailed descriptions of these programs, see "Review of Government and Utility Energy Conservation Programs," Clinton, Geller, and Hirst, Annual Review of Energy, Vol. 11:95-142, Palo Alto, CA, 1986. Annual Reviews, Inc.

fairly uniform. These tools are of three types: regulation, aids and incentives, and deterrents (pricing/tariffs). Each offers options for addressing similar issues. The effect of each can vary significantly, however. At stake in the choice of program tools are parameters such as program acceptance, participation, and the sustainability of program impacts.

Following the country reports, we discuss—on a conceptual level—the tools used by the governments of the different countries to promote residential energy conservation. We aggregate the basic tools listed above into three groups: 1. Those that "fix" the market (remove barriers etc.); 2. Those that change the market (through price controls, taxation, subsidization); 3. Those that alter the make-up of items on the market. The third category includes measures affecting energy efficiency from "upstream" (gentlemen's agreements for appliance efficiency improvements, mandated standards, etc.).

Within this typological aggregation, we discuss each tool individually, using examples from each of the countries. Many programs have impacts that fall into more than one of the above categories; the impacts of others do not clearly fall into any. This "greyness" may be seen as a positive aspect of programs. Those that use several tools and approaches toward the same end or set of interrelated ends (synergistic programs) appear to have better chances of achieving their goals than those using more limited tactics. The focus of each tool sub-chapter is how an individual tool is used, and what impacts are associated with its use.

In some cases, political, economic, physical, and social conditions limit the feasibility of using specific program tools. In other instances these contextual aspects can facilitate the use of specific program tools, but alone do not assure the achievement of a given goal. Understanding the context in which policies and programs are established and implemented is, therefore, key to understanding their potential and eventual impacts. Following our discussions of individual tools, we describe some of the important contextual aspects which both limit and enhance the potential of policies and programs to affect residential energy consumption. We approach these descriptions tool by tool, because aspects of context have different (both in terms of type and order of magnitude) influences on the use and impacts of each tool. The purpose of this descriptive chapter is to demonstrate and emphasize the importance of acknowledging and responding to context in the process of designing programs.

Scope

This study differs from previous studies in two important ways. First, we describe policies and programs in their full contexts both quantitatively and qualitatively. This aspect of our work is essential, because it allows the reader to separate features of a program that are specific to its situation from those that are generally common to programs of its type. This disaggregation is necessary to enable us to transfer what we learn here to new situations, settings, and goals, and to understand what is not transferable. The second difference is that the analysis is built on a descriptive, non-judgmental account of ways in which policy tools have been used in several countries. Our aim is to learn from historical experience. We are not interested in evaluating programs or criticizing specific governments' energy conservation efforts.

This project is limited to studying national programs. In many countries (West Germany and the United States in particular), regional programs have been of equal or greater significance for residential energy conservation. Regional and local programs are, however, beyond the scope of this report.

Terminology

In the field of energy analysis, a specialized vocabulary has developed that has been incorporated in much current writing. Researchers, however, use these words differently, so confusion and misunderstandings often arise. For that reason, we clarify our usage of several terms. Two terms used frequently in this report are "energy conservation" and "program impacts." We have attempted to use these terms consistently throughout the report, and explain our usage of them below. We do not intend to imply that these are the only valid definitions of the terms, but wish to avoid misinterpretation of our work resulting from semantic difficulties.

Energy conservation: Our working definition of energy conservation determines what we examine as energy conservation programs. Our definition must be broad enough to encompass the range of goals/objectives of the programs that were instituted in the countries studied. We depend on the programs themselves to provide the definition. In this way we avoid excluding programs because of limitations of our own perceptions as to what energy conservation is. The term "energy conservation" has been used in energy policy to reflect the goals of reducing consumption of oil specifically, reducing consumption of all energy sources generally, reducing the cost of providing energy services, and improving the efficiency of energy-using devices and processes (thereby increasing the services that can be provided with limited energy resources). We accept all of these in our working definition, thus allowing for the inclusion of fuel switching, retrofitted efficiency improvements, replacement of energy consuming devices with more efficient ones, and reduction of demand for energy services (lowered indoor temperatures, etc.) as energy conservation measures. Energy conservation programs are any government actions taken for the purpose of influencing the adoption of such measures.

Program impacts: When we use this phrase we are referring to specific, observable outcomes of programs, such as the number and type of participants, the number of measures adopted, etc. We do not evaluate these results as good or bad, nor do we attempt to determine the actual energy savings that can be attributed to specific programs, or the cost effectiveness of programs. It is important for the reader to make the distinction between the terms "program impacts" and "program success" when reading this report. We have avoided using the term "program success" in this report. As we are not performing program evaluations, as stated earlier, our definition of this term is irrelevant. We do, however, include in this report the judgments of analysts who have evaluated specific programs in their own countries. We feel that the conclusions drawn in such evaluations are relevant to gaining in-depth understanding of programs in their contexts. We must emphasize, however, that our role is only to report the conclusions of these evaluations, and that we have no role in choosing the criteria used to draw those conclusions.

For the reader's convenience we have provided a glossary with summarized definitions of these and other terms used in this report (see Appendix B). Appendix A contains a list of abbreviations used in the report and their meanings.

Basic Issues

The policies and programs studied in this report were motivated by the oil price shocks in the 1970s, and by anticipation of subsequent increases in energy costs. These stimuli have led to different responses and actions by national governments. Earlier actions tended to be aimed at responding to short-term concerns resulting from the perceived condition of crisis; later responses incorporated longer-term planning and attempts to bring about structural changes in the provision of energy services.

While social goals played a large role in determining the programs and tools chosen for meeting policy objectives, the logistics of how programs were designed and implemented were largely determined by interactions among institutions involved in addressing energy issues. These interactions and relationships, which we refer to as institutional structure, are quite different among the countries studied in this report. In general, a variety of government institutions, industrial representatives, consumer advocates, and academics have been involved in program design and/or implementation. Not all of these actors, however, participated in program design/implementation in every country. Similarly, the roles of the different actors have varied, reflecting a range of decision-making practices, from centralized, top-down to widespread cooperative efforts.

In addition, we have found that the extent to which existing infrastructures were available for implementing programs varied among the countries. Where existing infrastructures can be used, implementation of programs is simplified and the chance of a program being effective is often increased (ex: subsidies for retrofits through the existing home loan system in Sweden; Stiftung Warentest as a format for distributing information on energy efficiencies of appliances in West Germany). Where such infrastructures do not exist, program costs can be higher as a result of the need for training, establishing new bureaucracy, etc., and public acceptance can be more difficult to achieve. Each aspect of institutional structure affects program impacts.

Institutions have at their disposal different channels through which program objectives can be carried out. These channels vary, and include those linking the government and the public directly (''downstream'' efforts, which would include regulation in some cases), those reaching the public indirectly through key enterprises (like builders, appliances manufacturers—i.e., ''upstream''), and those attempting to lead by example (demonstration and trickle-down effects). Examples in this report indicate that different subgroups of the society are reached or ignored by programs largely as a function of the channels through which programs are implemented. This relationship is clear in disaggregations of program participation. When the targeting of programs is being considered, therefore, the channels chosen for program implementation should be closely examined. Considering the impacts of these choices is an important part of program design.

All the factors described above contributed to the development of residential energy conservation policies and programs, to the potential impacts of those programs, and to actual impacts of programs that are in progress or have been completed. With this in mind, we explore the experiences of the individual countries.

DENMARK

BACKGROUND

In 1973, Denmark's primary energy supply portfolio was similar to Japan's. Ninety-two percent of Denmark's primary energy was supplied with imported oil and the rest were mostly from imported coal.[1] Crude oil imports came almost exclusively from Middle Eastern countries. Unlike her Scandinavian sisters (Finland, Iceland, Norway, and Sweden), Denmark had essentially no potential for developing hydro-electric power. Nuclear power was considered a possible future source of electricity, but had not been developed.† Despite these limitations, Denmark's virtually complete dependence on imported fuels was not permanent. Higher prices for petroleum products opened up possibilities for exploring and extracting previously uneconomical petroleum sources in the North Sea. The first three Danish oil fields were in operation in the North Sea by the end of 1982. By 1985, oil's share of Denmark's primary energy supply had been reduced to 55 percent. During the first half of 1986, 60 percent of Denmark's total crude oil consumption came from the North Sea, one third of which was supplied from Danish wells. Coal usage in 1985 had increased from six to 39 percent of total primary energy, and natural gas from zero to three percent. The use of renewable energy sources had also increased to three percent. Twenty-four percent of the total primary energy supply that year came from domestic sources.[2] Furthering the development of new sources of domestic oil and natural gas, and perceived prospects for energy conservation and exploitation of renewables are central to Denmark's energy policy.

As in many other OECD countries, the residential sector in Denmark is responsible for a large share of total energy demand. In 1973, residential energy consumption was higher than that of any other sector (approximately 35% of the total). The high level of energy use in the residential sector reflects several factors acting simultaneously. The standard of living in Denmark is very high. Results from a survey performed by Professor Richard Estes, University of Pennsylvania, indicate that Denmark has the highest living standard in the world based on traditional measures such as economic development and social and political conditions.[3] The high standard of living is reflected in high levels of comfort. In the early 1970s, this could be seen in both the average indoor-air temperatures and in appliance

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[1] Meyer and Nørgård, 1987.

† The Danish annual "Status Report on Energy Planning" continued to mention nuclear power as a possibility through 1983. In 1984 the first status report that explicitly excluded nuclear power from energy planning was published by the Danish government.

[2] Ministry of Energy, Denmark, 1986.

[3] United Press International, 1986.

saturations (see Tables 1 and 2).

Table 1. Residential Indoor Temperatures[4] 1974, in Percent	
19°C or below	17
20-21°C	57
22-23°C	21
23-24°C	4
25°C or above	2

Table 2. Penetration of Household Electrical Appliances[5] in Percent			
	1972	1979	1985
Refrigerators	87.0	76.5	75.0
Freezers	45.6	59.7	62.0
Combis†	9.6	30.2	32.0
Washing Machines	43.5	58.2	60.4
Electric Ranges	53.7	71.7	N/A
Televisions	79.7	93.1	94.1

These energy services were acquired at high costs. The bulk of the energy use (76% in 1972) went to space heating. Keeping indoor-air temperatures at 20°C was an energy intensive activity in Denmark for two reasons. The heating season spans nine months, with an average of slightly more than 3,100 heating-degree-days (base 18°C) per year. In addition, the thermal condition of the building stock was poor in the 1970s. Unlike the Swedes, the Danes did not have a long tradition of demanding high thermal quality in building construction. In Denmark, the focus had been on aesthetic rather than material quality.

4 ScanTest, Danish Energy Agency, 1974.

5 For 1972: Schipper, 1982; for 1979 and 1985: Danske Elvaerkers Forening, 1987.

† Combination refrigerator freezers

SIGNIFICANT INSTITUTIONS AND ORGANIZATIONS

Residential energy conservation policies and programs in Denmark are generated by a network of people, described here as beginning and ending with Parliament (see Figure 1). Although the principles behind such a system exist in many countries, in Denmark the theory can be seen working in practice. Initiative, action, and reaction follow a circular path, allowing policy to evolve in response to community sentiment. This circular process allows the Danes to initiate and adapt policies and programs at various points within the cycle, in response to perceived need. This organizational structure is significantly different from those in many countries, where centralized, top-down approaches to policy and program development are preferred. This process is manageable because Denmark is, geographically, a very small country. All of the major governmental bodies are within a one-hour drive of each other. This allows decision-makers to get to know each other and to communicate easily without the practical constraints that exist in larger countries. The key actors in this process and their relationships are described below.

The Parliamentary Energy Committee is responsible for considering the needs and opinions of regional and sectoral factions, and of the public at large, and for composing Denmark's national energy policy. This committee's decisions determine the outcome of all energy debates in Denmark, including those pertaining to residential energy conservation.

In 1979, the Ministry of Commerce was divided into two separate Ministries; the Ministry of Industry and *The Ministry of Energy*. The Ministry of Energy absorbed some of the key staff of the Ministry of Housing and Building's Energy department, and took responsibility for formulating national Danish energy policies. The Ministry operates under guidance from the Parliamentary Energy Committee. The Ministry of Industry retained responsibility for promoting energy efficiency in the industrial sector.

The Energy Agency implements the policies of the Ministry of Energy. The Energy Agency is responsible for all routine administration related to such implementation.

The Energy Conservation Committee, within the Ministry of Energy, provides a comprehensive information program regarding residential energy conservation. The committee also conducts an annual survey on effectiveness of information programs and on changing consumer attitudes.[6]

Risø National Energy Research Laboratory is funded by and run under guidance from the Ministry of Energy. This laboratory is responsible for most of the state-funded energy research (including energy conservation research and development) conducted in Denmark.

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[6] International Energy Agency, 1987.

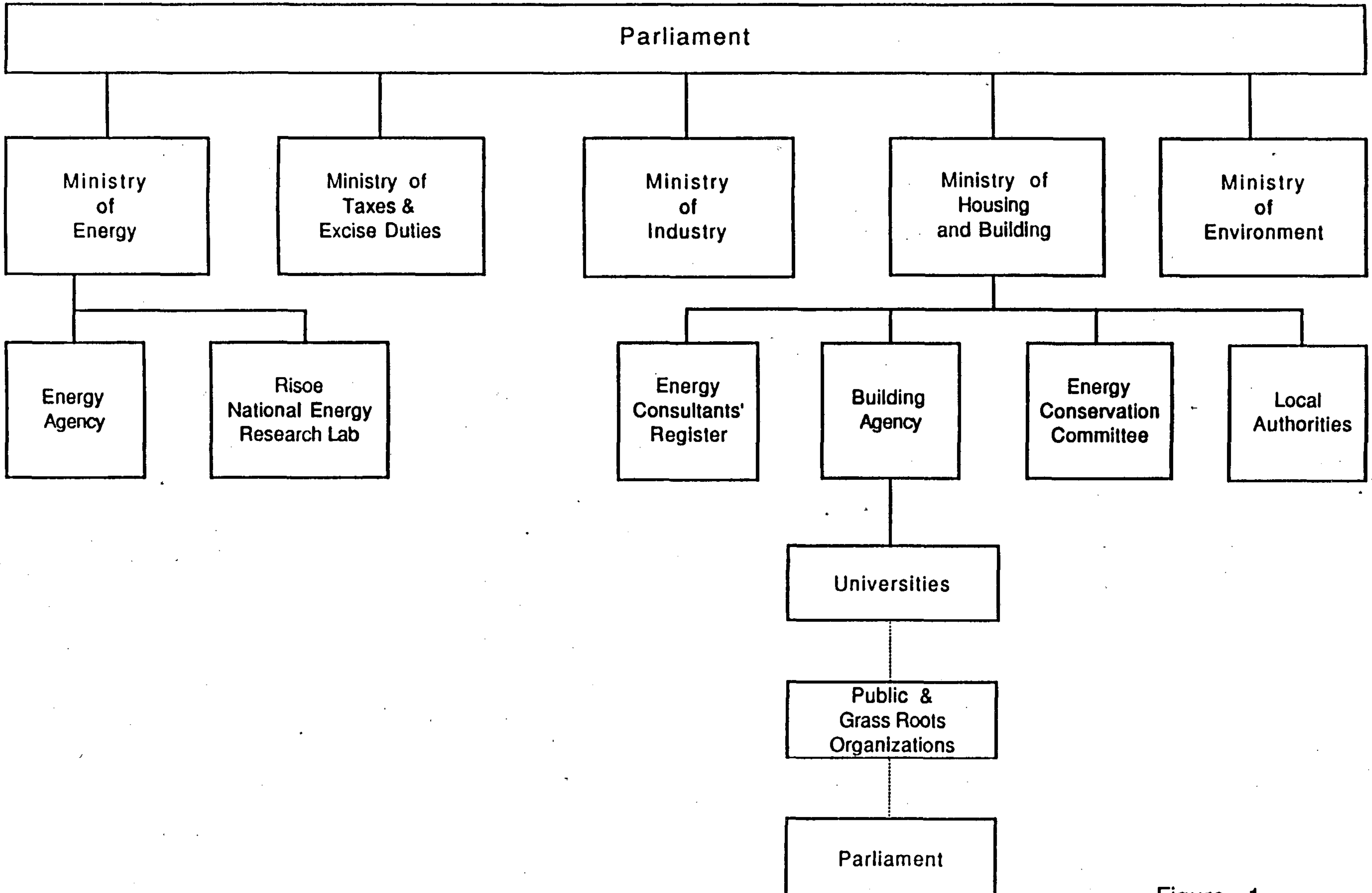


Figure 1
DENMARK

The Ministry of Housing and Building is responsible for implementing all programs involving residential property. The ministry distributes funding for grant-in-aid programs to the local authorities responsible for their administration. It also administers the Energy Consultants' Register. In addition, the ministry administers funds for the renovation of all public housing units and assures their compliance with the building standards. The ministry directs the implementation of residential building standards.

The Energy Consultants' Register is an organization of auditors who are trained and regulated by the Ministry of Housing and Building. The consultants perform building energy audits and make retrofit recommendations to residential building owners. The consultants are also licensed to issue energy certificates for buildings that conform with the standard.

The National Building Agency, within the Ministry of Housing and Building, is responsible for administering building energy research and development, both in general and in support of the development of the national building standards. The Building Agency has funded research carried out by some of the major universities in the country, including the Technical University of Denmark.

The Ministry of Environment works cooperatively with the Ministry of Energy and the Ministry of Housing and Building to ensure the avoidance of undesirable environmental impacts associated with energy use, energy conservation, and energy policies of the Danish government.

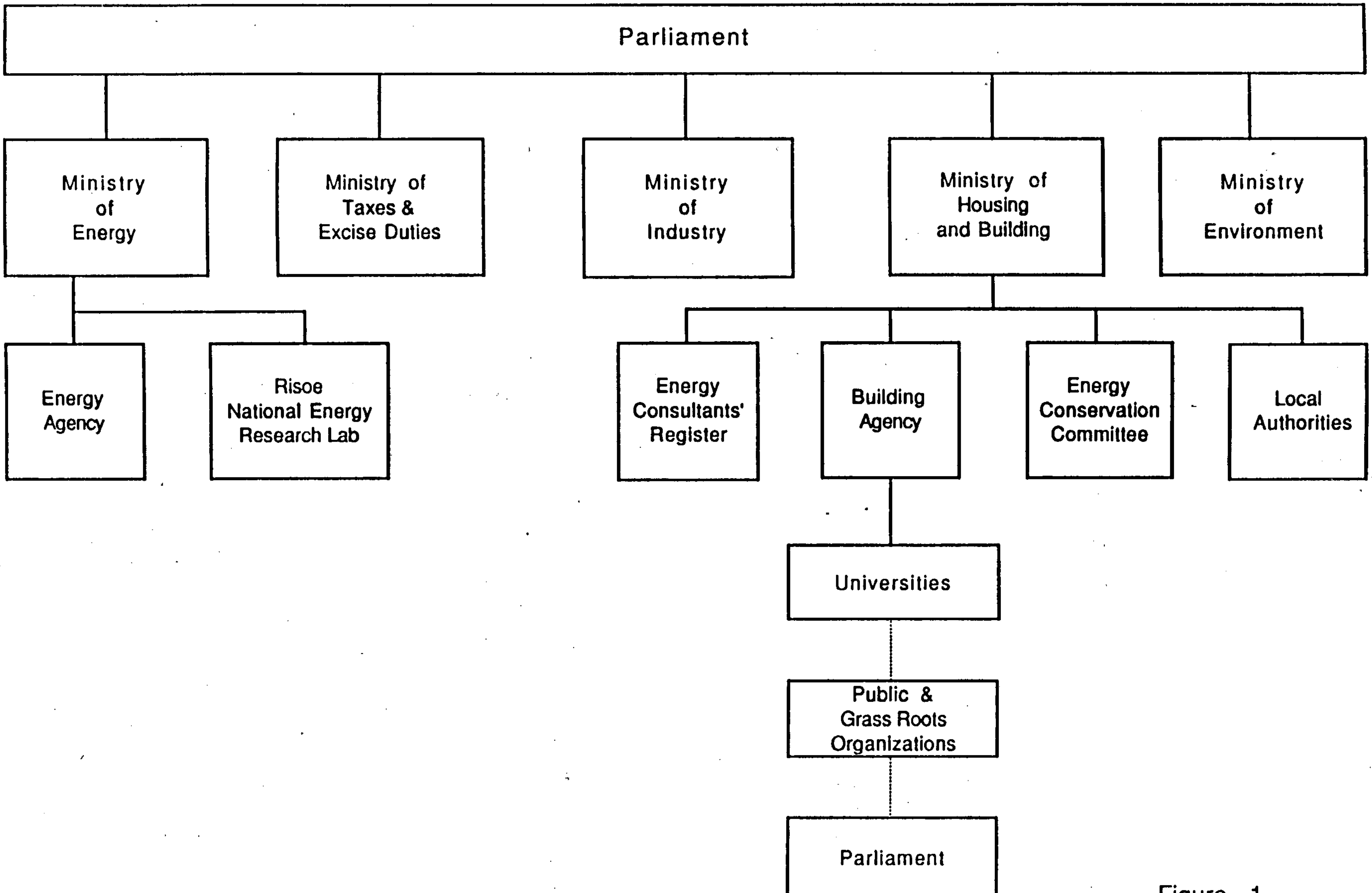
The Ministry of Taxes and Excise Duties is responsible for collecting all energy-related taxes.

Universities in Denmark play an active role in debates over energy supply, use, and conservation. Not all research conducted by the universities has supported the policies of the Ministry of Energy. University research has, on the contrary, been used as a forum for evaluating governmental energy policy and for exploring and suggesting alternatives. The universities use journal publications and the press to inform the public about these alternatives.

The Public in Denmark—individuals and grass roots organizations—contributes to formulating energy conservation policies and programs by actively voicing its opinions so that they are heard by members of the Parliament.

LEGISLATION

Energy policy objectives, the reasoning behind them, and tactics for achieving them are articulated in the Danish "Energy Plan." The first such plan was published in 1976 and focused primarily on energy supply. It was revised in 1981, at which time the role of conservation was clearly defined. In the new plan, 30 to 40 percent energy savings in space heating



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The Act on the Reduction of Energy Consumption in Buildings

In 1981, stringent construction standards for new buildings in Denmark had been in place for two years. Because of the slow building stock replacement rate, however, the standards cannot be expected to significantly alter the energy consumption level of the buildings sector for some time. In the 1981 Energy Plan, it was estimated that a 20 percent reduction in energy consumption for space heating in residential buildings could be achieved if a controlled program of retrofitting were put into place. The "Act on the Reduction of Energy Consumption in Buildings" was passed on June 10, 1981. It provided a framework for attempting to achieve the savings projected in the Energy Plan. The goal of the act was to stimulate retrofits of all residential buildings built before 1979, in order to bring them as close as reasonable to meeting the standards for new buildings. Retrofits of all public buildings were also required under the act. The extent to which retrofits were deemed reasonable was to be defined for each building individually, taking into consideration the age, use, and design of the building, the heat-supply context in the region, and economic justifications (including considerations of return on investment, total investment amount, expected energy savings, lifetime of the investment, and expected maintenance costs). The act called for the establishment of a program package that combined the use of energy audits (which include cost estimates for recommended measures), a buildings certification system, and subsidies for building improvements that meet audit recommendations.

REGULATIONS

Operating Standards for Oil-Fired Boilers

Since 1978, annual cleaning of oil-fired boiler units with a capacity of 120kW or less has been required. Most residential boilers fall into this category. In 1979, energy efficiency inspections became mandatory, along with adjustments of systems in conjunction with inspection results in order to meet minimum performance efficiency requirements. The cleanings and efficiency inspections are carried out by chimney sweeps, except when the owner has a maintenance contract with a registered service firm. In April of 1981 this regulation was amended to include oil-fired boilers with capacities greater than 120kW. For these

[7] Fraunhofer Institute for Systems and Innovation Research, 1982.

large boilers, annual inspections by heat consultants are required. The heat consultants prescribe cleaning and adjustment measures for individual systems. District heating plants are excluded from the regulation.

Standards for New Buildings

The first mandatory national standards for the construction of new buildings took effect in 1961. They included minimal insulation requirements, which remained in effect until 1977 when the first comprehensive energy-related standards were passed. The 1977 standards came into effect on February 1, 1979. Further revisions and tightening of the standards were passed in 1981 and took effect in April of 1983. Denmark has the strictest building codes within the EUR-10 and is exceeded only by Sweden in the world. Compliance with the building code is controlled by municipalities, which are responsible for approving plans before issuing building permits and providing mandatory inspections after construction.

Standards for Existing Buildings

The first mandatory requirements for existing buildings applied to apartment buildings being divided into separate owner-occupied units, and took effect in 1966. These requirements were increased substantially in 1972. Under the ''Act on the Reduction of Energy Consumption in Buildings'' (1981), the thermal quality of existing buildings was compared to that required of new buildings. Within specified limits based on acceptable cost and expected energy savings, the government wanted to bring all buildings up to this standard. In the act, 10 energy-conserving measures were defined which were to be required for the issuance of an energy certificate (see below) for a given building. These 10 measures, called the ''positive list'' were chosen to encourage investments with an average simple payback time of eight to 10 years (based on average cost and energy savings estimates).[8] The ''positive list'' had added value in that, through familiarity with it, the general population of Denmark learned what physical measures are important to reducing energy consumption in buildings. The list encompassed specifications for: 1. ceiling insulation, 2. floor insulation, 3. insulation of hollow exterior walls, 4. tightening of joints, 5. replacement of single-pane windows with double- and triple-panes, 6. insulation of outside walls behind radiators, 7. insulation of heating equipment, 8. installation of automatic room-temperature controls, 9. Energy-saving adjustments to heating systems, and 10. replacement of oil-fired heating systems with natural gas or renewable burning systems, upgrading of oil-fired systems for improved efficiency, or conversion to district heating. The eleventh item on the ''positive list'' of measures was left

[8] National Building Agency, Sweden, 1982.

for other recommendations which could be made at the discretion of a Registered Energy Consultant. This was in keeping with the recognized need to allow the flexibility which is necessary in applying blanket legislation to a diverse building stock.

Home Energy Certificates

As part of the "Act on the Reduction of Energy Consumption in Buildings," a certification program was established within the Ministry of Energy for determining the energy efficiency of all residential buildings. Under that program, building energy audits were performed at the request of building owners. The act also stipulated that tenants' associations had the right to request that building owners arrange an audit and make the results available to the tenants for review. If the owner failed to comply within six weeks of such a request, the tenants' association was authorized to arrange for an audit. The building audits were performed by Registered Energy Consultants (see below), under guidelines prescribed by the Ministry of Housing and Building.

When the audits confirmed compliance with the building standard, the consultants issued an energy certificate for the building and filed a copy of the certificate with the municipality. In cases where the building did not comply, the energy consultant provided a "heat-inspection report" describing the measures required in order to receive an energy certificate. Included in this report was a written cost estimate for the recommended repairs. If the owner chose to make the required investments in pursuance of an energy certificate, a second audit was required after the measures had been completed, to ensure that they were correct and complete, before an energy certificate would be issued. Although the building audits were provided only in response to voluntary requests, it was made known that after January 1, 1985, building owners would be required to tell potential buyers whether or not an energy certificate had been issued for the building. In cases where no energy certificate had been issued, the owner would be required to provide the buyer with a "heat-inspection report" prepared by a Registered Energy Consultant.

Appliance Labeling

As of June 1982, the Ministry of Energy had the right to establish regulations for labeling of domestic appliances, space-heating equipment, water heaters, and automobiles.[9]

[9] Fraunhofer Institute for Systems and Innovation Research, 1982, Annex.

Individual Heat-Metering in Multi-Family Buildings

The "Law of Rent" was amended in June of 1982, to require that owners of multi-family dwellings install individual meters if and when the majority of tenants in a building vote in favor of them.

PRICING AND TARIFFS

Pricing and tariffs are widely used in Denmark as a tool to encourage fuel switching and to try to keep the overall level of consumption down. In general, Danish household energy prices are high in comparison to those of other countries. For reasons related to international trade competition, industry is exempt from energy taxes. Residential electricity prices are three times higher than those paid by industrial consumers. The general policy regarding energy taxes discourages the use of oil. Excise taxes are imposed on oil products, coal, LPG (liquified petroleum gas) and electricity. Natural gas, district heating, and renewables are exempt from energy taxes in order to encourage fuel switching. Natural gas prices are controlled, so they stay below prices for home heating oil. A special tax is applied to light fuel oil.

Energy taxes were increased in December 1985, March 1986, and October 1986, in order to counter the effects of falling oil prices; the tax increases kept energy costs artificially high. Taxes on light fuel oil, which had increased gradually from 25 percent in 1978 to 32 percent in the first quarter of 1986, jumped to 57 percent and then 66 percent in the second and third quarters of 1986. Similar patterns were seen for electricity and coal. Electricity taxes, which had been relatively steady at approximately 35 percent, jumped to 40 percent in the first quarter of 1986 and to 50 percent in the second. Coal taxes increased from 17 percent in 1978 to 24 percent in 1982 to 27 percent in 1983, and reached a high of 48 percent in the second quarter of 1986. A 22 percent VAT (value added tax) is applied *in addition to* excise taxes on energy.

SUBSIDIES

Grants

The Danish government made several attempts to encourage investments in energy-saving retrofits through the use of individual grants before integrating them into a package program in the "Act on the Reduction of Energy Consumption in Buildings." The first grant program was introduced in 1975 and was available through 1980. Grants were offered for 20 to 35 percent of total investment costs, with a maximum of 2,000 DKK (Danish crowns) per dwelling. One and one half billion DKK (~300DKK/capita) in grants were distributed under this program, stimulating approximately five billion DKK (~1,000DKK/capita) in owner investments.[10] The program, however, did not produce the desired level of energy savings per krone invested because people used the grants primarily for retrofits of walls and windows, which produced cosmetic rather than thermal improvements. This experience prompted the use of a "positive list"—a list of specific investments eligible for subsidies under the "Act on the Reduction of Energy Consumption in Buildings." Between 1978 and 1980, a tax deduction was also available for energy savings retrofit investments in buildings. Participation in this program was much lower than expected, possibly because of the time lapse between the actual expenditure and the related tax savings.[11]

On November 5, 1980, two new grants replaced the previous grants and tax deductions. Under one of these grant programs, 325 million DKK were appropriated for investments in energy-conserving measures. Under the other program, 275 million DKK were appropriated for investments in energy conserving measures and/or costs related to maintenance and restoration of housing. The maximum grant per dwelling under both programs was six thousand DKK. The entire appropriation of 600 million DKK for the two grants was exhausted by mid-March, 1981 (4.5 months).

On June 10, 1981, both of these grants were replaced with a grant program that was legislated under the "Act on the Reduction of Energy Consumption in Buildings." To elicit a rapid response to the grant program, a limited period of availability was defined, with the grants decreasing in value to the consumer over time. The grants were available for all qualified investments made between 1981 and 1984.

The grants were offered to owners of single- and two-family homes, separately owned units in multi-family buildings, and farmhouses used as a principal dwelling year-round. Owners of rental units, non-profit housing complexes, and private cooperatives were eligible if separate kitchen facilities existed and the units were occupied year-round. Grants were available to subsidize measures taken in pursuance of an energy certificate. Only work carried out by companies registered for VAT was covered by the program. Contractors were not eligible for grants for work performed on their own buildings. For work begun between June 19, 1981 and June 1, 1982, a "heat-inspection report" was mandatory for grant eligibility. For measures corresponding to items one through 10 of the "positive list," work begun after June 1, 1982 did not require the participation of an Energy Consultant. Homeowners

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[10] National Building Agency, Sweden, 1982.

[11] Fraunhofer Institute for Systems and Innovation Research, 1982, Annex.

who had invested in energy-saving measures between January 1, 1981 and June 18, 1981 were eligible for the grant if the completed works were inspected by an Energy Consultant and deemed appropriate under the same criteria used in writing "heat-inspection reports." The Ministry of Housing and Building set rules for this auditing process, and managed the Energy Consultants, using state funds.

The grants were available for 100 percent of fees charged by Registered Energy Consultants for audits performed before June 1, 1982. Grants for retrofit measures were determined as a percentage of the total costs, including VAT, with the percentage decreasing over time as follows:

For owners of single-family dwellings Applications submitted before:	For owners of rental units etc. Applications submitted before:
1) the end of 1982, 20%	1) the end of 1982, 30%
2) the end of 1983, 15%	2) the end of 1983, 20%
3) the end of 1984, 7.5%	3) the end of 1984, 10%

These amounts and dates were changed as follows in December, 1982:

For owners of single-family dwellings Applications submitted before:	For owners of rental units etc. Applications submitted before:
1) September 1, 1983, 20%	1) September 1, 1983, 30%
2) the end of 1984, 10%	2) the end of 1984, 15%

An upper limit of 7,000 DKK per dwelling was imposed. Participants were allowed to make repeated applications, provided that the sum of the grants issued did not exceed this amount. The minimum investment per application was 500 DKK, except for grants solely intended to cover the costs of an audit, in which case there was no lower limit. There was no ceiling on the total amount of funds available for the grants.

Applications for grant payments were submitted to the municipal council, and the cost of administering the grants was absorbed by the municipalities. Grant disbursements were refunded to municipalities by the Ministry of Housing and Building.

Statistics through 1982 showed that 72 percent of the audits performed were on apartment buildings representing 17.7 percent of the total apartment stock. The bulk of the audits in this period were on buildings constructed during or after 1960, even though 69 percent of the total residential stock was constructed before 1960.[12] Investment costs per m^2 and per dwelling were significantly greater for older dwellings than for newer ones, which may partially explain the low participation by owners of older buildings. In 1981, 36 percent of the grants went toward modifying windows and skylights, 21 percent toward ceiling insulation, 11 percent toward special measures recommended by Energy Consultants, and eight percent toward insulating exterior walls.[13]

Energy Consultants' Register

The Energy Consultants' Register is an association of auditors, that was established in 1975 in conjunction with a grant program which came into effect during the same year. The purpose of establishing the register was to provide advice to homeowners who were making energy conservation investment decisions. Approximately 100 auditors were appointed by, and received training from, the National Building Agency. In order to qualify as an Energy Consultant, candidates were required to have engineering, architectural, or similar educational backgrounds and a minimum of five years of relevant, documented, experience. Under guidance from the Ministry of Housing and Building, the consultants provided energy audits of buildings to interested homeowners for a fixed fee.

In 1978, the grant legislation was amended, making consultations with the auditors compulsory for grant eligibility. Members of the register became responsible for: 1. controlling investment decisions, and 2. insuring the quality of retrofits by inspecting the work after completion. At that time, the number of consultants in the register was increased to 750. By 1983 the number of auditors had increased to 1,100, in response to the increased need that was stimulated by the "Act on the Reduction of Energy Consumption in Buildings." Fees charged for audits were prescribed in the act, as were requirements for timely fee payments and penalties for payment delays.

Guaranteed Loans

The "Act on the Reduction of Energy Consumption in Buildings" included provisions for guaranteeing home loans. Municipal councils were given the power to guarantee the portion of home mortgages corresponding to costs associated with "positive-list" measures when these costs would bring the total loan amount above the limit allowable under the "Act on Mortgage Credit Institutes."

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[12] National Building Agency, Sweden, 1982.

[13] Fraunhofer Institute for Systems and Innovation Research, 1982, Annex.

In addition, municipal councils were allowed to grant loans to members of specific target groups. Homeowners receiving advances on retirement pensions, widow's pensions, or disability pensions/benefits were eligible for such loans. The loans could be made for part or all of the investment costs associated with "positive-list" measures.

INFORMATION

Energy information programs have been supported in Denmark since 1974. Most of the energy information programs are implemented by the Energy Conservation Committee. The 1983 budget for these programs was 10.5 million DKK.

In conjunction with the "Act on the Reduction of Energy Consumption in Buildings," a special information program was established through the Ministry of Housing and Building. The purpose of the program was to inform the public about the act and associated programs and to provide specific information to various target groups. Methods for achieving these goals included: 1. distribution of pamphlets in libraries, and municipal and post offices; 2. campaigns on radio and television; 3. advertising in newspapers, trade journals, magazines for homeowners, and on billboards; 4. mobile expositions; and 5. direct mailings. The budget for the program was six million DKK in both 1981 and 82 and three million DKK in both 1983 and 1984.[14]

THE ROLE OF DISTRICT HEATING

A large part of the energy supply plan for buildings in Denmark depends on district heating plants. Connections to district heating grids are encouraged through the "Act on the Reduction of Energy Consumption in Buildings." Grants used to subsidize existing plants and excise taxes on other fuels are also used to promote district heating. In 1984, district heating accounted for 45 percent of the total heat delivered in Denmark.

In March 1985, the Ministry of Agriculture, the Environment Agency, and the Energy Agency jointly published a report discussing the possibilities of producing biogas with animal manure, and fueling cogeneration plants with straw for the dual purposes of reducing agriculture pollution and exploiting indigenous energy sources. In the report it was estimated that three million tonnes of straw per year (half of the average annual yield) could contribute 1MTOE (Million Tons of Oil Equivalent) to the energy supply. In response to

[14] National Building Agency, Sweden, 1982.

this report, Parliament passed a plan of action which prohibits the burning of straw in fields after 1989, and requires the agricultural sector to develop increased storage capacity for manure.[15]

SUMMARY

Using a combination of tools, the Danish government's residential energy conservation programs between 1973 and 1985 clearly focused on affecting the thermal condition of future and existing housing. A stringent national regulatory building standard was established. Successive attempts were made to stimulate retrofits of existing stock, culminating in the passing of the "Act on the Reduction of Energy Consumption in Buildings" in 1981. This act combined the use of audits, a grant system for an approved set of retrofit measures and before-and-after inspections, and a home energy certification system.

These tools were all used to eliminate the physical barrier of poor building shells, which hampered occupants' ability to control home energy consumption. Other complementary tools were used to remove market barriers to energy conservation. Information programs have been supported since 1974. Operating standards for large oil-fired boilers came into effect in 1978 and were extended to cover all boilers in 1981. Guaranteed loans for retrofits were targeted at low-income groups. Provisions for appliance labeling were established in 1982. Individual heat metering was made available to tenants who desired it in 1982.† In support of all of these tools, the government maintained a consistent policy of keeping residential energy prices artificially high.

CONCLUSION

The reasoning behind the government's focus on the housing stock is clear. Seventy-six percent of home energy costs were going toward meeting space-heating requirements because of the climate (a basically constant and certainly uncontrollable factor), the poor thermal condition of the housing stock, and high indoor temperatures. The establishment of a building construction standard was not sufficient because of the slow rate of new construction, which is reflected in the age of the housing stock (see Table 3). Newer homes, even when built to

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[15] Ministry of Energy, Denmark, 1986.

† Building owners were passing energy costs on to tenants and averaging those costs over dwelling units. For tenants who were prepared to modify their energy consuming behavior, individual heat metering was a benefit rather than a penalty.

higher standards, had little impact on consumption in the housing stock as a whole.

Table 3. Age of Danish Housing Stock, 1984[16]

Period Built	Percent of Total
before 1920	24.7
1920-1939	16.7
1940-1949	6.7
1950-1959	10.7
1960-1964	7.6
1965-1969	10.1
1970-1974	11.5
1975-1979	7.8
1980-1983	4.1
unknown	0.1

The physical conditions listed above, however, provided opportunities for the Danes to respond to the energy price shocks of the 1970s. High comfort levels translated into high elasticities of energy demand for consumers. The condition of the building stock provided a large potential for energy savings through retrofits. ScanTest survey data† have shown that the Danish people responded to the energy crisis by rapidly modifying their energy consuming behavior: turning off lights, showering instead of bathing, reducing other hot water usage, lowering indoor temperatures, shutting off non-essential rooms from the space-heating system, and using electric appliances less (see Figure 2). The survey data also show that these reductions in comfort have gradually been reversed. However, the energy savings that they previously produced have been supplanted with savings induced by retrofits of the building stock. Thus the reductions in energy consumption have been maintained.‡ Efficiencies in household appliances have also improved, but scientists at the Technical University of Denmark claim that there are still great gains to be made. They have designed and built prototypical refrigerators, for example, which consume only 20 percent of the electricity that an average refrigerator consumed in 1975.[17]

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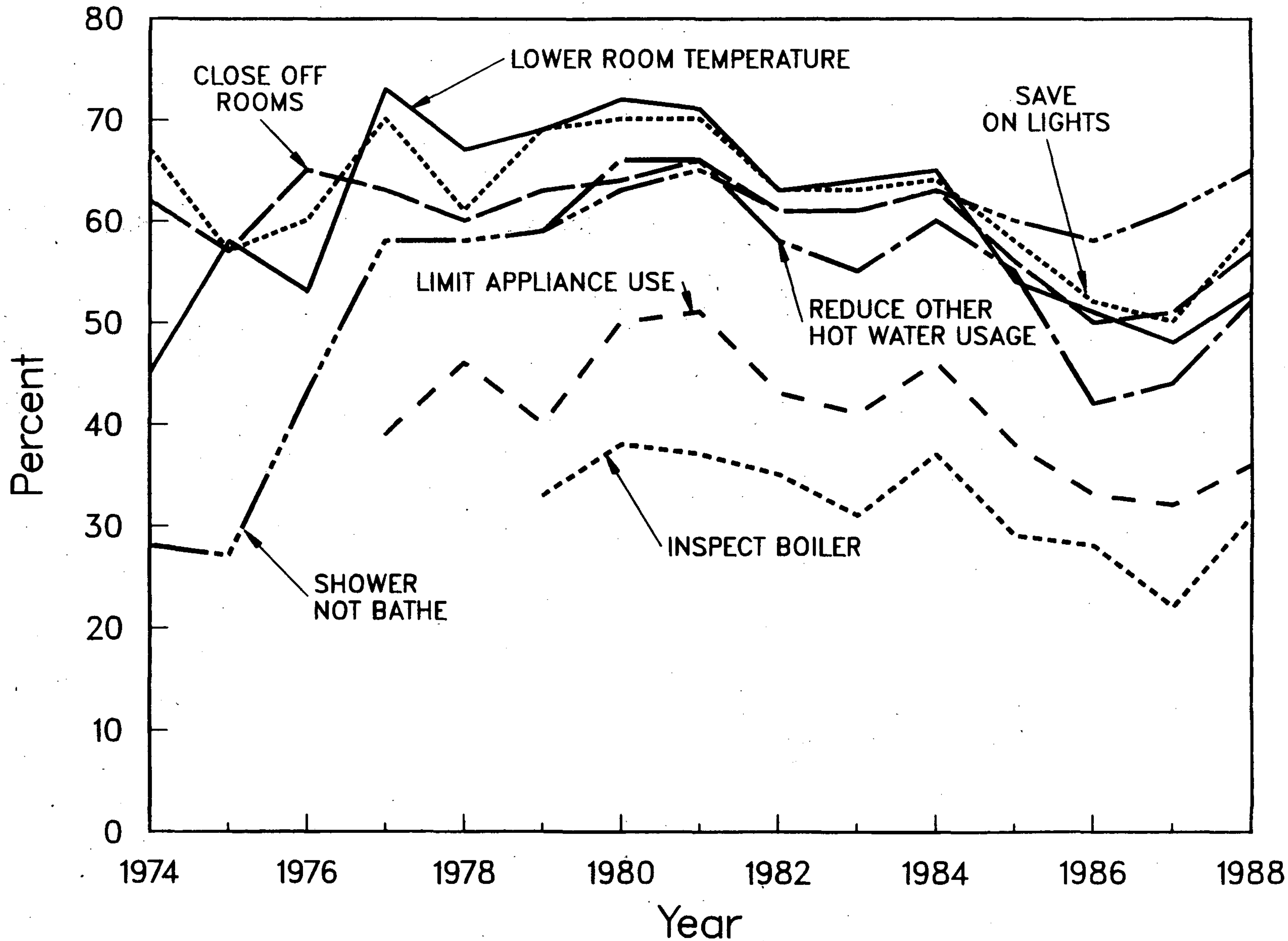
[16] Nordic Statistical Secretariat, 1985.

† ScanTest is an annual survey aimed at determining what efforts the Danish people make toward reducing household energy consumption. The surveys, which have been executed every year since 1974, are performed by the Institute for Scandinavian Media and Market Analysis under contract from the Danish Energy Agency.

‡ Annual delivered energy was reduced from 128.7 GJ/dwelling in 1972 to 86.3 GJ/dwelling in 1983 (33% decrease) in Denmark. These values are climate corrected.

[17] Nørgård, 1986.

DANISH HOUSEHOLDS ENERGY SAVINGS ACTIVITIES, 1974–1988
(Share of homes adopting measures)



Source: SCANTEST, Survey of approx. 2,000 households each spring
Provided by Energysparudvalg, Copenhagen

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FRANCE

BACKGROUND

In 1973, France was highly dependent on oil imports, which supplied 70 percent of all primary energy needs, and 56 percent of residential end use energy requirements. The government responded quickly to the first petroleum price shock with an energy policy focused on, in order of priority: substituting domestic sources of energy for imports, stabilizing and reducing energy costs to consumers, and stimulating domestic employment and economic activity.

All of these objectives may be addressed by energy conservation programs, and France was one of the first of the OECD countries to set up an agency specifically devoted to conservation: the Agence pour les Economies d'Energies (AEE—Office of Energy Conservation) in 1974. The AEE budget grew relatively quickly during the 1970s (see Table 4 below), but even after a major increase at the end of the decade, it still only amounted to about one percent of the Ministry of Industry's expenditures in the energy sector.[18] The emphasis was on new supply, with the bulk of public spending on energy devoted to the coal and nuclear industries (dominated by the public corporations Charbonnages de France and Electricité de France respectively), to promote domestic energy sources.†

The energy policy approach adopted in France should be understood within the context of the French system of national indicative planning, by which the government takes an active role in agreeing with private sector interests on specific targets for investment, construction, and economic activity. Central government planners are also involved in directing the comparatively large public service and publicly-owned corporate sector of the economy, and thereby directly influence many of the mechanisms for achieving economic planning targets.

In 1974, when total primary energy consumption in France was 184 MTOE (million tonnes oil equivalent), the government established a specific target of 40-45 MTOE energy savings resulting from conservation by 1982.[19] In other words, energy consumption for 1982 was targeted to be 40-45 MTOE lower than it would have otherwise been at 1974 intensities

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18 Leyral and Monnier, 1983.

† Other agencies besides the AEE were also involved in energy even at this time, however. Housing agencies offered a subsidy for energy conservation investments, the treasury ministry offered tax deductions, and there were separate agencies devoted to renewable, geothermal, and district heating programs, so the budget comparison is somewhat exaggerated.

19 Fraunhofer Institute for Systems and Innovation Research, 1982.

of use and predicted economic growth. This target was ambitious at a time when there had been very little prior experience with conservation, and conventional wisdom held that it was not a serious policy option. The high-profile, top-priority French nuclear program, was only expected to contribute a comparable amount to the nation's 1982 primary energy consumption during the same period (i.e., 40-45 MTOE).

Of the 45-MTOE target, 20 MTOE was to come from the residential/commercial (buildings) sector.† The reason for this emphasis, in the context of a national economic concern for oil imports, was that in 1973 the buildings sector (i.e., space and domestic water heating) was the largest consumer of petroleum, representing 36 percent of national oil use.[20]

Residential sector energy conservation programs in France targeted space-heating energy use, which represented 82 percent of total residential energy use in 1973.[21] Space heating was the portion of residential energy use that offered the greatest opportunity to achieve the key policy objective: reducing dependence on imported oil.

Energy conservation assumed greater political importance in 1981 with the election of the socialist government. In October, 1981 the national parliament adopted a State Plan for Energy Independence—the first formal and comprehensive legislative involvement with energy policy. This legislation was based on the government's election platform favoring conservation and renewable energy over the country's high-profile nuclear program. The AEE was merged with parallel agencies administering separate efforts in renewable energy, district heating, and geothermal energy to form the new Agence Francaise pour la Maîtrise de l'Energie (French Agency for Energy Management, or AFME), established by government decree on May 13, 1982. A national economic policy was adopted that emphasized public investments, income transfers, and new jobs to address the economic recession. Energy conservation was to become another instrument in support of the new policy.

The government created a unique, limited-duration central fund to subsidize capital investments in public works and the buildings sector as a means to stimulate the economy. This was the 25 billion FF Fonds Special de Grands Travaux (FSGT), 40 percent of which was spent on energy conservation in all sectors between 1982 and 1987. In the wake of the new government's policies and the large amounts of money central authorities made

† In official government statistics, policy and program summary documents, the residential and commercial sectors are often lumped together. Aggregate figures reported at the policy level are thus often combined.

[20] Observatoire de l'Energie, 1986.

[21] Ketoff, *et al.*, 1987.

available for energy efficiency improvements in all sectors, the period 1982-1985 was marked by a burst of residential energy conservation activity in France even while many other countries were scaling back their commitments in this sector.[22]

However, the political environment changed again in 1986. As broad political reaction to the government intensified, a review of French energy conservation policy was initiated by a subcommittee of the National Assembly's Commission on Production and Trade.[23] The subcommittee report charged that between 1981 and 1984 energy conservation had not achieved target levels, in spite of the large sums being devoted to it. The AFME also came in for criticism from the national inspector-general for not adequately documenting actual (as opposed to calculated) efficiency improvements and other impacts of government programs. These criticisms, along with easing international oil prices and pressures to reduce government spending, contributed to the gradual reduction of funds for and government commitment to residential energy conservation.

Table 4. Conservation and Renewable Energy—Public Expenditures
Millions of Francs (current)—All sectors[24]

	1976	1978	1980	1982	1983	1984	1985	1986
AFME	295	425	1025	1116	911	936	970	608
FSGT-AFME	N/A	N/A	N/A	600	570	1580	602	360
FSGT-Other†	N/A	N/A	N/A	500	400	2343	1376	1450
Other Agencies‡	N/A	330	860	2592	3160	2914	2816	
Regional Agencies	N/A	N/A	N/A	115	194	93	142	
TOTAL	295	755	1885	4923	5235	7066	5908	

N/A = not applicable.

The investment subsidy funds (FSGT), which were intended as a short-term measure to address national economic conditions, expired in 1987. Tax credits for conservation investments were eliminated the same year. The AFME continues its residential audit and

[22] Fraunhofer Institute for Systems and Innovation Research, 1982; AFME/EPERE, 1985; AFME, 1986a.

[23] Assemblée Nationale, 1985-86, no. 2985.

[24] AFME/EPERE, 1986b; Assemblée Nationale, No. 2985.

† Primarily Ministry of Urbanism and Housing/MEL.

‡ Includes Min. of Agriculture, MEL, federal buildings, ANAH, coal research, interest subsidies and others.

information programs, and housing rehabilitation subsidies are still available. However, as a result of a recent AFME reorganization and the election of a new government, the future of residential energy conservation programs in France is now somewhat uncertain.

The French experience with residential energy conservation programs should be seen in the context of the structural changes taking place in the residential sector. Three trends were evident. First, economic growth and new household formation led to a dramatic increase in the housing stock in France during the 1970s. The total number of heated dwelling units in France increased by more than 26 percent between 1973 and 1985, reaching 20.7 million units. The average number of persons per household decreased from 3.0 in in 1973 to 2.7 in 1985. Second, with higher income levels, a shift to more desirable single-family style housing occurred; the proportion of single-family units rose from 46.5 percent to 55 percent during this period. The third trend, which had been established in the previous decade, was toward increasing thermal comfort and control through central heating of the home. The proportion of the stock with central heating rose from 55.4 percent to 71 percent between 1973 and 1985. These changes took place during a period when, by comparison, the U.S. proportion of single-family homes and centrally heated homes remained very stable. The housing sector was thus the focus of an enormous amount of investment and activity, the result of coincident surges in household income and new household formation.

New housing construction and improved comfort levels in existing housing were also closely tied to shifts in fuel shares within the sector between 1973 and 1985. Electricity made the most dramatic increases in fuel share, from 6.8 percent of residential energy use in 1973 to more than 20 percent in 1985. The growth of electricity use in the residential sector in France was faster than in any other OECD country, as a result both of its adoption for space heating, especially in new homes, the increasing saturation of major domestic appliances. The proportion of homes heated by electricity increased from 8.5 percent to 20.5 percent while the proportion heated by oil fell from 52 percent to 36 percent. The conversion of existing housing stock to central heating has mostly used natural gas, which more than doubled its fuel share in the residential sector between 1973 and 1984, reaching 24 percent.[25] †

[25] Observatoire de l'Energie, 1986; AFME, 1987d.

† The increasing use of electricity and natural gas for space heating in France has implications for the interpretation of aggregate energy use statistics and the derivation of energy intensity measures. Because of their higher conversion efficiency at the point of end use, compared to oil, both gas and electricity (but especially the latter) yield lower end-use energy unit consumption to achieve the same energy output. Thus the fuel conversion itself shows up statistically as a reduction in energy use intensity.

Part of the attention to the housing sector took the form of efforts to modernize the existing housing stock. In 1973, France's housing stock was among the oldest in the OECD.[26] A strong national housing policy, with a deliberate emphasis on preserving and upgrading older housing stock, played a significant role in the institutional environment for energy conservation programs.

In the following pages, we describe in some detail the nature of the organizational context and the major programs introduced by the government of France since 1974.

ORGANIZATIONAL STRUCTURE AND RESIDENTIAL CONSERVATION PROGRAMS

The AEE was created in November, 1974 as a division of the central Ministry of Industry, and was made responsible for initiating and operating programs to support energy conservation in all sectors. The ministry was responsible for coordinating the efforts of a number of important agencies in the energy field. These included the powerful public utility companies, EdF and GdF (Electricité and Gaz de France, respectively), plus separate agencies devoted to research, demonstration, and support of renewable energy sources, geothermal energy, and district heating. Much of the AEE's early effort was devoted to the industrial sector, in spite of the recognition of the importance of energy use in buildings, because of the overall responsibilities of the Ministry of Industry and the origins of energy conservation policy in concerns about economic stability and industrial competitiveness. In the residential sector, the AEE was responsible for several national information campaigns. In addition, a subsidy for comfort (including heating) improvements in older housing was administered by the Agence Nationale pour l'Amelioration de l'Habitat (ANAH - National Housing Rehabilitation Agency), an independent organization established in 1971 to stimulate the upgrading of the country's older housing stock through financial assistance programs.

A major organizational change came with the consolidation of energy conservation and renewable energy agencies into the AFME in 1982. The AFME was constituted as an independent organization with the legal status of a public corporation (and hence able to undertake business operations and negotiate independent contracts). The AFME takes its policy direction from the Secretary of State for Energy, a junior cabinet minister with specific energy responsibilities under the Minister of Industry.

[26] Schipper, *et al.*, 1985.

The AFME's original mandate included three fields: 1) rational use of energy (conservation or substitution) in all sectors; 2) the development of renewable sources of energy supply; 3) conservation and substitution of primary and strategic materials. In the residential sector, the agency was given an expanded budget and directed to establish close working relationships at the regional level with other key government departments involved in the buildings sector and with local governments. The agency established jointly-funded programs with most of France's 22 regional governments, implemented through multi-year contract plans tailored to the needs of each region.

Regional bureaus of the AFME corresponded to the existing regional offices of many central agencies such as the ANAH, or the local building and equipment standards office (DDE). This represented a sharp change in program implementation style from the centralist operation of the previous AEE, recognizing the need for more local input and collaboration of local and regional governments.

The AFME budget comes from the appropriations of the Ministry of Industry and the Ministry of Research and Technology. The AFME is responsible to its board of directors, which is composed of senior officials from the Ministry of Industry, the Ministry of Research and Technology, the Ministry of Urbanism and Housing (now known best by its initials, MEL),† and other government departments. This board oversees the actions of the agency and helps, through its membership, assure the AFME's close relations with several other national agencies relevant to the residential sector, in particular the various national research centers, the ANAH, and Plan Construction (now PCA—Plan Construction and Architecture), an independent agency affiliated with the housing ministry and charged with promoting technical innovation in the housing field through research, development and demonstration programs in close cooperation with other public agencies and the construction industry.

These other agencies have been responsible for developing and managing some of the key residential conservation programs. In particular, since 1975 ANAH has devoted a portion of its rehabilitation funds to energy conservation. PCA and MEL are important for their leadership role in developing new building regulations and supporting demonstrations of new housing technology. A chart illustrating this organizational structure, with the most recent departmental names, appears in Figure 3. This figure illustrates only the government

† This ministry was known throughout most of the period studied here as Urbanism and Housing (MUL), but its name changed after 1985 to Property Management Housing and Transport (MELATT), and most recently to Equipment and Housing (MEL). Each time the name changed, of course, some of the organization's responsibilities and structure were also altered. To simplify labelling in the remainder of this paper, the ministry shall be referred to as MEL, regardless of which historical period is intended.

organizations directly involved with energy conservation. It omits private sector organizations, such as the national associations of consulting engineers and architects, energy service companies, heating contractors, manufacturers of insulation, heating system controls and components, appliances, etc. The development of government programs in France is typically undertaken in cooperation with private industry and these groups played a significant role in formulating, supporting, and promoting energy conservation programs. Other important players in energy conservation programs were the National Association of Public Housing Organizations (UNOHLM), which provided a connection to the large stock of low-rent collectively-managed housing stock, and the municipalities, many of which actively undertook their own energy conservation programs.

OVERVIEW OF PROGRAMS

France adopted a wide variety of energy conservation programs in the residential sector, almost exclusively aimed at reducing space heating requirements. A chronology of the main programs is listed in Table 6. Government initiatives had been mounted on four fronts by 1975: a special-purpose central agency had been created, information campaigns aimed at consumer behavior had been introduced, new building standards enacted, and financial incentives for conservation investments in existing houses (tax deductions and grants) were in place.

Since the emergence of the AFME in 1982, its programs in the residential sector have emphasized providing information to building owners, managers and decision makers to stimulate investment in energy-efficiency measures. The chief mechanism used by the AFME was the subsidy of residential audits. An effort has been made to assure homeowners of the cost effectiveness and security of energy retrofit investments by emphasizing both the financial incentives (tax credits and low-interest loans) as well as the technical effectiveness of the work (through auditor training and government-backed savings guarantees).

Residential energy conservation programs were directed to the entire housing sector using three general tools: audits and subsidies directed to the existing housing stock (owner-occupied and rental), and regulations for new housing construction. The major initiatives, as listed in Table 5, are outlined in the next sections.

Table 5. France—Residential Conservation Programs by Type

Regulations and Standards
- Building Standards and Regulations
- Appliance Labeling
- Other

Information Programs
- Meteo-chauffage
- 19° campaign
- Haute isolation label

Residential Audits

Financial Incentives
- Tax credits
- Housing rehabilitation grants
- FSGT subsidies
- AEE grant

Integrated Local Programs
- Villes Pilotes

Price and Tariff Policies

Research, Demonstration and Development
- H2E85 and Batiment Econome

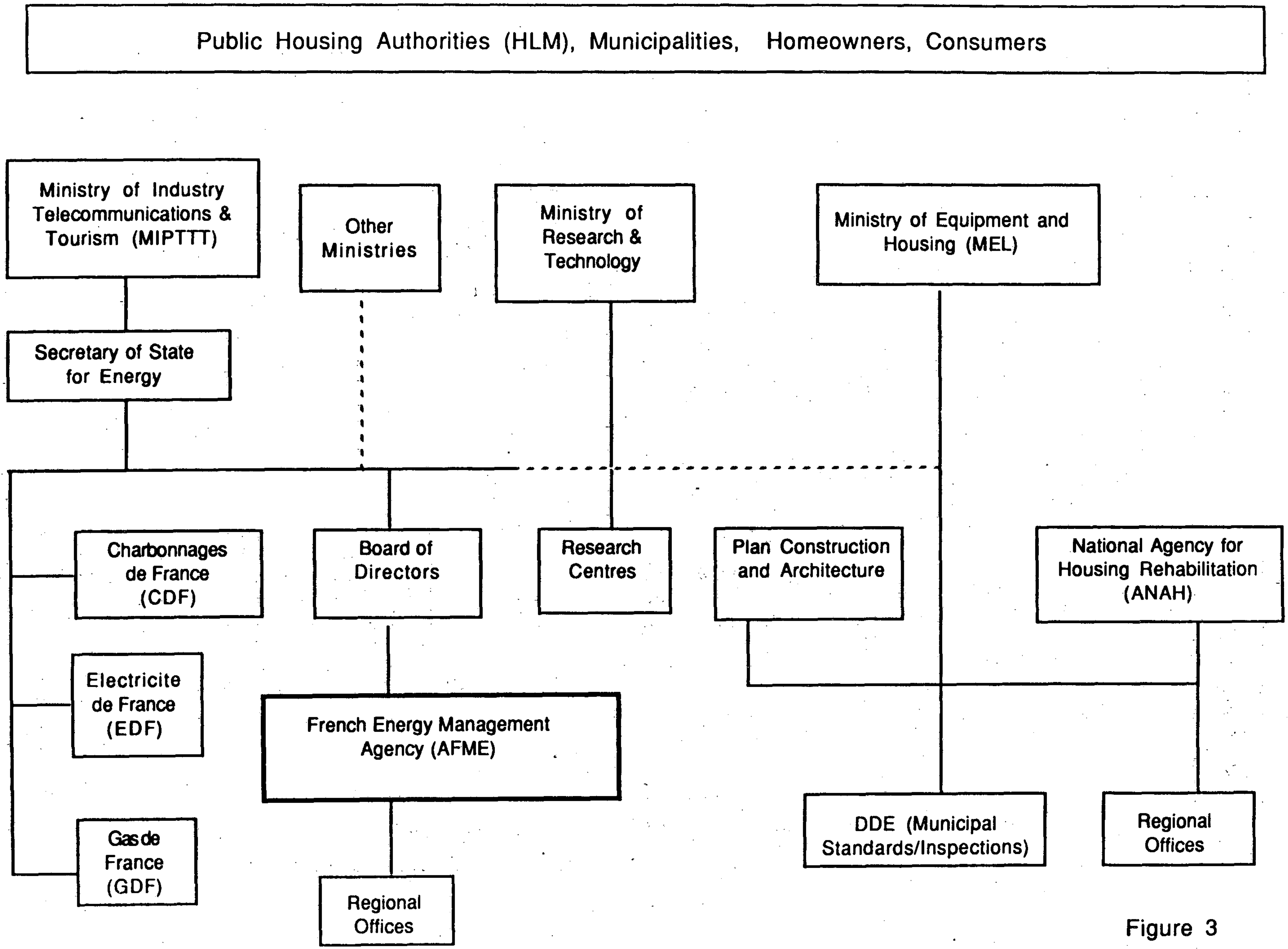

Figure 3
FRANCE

Table 6. Residential Energy Conservation Program Time Line—France

1974	Tax deduction for conservation investments created Thermal regulation for new buildings introduced AEE formed Initial indoor temperature regulation - public bldgs.
1975	Separate metering regulation ANAH subsidies provided for energy improvements
1977	Thermal regulations increased for electric-heat homes Heating system inspection regulation
1979	AEE introduced 400 FF/TOE grant Indoor temperature regulation extended to all buildings DDE/PALULOS grants introduced by ANAH Meteo-chauffage program started
1980	H2E85 program started
1981	National Assembly passes State Plan for Energy Independence AEE grant eliminated Meteo-chauffage phased out HI (later H2E85) labels introduced for new buildings
1982	AFME formed by merging previous agencies Thermal insulation standards for new buildings increased Residential audit program introduced FSGT funds introduced Tax deduction changed to tax credit Villes Pilotes program initiated
1985	H3E90 (later Batiment Econome) program replaces H2E85
1987	FSGT expired Tax credit eliminated
1989	New building regulation takes effect

REGULATIONS

Building Standards and Regulations

Mandatory thermal standards for all new residential buildings were introduced in 1974 to take effect the following year (Decree no. 74 306, 10 April, 1974). This initial thermal standard was a performance code, which specified the maximum allowable heat loss rate for the entire structure in relation to its volume. Detailed calculations yielded a total heat loss rate for the structure, which was divided by the habitable volume to get an overall rate of heat loss expressed as $W/m^3{}^\circ C$. Maximum levels of the resulting "G-coefficients" were established for all buildings heated to more than 14°C. Requirements initially varied among three climatic zones and seven different building types. In 1976 and 1977 further distinctions were added to differentiate requirements by type of fuel used for space heating (the allowable heat loss rate was lower for electrically heated homes) and type of heating system (the allowable heat loss rate was lower when heat was supplied collectively with no individual controls).

The initial French requirements were not especially demanding, by comparison with the building standards required in other EEC countries, even allowing for differences in heating degree days.[27] But the new thermal standards introduced in 1975 were important because of the growth of the housing stock during the following 10 years. Average annual new house construction during this period was 137,000 multi-family units per year and 244,000 single-family units (including row- and semi-detached houses).

In 1982, a new building regulation was introduced, based partly on experience gained through research and demonstration projects. The new standard added ventilation heat losses to those occurring by transmission through building elements, and reduced the allowable G-factor (rate of heat loss/unit volume). It also made allowance for solar heat gains: i.e., the requirements were no longer based strictly on heat losses, but on net annual space heating requirements. The result was a more sophisticated analysis of building heating needs, and more stringent requirements for improved insulation and air tightness.[28] The categories for different minimum requirements were reduced to two building types, with three size categories for each. The more stringent requirements for electric space heating were retained.

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27 Fraunhofer Institute for Systems and Innovation Research, 1982.

28 AFME, 1987c.

Further revisions to France's building standards were approved in April 1988, to take effect January 1, 1989. The new requirements introduce another factor into the heating calculations: the efficiency of the heating system itself. In addition, for the first time, hot water heating efficiency will be included as a factor in the building regulation's heating requirements calculations.

The new standard gives builders a choice of four different ways to meet the requirements. All calculations can be avoided by selecting from a range of approved technical solutions in each of five building component categories: insulation, fenestration, orientation, ventilation, and heating/hot water system. This option provides a wide range of flexibility in selecting, for each category, a suitable technique. Selection of average efficiency heating systems would require higher levels of insulation, for example. This option is intended mostly for detached single-family houses typically constructed by small contractors.

The second option permits builders to calculate heat losses resulting from transmission and infiltration, but then adopt standard solutions from among the approved range for orientation and the heating system. To allow for carefully designed solar homes, a full calculation of passive solar gains, in addition to heat losses, represents a third option. Finally, builders may opt, in large or complex buildings, to calculate all parameters and attempt to optimize the entire building and system design within the overall thresholds and trade offs permitted by the regulation.[29]

The latest increase in building standards was imposed despite initial opposition from builders and contractors, some of whom appeared to still be struggling to meet the 1982 standards as recently as 1986.[30]

The AFME has estimated that homes constructed after the new standard takes effect will have thermal energy consumption levels 50-60 percent lower than similar homes built to pre-1975 standards.[31]

Table 7, below, presents French building regulations in a context that enables comparison with those of other countries in this report. Because French thermal standards rely on flexible performance calculations rather than prescriptive insulation levels, the values in the table should be taken as indicative, rather than as minimum requirements.

[29] MEL, 1988.

[30] Olive, 1986.

[31] Dallaporta and Herant, 1988.

Table 7. France—Minimum Standards For New Buildings[32]
(Non-electric heating)
Climate zone H1 (Lille-Paris-Lyons)

year	approx. ach	Legislative limits to G-coefficient ($W/m^3 °C$)		Typical solutions U-values ($W/m^2 °C$)		
		detached	apartment	roof	walls	floor
1974	1.0	1.6	1.27	0.5	1.05	0.9
1982	0.7	1.0	0.90	0.3	0.7	0.82
1988	0.5	.65	n.a.	0.3	0.65	0.45

Appliance Labeling

In 1976 the Ministry of Industry introduced compulsory labeling of energy consumption for all heating units, boilers, refrigerators, washing machines, TV sets, ranges, and ventilation equipment.[33] The labeling program initially fell under the authority of the AEE (at that time closely attached to the Ministry of Industry). But there were no rigorous efforts to enforce the regulation. The regulation continues in effect, and in major retail outlets it is common (but by no means universal) to find stickers on domestically manufactured appliances indicating their typical hourly energy consumption. However, the same appliances are also commonly sold without such stickers.

There is contradictory evidence as to whether or not French appliance manufacturers have kept pace with the efficiency improvements introduced by other European manufacturers. The energy consumption of a typical refrigerator is reported to have fallen by about 50 percent between 1974 and 1986.[34] However, such improvements are not immediately apparent from an examination of the appliance saturation and electricity consumption statistics in the decade following the first oil price shock.[35] During this period, appliance ownership and use in France increased rapidly from what were initially low levels. The proportion of homes with freezers and dishwashers, for example, increased by a factor of more than four

[32] CSTB, 1982; Fraunhofer Institute for Systems and Innovation Research, 1982; AFME, 1987c; Charbonnier, 1988; MEL, 1988.

[33] Fraunhofer Institute for Systems and Innovation Research, 1982; AFME, 1986b.

[34] Despretz, AFME, 1988.

[35] Schipper, *et al.*, 1986.

times.[36] Largely as a result of the acquisition by many French households of their first refrigerator, washing machine, electric oven or dishwasher, appliance electricity use per household virtually doubled between 1973 and 1985.[37]

The lack of official interest in appliance efficiency at a time when the nation was experiencing such a large increase in the new appliance stock may indicate a missed opportunity to curb growth in electricity use, especially when such appliances have relatively long useful lives. Even with the gradual introduction of more efficient appliances because of competition in the European market, it will now take many years for the current stock to be replaced.

While the AFME provides information to consumers on appliance efficiency and operation, it has only recently begun to draw attention to the rapid increase in appliance electricity consumption in households. The agency has established a group to define priority actions for energy conservation in this sector, intended to encourage wider use of more efficient appliances now available on the market, as well as development of more efficient appliances.[38]

Other Regulatory Measures

In addition to the new building standards discussed above, the following regulatory measures were enacted, largely under the authority of the Ministry of Urbanism and Housing (now MEL):

Automatic Heating Controls (Ministerial Order of 10 April, 1974): introduced mandatory standards for large building heating systems that required automatic thermostatic controls so as to avoid excessively high room temperatures.[39]

Individual Metering of Hot Water and Heating (Decrees 75 496 and 75 1175, 19 June and 17 December, 1975 respectively): Domestic hot water charges (for all buildings) and domestic space heating fixed and variable charges (for new buildings only) had to be divided among all units in multi-family buildings, according to their individual consumption. Building owners were given until 1985 to equip their buildings with such meters. A clause exempted those cases for which the installation would be "too

[36] Ketoff, *et al.*, 1987.

[37] Angioletti, 1988.

[38] *ibid.*

[39] Fraunhofer Institute for Systems and Innovation Research, 1982; LeVaillant and McInnes, 1981.

difficult.''[40] The introduction of this regulation created some technical difficulties in finding an accurate enough meter and overcoming measurement and installation problems. The original deadline was postponed three years in order to permit agreements to be reached between the government equipment suppliers and the building industry on the technical standards involved. Several electronic meters have been approved for use, and others are still being tested.[41]

Heating System Inspection Requirement (Ministerial Order of 5 July, 1977): instituted a requirement for inspection every three years for heating systems larger than 100 kW.

INFORMATION

Much of the AEE's initial effort was devoted to information programs. These included advertising campaigns and promotional literature advising householders to use less energy. The first two programs that we describe came later and were more sophisticated efforts specifically targeted and subject to evaluation. The third is an example of an information program that was used to augment other types of programs: in this case a new home labeling program was used to aid in the transfer and commercialization of new technologies in the housing market.

The government of France used a variety of information approaches in the residential sector: multiple communications media, special events, public displays, campaigns and other techniques. Only a small sample of national programs is described here.

Météo-chauffage Campaign

The Météo-chauffage campaign was intended to encourage building managers to delay turning on heating systems in the fall and to prepare to shut them down earlier in the spring, based on meteorological information. Regional three-day forecasts of outdoor temperatures were provided along with advice on the operation of heating systems. The campaign relied primarily on the broadcast media to deliver the forecasts. The targets of the campaign were households with control over their own heating systems and managers who controlled collective heating systems for multi-family dwellings. The program was implemented for eight-week blocks in the fall and spring.

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[40] Fraunhofer Institute for Systems and Innovation Research, 1982.

[41] Plazy, 1987.

First run during 1979-80, this program continued through 1981. After 1982, heating system advice provided by AFME continued to be available by telephone from all major meteorological offices in France and was advertised in the shoulder heating seasons, although the campaigns in the mass media were discontinued.[42]

This program was evaluated by the AFME in 1983, and was followed closely by weekly surveys while it was in progress. Comparisons with previous years' data on climate-adjusted energy use and date of heating system startup suggest that the weather information program yielded significant changes in consumer behavior. The AFME has estimated savings from residential/central heating systems (the largest portion of total residential sector savings from this program) to have been about 440,000 TOE in 1979, 315,000 TOE in fall of 1980 and 382,000 TOE in the fall of 1981.[43] These figures are in the range of 1.5 percent of annual space heating energy use in the sector.

19°C Campaign

In December 1974, France established a maximum indoor temperature of 20°C for public and institutional buildings. In October 1979 this decree was modified to reduce the maximum indoor temperature to 19°C in all public and private buildings throughout the country. The new regulation was accompanied by a massive publicity campaign funded by AEE and designed to reinforce its message, chiefly via television advertising and media announcements. Although the program was introduced as a regulation, it was clear from the beginning that it was unenforceable, and so it may be more fruitfully considered here as an information program. Nevertheless, the adoption of a national regulation can be seen as an attempt to give the program strength and credibility.

Although substantial savings appeared in the commercial sector and were attributed to this program, the residential sector results were ambiguous.[44] The AFME evaluated the campaign in the 1980-81 heating season and concluded that it only had an effect in single-family houses with central heating, in which measured average indoor temperatures were reduced by about 0.4°C. For other types of housing, there were no statistically significant differences in measured indoor temperature between the test group and a control group of respondents who had not been exposed to the campaign. [45]

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[42] AFME, 1985.

[43] AFME, 1981.

[44] *ibid.*

[45] *ibid.*

These results should be distinguished from the general response during the 1970s to government exhortations to lower indoor temperatures. AFME data on average indoor temperature (includes commercial buildings) by year are shown in Table 8. Caution should be exercised in interpreting these results because they appear to be derived from self-reported surveys, not actual measurements.

Table 8. Average Indoor Temperatures - Res/Comm Sector[46]

	1973	1978-79	1979-80	1980-81
Temperature (°C)	20.3	19.3	18.4	18.2

Public support for state "regulation" of indoor temperature was substantial well into the 1980s. However, the promotion of indoor temperature controls in private residences subsided with declining public interest and a growing reluctance to accept reduced levels of comfort. The results shown in Table 9 are indicative of changes observed between 1982 and 1984 from an AFME survey and show comfort preferences and indoor temperatures creeping back up during the 1980s.

Table 9. Attitudes toward Indoor Temperature - France[47]

Respondents agreeing with statement:	Nov. 1982	Nov. 1983	Dec. 1984
public authorities are right to set temperature limits	64%	59%	59%
it's essential to not exceed 19°C	56%	48%	51%
the house is just as comfortable, only slightly cooler	33%	30%	27%
household never exceeds 19°C	39%	34%	32%
household uses room heaters less	50%	39%	44%
occupants wear warmer clothes	34%	33%	33%
household has undertaken conservation improvements in past year	16%	16%	16%

46 CEREN; cited in Fraunhofer Institute for Systems and Innovation Research, 1982.

47 AFME, 1985.

Labeling Program for New Houses

The ''Haute Isolation'' program was initiated in 1981 by MEL to supplement their efforts to raise the standards for new residential construction. The program was promotional, labeling new residential structures as ''High Insulation'' if they exceeded the standard for new buildings. The program was also intended to encourage the industry to develop experience with new techniques and new calculations of effective thermal performance.[48] When the building standards were upgraded in 1982 (to approximately the level previously required to qualify for the labeling program), the program requirements were increased and the name was changed to ''Haute Performance Energétique'' (HPE—one to four stars). After 1982 the program was closely tied to the H2E85 research effort (Habitat Econome en Energie—1985) intended to reduce residential energy use in new housing. A series of brochures and promotional materials dealing with specific housing projects that met the program requirements were produced and widely circulated in the design/construction industry to stimulate awareness. The program's promotional efforts were thus not particularly focused on consumers (i.e., home buyers), but on the building industry.

However, housing that met the labeling standards could qualify for additional financing benefits under various national and credit institution programs. The available incentives included the tax credit for conservation investments (see below), exemption from a special connection fee imposed by EdF on new electrically heated homes, as well as special grants and interest rate subsidies on loans.

The HPE label has been given to 200,000 new housing units, 60 percent at the two or three-star level. With the imposition of new, more stringent building standards for 1989, the HPE one- and two-star labels will become redundant (no longer exceeding the minimum standard) but the three- and four-star levels will be retained as the program continues.[49]

In 1985, the AFME evaluated the costs of the higher standards necessary to meet the HPE labeling requirements and concluded that at prevailing prices the economic optimum for investment in new housing was equivalent to the HPE three-star level.[50]

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48 AFME, 1986b.

49 Olive, 1986.

50 AFME, 1986a.

RESIDENTIAL ENERGY AUDITS

The residential audit is central to French efforts to improve the thermal performance of the existing housing stock. The purpose of the French audit program, as with other programs of this type, is to motivate investment by building owners and managers who already display some interest in energy conservation, and to ensure the highest returns on conservation investments. In this sense, the audit program could be considered a special kind of information program intended to inform homeowners and building managers about the major energy losses in their buildings and to help them make effective conservation investment decisions. For this reason, the program was described by the French authorities as a "decision aid." The French program also became increasingly oriented toward improving the technical proficiency of private sector technical and professional contractors in the construction industry. From the program's inception, audits were carried out by independent private contractors working directly for a building owner/manager. Public subsidies were available upon application, after the audit had been completed, by the owner/manager who had contracted for the audit.

Subsidies for audits began in 1979, when a grant for a portion of energy efficiency improvements was introduced (see AEE Grant description below). Because the grant was tied to the expected energy savings, a preliminary audit of some sort was a prerequisite to the grant application. This grant program was reviewed in 1981 as the AFME was being set up. One of the conclusions was that there was a need for a standard method to calculate and allocate energy consumption in existing houses (to match the acquired expertise in the new building code calculations of energy requirements for new buildings). The existing audit program was introduced in 1982.†

The AFME perceived a technically objective energy audit as a prerequisite to appropriate conservation investments in buildings. The importance of audits to building managers and owners became pronounced in the early 1980s as many of the most obvious and simple investments had already been made, and building operators were faced with an increasing variety of equipment and techniques being promoted by suppliers and contractors.[51] State investment incentives and subsidies were increased at about this time, and the FSGT funds were created to subsidize investments in public works and buildings. Because of these developments, the AFME introduced its new audit program as a crucial contribution to improving energy efficiency in the building stock. Audits were widely promoted in the

† The French audit program relied exclusively on personal inspections backed by engineering calculations, i.e., comparable to a U.S. Residential Conservation Service "Type A" audit.

[51] Beaud, 1987.

industrial and commercial sectors as well.

With the decision to launch a widespread audit program, the AFME initiated an array of supporting actions, including the development of appropriate methodologies and computer software for use by professionals in the field; training of private sector technicians; establishment of joint program financing agreements and application procedures involving different regional agencies; promotional efforts with national professional associations whose members would do the work; and advertising of the program to building managers, operators, and homeowners.

The program initially gave direct grants of up to 70 percent of the costs of conducting the audits, but in 1985 this proportion was reduced to 50 percent. The AFME was also able, by joint funding agreements with regional governments, to shift an increasing share of the subsidy burden to other agencies as the program continued.[52] There are ceilings on the value of the grant, depending on the type of building:

- 1,100 FF for single-family houses,
- 1,000 FF + 120 FF per unit for a building of 2-50 units,
- 7,000 FF + 50 FF per unit for 50-100 units,
- 9,500 FF + 30 FF per unit for more than 100 units.

The ANAH also subsidizes audits in the same fashion. It has its own application procedures which are administered regionally. Audit subsidy responsibilities are shared between the AFME and the ANAH according to the type and age of the housing stock. Consistent with its overall mandate, the ANAH is responsible for supporting audits in privately owned apartment (rental) buildings constructed before 1976. The AFME deals with the remainder of the housing stock, including owner-occupied housing, condominiums, public (non-profit, low-rent) housing and all housing built since 1975.

Three types of professionals can perform the audit:

- members of professional associations or national contractor organizations that have established contractual agreements with the AFME regarding standards and guarantees of audit quality;
- consulting engineers, architects, and inspectors who specialize in this field and are certified;
- housing contractors who are able to guarantee their results in accordance with MEL requirements.

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[52] AFME, 1986b.

Homeowners obtaining an audit were also eligible to claim the non-subsidized portion of their audit costs under the terms of the tax credit for conservation investments in force from 1982 to 1986 (see below).

Table 10. Residential Sector Audits

	1983	1984	1985	1986	Total
Housing Units Audited					
social	180,344	171,198	137,260	42,600	531,402
private	169,792	198,948	170,921	72,400	612,061
Villes Pilotes†	35,209	32,122	21,860	25,300	114,491
Audit Subsidies (10^3 FF)‡					
social	13,751	14,082	8,045	3,408	39,286
private	23,482	30,902	25,093	7,550	87,027

Table 10 shows audit activity through 1986. Several significant trends can be seen. First, interest in the audit program declined more or less proportionately to the fall in the price of oil during 1986.[53] This trend appears to have continued into 1987, with preliminary reports indicating the number of audits was down 50-60 percent from the previous years.[54] Second, the unit cost of the audits (to the central government) has consistently declined because of the factors mentioned above: declining proportion of audit costs subsidized and increased joint funding with other agencies. Third, the unit cost of social housing (moderate rent, non-profit) audits is much lower than that of private housing audits. This is probably a result of the larger number of units in each public housing complex. Social housing audits were widely promoted under special agreements between the AFME and UNOHLM, so that audits were frequently undertaken for hundreds or even thousands of units at a time under the management of a single local authority.

The portion of the housing stock audited up to the end of 1986 corresponds to just over 6 percent of the total stock of heated dwellings in France. The proportion of audited buildings that were subsequently retrofitted with energy conservation improvements varied considerably depending on the location and linkages between audits and financing of

† Villes Pilotes includes some commercial audits as well.

‡ AFME and ANAH.

53 Guyot, 1987.

54 Debergue, 1987.

investments. The FSGT grants in support of energy conservation investments (see below) required an audit prior to receipt of the subsidy. Thus, although the subsidy recipients were not required to follow the recommendations of an audit, they were at least obliged to have one done. This follow-up rate, during a period of two years after the audit, ranges from about 50 percent to 85 percent in surveys taken by a variety of organizations for different programs and housing types.[55] In more recent cases, for which only one year of followup data was available, these rates diminished to a range of 20-50 percent, suggesting declining interest in energy conservation investments.

Average investments per household also varied widely. Some dwelling units in need of substantial improvement for modernization and comfort (e.g., central heating, domestic hot water supply) faced investments on the order of 30-40,000 FF/dw. Results from a survey of average unit consumption, investment amounts, and post-retrofit energy consumption in two communities suggest an average investment of 21,000 FF per TOE saved.[56]

This rate of household investment in energy conservation should be compared to that of all French households (i.e., including those who did not receive audits). The proportion of all households having undertaken energy conservation investments prior to 1985 was 38.5 percent (for single-family housing the proportion was 48.9 percent). In 1985 about 15 percent of households reported undertaking some energy conservation investments.[57] Survey results indicate that in 1984, 8.1 percent of households living in pre-1975 housing undertook energy retrofit work averaging about 8,000 FF in cost. Of these households, 78 percent were homeowners and 74 percent lived in single-family houses.[58] Almost all of these investments were on insulation and improvements to the heating system.

With average savings on the order of one TOE per dwelling per year[59], the total savings from households that have been audited (assuming 75% follow up to the audits) would be on the order of one MTOE/year, or about two percent of total residential energy use in 1985.

The French experience with audits can be compared with that of the Residential Conservation Service (RCS) program in the U.S. The proportion of the housing stock audited (less than 2% per year) is similar to the U.S. proportion in individual utility service areas although RCS audits were typically free of charge, or available for only a nominal fee. The reported follow-up rate in France appears higher than that for RCS audits, although it is not

55 Guyot, 1987.

56 Dallaporta, 1987.

57 *ibid.*

58 AFME/EPERE, 1986c.

59 *ibid.*

clear that available figures from France are comparable in terms of rigor and program characteristics to those found in the RCS program evaluation.[60] In both cases, the national averages obviously mask a great deal of local variation in program implementation and results.[61] It is of some interest that U.S. evaluations found the RCS audit program to have, at best, ambiguous cost effectiveness,[62] but the French audit program continues to be the centerpiece of France's residential conservation programs in existing buildings.

SUBSIDIES

During the past 15 years, France introduced a variety of incentive programs for direct investment in residential energy conservation (including fuel switching). Some of these were phased out after a short life. The most durable measure was the income tax deduction/credit, which built on an existing tax mechanism.

Tax Credits

In late 1974, the government added energy savings investments to an existing list of household improvements whose expenses could be deducted from the taxable income of owner-occupants in pre-1975 homes (Bill no. 74 908 of 29 October, 1974).† These income tax deductions allowed a total of 7,000 FF, plus 1,000 FF per dependent, to be deducted for mortgage interest and remodeling expenses each year. In 1976, heating system improvements and fuel switching were also added to the list of eligible deductions. Of course, if a taxpayer was already taking the maximum deduction, the addition of a new category for energy conservation improvements provided no incentive.

The system was changed in 1982 by altering the nature of the tax benefit from a deduction to a credit, designating a specific amount for energy conservation expenditures only and adjusting the allowable ceiling. The new ceiling was set at 8,000 FF + 1,000 FF/dependent specifically for energy conservation.[63] Total property expense allowances for a household with two dependents thus rose from 9,000 FF to 19,000 FF. The energy conservation credit could be spread over a number of years if expenses in any given year exceeded the eligible amount, permitting large investments to be deducted from taxes payable cumulatively.

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60 U.S. Dept. of Energy, 1984.

61 Walker, *et al.*, 1985.

62 *ibid.*

† Landlords are able to treat energy conservation investments in their properties as expenses deductible from taxable revenues (rather than as depreciating assets).

63 Fraunhofer Institute for Systems and Innovation Research, 1982.

However, only 25 percent of the allowable expenses could now be claimed as a credit. This change in structure of the tax concessions benefited households with low marginal tax rates (i.e., those with marginal tax rates below 25%). At the same time, eligibility requirements were changed to include all homes built before July 1981.

In 1985, the ceilings for eligible expenses were raised to 12,000 + 2,000 FF/dependent. The tax credits for energy conservation measures were eliminated in early 1987. Reasons offered for their elimination were that the incentives were too expensive for the national treasury and that the most significant energy conservation measures had by then already been undertaken.[64]

Eligible investments under the tax credit program for *existing houses* included heating system replacement (including heat recovery connection to district heating, replacing boilers, burners, furnaces, electric heaters) as well as heating controls and metering improvements, insulation (at least 5 cm.) of opaque building elements, double glazing or storm windows, insulated shutters, weatherstripping and air tightness measures. Another list of eligible investments applied to *both new and existing* houses: renewable energy installations, heat-pumps, connection costs for renewably-fueled district heating, multi-fuel equipment and residential energy audits.[65] In all cases, eligible expenses were net of any other applicable subsidies or grants.

The costs of this incentive program in terms of foregone tax revenue have been estimated for the first four years of the tax credit variant of the program.[66] For 1982, the foregone taxes were 540 million FF, increasing the following year to 970 million, then to 820 million in 1984, and 870 million in 1985.

The program has been evaluated by the use of questionnaires related to residential conservation investments. Results indicate that 2/3 of all taxpayers were familiar with the existence of the tax incentive. The AFME credits this widespread familiarity with stimulating about 30 percent of the total activity in residential retrofits.[67]

Estimated energy savings as a direct result of the tax credit program in 1985 were 866 KTOE (approximately 2% of total energy use in the residential sector). Savings were calculated using total investment numbers and AFME estimates of national average unit costs of energy savings resulting from different categories of conservation investment (in FF/TOE saved). Applying these aggregate results to households again, and relating them to the

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64 Olive, 1986.

65 AFME, 1984.

66 AFME/EPERE, 1986c.

67 *ibid.*

average retail costs of energy, the AFME concluded that, at 1985 price levels, the effect of the tax benefits was to reduce the average investment payback period for the household to just over three years.[68]

Housing Rehabilitation/Modernization Grant Programs

The key agency providing funding for energy conservation improvements in existing housing has been the ANAH. The ANAH's principal mandate since its formation in 1971 has been to bring all pre-1948 housing stock up to modern comfort levels by providing grants subsidizing the cost of the work involved.† The ANAH has been active in subsidizing energy conservation investments since 1975. Initially, energy conservation improvements funded under the ANAH program were limited to those that fell into the category of comfort improvements for buildings constructed before 1948. The agency is entirely funded by a rental tax on older housing units.

In 1980, a separate funding program was established by ANAH to specifically subsidize energy conservation improvements. This program provides grants to landlords or renters in the private rental housing sector to cover audits, thermal insulation, heating system improvement or replacement, and renewable energy substitution. Only buildings constructed before 1976 (i.e., before the first thermal requirements in the building code were introduced) are eligible. Eligible measures for subsidy and the proportion of the costs that will be covered by ANAH vary depending on the specific measure involved, the type of building, the location (priority to the Paris region), and the income of the applicant. As a general rule, the subsidy for energy conservation could not exceed 40 percent of total costs (50% for "experimental" renewable energy projects, and up to 60% when the recipient has limited income).

The subsidy is restricted to units that are the occupants' principal residence. Landlords must agree to continue to rent for at least 10 years after receiving the grant. Owners of cooperative or condominium units currently being rented may claim a prorated share of improvements to jointly-owned portions of the property or may claim retrofit work undertaken on their unit alone.

ANAH subsidizes energy audits as well as conservation improvements. Audit subsidies are provided under the same terms as the AFME program (see above) but to that portion of the housing stock with which ANAH is specifically concerned (i.e., private rental units built before 1976). Of the total number of residential audits shown in Table 10 above for the

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68 *ibid.*

† 1948 was the year of the first modern French building code, which required all new housing to be equipped with running water, hot water supply, toilets, bathrooms, and heating systems.

private housing subsector, approximately 510,000, or 84 percent, were funded through ANAH.[69] The role of subsidies for energy conservation measures within the overall activities of ANAH increased sharply in the early 1980s. In 1980, only four percent of the total subsidies dispersed by the agency were for energy conservation measures. This increased steadily to reach almost 25 percent in 1985 (the last year for which data are available). The annual total of subsidies disbursed by the agency for energy conservation measures alone (i.e., applicants requesting grants only for energy measures) rose steadily from about 15 million FF in 1980 to more than 110 million FF in 1985. In addition, many of the applicants funded under the broader framework of comfort improvements in the older housing stock included energy conservation measures along with other investments (unfortunately, these amounts cannot be isolated statistically).

In relation to its broader mandate of housing rehabilitation, ANAH recognizes that energy conservation measures upgrade the quality of older housing stock. In 1986, a new comprehensive audit/inspection service (diagnostic global) was declared eligible for ANAH funding support. This audit procedure is intended to address all the inspection and technical analysis needs of the older housing stock, including structural, acoustical, and moisture inspections as well as those for energy efficiency. The agency has recently been directed to reduce its spending on separate energy conservation subsidies in order to direct more funds to improving the housing stock in the housing-scarce Paris region.[70] As a result, in 1988 it reduced its subsidy level from 40 percent of the cost of energy conservation work to 25 percent. However, the incorporation of an energy audit component in this comprehensive analytical tool for housing rehabilitation suggests that energy efficiency considerations will continue to play an important part in the agency's rehabilitation work.

Another special rehabilitation incentive program has been available through the Directions Départementales de l'Equipement (Standards and Inspections Office) since 1979. A grant is available for owner-occupants undertaking rehabilitation work on their principal residence, or on the residences of their parents or children. The program is for those with limited incomes. In addition, the building must be at least 20 years old, and the energy retrofit work must be undertaken concurrently with other improvements intended either to bring the building to current general building standards or to improve comfort.

A grant of 20 percent or 25 percent (depending on the type of work) to a maximum of 17,500 FF is available for all work, including the energy retrofit component, if the building is upgraded to current standards. In the case of comfort improvement investments, the only

[69] Garand, ANAH, 1988.

[70] *ibid.*

energy retrofits eligible for subsidy are ceiling or attic insulation, at a fixed rate per square meter of insulated surface. Rehabilitation work undertaken by the occupant is also eligible for subsidy.[71]

Another grant was introduced in 1979 by MEL, to be administered by UNOHLM. Like the other two grants described, this funding is generally intended for upgrading of the housing stock. This funding program, termed PALULOS (Prime a l'Amelioration des Logements a Usage Locatif et Occupation Sociale), is available solely for low-income rental housing (non-profit social housing), which is highly organized, locally and nationally. The grant covers 40 percent of rehabilitation and modernization costs (including energy retrofits), up to a total of 21,000 FF.[72]

Total annual costs of the three programs together (funded by MEL) were about 400 million FF at their peak in 1980.[73] The availability of FSGT funds for social housing rehabilitation and upgrading after 1982 substantially supplemented this amount (see below).

The housing rehabilitation programs played an important role in addressing the need for better thermal performance in some of the oldest housing stock. One strength of these programs was their recognition in the housing industry. There was a close organizational connection between the funding agencies in the housing sector and the industry itself, including renters' organizations, builders, contractors, and suppliers. In addition, because the rehabilitation programs addressed the overall needs for improvement of the housing stock, energy conservation could become an accepted part of necessary renovation work as a matter of routine, instead of being a separate consideration requiring special applications and funding procedures. Finally, these programs tended to be long-lived, reflecting government commitment to improving the quality of housing.

FSGT Subsidies

The Fonds Special des Grands Travaux was a unique central fund created to stimulate the economy through direct investments or subsidies in public infrastructure (e.g., roads, communication facilities) and improved quality of the building stock. The fund was financed through two related mechanisms: 1) a tax on gasoline, and 2) a special long-term bond issue floated on the basis of repayment from the continuing stream of gasoline taxes. The gasoline tax was initiated at the level of 1.4 centimes/liter in 1982, but had steadily increased to 12.2

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[71] Fraunhofer Institute for Systems and Innovation Research, 1982; AFME/EPERE, 1985; AFME 1986a.

[72] Fraunhofer Institute for Systems and Innovation Research, 1982.

[73] AFME, 1982.

centimes/liter by the end of 1986.[74]

These funds were made available to various government departments in four separate installments but were not necessarily spent in the year in which they were received. During the five years of the program, the total amount committed by the central government was 25 billion FF. Of this amount, about 10 billion FF were spent on conservation investments in all sectors. In the residential sector, the FSGT funds were administered by MEL. Between 1982 and 1986 (effectively the last year of residential FSGT funding) a total of approximately 5.6 billion FF was spent on residential sector energy conservation. This amount was divided as shown below in Table 11.[75]

Table 11. FSGT Spending by Year and Program—Housing Sector
(million FF)†

	1982/83	1984	1985	1986	1987	Total
PALULOS	891	997	1285	1412	204	4789
PAH	-	141	253	151	-	545
HPE	80	100	50	n.a.	-	230
Total - MEL	971	1238	1588	1563	204	5564

The FSGT funds were used mainly to supplement the funding of existing financing programs (PALULOS and PAH). Although these programs had objectives beyond energy conservation, the FSGT funds were designated for conservation investments. One of the prerequisites for receiving the subsidy was an energy audit, which stimulated the demand for audit funding by both the AFME and ANAH (see above).

The PALULOS program, through which the bulk of the FSGT funds were distributed, was available only to multi-family non-profit social housing. Two-thirds of this stock was constructed between 1955 and 1975. Because of efforts to keep costs low, inexpensive materials and construction methods were used, and much of the stock is now in need of

74 AFME, 1986b.

75 AFME, 1986a; MEL, 1987.

† Notes to table: PALULOS - subsidy for non-profit, low-rent social housing (source - MEL, 1987); PAH - program for housing rehabilitation, administered by ANAH (source - *ibid.*); HPE - Haute Performance Energetique: new home labeling program (source - AFME, 1986a: budget allocation, not actual spending).

improvement. The FSGT program enabled the non-profit housing sector to undertake major thermal and heating system improvements which would otherwise have been very difficult to finance. However, the FSGT program only reached about 20 percent of the total social housing stock (about 600,000 units).

Grant Program - AEE

In 1979, the AEE introduced a grant for energy conservation investments in all sectors, providing a subsidy of 400 FF per annual TOE saved. The program was abandoned in 1982 because of high administrative costs and ineffectiveness. Although the grant may have been attractive when the program was first introduced, the costs of conservation increased substantially as a result of inflation, weakening the grant's incentive value. Another factor mitigating the influence of the grant (and increasing the cost of conservation measures) was the growing penetration of the simplest and least costly conservation measures in the housing stock.[76]

The AEE estimated that 410,000 dwellings participated in 1979/1980, and 500,000 in 1981 (i.e., 2-3% of the housing stock per year). In 1980, most grants were for investments in thermal insulation (36% of total), or new heating systems (28%). Heating system controls (15%), maintenance (12%) and renewable/alternate energy source investments (6%) were also important. The AFME estimated total annual energy savings of 260 KTOE (approximately 1% of annual space heating energy use in the residential sector).[77]

Other Financial Incentives

A number of financing mechanisms are available primarily to owner-occupants for energy-efficiency improvements. The government supported a special subsidized loan program during the early 1980s, at a time of very high interest rates, covering 80 percent of the cost of energy improvements for owner-occupants and renters. Terms of the loan were very flexible but required an audit and the undertaking of the retrofit work by an approved contractor who could guarantee specific savings. MUL/MEL also provided subsidized loans for the purchase of new houses bearing the HPE label (see previous description). Most of the state-owned commercial banks also offer special low-interest loans for energy-efficiency improvements to owner-occupied homes.

[76] Beaud, 1987.

[77] Fraunhofer Institute for Systems and Innovation Research, 1982.

VILLES PILOTES:
A NATIONAL PROGRAM FOR DESIGNATED COMMUNITIES

The Villes Pilotes or "Pilot Communities" program is intended to concentrate a variety of promotional and technical assistance for energy conservation in a geographically-defined sponsoring community. This program emerged as an early example of a mechanism for regionalizing the activities of the AFME and promoting its audit program.

The AFME has, since its creation, placed a high priority on negotiating agreements with regional governments to jointly fund energy conservation and renewable energy programs appropriate to the needs of each region. By 1985, the AFME had negotiated 16 detailed contract plans as the basis of joint activity in different regions, and had signed nine agreements with a total value of 263 million FF.[78] The buildings sector typically plays an important part in these agreements, and the preferred method of delivering conservation programs to the buildings sector is through the Villes Pilotes program, in which there is a joint national/regional/local government agreement. Local authorities agree to stimulate interest among building managers and contractors, while the AFME (through its regional office) delivers promotional services, publicity, and technical advice. The objectives are to undertake as many energy audits as possible in the residential and commercial sector, to stimulate the local building contractors and technical services trades to provide energy conservation services, and then to promote the availability of financial incentives for conservation investments to building managers and homeowners. Single-family homes have been targeted by the Villes Pilotes program because they were more difficult to reach through the large subsidy programs (FSGT, ANAH, etc.), most of which were intended for multi-family housing, and because audit results suggested substantial potential for energy savings in this sector.

The pilot community approach was intended not only to provide a means of stimulating local conservation investments and encouraging the emergence of a strong local energy services industry, but also to encourage widespread training of tradesmen in this field and to give the government and researcher better understanding of the quality of the existing building stock and the potential for energy conservation.[79]

The pilot community effort begins with a multi-government agreement about the designation of an interested town and the roles of the various participants. During an initial period of several months, the AFME provides promotional assistance such as displays of infrared aerial thermography to attract attention and graphically demonstrate heat losses. Campaigns involve local businesses, institutions, public agencies and even schoolchildren in the

[78] AFME, 1986a.
[79] AFME, 1987b.

promotion of energy audits and conservation awareness. The community's financial institutions are also involved in helping to underwrite loans for eventual energy-efficiency investments. Special efforts are made to inform local energy users about national incentive programs and to assist with grant applications. The AFME provides complete savings guarantees to building managers in order to encourage their participation, and even the non-subsidized portion of the audit costs can be reimbursed when conservation investments are subsequently undertaken.[80] During succeeding years, it was expected that a large proportion of the community's building stock would be thermally upgraded as a result of these efforts.

There are 40 Villes Pilotes throughout France, ranging in size from 6,000 to 40,000 inhabitants. As of mid-1988, 35 of the operations were regarded as completed, and the remainder were still in the process of being evaluated. For the completed operations, results are measured by the AFME mainly in terms of the number of audits undertaken and the rate of subsequent adoption of conservation measures. The equivalent of 125,000 dwelling units were audited (including commercial space at 100 sq.m. per equivalent dwelling unit), representing 16.5 percent of the building stock, but the response in the residential sector was only about 61 percent of targeted levels. The average rate of adoption of subsequent conservation measures was 38 percent, which appears to be lower than the overall rate for audit programs in general. However, as pointed out above, many of the audits were carried out as prerequisites to obtaining FSGT subsidies (and hence with very high rates of follow-up). Average cost of the follow-up conservation improvements for single-family housing units was more than 14,000 FF with average savings estimated at 0.6 TOE/dw per year.

The pilot communities were intended to generate publicity and interest in energy conservation. There continues to be demand for special audit campaigns in the vicinity of the pilot communities, in part as a result of the spill-over effect from the intense publicity effort. The AFME is responding to these requests with a promotional program directed to semi-detached and grouped houses.[81]

PRICES AND TARIFFS

The French government has not emphasized the use of pricing policy to explicitly encourage residential energy conservation, nevertheless, significant taxes have been used to discourage residential oil consumption, and to generate revenue. Electricity has been taxed as well, but at a lower rate. All fuel prices are currently subject to an 18.6 percent VAT. In addition to

[80] *ibid.*

[81] Debergue, AFME, 1988.

the VAT, electricity prices are also subject to community, department and city taxes which add from 4 to 13 percent (in 1986) to the price. Tariffs have been designed to reduce electricity consumption during certain times of the day or year. Although the price of electricity is above both that of oil and natural gas, EdF has been very successful in marketing electricity. The share of dwellings (especially new dwellings) using electricity for space heating has grown dramatically from the early 1970s to the present.

There are two residential oil price schedules based on the amount consumed. Within these schedules there are 13 geographic zones. The price per liter falls slightly from the first to second schedule (around 2%), and from zone to zone (around 5%).

There are five natural gas price schedules. These schedules correspond to different end use combinations, i.e., cooking, cooking and hot water, and full (cooking, hot water, and heating). There is a fixed charge (a subscription or maintenance charge), and a charge proportional to the amount consumed. All charges are dependent on the quantity consumed within six geographical regions. The regional variation is at most 0.02 FF per kWh (1986). There are large variations in both the fixed and variable charges among the schedules.

The evolution of electricity tariffs reflects the influence of EdF's changing load structure. EdF's rapid capacity expansion since 1973 has had several important consequences for the management of its load pattern. It has meant the need to aggressively promote electricity use in households to expand its market. Up until 1985, EdF used the labels "household," "comfort," and "super comfort" for its progressively higher voltage residential service categories, to market the benefits of selecting the highest level of demand. At the same time, the growth of residential space heating has also meant that EdF's load pattern became very strongly seasonal, with sharp cold-weather peaks. More *efficient* homes with higher levels of insulation have made these peaks even more pronounced. To address both of these issues simultaneously, the utility adopted a new tariff structure in 1985.

EdF's tariffs have always been based on marginal costs; EdF has also consistently offered incentives for electrification. In 1985, three tariffs were adopted, one in conjunction with another promotional effort labeled "bi-energie." (This is described in more detail below.) Each of the tariffs consists of a fixed subscription charge, and a proportional charge based on the amount consumed.

Under the basic electric tariff structure, the consumer selects a kW subscription in 3 kW increments. The subscription charge per kW increases depending on the capacity requested. In addition, the consumer pays a charge based on the amount of electricity consumed. This charge was 0.75 FF per kWh in November, 1986. The second tariff structure is based on the time of use. Again, the consumer selects a capacity subscription charge, but this can be up to 40 percent greater than the basic tariff (in 1986). During peak hours the variable charge is the same as the basic tariff, while the off-peak charge is *reduced* by almost 50 percent.

The third tariff, the new "peak day" tariff (EJP), designed in conjunction with the bi-energie promotion, is used to persuade consumers to use electricity for space and/or water heating on all but the coldest days of the year. On these coldest days, the customer would use another fuel (such as heating oil or propane). While the subscription charge remains the same as the time-of-day tariff, the EJP tariff offers customers a reduction of about 35 percent of the variable charge during most of the year, without restrictions. EdF has the right to demand full marginal costs during the seasonal peak periods of 400 hours per year: these are almost *ten* times the off-peak energy charge. This provides a very strong incentive for consumers use the alternative fuel. The procedure is described as follows: EdF installs special metering and signaling equipment for its EJP customers, customers agree that they will pay full marginal costs for any electricity used during the seasonal peak period, which will be determined by EdF as comprising 22 days (18 hours per day) between November 1st and March 31st, and EdF provides a line pulse signal at which time the implemented technology automatically switches to the alternate system. Each year, EdF uses all 22 days, but no more.[82]

Thus, while all fuels are taxed in France, and official policy is to encourage the use of electricity, the equivalent energy cost of electricity for residential use is almost three times that of other fuels (in 1986). In spite of this difference, EdF has had great success in marketing electricity for residential space heating, especially in new and single-family homes. Increasing thermal efficiency of these homes, as required in the building code (especially when electrically heated) has reduced the overall heating requirements to the extent that the incremental cost of electric space heating compared to other fuels is low. However, this same thermal efficiency has meant that the electric space heating load curve has become more sharply peaked. EdF's innovative pricing responses to this situation are an interesting example of the logical consequences of promoting thermally-efficient, electrically-heated housing.

RESEARCH, DEMONSTRATION AND DEVELOPMENT — H2E85 (Habitat Econome en Energie pour 1985) PROGRAM

This program was the premier effort by France to support and apply practical energy conservation research, development, and demonstration in the residential sector. Coordinated by

[82] Gilbert and Guenot, 1986.

PCA, the program also involved the AFME, CSTB (Centre Scientifique et Technique du Bâtiment), MEL, and private professional groups. In keeping with the overall thrust of national energy R&D efforts, which were targeted at the energy trade balance and at improving the competitiveness and innovation of French equipment suppliers, this program focused on developing and implementing new housing technologies for widespread application in new construction and possible inclusion in national standards.

The H2E85 program was intended to reduce the total energy consumption in a new dwelling by half from the baseline of the 1974 building standards, and to make the necessary techniques for this reduction commercially available for widespread adoption after 1985. In addition to this technical target, the program set an economic target: by 1985, incremental costs for these efficiency improvements should not exceed 5,000 FF for an 80-square-meter dwelling (in 1980, these incremental costs were estimated at 30,000 FF).

The program funded technical R&D in national laboratories and by commercial manufacturers. It also emphasized transfer of technical knowledge to practitioners (contractors and installers) through demonstration projects across the country and regular training and information seminars. The goal throughout was to apply emerging technologies and methods in a practical manner so as to significantly reduce costs and increase efficiency at the same time.

The program established 11 groups of related technologies for which industrial research and demonstration tasks were identified and implemented. These groups were: insulation, windows, passive solar systems, air management, control systems, electrical heating and hot water, gas heating and hot water, solar heating and hot water, heatpumps, district heating networks, and other technical equipment. The most promising systems, on which the most effort was focused, included superinsulation, window components, air management, control systems, condensing furnaces and heatpumps. Grants were provided to industry to design and develop products, systems and installation procedures, as well as to disseminate these innovations.[83] Annual design competitions required professionals to submit proposals for housing projects around the country.

The program has made some very important contributions in terms of bringing together the public and private agencies in this field. However, it appears to have fallen well short of its ambitious objectives both in terms of cost effectiveness and ease of commercialization. A new program, with less precise objectives but aimed at more broadly reducing operating costs in existing buildings, was introduced in 1985 to build on this program's institutional

[83] Olive, 1984.

successes: H3E90 (Habitat Existant Econome en Energie pour 1990). This program was renamed Bâtiment Econome and given an expanded mandate to consider commercial as well as residential buildings.[84]

CONCLUSION

The French energy conservation programs had two important attributes. The first was their comprehensiveness: the public sector was active in supporting information programs, decision aids, financing, and technical innovation for each of several housing subsectors. The second attribute was the programs' integration through linked central agencies to the housing and construction industry, which enabled them to be readily incorporated into existing institutions and channels of communication.

The French programs were dominated by centrally-conceived initiatives, which were national in scope. French planners deliberately adopted ambitious goals and put in place a wide variety of programs to achieve them. Some of these programs were quite innovative: the early adoption of performance codes for new residential construction, or the Villes Pilotes effort to integrate programs through local promotion, for example. The most consistent element of these programs is their linkage to policies to improve the overall quality of the housing stock. For example, there were programs that offered tax benefits to building owners for conservation investments, grants and technical advice for building modernization and rehabilitation, and a combination of demonstration projects, incentives and regulations to spur technical innovation for new construction. There have been consistent central and regional government efforts to improve the quality of the older housing stock through programs of technical advice and subsidies (grants and loans). Thermal upgrading of the building shell was thus able to "piggyback" on the existing institutional organization and subsidy structure (e.g., through ANAH subsidies).

A particularly interesting feature of the French residential retrofit experience is the relatively large proportion of households that consistently reported undertaking energy conservation measures. Several surveys (see above) suggest that in the early 1980s, 12-16 percent of the households in the country took such measures in any given year. This proportion is much higher than the participation rate in government programs, and many respondents indicated that direct incentives from the government were not a major factor in their decisions.[85] Before concluding that the government programs were ineffective, however, consideration

[84] Plan Construction, 1987.

[85] SOFRES, 1985.

should be given to the spill-over effects of government subsidy and promotion programs (i.e., programs may influence the behavior of non-participants as well).

The structural trends in the housing sector have fit well with residential energy conservation programs and have contributed to their effectiveness. The role of housing agencies in supporting modernization, and in striving to meet the demands for higher quality and comfort levels as household incomes rose, has provided an avenue for the introduction of more efficient thermal technologies. The existence of incentive programs probably accelerated the turnover of inefficient heating systems and increased the number of home comfort improvements over that which would otherwise have taken place. The increasing proportion of single-family home ownership has helped to create a larger class of consumers who have a stronger interest in conservation. Government information programs and interest rate subsidies help motivate and finance improvements. Although the single-family portion of the housing stock was under-represented in the AFME energy audit programs, survey results suggest that this group comprised a larger proportion of those who undertook energy conservation measures.

Government agencies were able to link their efforts in order to take advantage of the dynamics of structural change in the housing sector. The development of building regulations provides an excellent example of how different agencies were able to integrate programs that funded technical research and innovation, demonstration projects and information transfer, financial incentives to consumers, training, regulation and inspection—all with the ultimate objective of speeding the adoption of technical innovations by the building industry. The H2E85 program helped spur builders and equipment suppliers to develop new housing technologies, the HPE label gave them a way to market them and provided a subsidy to consumers, and the experience gained in these programs led to a revision of the national building code.

In spite of the number and variety of programs introduced by the French government in the residential sector, it is difficult to identify a single example that stands out as having had a dramatic impact on energy use in the sector. The building standards requirements for insulation introduced in the 1970s were an improvement over previous practice, but the early insulation levels were not rigorous by European standards. The grant and audit programs introduced by the AEE and then the AFME reached only 2-3 percent of households annually during the early 1980s. A wide variety of incentive programs, offering subsidized loans or grants for energy efficiency improvements, either alone or in combination with other housing rehabilitation work, were clearly important for existing housing, although each program by itself might have reached only a very small proportion of the stock. Indeed, what is striking in the French case is that program evaluations indicate that none of the diverse residential programs individually made a large impact on sectoral energy use.

Nevertheless, there have been obvious reductions in energy intensity. Between 1973 and 1985, delivered energy use per household declined by 21 percent, a performance all the more impressive in light of France's relatively modest initial level of energy use per household.[86] Space heating energy use fell by over 27 percent. So France achieved impressive efficiency improvements while experiencing structural changes in the residential sector that included sharp increases in central heating (comfort) and in single-family housing share.

In the residential sector, the French experience with energy conservation is one of a central agency (the AFME) playing a supportive role, providing leadership, funding, information, and helping integrate the implementation of other agencies' programs (e.g., through the Villes Pilotes program). The housing agencies, with their ongoing efforts to improve techniques and standards in new housing as well as to upgrade the quality of existing housing, were able to incorporate energy conservation as an important element of their programs. While the effects of any single energy conservation program may thus have been limited, the aggregate results, which were reinforced by broader structural trends, were substantial.

[86] Ketoff, *et al.*, 1987.

JAPAN

BACKGROUND

Of the OECD countries, Japan had the most vulnerable energy supply at the beginning of the energy crisis. In 1973, 87 percent of Japan's primary energy was supplied with imported fuels. Eighty percent of the imported fuel was oil, and the remaining 20 percent was coal, gas, and uranium.[87] Of the oil imported by Japan in 1976, 79.5 percent came from Middle Eastern countries.[88] Of the 13 percent of primary energy that was domestically produced, five percent came from hydroelectric power that could not be expanded significantly. The great extent to which Japan was dependent on imported oil and the lack of possibility for developing domestic energy sources led policy makers to focus on the energy supply issues of establishing secure sources and minimizing long-term costs.

Unlike in other OECD countries, the industrial sector in Japan dominated total national energy consumption when the first oil crisis began. The industrial sector accounted for 65 percent of the total in 1973. This distributional characteristic of national energy requirements influenced energy policy decisions made in response to the oil crisis: most of the measures taken were aimed at industry. Even by 1982, the residential sector accounted for only 12-13 percent of total energy consumption in Japan. Thirty-nine percent of this went toward domestic hot water and 31.1 percent was for space conditioning.[89] The low level of residential energy use, however, reflected a lack of energy intensive end-use devices rather than high energy efficiency.† In fact, for the residential sector, the largest conflict with energy conservation policy objectives was the desire to continue increasing the standard of living. This conflict arose from the fact that, during the 1970s, Japan was just beginning to achieve indoor comfort levels comparable to those in the other countries we are examining.

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[87] Perkins, 1985.

[88] Agency of Natural Resources and Energy, MITI, 1986.

[89] Energy Conservation Center, 1986.

† Also of significance is the Japanese method of space heating, which is most commonly to employ kerosene burning stoves that heat individual rooms, as opposed to central heating systems. The Kotatsu, which runs on electricity, is also common, and is used under a table that people sit around to warm themselves.

SIGNIFICANT INSTITUTIONS AND ORGANIZATIONS

The Japanese government has developed a set of institutions responsible for establishing energy policies and programs that appears on the surface to be similar to the institutional structures of many countries (see Figure 4). These governmental bodies, however, work very closely and cooperatively with industry. This attribute sets Japan apart from any of the other countries that we have studied. In Japan: 1. the top positions in government agencies are often filled with leaders from private industry; 2. industrial advisory committees are involved in state policy development and are headed by members of government agencies; 3. mobility exists between industry and governmental agencies (industrial employees are often given temporary appointments in governmental positions); 4. employees have mobility both within the government and within private companies, and assume a variety of positions and responsibilities within an organization. The result of this is an uncommonly cooperative environment which has made significant energy efficiency gains.

The Emergency Measures on Oil Headquarters was established in 1973 as the first Japanese governmental body responsible only for addressing energy issues. The headquarters was responsible for advising the prime minister on solutions to the nation's energy supply problems resulting from the oil price shock in 1973. The headquarters was an ad hoc committee, which met for only one year and was comprised of the heads of the Japanese ministries.

The Comprehensive Energy Measures Promotion Cabinet Conference was established on the 15th of February, 1977. This cabinet is a forum for obtaining the views of ministers on issues related to the promotion of energy conservation measures. The cabinet currently meets biannually and is chaired by the prime minister.

The Ministry of International Trade and Industry (MITI) formulates energy conservation policy and implements specific programs under the guidelines put forth in the Energy Conservation Law. MITI's conservation policy has focused on providing government support for voluntary private industry efforts. This support has been in the form of information, guidance, and funding.

The Energy Conservation Center (ECC) is a non-profit organization, established in October of 1978 and is the central organization responsible for promoting energy conservation in all energy-consuming sectors. This organization is comprised primarily of representatives from industry but is headed by the executive manager of MITI.

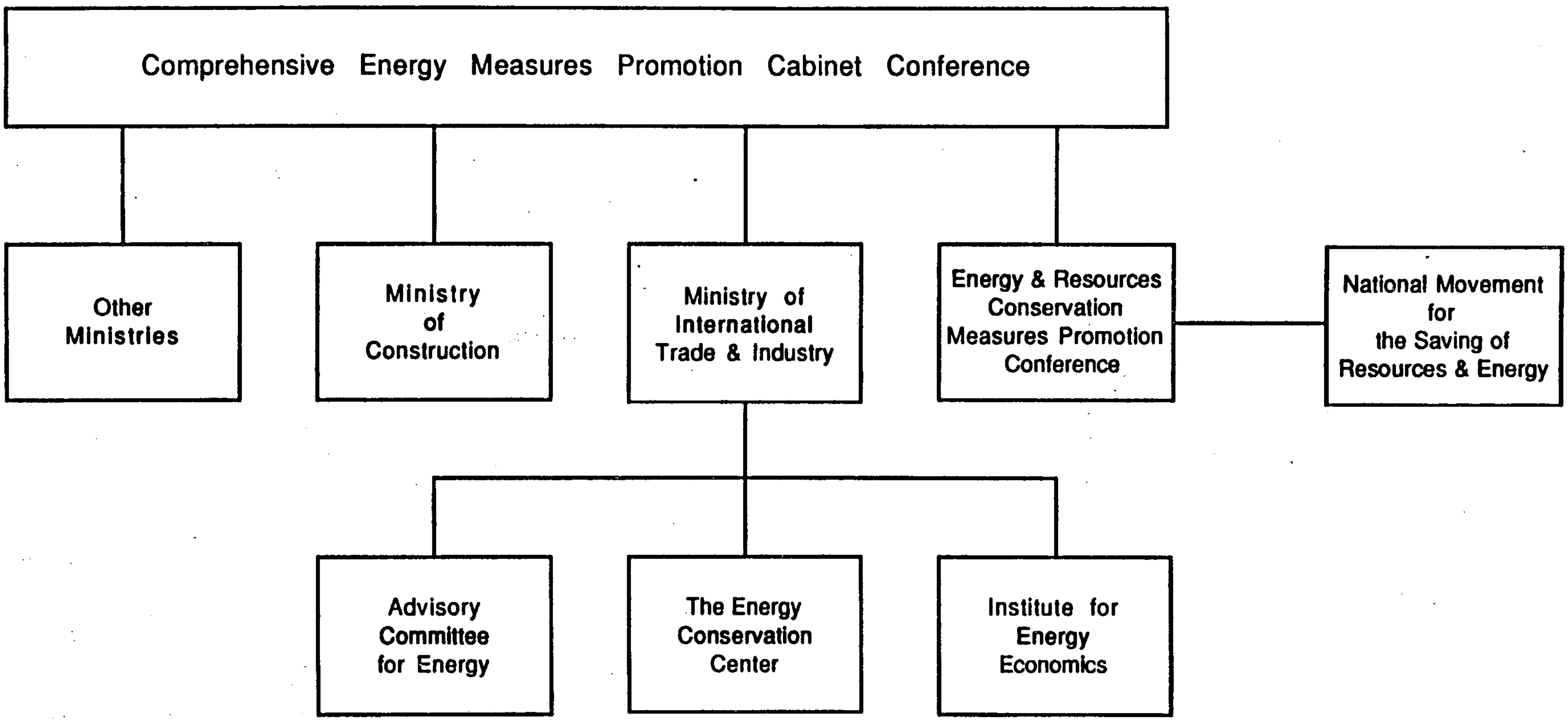

Figure 4
JAPAN

Major activities of the center include:

Publicity to increase public awareness of energy conservation
Guidance and counseling regarding energy conservation technologies
Education and training of people engaged in energy management activities
Administration of national examinations for energy managers
Research and development of energy conservation technologies
Publication of results from energy conservation studies
Collection, analysis, and processing of data and information related to energy conservation
Measurement and research for the prevention of air pollution resulting from energy consumption
Research on the appropriate use of energy technologies, based on air pollution considerations
International cooperation to resolve energy issues.

The annual budget for the ECC comes from several sources, including:

1. Interest from the Foundation Fund—a fund supported by contributions from the government, public organizations, and private companies
2. ECC business income
3. Membership fees
4. Direct government subsidies

Of the FY 1985 budget, 14 percent came from direct government subsidies and three percent came from interest from the Foundation Fund (government contributions to the Fund for 1985 accounted for 20 percent of total contributions).[90] The center has eight local branches in addition to its headquarters in Tokyo.

The Institute for Energy Economics is a research institution that provides support to MITI in determining the options for and impacts of energy policies and programs. The institute is privately funded but operates under direct guidance from MITI's executive manager.

The Advisory Committee for Energy is a state body that reports to the minister for MITI. Members include representatives from MITI, industry, banking institutions, unions, and academia.

The Ministry of Construction works in consultation with MITI on specific building conservation measures. Among its responsibilities is the development and updating of the building construction judgment standards.

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90 Energy Conservation Center, May, 1985.

The Energy and Resources Conservation Measures Promotion Conference was established November 25th, 1977 as a reorganization of the "Headquarters of Resources and Energy Conservation Movement." This is one of the bodies responsible for promoting energy conservation. It is chaired by the vice-chief secretary of the Cabinet Secretariat and vice-chaired jointly by the permanent vice-director of the Economic Planning Agency and the administrative vice-minister of MITI. The presiding members are members of the vice-minister's conference.

The National Movement for the Saving of Resources and Energy was established in December, 1984. This private agency is responsible for involving non-governmental bodies in a long-term nationwide movement for saving resources. The organization works in cooperation with the Energy and Resources Conservation Measures Promotion Conference. Members of the Central Conference† include:

- 15 consumers' and women's organizations
- 23 educational and cultural organizations
- 67 economic and business organizations
- 8 press and advertising organizations
- 11 other organizations

Forty-seven local conferences have also been established to coordinate the efforts of more than 2,000 participating organizations.

LEGISLATION: THE ENERGY CONSERVATION LAW

The Japanese government made its first move toward establishing a comprehensive national energy policy in November, 1977. At that time, an official report was published by the Advisory Committee for Energy and the Energy Conservation Committee‡; that report provided the conceptual foundation for all future energy policy and programs in Japan. The report included the results from the Comprehensive Energy Measures Promotion Cabinet Conference and approximately 10 additional conferences held by the Prime Minister and the Minister of International Trade and Industry along with other ministers concerned about energy and energy-related issues. The report outlined the following methods for achieving

† Note: In English translations of Japanese names, the term "conference" is often used as we use the terms "committee" and or "agency." These "conferences" are not events occurring at one specific time, as the term would indicate in English.

‡ The Energy Conservation Committee is a subcommittee of the Advisory Committee for Energy.

the energy supply objectives mentioned previously:

A. Stabilization of crude oil supply through increased human and economic exchange with supply countries. Development of domestic sources of oil and natural gas.

B. Development of domestic and world sources of coal. Development of alternative energy sources, including: nuclear, LNG, domestic energy sources, and oil substitutes.

C. Reduction of oil use in electricity production. Exploration of oil substitutes.

D. Conservation through reduced consumption, rationalization of energy use, and increased R&D for technologies (Moonlight Project).[91]

The objective of Japanese conservation policy is to suppress growth in energy demand without impairing economic growth.[92] Most of the Japanese conservation programs have been aimed at industry because the industrial sector accounts for the largest share of Japanese energy demand. The relatively low energy consumption rate in the residential sector in comparison to the other sectors in Japan, and the fact that residential energy demand was growing in the 1970s as a result of changes in the structure of household energy use, led to a de-emphasis of residential issues in the development of conservation programs. The residential sector was not ignored entirely, however, in Japan's energy conservation policy.

On October 1, 1979, the "Law Concerning the Rationalization of Energy Use," otherwise known as the "Energy Conservation Law," was passed. In this law, the goals stated in the 1977 report were recapitulated, and explicit measures to be taken toward achieving them were prescribed. The legal framework for implementing national energy policy was also provided. This law is of particular interest because it was used to try to address the energy question as a whole, describing measures for all of the energy-consuming sectors and using available the program types within one piece of legislation. In that way, the long-term and macro perspectives of Japan's energy future were maintained as the driving impetus behind programs. In addition, the primary responsibilities established by the law were all given to the Ministry of International Trade and Industry (MITI). This centralized the development and implementation of energy conservation programs, making the collaboration of relevant industries easy.

The portions of the Energy Conservation Law aimed directly at the residential sector focused on providing information to consumers. The information disbursed under these programs ranged from guidelines for housing construction to propaganda on the national

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[91] Energy Conservation Center, 1986.

[92] *ibid.*

"morality" of belt-tightening tactics. Other parts of the law, aimed directly at industry (i.e. upstream), focused on efficiency improvements for technologies used in the home, and, thus, although programmatically indirect, directly affected consumption in the residential sector. The following are specific programs that originated in the Energy Conservation Law.

Building Standards/Guidelines

The Energy Conservation Law requires anyone planning to construct a building to minimize heat loss through the building envelope. To enable builders to comply with this requirement, the law requires the minister of MITI and the minister of Construction to establish voluntary construction and design standards as guidelines for preventing heat loss. The first construction standards for residential buildings were promulgated on February 28, 1980. These standards were developed by the Ministry of Construction, with the advice of experts from private construction companies. They were provided as guidelines in the form of heat-loss coefficients and a coefficient indicating efficient use of air conditioners. For new buildings with floor areas greater than 2,000 m^2 an energy conservation plan is required before a construction permit will be issued.[93]

Building Materials

The minister of MITI was given the power to advise or guide manufacturers regarding improvement of the insulating properties of materials used to prevent heat loss in buildings (through walls, windows, etc.).

Appliance Efficiencies

Manufacturers of energy-consuming appliances are required to try to improve the energy efficiency of their appliances. The minister of MITI was required to establish and publicize standards for the efficiencies of appliances that are widely used in Japan. These standards were intended to guide appliance manufacturers making energy efficiency improvements. Certain appliances, deemed by MITI to require substantial efficiency improvements, were to be categorized as "Designated Machines." For such "designated" equipment, MITI was given the power to advise manufacturers to make efficiency improvements and to provide them with performance targets.

In compliance with the call for equipment standards, the Agency of Science and Technology, under guidance from MITI, developed the Japanese Industrial Standards (JIS), also

[93] International Energy Agency, 1987.

referred to as Judgment Standards, for construction materials and equipment to be used in residences. The Judgment Standards included targets for energy efficiency improvements. The Judgment Standards for air conditioners and refrigerators, which were issued in October, 1979, called for significant energy efficiency improvements. As a result, both air conditioners and refrigerators became ''designated'' appliances.

Refrigerators: Manufacturers and importers of refrigerators were required to achieve an average 20 percent efficiency improvement (based on a weighted average of electricity consumption) over the consumption rate for the 1978 ''refrigeration year'' (October 1977 - September 1978).† This improvement was to be made by no later than the end of the 1983 refrigeration year (i.e. by September 1983). On December 10, 1983, the ''designated'' status was removed from refrigerators because the desired efficiency goals had been well surpassed.[94]

Air Conditioners: Manufacturers and importers of air conditioners were required to achieve an average 17-percent efficiency improvement over the consumption rate for the 1978 refrigeration year. This improvement was to be made by no later than the end of the 1983 refrigeration year (September 1983). The original goal of a 17-percent efficiency increase was surpassed in 1984, but additional improvements were perceived as attainable, so the ''designated'' status was not rescinded. The following table shows the actual percentage improvements achieved over the 1978 stock.

† In Japan the term ''refrigeration year'' is used to refer to the year beginning October 1 and ending September 30.

[94] Sagawa, 1984.

Table 12. Japanese Air Conditioner Improvements

Category (share)			Targeted Improvement (E 1983/E 1978)	Improvement FY 1984	Improvement FY 1985
Room Air Conditioners‡	Window Type	Regular Size† (~28%)	~10%	14%	15%
		Large Size (~1%)	~15%	20%	21%
	Separate Type	Regular Size (~70%)	~20%	24%	25%
		Large Size (~2%)	~15%	23%	23%
	Average		~17%	20%	22%
Package air conditioners			~15%	18%	19%

Appliance Labeling

The minister of MITI was responsible for establishing and publishing rules for the content and presentation of energy efficiency information labels on appliances. MITI was also given the power to officially notify the manufacturer or importer of appliances deemed to be insufficiently labeled of the labeling regulations and requirements for compliance. Labeling requirements were set by MITI in conjunction with the Judgment Standards developed by the Agency of Science and Technology, which were applied as the JIS MARK Indication System.

Prices and Tariffs

The government is required by the Energy Conservation Law to pursue financial and taxation measures that promote the efficient use of energy. With this in mind, and with the goal of contributing to the "rationalization" of energy expenditures, all controls on the price of oil products were abolished, and a policy of deregulation was established in April of 1982. Taxes on petroleum products do, however, exist and are designed to encourage fuel switching away from oil. A 4.7 percent ad valorem tax†‡ on petroleum and petroleum products has been maintained. A similar but lower VAT of 1.2 percent was applied to imported LPG,

† "Regular Size": those which cannot remove more than 3,550 Kcal per hour.

‡ "Room Air Conditioners": those which consume no more than 3 kW of electricity.

†‡ See "Prices and Tariffs" chapter for an explanation of ad valorem, value added, and other taxes.

LNG, and domestic natural gas in 1984. Electricity and gas prices paid by consumers are controlled by the Japanese government, but no tariff changes have been made since 1980.

Electricity prices, which were already high in 1979, doubled on April 1, 1980.[95] The doubling was motivated by a combination of factors affecting electricity supply: the price of oil had increased from 18 to 32 U.S. dollars per barrel; at the same time, the yen was devalued from 190 to 250 yen per U.S. dollar. Meanwhile, increased investments in nuclear power were causing electricity production costs to climb. Higher electricity tariffs, therefore, were required to recover from the large and sudden increases in marginal cost. In addition to increasing electricity tariffs, the government imposed higher daytime rates on industry, along with discounted prices on holidays, for load management purposes. Residential electricity prices have remained relatively stable since 1980, but dropped in 1986, reflecting the price crash in the oil market of that year. Residential electricity prices are based on an increasing block rate with three price tiers. In addition, there are two nighttime tariffs for homes with electrically heated domestic hot water.

Research and Development

In order to promote energy-efficient technologies, MITI was required to promote research and development, and the dissemination of information obtained through R&D efforts.

The Moonlight Project, which was initiated in response to the call for R&D in the Energy Conservation Law, encompasses the main government-sponsored energy conservation R&D efforts in Japan. Although funded by the government, all Moonlight Project research is contracted out to private companies. Most of the specific research carried out under the Moonlight Project addresses industrial and commercial issues, but some has direct implications/applications for the residential sector. These include:

1. International Cooperation in R&D: participation in international energy conservation R&D efforts and information exchange with the IEA, USA, France, etc. Between 1983 and 1986, this project focused on research and implementation of advanced heatpump systems, based on an IEA agreement. Since 1984, bilateral collaboration between Japan and other countries, such as France, has also been emphasized.

2. Energy Conservation Technology Assessments: research into new energy conservation technologies and methods for improving the effectiveness of technology development. Since 1983 the focus of this project has been the development of an energy flow model and work

[95] Energy Conservation Center, 1979.

on improving technology evaluation methods.

3. Technology Development: Subsidy of private firms involved in R&D of energy conservation technologies.

4. Standardization: updating of JIS standards; promotion, through the JIS Mark indication system, of investment in energy-conserving equipment. Between 1983 and 1986, the focus of research was on standardizing energy conservation features of building materials and appliances.

5. "Development and subsidization" of appliances: promotion of fuel switching (away from oil) and improved efficiencies through subsidy of firms doing appliance R&D. The primary efforts since 1983 have centered on developing household heatpumps and special heatpumps for cold regions.

The budgets for the above projects for 1983 - 1986 were as follows:

Table 13. Budgets 1983 - 1986 for 5 Moonlight Subprojects (in M yen)[96]

Year	'83	'84	'85	'86
1. International	22	22	20	25
2. Assessments	11	10	69	88
3. Technology Development	477	367	140	68
4. Standardization	42	39	32	23
5. Appliances	50	71	55	55
sum of 1 through 5	602	509	316	234
Total Moonlight Project Budget	9590	9629	11146	12326
sum of 1-5 as % of M. P.	6	5	3	2

We present these budgets to give a general picture of the recent research strategies that have been followed by the Japanese government. They are not meant to reflect the trends of all government investments in residential energy conservation R&D, nor are the projects listed strictly limited to the residential sector. One can see from them, however, a shift away from projects that were not seen as productive, while steady funding levels were maintained in

[96] Energy Conservation Center, 1984, 1985, 1986.

other research areas. The five projects listed in the table above are part of the Moonlight Project; subsidies for general technology development in private firms received much of the funding for these five projects. Reductions in funding for private technology development have produced a strong downward trend in the aggregate funding of these programs, which does not accurately reflect the status of residential R&D projects in general. In fact, MITI has continued to subsidize R&D projects in private firms using funds that are not connected to the Moonlight Project. This alternative funding is available for up to 50 percent of the costs of specific R&D projects. For three years, MITI financed the development of small gas-fired heatpumps with waste-recovery features for the residential sector. This funding went to Toyota, Nissan, Yamaha, Toshiba, Hitachi, and Tokyo Gas. Tokyo Gas began selling the heatpumps in August, 1987.

Information Programs

To a large extent, the Japanese government relies upon its citizens' patriotic commitment to achieve energy conservation goals on a voluntary basis in the industrial, residential, and commercial sectors. Most of the government's efforts to achieve energy conservation focus on providing information to the Japanese people. The justification for these efforts is the concept of voluntary compliance. The government was explicitly required by the Energy Conservation Law to "endeavor, through educational, publicity and other activities, to deepen the awareness of the public regarding the rational use of energy and [to] promote energy conservation by the public."[97]

Information programs are administered through the ECC, which uses posters, pamphlets, mass media, contests in factories and schools, symposiums, and exhibitions for educating the public. A monthly bulletin entitled "Energy Conservation" is also distributed. Several periodic special events are coordinated by the ECC. The primary events are described below.

1. Energy Conservation Month (February every year) was established by the Headquarters of Resources and Energy Conservation Movement on March 29, 1976 and has been observed every year since 1977. The purpose for its establishment was to give consumers and government and municipal offices throughout the nation a period for concentrating on energy conservation; Energy Conservation Month had previously only been observed in factories.

Energy Conservation Month is observed in February, typically the coldest month of the

[97] Energy Conservation Center, 1979.

year, in order to emphasize the peak seasonal aspect of residential energy consumption. During the summer, an Energy Conservation Summer Campaign is used to encourage consumers to limit their use of air conditioners and other end-use devices.

2. Energy Conservation Day (the first day of every month) was established at the Energy and Resources Conservation Measures Promotion Conference on January 24, 1980. On this day, efforts are made to maximize publicity and ''enlightenment activities'' take place. Special events for the day at central government offices are:

a. morning and evening service by official cars is curtailed†
b. the number of elevators in operation is reduced by 50 percent
c. a ''lights-out'' ritual is performed during the lunch recess†
d. special disposal of office wastepaper is carried out

3. The Energy Conservation General Review Day was established during the Comprehensive Energy Measures Promotion Cabinet Conference in October, 1980. This day, which falls on the first day of December every year, coincides with Energy Conservation Day, but is meant to place extra emphasis on conservation for the beginning of winter. On this day, consumers are encouraged to closely examine their energy-consuming behavior.

BEYOND THE ENERGY CONSERVATION LAW

Loans

The ''Energy Conservation Extra Loan System,'' run by the Housing Finance Corporation, grants special loans for new residential construction and for retrofits. Eligibility requirements for the loans are determined by the Ministry of Construction, based on compliance with the building standards. These construction requirements are most stringent for homes built in Hokkaido, the northernmost and coldest region in Japan.
Loans are issued for the following measures:

† Limited to the extent that business and security considerations allow.

Measure	Maximum Amount in thousand yen	Comments
Insulation, pre-1987	200	500k yen allowed in northern regions
Insulation, 1987	500	700k yen allowed in northern regions
Installation of efficient hot water supply system	200	apartments only, amt. per unit
Installation of efficient water and space-heating system	500	apartments only, amt. per unit
Installation of solar water heater	100	
Installation of passive solar	500	apartments only, amt. per unit

The loan periods are from ten to thirty years for new construction and twenty years for retrofits. Although the interest rates are fixed, they are not significantly lower than private bank rates. Also, the maximum amounts of these loans are in general much smaller than the total investment costs, amounting to less than 10 percent of construction costs for most new buildings. For these reasons it is usually not worth using the loans for new houses that would require additional private financing. Participation has therefore been greater among homeowners investing in retrofits.

Campaigns to Adjust Consumer Behavior

In anticipation of the passing of the Energy Conservation Law, the Japanese government encouraged national energy conservation efforts with "Countermeasures for Cutting Back on Oil Consumption" in March, 1979.† Some of the measures addressed behavior related to energy consumption in the residential sector. Measures included were:

1. Thermostats were to be installed in every room in homes.
2. Indoor temperatures were to be kept at a maximum of 19°C in the winter and at a minimum of 28°C in the summer.
3. Special attention was to be paid to turning off electrical appliances such as televisions, air conditioners, and lighting fixtures when not in use.

These measures have been promoted in major publicity campaigns. In 1982, the wording used regarding indoor air temperatures was modified, replacing specific temperature recommendations with a call for people to use heating and cooling equipment to a "moderate extent."[98]

† The "countermeasures" were defined by the Conference for the Promotion of Countermeasures for Energy Conservation and for Conservation of Natural Resources.

[98] The Institute of Energy Economics, 1983.

SUMMARY

The framework for most of the residential energy conservation programs in Japan can be found in the 1979 "Law Concerning the Rationalization of Energy Use." This law was intended to address comprehensively the areas in which energy could be saved in the sector. To achieve this goal, the government needed to address a variety of issues affecting energy demand in the sector. The most important of these issues was the governments' desire to reduce the growth in energy consumption while at the same time allowing the Japanese standard of living to continue to increase. Although the reduction of demand for energy services was promoted through information campaigns, the primary focus of Japanese energy programs was to improve the energy efficiency of end-use devices.

Several tools were used for meeting this goal. The government provided large subsidies for industrial R&D projects. Target efficiency improvements were set for the appliances that consumed the most energy. An appliance labeling system was established and labeling was required for both domestic and imported appliances. These efforts led to significant appliance efficiency improvements. Policy aimed at housing construction was less aggressive. Voluntary building construction guidelines were established and the government provided advice to manufacturers of building materials for improving material thermal properties. Special loans were also made available for new construction and retrofits designed in compliance with the construction guidelines. These loans were not very attractive, however, because their maximum amounts were small and their interest rates were not significantly lower than those of banks.

Energy pricing policies were aimed at allowing residential consumers to experience the price fluctuations of the energy market. The prices for petroleum and petroleum products were deregulated and taxed. Natural gas and electricity prices paid by residential customers were regulated, with increasing block rates applied to electricity sales.

CONCLUSION

To understand the government's role in affecting energy conservation in the residential sector in Japan, one needs to understand two things: the relationship between the Japanese government and industry, and the significance of MITI's responsibility for establishing energy policy. The goals set by MITI were based on an industrial perspective of what was achievable. This is reflected in the policies and programs that MITI produced. On paper, the "Energy Conservation Law" is a comprehensive package of energy programs, but in practice it addressed aggressively only those areas that were directly related to industrial production.

The most significant negative result of this is the fact that the potential for saving energy by improving building envelopes was all but ignored. The thermal properties of the housing stock in Japan are notoriously poor. Three factors interacted to produce this result. First, after World War II there was an extreme housing shortage in Japan; building materials and land were scarce (wood had to be imported), and housing costs were very high. The need to produce lots of housing during a short period of time and with limited materials (waste metals from ship building and other industries were commonly used as structural materials) encouraged production of low-quality housing. Because of Japan's relatively mild climate,† thermal quality in housing was not a high priority when energy prices were low.

Institutional barriers limited the Japanese government's ability to improve the thermal quality of housing when energy prices rose significantly in the 1970s. Control of the construction of residential buildings has traditionally been in the hands of the Ministry of Construction. Interfering with the "traditions" of the housing industry was seen as being outside of MITI's territory. In addition, increasing already high housing costs was seen as economically undesirable, especially because demands for comfort were just beginning to be met. Thus construction standards (developed within the Ministry of Construction) were only addressed symbolically in the form of "guidelines," and no incentives for retrofitting existing housing were provided. In addition, efforts to improve the thermal properties of building materials were unlikely to succeed without the creation of a market for their use.

Because the Japanese government did not establish strong, mandatory construction standard, it missed a large opportunity for reducing consumption in the residential sector. Between 1973 and 1983, Japan was second in the world (the United States was first) in the amount of housing being constructed. During this period 15.4 million dwellings were built.[99] The impact of the new construction on the housing stock was greater than that in other countries because the majority of the construction was replacement housing. This fact is a result of the limited amount of habitable land in Japan.

MITI's apparent impotence to effectively influence the housing stock contrasts the aggressive efforts and achievements in home appliance efficiencies. The impact of these improvements on total household energy consumption is significant, as new appliances represent a large share of the overall appliance stock in Japan. The number of energy-consuming devices in the residential sector increased greatly in the 1970s and early 1980s as previously unmet demand for energy services in the home were rapidly satisfied. One of the most dramatic examples of this can be seen in the saturation of air conditioning systems in

† Japan has 1,975 heating degree days and 300 cooling degree days annually.

[99] Energy Design Resources Inc., 1986.

residences:

Table 14. Percentage of Households With Air Conditioners[100]

Year	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76
%	2.0	2.8	3.9	4.7	5.9	7.7	9.3	12.9	12.4	17.2	19.5
Year	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	
%	25.7	29.9	35.5	39.2	41.2	42.2	49.6	49.3	52.3	54.6	

Because of the dynamic between the rapid rate of appliance saturation and significant achievements in appliance efficiencies, energy demand data for the residential sector over time are misleading.† The general trend of increased energy use is accurate, but the increased level at which energy services are being provided cannot be seen in the aggregated consumption values. Improvements in comfort have more than compensated for energy savings resulting from improvements in household appliance efficiencies. Growth in electricity demand, however, has been restrained by increased appliance efficiencies. For example, while other industrialized countries made efficiency improvements of 24 to 42 percent for refrigerators between 1970 and 1984, Japan achieved 66 percent efficiency improvements between 1973 and 1984. For an average new 2-door, 170-liter refrigerator, this represented a drop from an average monthly consumption rate of 79.6 kWh in 1973 to 27.0 kWh in 1984.[101] ‡ The growth in the stock of electrical appliances has now slackened as saturation levels have been reached (see Table 15).

100 Economic Planning Agency, Japan, 1987.

† Annual residential delivered energy in Japan increased from 30.9 GJ/dwelling to 36.1 GJ/dwelling (17% increase) between 1973 and 1983 (these values are climate-corrected in order to eliminate the influence of abnormal weather fluctuations).

101 Energy Conservation Center, 1986.

‡ Note that absolute values for energy consumption of appliances are not comparable among countries because of differences in measurement and reporting procedures. To complicate the situation even further, the capacity of national appliances in stock has been increasing. In Japan, the average refrigerator size increased from 150 to 170 liters in the mid- to late 1970s to a current average of 300 liters. Despite this increase in size, the average refrigerator in Japanese homes currently uses significantly less energy than the average refrigerator used 10 years ago (Haruki Tsuchiya, 1987). Percentage changes are therefore the most useful measure of efficiency improvements for making comparisons among countries.

Table 15. Penetration of Household Electrical Appliances in Percent (1986)[102]	
Refrigerators	98.4
Air Conditioners	54.6
Washing Machines	99.6
Vacuum Cleaners	98.2
Electric Ranges	45.3
Color T.V.s	98.9

On the whole, the growth in electricity demand was not as extreme as the increase in delivered services might otherwise have produced. Aggressive government encouragement of industry R&D on appliance efficiency gains certainly played a role in producing this result.

Sacrifices in energy services, although they were not sustained, also slowed the growth in energy demand. The extensive information programs supported by the Japanese government prompted significant short-term decreases in household energy consumption as a result of behavioral changes. Information provided to consumers was primarily aimed at "belt-tightening" in an atmosphere in which the saturation of energy services was already low. The early sacrifices made by the Japanese people were in that sense more "real" than those made in countries where comfort levels were already high in 1973. The potential for producing irreversible energy savings through behavior education was therefore low. Similarly, the potential for influencing consumption through pricing strategies was limited because the demand for energy services was growing and inelastic. Actual annual delivered energy increased from 30.9 GJ/dwelling in 1973 to 36.1 GJ/dwelling in 1983 (16.8% increase).†

[102] Economic Planning Agency, Japan, 1987.

† These numbers are climate-corrected.

SWEDEN

BACKGROUND

When energy prices began to rise dramatically in 1973, the Swedish government already had a long standing objective of reducing dependence on imported energy. Before World War II, 60 percent of Sweden's total primary energy (TPE) was imported. By the late 1940s the imported share of TPE in Sweden had increased to 70 percent. Stresses on foreign oil supplies during the Korean War and the Suez Crisis in 1956 brought the vulnerability of Sweden's energy supply picture into focus for the Swedish government.[103]

The most dominant energy source in Sweden in 1973 was petroleum products (73% of TPE),[104] all of which were imported. Although Sweden's oil imports came from more diverse sources than Denmark's, the largest fraction came from the Middle East (39% in 1970), with the remainder almost evenly distributed among North Africa (Libya and Algeria), Venezuela, Nigeria, and the Eastern block (Soviet Union, Poland, and Romania).[105] The remaining 27 percent of TPE was provided as follows: 13.4 percent electricity (generated primarily with hydro), 4.2 percent coal, and 9.4 percent other solids.[106]

An environmental policy that effectively precluded further expansion of Sweden's hydroelectric capacity was adopted in the early 1970s. This policy helped to secure the role of nuclear power in energy planning in Sweden. The decision to develop nuclear power was already part of the Swedish government's plan to achieve energy self-sufficiency. During the 1950s, Sweden had Europe's largest sources of uranium, and heavy-water reactor research and development promised to stimulate domestic industry. In the mid 1960s, however, Swedish heavy water reactor technology was abandoned because of unresolved security problems.[107] Despite this turn of events, the development of nuclear power was not eliminated from Swedish energy policy. Instead, light-water reactor technology from the United States was adopted. The light-water reactors required concentrated uranium, so Swedish uranium sources were abandoned as well.[108] The first Swedish nuclear reactor came on line in 1972, just before the first oil crisis. Since then 11 additional reactors have come on line, boosting Sweden's total nuclear capacity to 9.6GW(e) in 1986.[109] These reactors have

[103] Klingberg, *et al.*, 1982.
[104] Statistiska Centralbyrån, July 1976.
[105] Industridepartementet, Sweden, 1974.
[106] Statistiska Centralbyrån, July 1976.
[107] Widegren-Dafgård, October 1988.
[108] Klingberg, *et al.*, 1982.
[109] KRAFTSAM, 1987.

provided electricity to meet the bulk of the increase in demand since 1974, and they produce ~50 percent of the total electricity generated annually. Because of the availability of hydro- and nuclear-generated electricity, the Swedish people have enjoyed relatively inexpensive electric power. They have not suffered the same economic impacts from the oil crises as consumers in countries like Denmark and Japan, where the electricity supply industry was highly dependent on oil for power generation at the turn of the decade. Low electricity prices in Sweden made fuel switching from oil to electricity for end uses such as space heating popular during the 1970s and early 1980s as oil prices escalated (the price of home heating oil increased ~80% between January 1, 1979 and January 1, 1980).[110]†

Continued growth in electricity demand became problematic in 1980, however, when the Swedish public voted in favor of a nuclear referendum which called for elimination of nuclear power plants from Swedish electricity supply. The Swedish Parliament responded to the nuclear referendum by deciding that no more than a total of 12 nuclear reactors would be allowed to come on line. Those reactors would be decommissioned at the end of their economic lives or in the year 2010, whichever came first. Although the seriousness with which the Swedish government has approached phasing out nuclear power is debatable, interest in achieving that goal and resolving the problem of replacing nuclear power as an energy source has grown considerably in the aftermath of the 1986 Chernobyl nuclear accident.

By 1986, the share of Sweden's primary energy supply that was met with petroleum products had been reduced to 50 percent (from 73% in 1973).[111] A large share of the displacement of oil came from electricity generated in nuclear plants, which increased from 0.5 percent of TPE in 1973 to 16 percent in 1986.[112] In 1986 Sweden had approximately 3.7GW(e)[113] capacity in oil-fired condensing plants, but this was and is reserved for back-up of hydroelectric capacity in drought years.[114] Unlike nearby Norway and Denmark, Sweden has no domestic natural gas resources. Some fuel switching to natural gas has been supported by the government because of the environmental advantages of gas over other energy

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110 Bostadsdepartementet, 1980.

† Electricity was cheaper than oil, at the margin, for about five years (1981 - 1985) in that the cost of a unit of useful heat from an oil-fired boiler running at 70 percent efficiency was greater than the cost from an electric boiler or resistance heater running on an all electric discount electricity rate. Fear of continued increases in oil prices, fueled by government subsidies for fuel switching away from oil, magnified the effect of the price differential.

111 Statistiska Centralbyrån, August 1987.

112 *ibid.*

113 Hawk and Schipper, 1988.

114 Statens energiverk, 1986.

sources, however. As a result, natural gas has begun to be imported from Denmark. Natural gas accounted for 0.5 percent of TPE in 1986.[115] Coal use has increased slightly, but poses environmental problems that are of great concern in Sweden. Virtually no coal-fired condensing plants exist in Sweden, but approximately 2 TWh(e) is produced in coal-fired cogeneration plants.[116] Small increases have also taken place in the burning of wood and other renewables since 1973. The share of TPE provided with such domestic solid fuels has increased modestly from nine percent in 1973 to 14 percent in 1986.[117]

Because opportunities to increase domestic energy production have been limited, energy conservation has played an important role in the Swedish government's energy planning. That role is likely to continue well into the future as the Swedish government struggles to replace the share of electricity that is currently generated with nuclear reactors.

Energy consumption in Sweden increased steadily, between four and five percent per year, on average, after World War II. Between 1955 and 1965, total delivered energy increased, on average, 5.1 percent/yr. Between 1965 and 1970 growth was slower, but continued to increase at a rate of 4.4 percent/yr.[118] Electricity consumption grew faster than consumption of other energy types, with an average annual growth rate between seven and eight percent in the 1960s. Between 1970 and 1979, growth in energy consumption had dropped to one percent/yr. Electricity consumption continued to lead this growth, increasing at a rate of 4.4 percent/yr.[119] The growth in energy consumption in the postwar period was uniform among sectors; the sectoral breakdown of energy consumed was therefore relatively constant. The largest share of TPE consumed (45%) was used in buildings (primarily for space heating); 40 percent was consumed within the industrial sector, and the remaining 15 percent went toward transportation. More than 50 percent of electricity was consumed in industry, with approximately 40 percent used in buildings.[120]

In 1972, 25 percent of Sweden's energy demand came from the residential sector. Because space conditioning is the most energy demanding end use in most residences, the thermal condition of the housing stock is an important determinant of a country's total residential energy demand. Swedish housing is noted for its high thermal quality. Building regulations in Sweden have included insulation requirements since 1967. These were motivated by indoor climate problems rather than energy efficiency, however. Requirements

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[115] *ibid.*

[116] *ibid.*

[117] Statens energiverk, 1988.

[118] Bostadsdepartementet, 1980.

[119] *ibid.*

[120] Industridepartementet, 1975.

that specifically addressed energy conservation were first added to the code in 1976. The thermal transmission requirements in the Swedish building code were the first in the world and continue to be the most stringent. The requirements passed in 1976 exceeded those of Denmark in 1984 (the strictest regulations in the EEC and second most stringent in the world). Since then, the Swedish government has continued to strengthen the code. Since 1984, particular attention has been paid to homes with electric-resistance heating. On January 1, 1989 the stricter requirements for electric-resistance heating were extended to apply to all new dwellings. The Swedish housing industry has worked toward honing its construction skills and improving technologies and techniques for producing good thermal performance since the turn of the 18th century, when depletion of Swedish forests by the steel industry and space-heating use severely restricted the availability of wood, which was the primary home heating fuel at the time. Actual construction practices have historically exceeded the requirements of the building code *on average*.

In addition to the impacts of the building code and the long-standing practice of addressing thermal concerns in housing construction, the relative newness (by European standards) of a large portion of the housing stock has contributed to making Swedish dwellings stand out as highly thermally efficient in international comparisons. In the fall of 1979 the housing stock in Sweden included 1.37 million single-family dwellings (SFD) and 1.98 million multi-family dwellings (MFD) that had been built before 1976. An additional 165,000 SFD and 56,000 MFD were built between 1976 and the end of 1979. The total number of dwellings was, therefore, 3.56 million (~1.53 million SFD (includes duplexes) and ~2.03 million MFD). As shown in the table below, 42 percent of all dwellings in 1980 were built during the preceding 20 years (1960 - 1979). Forty-five percent of all MFD were built during this period.[121] The Million Homes Project (1963 - 1973) was largely responsible for this outcome.† Although critics of the housing produced under this program argue that many of the "million homes" are of lower thermal quality than is expected in Sweden, these units are, nevertheless, highly efficient in comparison to the housing stock in the rest of the world.

[121] Bostadsdepartementet, 1980.

† The Million Homes project was aimed at relieving Sweden's housing shortage by encouraging the housing industry to produce one million new dwellings during a 10-year period.

Table 16. Age of Swedish Housing Stock, 1980[122] In Percent			
Period Built	SFD	MFD	All Dwellings
before 1920	24	9	16
1920-1940	18	13	15
1940-1960	19	33	27
1960-1975	29	42	36
1975-1979	10	3	6

Despite the relatively high thermal quality of Swedish housing, the dominant energy end use in the residential sector in the 1970s was space heating. This was due in part to the comparatively harsh climate: the average annual season in Sweden has 4011 heating-degree-days (base 18°C) spread over nine months (~900 HDD more than Denmark). In addition, central heating was adopted early on and extensively in Sweden and indoor temperatures were high, by international standards.

Table 17. Saturation of Central Heating in Swedish Dwellings[123] In Percent	
1945	46
1960	74
1965	83
1970	92
1975	96
1980	98
1985	99

[122] Bostadsdepartementet, 1980.

[123] Source: Statistiska centralbyrån, 1986-1987 except 1985 figure, preliminary, from Statistiska Centralbyrån, FOB 1985 census. Note: Central heating includes all dwellings with full electric heating.

Table 18. Swedish Residential Indoor Temperatures[124]
1975-1976
In Percent

	Single-family	Multi-family
below 18°C	2	2
18-19°C	24	20
20-21°C	59	54
22-23°C	15	20
24-25°C	0	3
above 25°C	0	0

Improving the thermal performance of existing dwellings, thereby saving heating energy, and reducing the use of oil-fired boilers for residential space heating have been the focus of the residential energy conservation programs in Sweden.

Space heating in the majority of Swedish homes during the 1970s was provided by oil-fired boilers (~71% of SFD and ~61% of MFD in 1977).[125] Of the total energy consumed in residences, 70.5 percent was in the form of oil, 14 percent electricity, nine percent district heat, 5.5 percent solids (primarily wood, with one tenth coal), and one percent natural gas.[126] In addition, in 95 percent of all district heating plants, hot water was produced by burning oil (which provided heat for 3% of SFD and 37% of MFD in 1977). Fifty-seven percent of total residential energy consumption occurred in SFD, with MFD accounting for the remaining 43 percent.[127]

The share of Swedish SFD with electricity as the main source of space heating grew from 11 percent in 1970 to 26 percent in 1977. Seventy-one percent of new SFD built 1974-1977 were electrically heated. In addition, ~10,000 existing SFD/yr were converted to electric heating during the 1970s. This trend was magnified in the 1980s: nearly 20 percent of the single-family housing stock converted from oil to electric-based heating between 1980 and 1985. Demand for district heating also increased, with four percent of new SFD tying into district heating grids. Between 1967 and 1977, 60-65 percent of new MFD per year

[124] Energisparkommittén, 1983. Note: Multi-family values are shown as reported (total 99%).
[125] Bostadsdepartementet, 1980.
[126] International Energy Studies, March 1987.
[127] Industridepartementet, 1975.

connected to district heating systems. In addition, ~30,000 apartments/yr were converted to district heating during the same period. The fuel switching to electricity and district heating in MFD was, as desired by the Swedish government, primarily away from oil-fired boilers. The percentage of MFD heated with oil-fired boilers dropped from ~70 percent in 1970 to ~60 percent in 1977, with most of the reduction absorbed by district heating.[128] The percentage of SFD heated with oil-fired boilers dropped from 80 percent to 67 percent during the same period.[129]

Because the thermal condition of the housing stock was better in Sweden than in other countries, opportunities for achieving large savings through building envelope retrofits were smaller than in the other study countries. This explains in part the smaller percentage of energy savings achieved in Sweden than, for example, in Denmark. Nevertheless, Swedish building owners managed to affect their energy usage to a considerable extent, thereby maintaining Sweden's firm position of having the world's most energy-efficient buildings.

The increased popularity of electrical heating in Swedish households, while reducing the country's dependence on oil, has in recent years caused winter peak load problems. The electricity demand from the new well-insulated, electrically-heated single-family homes is particularly troublesome because it peaks dramatically on the coldest days of the year. In addition, tightening of Swedish building envelopes, although reducing overall energy demand, has caused an increased dependence on electrical energy for the operation of mechanical ventilation systems (necessary for keeping indoor air contaminants down to an acceptable level). These impacts, and the Swedes' strengthened determination to decommission their nuclear power plants, promise to put increased pressure on the Swedish government to reduce electricity demand by improving the energy efficiency of electrical end-use devices.

While concentrating heavily on the thermal efficiency of buildings, the Swedish government has paid little attention to the efficiency of household electrical appliances. Although appliance saturations were already high in 1973, the fact that appliances have much shorter lives than houses and are replaced in shorter time intervals means efficiency improvements to new machines can have rapid impact on overall residential energy consumption. The relatively rapid replacement cycle for appliances is illustrated by the fact that more than half of the stock of refrigerators in Sweden in 1973 had been replaced by 1985.[130]

[128] Bostadsdepartementet, 1980.
[129] Carlsson, 1989.
[130] Statens Vattenfall, 1985.

Table 19. Penetration of Household Electrical Appliances[131] in Percent

	1973	1978	1985
Refrigerators	94	82	79
Freezers	40	48	55
Combis	8	18	20
Clotheswashers	49	66	89
Clothesdryers	9	17	40
Electric Ranges	85	92	94
Dishwashers	11	22	28
Color TV	27	76†	83
B&W TV	70	32†	20

Data from the Swedish company Electrolux, one of the largest manufacturers of household appliances in the world, indicate that significant efficiency gains have been made in Swedish appliances despite lack of pressure from the government. The energy consumption of Electrolux freezers, for example, was reduced by 56 percent between 1975 and 1983 (for 300-liter units). The international trend toward more efficient appliances helped motivate Electrolux to make these improvements.

SIGNIFICANT INSTITUTIONS AND ORGANIZATIONS

Energy conservation in Sweden's residential sector is promoted by a myriad of government institutions, which interact with each other and with private organizations. Understanding who the key actors in the residential energy conservation scene are, and the relationships between them, is an important step toward understanding the policies and programs that they have put forth. The most important of these are listed below (see Figure 5).

The official national energy policy and plans, including those for promoting energy conservation are passed by the *Swedish Parliament*. The *Ministry of Housing and Physical Planning* (Bostadsdepartementet, Bo) has primary responsibility for establishing and

[131] LBL data base, gathered from Statens Vattenfall.

† Figure for 1979.

implementing residential energy conservation policy and programs. Programs established by the ministry include the use of grants and loans, regulations, standards, research funding, and dissemination of information and advice. The ministry delegates the development, implementation, and administration of such programs to several agencies:

The Swedish Council for Building Research (Byggforskningsrådet, BFR) promotes research aimed at urban planning, building construction and production techniques, building energy conservation, and the development of new building related energy technologies such as solar equipment and design. BFR initiates, funds, and coordinates research projects in these areas, and publishes research findings. The primary recipients of funding from BFR are the Swedish universities, the National Institute for Building Research, and private consultants.

The National Institute for Building Research (Statens institut för byggforskning, SIB) is a centralized research facility devoted to promoting developments in building design, production, and management. Building research carried out at the institute is intended to meet research needs not met elsewhere. The research at the institute is funded and managed by BFR. The institute's energy research is specifically aimed at improving the efficiency of energy use in Swedish buildings.

The National Board of Physical Planning and Building (Statens planverk, SPV) was, until recently, the central agency for gathering knowledge and experience related to physical planning and building in Sweden. SPV was responsible for using that knowledge and experience in order to issue regulations, recommendations, and advisory services regarding building construction. SPV was also responsible for planning the use of physical resources such as land and water (including zoning, etc.). SPV coordinated related efforts and regulations of other authorities, and administered funds to support local auditing and advisory programs and other measures for the renovation and retrofit of the housing stock. SPV had three divisions, which were responsible for physical planning, building activities, and administration. The role and responsibilities of SPV came under scrutiny in 1987, and on July 1, 1988 SPV was combined with Bostadsstyrelsen (see below) to form a new agency called Boverket.

The National Housing Board (Bostadsstyrelsen, BOS) is an administrative agency responsible for issues related to building use. The board administers subsidized state loans for new buildings and building renovations. As part of this function, BOS has administered subsidies for the adoption of energy-conserving measures in buildings. BOS is also responsible for managing and coordinating the efforts of the regional housing authorities (see below).

The National Board of Public Building (Byggnadsstyrelsen, KBS) is responsible for most state-owned buildings in Sweden. KBS is the primary source of government administrative and technical expertise on building management and construction. Because of this expertise, KBS participates in many government investigations into the promotion of energy conservation in buildings in general. In this way, KBS has played an important role in the development of new energy efficient construction techniques.

The Ministry of Environment and Energy (Miljö och energidepartementet) was established on January 1, 1987 in order to strengthen and coordinate the institutional organization responsible for environmental and energy issues, and to create a more powerful environmental policy within the government. The Ministry assumed responsibilities in these areas that previously lay in the Ministries of Industry and Agriculture. Although the Ministry's activities in the area of energy are primarily supply oriented, it does engage in limited activities in the area of energy demand, primarily through its subordinate body, the National Energy Administration.

The National Energy Administration, (Statens energiverk, STEV) was established in 1983 under the Ministry of Industry as the central agency responsible for addressing energy issues and questions. STEV now operates under the Ministry of Environment and Energy and is responsible for developing Sweden's national energy plans and for preparing support material for political decisions related to energy. STEV is responsible for distributing funds for supply-side energy research. STEV also is responsible for the coordination of various energy conservation programs, the development of community energy plans, and the provision of information and training for professionals in the energy field.

The Energy Conservation Committee (Energisparkommitten, ESK), was established in 1974 under the guidance of the Ministry of Industry for the purpose of "increasing general awareness in society of energy matters and assisting efforts to improve efficiency and conservation in all kinds of energy use."[132] The committee was responsible for producing and distributing information packages toward that aim, and for collecting data on energy use and measures for improving energy efficiency. In 1983, ESK was disbanded, and its responsibilities were assumed by the National Energy Administration.

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[132] Byggforskningsrådet, 1985.

The National Swedish Board for Technical Development (Styrelsen för teknisk utveckling, STU) finances research on the development of industrial processes, and administers special funds for projects on improving energy efficiency. STU also funds research on electrical power production (excluding solar) and supports the development and demonstration of wind power generation in cooperation with electrical power utilities. STU is also responsible for promoting the technical transfer of research results.

The Ministry of Industry (Industridepartementet) was responsible for issues related to energy supply until the Ministry of Environment and Energy was established. Currently the most important roles of the Ministry of Industry, from the point of view of residential energy conservation, are its funding and guidance of the National Testing Institute, and its funding of research through the National Swedish Board for Technical Development.

The National Testing Institute (Statens provningsanstalt, SP) is responsible for the testing and evaluation of industrial processes and products. SP has been doing energy work since the mid-1970s. The two largest areas of testing in the institute are currently energy conservation in buildings and small-scale energy production. As part of the former, SP tests space-conditioning equipment and appliances for, among other things, their energy consumption. Requests for testing of specific products come from other agencies, such as Konsumentverket. The institute is also involved in evaluating the energy efficiency of building design demonstration projects. SP is funded and directed by the Ministry of Industry.

The Ministry of Finance (Finansdepartementet) has several energy-related responsibilities. The most significant of these, from the residential energy conservation perspective, is the setting of energy taxes.

The State Price and Cartel Agency (Statens pris- och kartellnämnd, SPK) is responsible for providing information to the Ministry of Finance on all matters related to the Swedish economy. As part of this responsibility, SPK follows price changes and the economic affairs in domestic and international markets (excluding the banking and insurance industries). Two important aspects of this work are: 1. the tracing of the domestic and international oil markets and the supply costs and price trends of domestic power and fuels producers, and 2. the analysis of potential impacts on the various sectors of the economy of Ministry of Finance actions/decisions regarding prices and taxes.

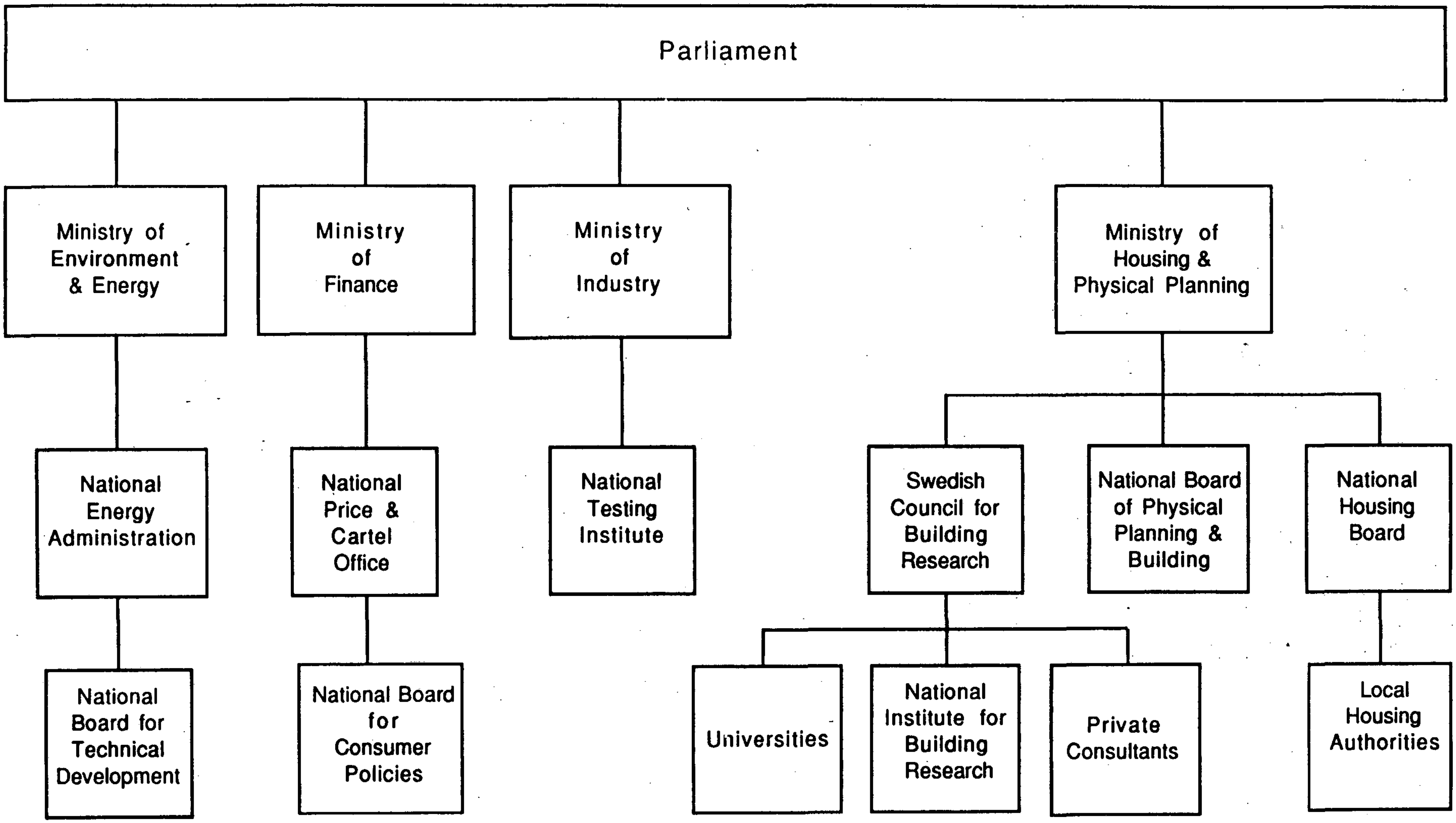

Figure 5
SWEDEN

The National Swedish Board for Consumer Policies (Konsumentverket, KOV) is the Swedish government's central agency responsible for addressing consumer issues. Providing information to consumers regarding energy conservation is one of KOV's primary responsibilities. The board collects and distributes information on the energy consumption of household space-conditioning equipment and appliances. KOV also compares manufacturers' of such equipment and appliances energy efficiency claims with test results from agencies such as the National Testing Institute.

Although residential energy policies and programs were typically established and funded by the national government in Sweden, local government agencies played a central role in their implementation. Regional and local agencies are linked to the national government through the *Länsbostadsnämnd* which are the regional housing authorities within Bostadsstyrelsen. Local agencies, under the direction of the Länsbostadsnämnd, administer national grants and loans, ensure compliance with regulations such as the building code, and provide consultation and information services.

LEGISLATION

The first comprehensive national energy plan was adopted in Sweden in 1975. The primary goal in this plan was to limit national growth in total energy consumption to two percent/yr (average) through 1985. In addition to this goal, the energy plan called for reducing national dependence on oil, better planning for conservation of energy resources, and ultimately holding energy consumption at a constant level from the beginning of the 1990s. In addition to setting these goals, projections of future electricity supply requirements were made in the plan. The country was expected to need an additional 160 TWh of electricity by 1985. In order to meet this projected increase in electricity demand, hydroelectric capacity was to be expanded from 61 to 66 TWh. Plans for nuclear development were also expanded from a previously planned total of 53 TWh for 1985 to 63 TWh (+10 TWh).[133] Although no specific measures for space heating were prescribed, an assumption that energy consumption for space heating in homes could decrease 0.9 percent/yr was built into the two percent/yr target. This drop in energy consumption in residential buildings was to be achieved through: amendments of the Building Act and building statutes, and expansion of energy conservation subsidies. As part of this plan, an energy research program was established, which included studies of comfort in buildings.

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[133] Industridepartementet, 1975.

In 1979 a new national energy plan was adopted in response to the second oil crisis. In the new energy plan, establishing a reliable Swedish energy supply was heavily emphasized. The explicit goal of the 1979 plan was to introduce in the following two decades a new energy supply system that could meet the majority of the country's energy needs. This new energy supply system was to be based on the development of reliable, preferably renewable and domestic, energy sources that would have the fewest possible impacts on the environment and the lowest possible societal costs.[134]

Energy conservation played a key role in the ambitious plan. Large financial resources were to be applied to energy conservation efforts for the purpose of reducing overall energy demand. Energy conservation became part of the energy supply solution, largely because the 1979 plan required energy policy to address both energy conservation and supply. The 1979 energy plan also required adoption of both short- and long-term measures. In the long term, conservation and fuel switching to secure energy sources were central to the energy plan. Oil consumption was to be reduced greatly, through conservation, increased use of solid fuels, and the development and demonstration of new energy supply technologies that harness renewable energy sources such as solar radiation and wind. Experiments and evaluations of such technologies were called for in the new energy plan. Natural gas use, which had previously been very limited, was to increase. Measures to establish a more secure oil supply were also required.

Because a large portion of the national oil consumption was used to meet space-heating requirements, introducing alternative fuels for space heating was important. A large percentage of space-heating requirements were met with district heating. Burning alternative fuels in municipal district heating plants was expected, therefore, to play a large role in reducing Sweden's oil dependence.

The most recent national energy plan in Sweden was promulgated in 1985.† The government's goals of reducing dependence on oil, phasing out nuclear power, and developing new energy sources with low environmental impacts are restated in this energy plan. The primary methods for achieving these goals are identified as encouraging fuel switching, energy efficiency, energy R&D, and improving the market for renewable and alternative

[134] Bostadsdepartementet, 1980.

† A series of reports were published in Sweden in 1987 as supporting documentation for a proposed new energy plan in response to the 1986 Chernobyl nuclear accident. The primary change put forward in the proposed new plan was the advancement of the decommissioning of Swedish nuclear power plants by targeting two plants to be decommissioned by the mid 1990s. The remaining plants would still be decommissioned by 2010. As of this date, however, no official new energy plan has been passed by parliament.

energy sources.[135] The new plan emphasizes using information campaigns, advisory services, education, and pricing as the primary tools for encouraging households to improve the efficiency with which they use energy. In the 1985 energy plan, improving end-use efficiencies is depicted as the path to reduced dependency on nuclear power.[136]

Even before the first comprehensive energy plan was adopted in Sweden, improving the thermal characteristics of buildings, especially housing, was recognized as an important way to conserve energy. Because of the slow rate of new and replacement housing construction, retrofits were seen as necessary for affecting the overall energy use of the residential sector. In 1974 the first subsidies for investments in energy measures in housing were offered and funding for R&D on energy use in buildings increased.

In August 1976, the Swedish Parliament enjoined the Board of Planning and Construction to study the technical and economic feasibility of potential methods for conserving energy in existing buildings during the following ten years. The board was required to estimate the potential energy savings from implementing various conservation measures, to recommend specific measures to be promoted for achieving those savings, and to recommend methods of assuring that the measures were effectively carried out. The study was limited to buildings already slated for remodeling or in need of other maintenance.

The Ministry of Housing and Physical Planning performed an economic analysis of the reports submitted to them by the Board of Planning and Construction. The economic analysis was intended to address the parliamentary requirement that the scale of the Energy Conservation Plan be determined by economic profitability. The results of the economic analysis were published in a departmental memorandum, giving cost estimates of four conservation scenarios, including manpower requirements, total resource requirements, and economic profitability for each of the four cases. The method used for estimating the economic profitability of specific conservation measures was provided, with life-cycle cost calculations producing öre/kWh estimates. The memorandum was produced through a cooperative effort that included contributions from: the Ministry of Economic Affairs, the Ministry of Education and Cultural Affairs, the Ministry of Labor, and the Ministry of Industry. The National Board of Planning and Construction, the National Housing Board, the National Council for Building Research, and scientists from universities critiqued drafts of the memorandum.

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135 International Energy Agency, March 1987.

136 *ibid.*

Studies such as this one are an important part of the Swedish government's process of developing energy and energy conservation plans. The studies are used as a forum for exploring, analyzing, and debating the various alternative solutions to perceived problems and goals. The Swedish government also sponsors evaluations of programs in progress in order to "fine tune" them, and post-program evaluations so that knowledge gained through experience can be used in new programs.

As a result of the aforementioned study, parliament passed a bill which resulted in the improvement of subsidies for energy conservation in housing, public buildings, and government buildings.[137] In addition funds were provided to local authorities for energy conservation information and advisory services, funds were allocated for audits of existing buildings, and funding for research and certain information and training projects was increased. In December of the same year, an Energy Conservation Plan for Existing Buildings was submitted to Parliament by the Ministry of Housing and Physical Planning and later passed. The resulting Energy Conservation Plan was to be executed during a ten-year period, from 1978 to 1988, and was to be reviewed after three years. The goal of the plan was to reduce, through building retrofits, the total gross annual energy consumption of the 1978 building stock (including commercial and industrial buildings) by 39-48 TWh, or 25-30 percent by 1988. These savings were estimated to be equivalent to 3.4 to 4.1 million tons of oil per year.[138]

Costs to the nation of executing the plan were estimated at between 21 and 33 billion SEK over the ten years. Total investments were estimated to be between 31 and 48 billion SEK (at first-quarter, 1977 prices). The plan was designed to be implemented in stages: funding would grow from 1.8 billion SEK for fiscal year 1978-1979 to 2.7 billion SEK for fiscal year 1979-1980, and to 3.6 billion SEK for 1980-1981.[139]

A government task force was appointed to direct and coordinate the development, implementation, and evaluation of the Energy Conservation Plan. The task force was also responsible for developing specific goals to be achieved by the conservation program, and to provide a forum for discussion of the program and its impacts.[140] Local authorities received federal funding to implement the program. The largest share of this funding was budgeted for advisory and other services. Some of this funding was to be reduced later on and to be covered instead by fees for services such as audits.

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[137] Ministry of Housing and Physical Planning, Sweden, 1978.

[138] *ibid.*

[139] *ibid.*

[140] *ibid.*

As called for in the original Energy Conservation Plan, the programs for promoting retrofits in existing buildings were evaluated after three years by the energihushållningsdelegation (energy conservation delegation). This evaluation was seen as necessary because all retrofits were voluntary, and the government wanted to know if incentive programs were effective. The energy conservation delegation provided a long and detailed outline of suggestions for modifying the conservation programs implemented under the plan. These included new ideas regarding the role of local authorities in disseminating information and providing building audits, and several recommendations for modification of the building retrofit subsidy program affecting eligibility requirements, subsidized measures, and program administration.[141] These suggestions were the impetus for a broad range of changes that occurred in several programs including those for subsidized efficiency measures in building construction, local energy planning, and local information and advisory programs.

In 1981, parliament passed a bill adjusting the goals of the Energy Conservation Plan for Existing Buildings. The new bill called for reducing the energy consumption of the 1978 building stock by 48 TWh (gross) by 1988. This reduction was to be achieved through a 28 TWh reduction in the residential sector, 15 TWh in other non-industrial buildings (churches, hospitals, commercial buildings, etc.) and 5 TWh in industrial buildings, all with the minimum possible environmental impact and lowest possible public cost. Two programs were established to achieve this goal. One was intended to promote an overall reduction in energy use; the other was intended to encourage fuel switching. Both programs were intended to reduce the country's dependence on oil.[142]

REGULATIONS

Rationing

As part of the energy conservation campaign run by Energisparkommittén (see information section below), both gasoline and home heating oil were rationed in 1973 and 1974. Oil consumption in residences was rationed to 75 percent of an average normal "base" level. Actual consumption was controlled by the oil distribution companies (municipalities in many cases). Electricity consumption was also restricted.[143]

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141 Bostadsdepartementet, 1980.

142 Swedish Council for Building Research, 1985.

143 Bostadsdepartementet, 1980.

Standards for New Buildings

In 1973, Sweden had the most efficiently heated homes of any country in this study. Thermal requirements had been included in the Swedish building code since 1967 (although they were intended to address indoor climate and hygiene problems rather than energy efficiency). In 1976, strict energy efficiency requirements were added to the building code. These have been repeatedly strengthened, and the thermal quality of new Swedish homes has continuously improved.

The Swedish government utilizes a complex housing system with important links among institutions, industry professionals, and potential home buyers in order to implement building regulations. Many important links between the actors in the housing system were forged long before 1973. The political process in which changes in the building code in Sweden are debated includes a long period used for formal collection of written comments (''remissyttrande'') and for informal discussions. The formal written comments communicate the positions of various participants, and the informal discussions allow these participants to compromise. When the process is over, almost all participants agree to abide by the spirit and letter of the resulting building regulations.

Svensk Byggnorm 1967 (SBN67) was the first uniform national building code in Sweden. Previous regulations, known as BABS, had been promulgated as attachments to municipal building ordinances.† The thermal requirements in SBN67 and suggested values for thermal transmission of major components of SFD in subsequent versions of the Swedish building code are shown in Table 20. SBN67 was developed by the Royal Building Authority (Kungliga Byggnadsstyrelsen). After developing the code, the Royal Building Authority was replaced by the National Board of Physical Planning and Building (Statens Planverk, SPV), which published SBN67 as its first official act. Soon after, SPV began working on its own building code, and suggested that SBN67 be replaced. In 1975, SPV published its first building code. Like SBN67, however, SBN75 contained no energy requirements. The first energy requirements were passed as a supplement to SBN75 in 1976. Window specifications were added later the same year.

† Factory production became an important method of housing construction in Sweden in the 1960s. The unification of the building code made it easier for builders to apply industrial techniques to building construction.

Table 20. Component K-Values Suggested for Meeting the Swedish Residential Building Code Requirements
in W/m^2-°C for Single-Family Dwellings*

	WALL	ATTIC ROOF	FLOOR	WINDOWS (PANES)	SOURCE
Pre-1972**	0.69	0.39	0.43	3.0 (2)	SBN67
1977	0.3	0.2	0.30	2.0 (3)	Supplement to SBN75
1984***	0.17	0.12	0.20	2.0 (3)	ELAK

Although the U-values required in the supplement to SBN75 represented considerable reductions in thermal transmission from values stipulated in SBN67, they were already common practice for 80 percent of the construction industry when they were passed.† Ventilation recommendations in the code for maximum air leakage rates in different dwelling types, however, represented a major change in average building practices. In addition, the thermal transmission requirements for windows were reduced to levels that could only be satisfied by triple glazing, which was not commonly installed in new homes at the time.

SBN75 was designed, following a German model, as a performance standard. Thermal transmission values for building components were given in the code, however, as suggested methods of meeting the performance requirements (see Table 20). These suggestions included trade-offs among various components, which would produce comparable total design energy losses for the home.‡ Trade-offs were also allowed for the maximum window area requirement of 15 percent of the outer area of the floor on which the windows are installed. The thermal transmission requirements for the window panes, however, were absolute.

An important aspect of the performance nature of the code was that the entire building, including the heating equipment, was expected to function as a system. In keeping with this idea, requirements in the code extended beyond the building envelope. Maximum exhaust temperature values and minimum values of CO_2 produced in combustion were defined in

* Units shown are metric: R = (5.9/k).

** Actual practices (Schipper, *et al.*, 1985) were 0.35, 0.28, 0.30, and 2.7 in 1973.

*** Applies only to homes with electric-resistance heating.

† Finney, August 1988.

‡ Design energy losses were calculated using an equation of the form:
(energy required by house) = A + B * floor area
where A represented water heating requirements and B represented the overall transmission losses of the building envelope. The indoor temperature was assumed to be 20°C.

order to ensure minimum performance efficiencies for oil-burning boilers. Heating-system capacities were expected to be matched to the design heat losses of the building shell, both to save energy (by avoiding oversizing) and to insure that no space became too cold or moist (by avoiding undersizing). Heat-recovery systems were required in buildings with ventilation systems that exhausted over 50MWh/yr (180GJ/yr—in effect, for commercial and large apartment buildings). Insulation of distribution pipes was also required.

The energy performance requirements in SBN75 were designed to achieve energy efficiency without sacrificing comfort. The energy savings were intended to be achieved primarily by technological means, relieving building occupants of many small tasks they would otherwise have to carry out. Several requirements were included in the code that both encouraged and made possible simplified occupant control and maintenance of building systems in order to meet both the efficiency and comfort criteria. These requirements included installation of heat distribution systems that could be divided into separate subsystems to take into consideration different heating requirements in different parts of the building(s). Automatic night-setback temperature controls were required in SFD. Water heating energy use in apartments was to be individually metered to encourage building occupants to reduce their hot water consumption. Individual metering of energy used for space heating was not required, primarily because the available metering technologies were neither cost effective nor accurate enough. Operating instructions for heating systems had to be supplied to building owners.

The promulgation of the energy supplements to SBN75 was an important milestone in the regulation of the buildings sector in Sweden. The supplements established a breadth and form of energy requirements for the Swedish building standard and left room for revisions as technologies and construction methods improved. The supplements sharply increased the energy-related requirements for components already regulated in SBN67 and added new regulations for previously unregulated components and equipment. Although the impact of the new code on actual construction practices was considerably less than the changes in the building regulation indicate, the code communicated the message that energy concerns are an extremely important element of a building's design and function. The code also conveyed the concept that the building envelope and the equipment within it should function as a system, which is reflected in the fact that heating equipment, metering, and other requirements were established in the building code. In the other study countries, similar requirements were legislated in regulations separate from the building codes.

The development of SPV's next code—SBN80—was careful and labored. Six committees, representing a wide range of interests, studied the new code, in order to ensure that everyone would accept it. In the end, SBN80 made only very small amendments to SBN75. The only changes to the energy requirements of the code were that building slabs had to be insulated and that an air tightness requirement of 0.5 ACH was introduced (this value had previously been included in the code as a recommendation).[144]

[144] Finney, August 1988.

The Three-Mile Island nuclear accident in March, 1979, spurred public debate over nuclear power in Sweden. The passage of the Nuclear Referendum of 1980 requiring a phase-out of nuclear power by 2005 led to new concerns regarding residential space heating. Existing nuclear plants, in combination with hydro power, produced cheap electricity. Additional nuclear power stations that were yet to come on-line promised to provide surplus electricity thus magnifying this situation. Increases in oil prices had caused electric space heating to become relatively inexpensive, compared to burning oil. Policy makers feared this would lead homeowners to rely excessively on electricity for heating. Their concern was justified: between 1980 and 1985, nearly 300,000 SFD, almost 20 percent of all SFD, fuel switched from oil to electricity, and 80 percent or more of new SFD, as well as an increasing number of MFD were built with some form of electric space heating. By 1983, electricity was the most common space-heating source in all SFD, and by 1985 more than two thirds of all SFD had some form of electric heating for their principal or secondary heat source.[145] Electric space heating was becoming a problem.

In April 1980 the Electricity Use Committee (Elanvändnings Kommittén, ELAK) was formed to study the problem and to look for ways to temper the growing the demand for electricity in the residential sector. ELAK's primary concern was homes being built to use only electric resistance heat. For these homes, fuel switching at a later date would be impossible without expensive investments to convert the entire heating system.

ELAK proposed that new SFD built with electric resistance heating be insulated more than other homes. The new ELAK† code, passed in 1984, was designed to require enough extra insulation and/or other measures to produce design heating requirements that were 40 percent less than those of a similar home built to meet SBN80. These new requirements were intended to protect home buyers with no alternative to electric heating from possible increases in future electricity rates. The requirements were stated in performance terms, but an "approved solution" was supplied, as in the case of the normal SBN energy requirements (see Table 20). In addition to offering approved solutions to the ELAK requirements, Statens Planverk was responsible for the development of a special computer program, ENORM, that provided builders with a tool for estimating the heating requirements of houses to be built.

The ELAK code tackled several specific aspects of residential energy use. Because the very tight building envelopes called for in the code reduced natural ventilation levels, mechanical ventilation was required. Hot-water heatpump systems using exhaust air as a heat source met this requirement. ELAK also raised the minimum efficiency requirements of combustion equipment slightly. More importantly, ELAK addressed the fundamental issue

[145] Statistiska Centralbyrån, 1986.

† Elak means "nasty" in Swedish. To some observers, the name of the committee was aptly chosen.

that the concerns over nuclear power had raised—fuel switching capability in heating systems.

ELAK required that all combustion equipment in new homes be designed so that they could be converted to burn domestic solid fuels (mainly wood) without extensive rebuilding or additions. Systems that burned natural gas were exempted from this requirement. Furthermore, the code required that heating systems in electrically heated homes with hot-water heat distribution systems be sized to supply water with a maximum temperature of 55°C (conventional heating systems could produce much higher temperatures). This requirement provided fuel flexibility: homes with low-temperature heat distribution systems could be connected to low-temperature district heating networks or other sources of heat in the future. The ELAK code even required that oil-fired boilers be easily adaptable to electricity. By including requirements for flexibility as well as efficiency in the ELAK code, the Swedish government took an important step toward preparing the residential sector for an uncertain energy future.

When the ELAK code was proposed, it was not readily accepted by the building community because the requirements called for greater changes from common construction practices than previous codes had. Only about 20 percent of new SFD construction met the ELAK requirements when they were first proposed. Part of the resistance to new, more stringent, requirements was based on the fear that they would lead to significantly higher construction costs. This concern had been intensified by the fact that the Swedish home loan program represented a large and growing share of the total national budget. A careful study suggested, however, that energy-related measures had not been a determining factor in escalating construction costs. Nonetheless, implementation of the ELAK code was postponed for one year (from January 1, 1983 to January 1, 1984), to give construction companies (and researchers) more time to examine costs and potential problems associated with the code.

Despite the early opposition to ELAK from the construction industry, most factories and several site-building companies produced designs that incorporated the new ELAK requirements, and even exceeded them. Other companies decided to produce only homes with hydronic systems and multiple-fuel boilers, letting occupants choose their energy source. Such homes were only required to satisfy SBN80.† Still other companies did not want to build two kinds of homes, but wanted to sell homes with electric resistance heat. These companies offered homes that met ELAK requirements and that allowed buyers to choose either kind of heating system. Many buyers opted for the more efficient design, to save energy, and the hydronic system, to provide fuel flexibility.

† The extra costs of a multi-fueled boiler and a hot-water circulation system were roughly comparable to the extra costs of insulation and ventilation in an ELAK house.

One important problem did arise as air tightness became important for meeting the overall goals of the ELAK code: moisture build-up inside walls. Even with minimum ventilation requirements, not every space in every home was sufficiently ventilated (this problem was often aggravated by occupants who did not use ventilation systems that were provided). The moisture problem became a national scandal. In addition, flaws in construction, which were not critical to performance of homes built to the less stringent SBN80 standard, had a greater impact on the performance of ELAK homes. As a result of these problems, negative opinions about the ELAK requirements lingered for several years. Today, however, most builders can meet the ELAK requirements without the problems that were encountered when the code was new. The marketplace seems to have proven that ELAK was realistic.

SPV began to work on a new code to replace SBN80 in 1983. Efforts to introduce a new code, however, repeatedly met opposition. The first version of SPV's new code was flatly rejected by Parliament. In addition, in November 1984 new economic requirements were placed on future building code changes: SPV was required to prove that new measures called for in the building code would not increase the construction costs of new buildings. In the autumn of 1987 another new version of the code was rejected because it was too complicated—too technical. Parliament placed yet another requirement on SPV: regulations had to be easily understood and brief. The cost calculations made in the new code were approved, but the entire code failed the simplicity requirement.

In June, 1988 a new version of the code was accepted, and SBN89, took effect on January 1, 1989. In the new code, the special requirements for homes built with electric-resistance heating systems (ELAK) were extended: all homes are now required to be built at or above the old ELAK level. Previous building codes consisted both of specific requirements and of recommendations for meeting those requirements. In order to pass the simplicity requirement, SPV was forced to remove all of the recommendations; these have been published separately in a special handbook to help members of the building industry meet the code requirements.

Another important aspect of the new regulations is that municipalities must pay landowners not to build on their own property. Previously, municipal governments could simply forbid building, in order to avoid new municipal costs such as building and maintaining schools and sanitation systems. This change in the code addressed an issue that had been controversial for 20 years; it is part of the reason that the new code met political opposition before passing.

Standards for Existing Buildings

In 1982 and 1983, SPV worked toward fulfilling a government order to develop a code for existing buildings. The original proposal was built on the concept that every building should be as thermally efficient as a new building; however, problems arose in buildings that were being retrofitted. In some cases, the architectural character of older buildings was said to be damaged by retrofit projects. In other cases, cosmetic and other non-energy related changes were made under the auspices of energy conservation measures, increasing the cost of retrofits and not producing energy savings. Entire kitchens, for example, were torn out as a side-effect of the home improvement loan system. As a result of these problems, the the order to design a code for existing buildings was changed. Retrofit requirements were to address each building individually, maintaining the old building with only minor changes and without reference to the code for new buildings.

The change in attitude regarding the retrofit of existing buildings prevented SPV's recommendations from becoming law. The current requirement for existing buildings is caution. When a building is to be renovated, the building owner must apply for a building permit. At that time, a municipal representative discusses potential energy conservation measures with the building owner. In practice, consideration of such measures is abandoned immediately for economic reasons. The *process* however, requires that individual attention be paid to existing buildings.

Enforcement and Quality Control

Statens Planverk (SPV) certifies construction materials' durability and effectiveness and approves certain construction solutions. This generic certification is called ''typgodkaennande'' (type approval). In the type approval process, samples of each product are tested once by the National Testing Institute (Statens Provningsanstalt, SP), eliminating much onsite inspection time. SP has also developed widely accepted methods for testing the air tightness of buildings. In addition, Statens Planverk trains and certifies construction company employees (at the companies' expense) to inspect projects under construction and see that the code specifications are followed and met in actual construction.

SUBSIDIES

The Swedish government has succeeded in continuing to tighten already stringent thermal requirements in the building code, and the actual performance of new homes in Sweden has met or exceeded expectations, in part because of the unique Swedish national home loan system. This subsidy program relates financial incentives to the thermal requirements in the building code and encourages builders to exceed the code requirements. The home loan system has directly incorporated the building code requirements since the late 1950s for MFD and since 1964 for SFD. The loan system provides enough funds for all of the basic elements of a house, including those related to energy use and conservation. Essentially every requirement for saving energy is funded by the loans. Extra energy-saving equipment that is available and "approved" is also funded. Insulation beyond that required in the building code is also funded, in proportion to the decrease in the K-value obtained.†

The funding of energy conservation measures in new homes that exceeded the minimum requirements of the building code was a key element in acceptance of new codes in 1975-1976 and 1983-1984. The funding removed the barrier of higher first costs that had kept builders from developing new ways of saving energy (which had higher initial costs), and deterred banks and buyers from investing in measures to save energy. As a result of generous government funding, the thermal properties of new homes improved continuously throughout the 1970s and 1980s although the pace was slightly faster after the second oil price shock and the imposition of each new energy requirement. Because of this continuous trend of improvement, homes built immediately before 1973 were better insulated than was required by SBN67. The home loan system stimulated improvements in thermal insulation levels of new homes after the imposition of SBN75 as well. Because of these improvements, the drop in K-values required by ELAK in 1984 was, in actual practice, smaller than a comparison of SBN80 and ELAK would suggest (see Table 20). The relationship between requirements and incentives in Sweden is unique among the countries we have studied, and has been key to the acceptance and implementation of strengthened thermal requirements for new homes.

A system of special grants and loans for investments in energy conservation measures in buildings became available in Sweden in May, 1974. These special subsidies were offered in response to rising oil costs and were intended to cause rapid decreases in energy consumption for space heating.[146] The grants and loans offered through this program were paid for from the national budget and subsidized three general types of investments: improvement or replacement of heating and ventilation systems; conversion to district heating; and improvement of insulation of walls, windows, and roofs/ceilings. These retrofit measures were chosen based on cost-effectiveness criteria. Measures were required to be cost effective but not too cost effective: some measures were not subsidized because the existing financial incentive was considered to be strong enough, and costs low enough, that there was no need for support or financing.[147]

The original grants and loans were available to all single-family and multi-family building owners (vacation homes were excluded). Under the initial program provisions, retrofit work had to begin before January 1, 1976 but could not begin before the grant/loan was

† The actual formula takes the difference between the K-value in the code and the actual value chosen and multiplies it by the area of the wall times a constant that reflects the unit cost of insulation and studs. The loan amount increases with insulation thickness but only up to a point. The formula assures that excessive values for wall thickness are not funded.

[146] Byggforskningsrådet, 1984.

[147] Bostadsdepartementet, 1980.

approved. Only investments in measures affecting occupied space were eligible (basements and garages were excluded).

Grants: Grants for up to 2,000SEK/dw were offered to cover 35 percent of approved investment costs of no less than 1500SEK.

Special Energy Loans: In addition to the grants, interest-subsidized loans for up to 4,000SEK/dw were offered to cover 65 percent of approved investment costs. These loans were amortized in equal amounts over ten years. No security was required for the loans for SFD. Loans for more than 20,000SEK for MFD required security, however. Retirees (age 60+), handicapped persons, and members of low-income groups were eligible for interest-free loans of up to 6,000SEK. Because these interest-free loans were targeted at low-income households, they were need based; applicants had to prove that their income and capital were smaller than a designated maximum.

Grant and Loan Approval: Administration of the program was largely in the hands of local/regional housing authorities called länsbostadsnämnd. As part of the application process, building owners had to submit work plans to the länsbostadsnämnd for approval. Approval was granted to applications that demonstrated that approved measures would be carried out under "reasonable investment costs." Reasonable investment costs for specific measures were defined by local housing authorities, based on national average investment costs. Grants and loans were not mutually exclusive.

Home Improvement Loans: In order to accommodate residential building owners interested in investing in energy efficiency measures beyond those that could be paid for by the maximum special grant and loan amounts, the existing home loan system was expanded. Home improvement loans were offered to cover investments in energy-saving measures alone and/or in conjunction with other building remodeling. Building owners applying for these loans were still eligible for the 2,000SEK/dw special energy grant. The loans covered up to 90 percent of approved investment costs, with no loan ceiling. SFD loans were based on an interest rate of 6.5 percent, amortized over ten to 25 years. The interest rate fluctuated annually. Security was required for these loans in all cases.

The government's original expectations were that the special energy investment subsidy program would supply grants to approximately 20,000 dwelling units (approximately 0.6% of the total dwelling stock). The total estimated funds required for the grants and loans were 140 million SEK; however, applications for the grants and loans far exceeded the government's expectations. Early in 1975 experts from the National Housing Board estimated that 700 million SEK would be needed to fund the eligible grant and loan applications through December of 1975. Because of the overwhelming participation rate, the program was made permanent on May 1, 1975, canceling the originally planned expiration date of January 1, 1976. Several changes accompanied the extension of the program. To be sure that subsidized measures had adequate energy saving potentials, a list of specific eligible measures was published. This list differed for SFD and MFD. Minimum and maximum levels of insulation to be added were established, varying among four climate zones in Sweden. In addition, maximum levels of existing insulation were established, above which the addition of insulation was not subsidized. These specifications for subsidizing the addition of insulation were used to target homes that were built before 1950, and were, in general, poorly insulated in comparison with the newer building stock.[148]

The Swedish program of special grants and loans for energy-conserving retrofits in residential buildings is the best example we have of fine-tuning a program while it is in progress. The program underwent many changes during its lifetime. The list of investment measures subsidized under the program was repeatedly changed, as were the grant and loan ceilings and the percentage of investments these covered. Consumer response to the announcement of program changes was rapid and dramatic: for example, anticipation of the new more generous rules for fiscal year 1977-1978 caused participation in the program in 1976-1977 to drop significantly. The abolishment of subsidies for replacing oil-fired boilers in 1975 also contributed to this effect.

Between 1978 and 1980 the measures adopted by program participants shifted significantly; a big drop in the number of grants/loans going to insulation of exterior walls occurred and, in their place, subsidies for improvements to and replacements of heating and ventilation equipment (especially for the installation of heatpumps in SFD) increased. This shift was in part caused by changes in grant/loan rules, which reduced possibilities for getting subsidies for insulation of exterior walls by excluding homes that were already insulated to a certain level of insulation and increased subsidy allowances for heating and ventilation system improvements. These increases were aimed at stimulating the markets for heating systems that burned solid fuels and for heatpumps. Connections to district-heating grids were by far the most commonly subsidized measure in multi-family buildings. Insulation measures only became popular in multi-family buildings during the later stages of the subsidy program.

The program was gradually curtailed, beginning on June 30, 1979, when the interest subsidy on special energy loans was eliminated for SFD. On July 1, 1980, the national government special energy investment loan coverage was reduced from 100 to 30 percent of the approved investment costs (minus the 3,000 SEK grant). The remaining 70 percent was offered under priority loans from the National Mortgage Institute. This change was intended to shelter the state budget from the increasing financial demands of the grant and loan program. Also, as of December 15, 1980, labor costs for retrofit measures in SFD were approved only when the work was carried out professionally, eliminating the loophole

[148] Bostadsstyrelsen, 1975.

through which do-it-yourselfers had previously been able to qualify for labor cost subsidies.

On July 1, 1981, the special energy grants were abolished and the loan program underwent major revamping. Both single- and multi-family building owners responded to the announcement of this change with a flurry of applications sent in before the final deadline. Single-family home owners' interest in the subsidy program dropped significantly after the grants were discontinued. The participation of multi-family building owners, however, continued to increase.

On January 1, 1984, the entire special subsidy program for energy conserving retrofits in existing residential buildings was absorbed into the existing national home loan and housing improvement program. The loan subsidies for installing heatpumps were eliminated from that program in 1986.[149]

Because the special subsidy program allowed building owners to make multiple applications over the years, it is difficult to say anything meaningful about the number or nature of program participants. Shifts in the number of applications received during different periods of the program indicate, however, that adjustments to such factors as the size of the subsidies and the types of measures covered had significant impacts on program participation. The existence of the grant portion of the subsidy seemed to be a major determinant of program participation for single-family homeowners, but played less of a role for owners of multi-family buildings. In general, SFD owners responded more rapidly to changes in the program than MFD owners.

There are no real thorough analyses of the impact of the measures adopted under the program on aggregate energy consumption. A rough estimate is given in "Program för Energihushållning i Befintlig Bebyggelse: Betänkande från Energihushållningsdelegationen" of 2,900 GWh savings (gross) per year from subsidized measures in existing residential buildings (0.25 MTOE/yr). In the same report, ~50 percent of the reduction in energy use in dwellings for fiscal years 1977-1978, 1978-1979, and 1979-1980 is attributed to measures funded by subsidies and the rest to non-subsidized investments/measures.[150] That fraction roughly represents the the ratio of homeowners that invested in eligible measures without taking advantage of the subsidies to those who did so with the subsidies. In 1978, more than 530,000 measures were taken in SFD. Of those measures taken, 133,000 were eligible for subsidies. The rest were unspecified measures and window weatherization. Approximately 62,000 measures were subsidized; therefore, ~71,000 eligible measures were carried out without subsidies.[151]

149 Overholm, 1988.

150 Bostadsdepartementet, 1980.

151 *ibid.*

RESEARCH AND DEVELOPMENT

The national Swedish energy research and development program, entitled "Huvudprogram för Energiforskning" (Main Program for Energy R&D) was established in 1975 for the purpose of promoting and accelerating the development of both energy efficient technologies and new energy supplies. This program provides extensive national funding for energy-related R&D.

Main Program for Energy R&D
Fiscal Appropriations[152]
in current million SEK

1975-78	366
1978-81	835
1981-84	1400
1984-87	1190
1987-90	882

Approximately half of this funding supports energy supply research. A significant fraction of the remaining funds in each three-year funding period has been used to support building research aimed at both developing designs and technology to save heating energy, and evaluating actual experience with test houses.† These research funds are administered through the Swedish Council for Building Research (Byggforskningsrådet, BFR).

BFR is a national institution which is used to provide centralized coordination of research on buildings. There is no other example of a national institution of this scale devoted to building science in the countries we have studied. In this respect BFR is unique. The magnitude of research funded through BFR is also impressive (BFR's budget was approximately 308 million SEK for fiscal year 1981-1982 and 224 million SEK for fiscal year 1986-1987). In addition to the funds from the Main Program for Energy R&D, BFR receives and distributes funds from a building research fee paid by employers in the building industry, and special national funds for experimental building activities.

The private sector is actively involved in promoting better solutions to meeting the building code. For example, Rockwool and other insulation companies have carried out intensive R&D, built test homes, etc., to promote their business and learn how to reduce the

152 National Energy Administration, Sweden, 1988.

† In the Villa-80 experiment, for example, homes that satisfied SBN75 were compared with homes with less insulation. Seven pairs of homes, built by private companies, were studied to see which measures saved the most energy under actual operating conditions. Occupants were interviewed to estimate the impact of their behavior on the test results. The results were deemed useful in highlighting the importance of insulation, versus complicated heating systems, in providing economic and reliable energy savings.

cost of meeting thermal requirements. Demonstration is then linked to promotion. Some construction companies have tested and compared homes built before and after important changes in practices were made, in order to convince themselves, the authorities, and, of course, their customers, that the energy savings they have advertized were obtained. This publicity has in turn boosted the market for more efficient comfort, which in turn increases the acceptability of the building codes and their goals. These companies pay for such R&D, which is always related to the current or proposed building code, with both government support (usually from BFR) and their own funds.

PRICES AND TARIFFS

Residential electricity and district heating prices in Sweden are set by utilities.† In principle, state- and municipally owned utilities are non-profit organizations and are required to set rates based on production and distribution costs. State-owned utilities are required to pay an annual proceeds requirement to the national government. This fee is added to the utilities' marginal costs and thus influences customer rates. Each utility computes "costs" individually. Because of differences in computational methods, and because of actual differences in production and distribution costs, energy prices in general vary from region to region in Sweden. The actual variation in electricity prices is fairly small: most electric utilities follow the price setting lead of Vattenfall, Sweden's largest electric utility. Vattenfall is state-owned and produces half of the country's electrical power.‡ District heating rates, on the other hand, vary dramatically, with customers who are billed at the highest rates paying more than twice as much per kWh as those who are billed at the lowest rates.[153] Alternative rates for district heating are used when new plant facilities are being built or existing plants are being expanded, to keep initial/first costs from causing rates to rise above those for heating oil.

Although there are no nationally mandated rate structures in Sweden, in practice electricity and district-heating rates are constructed in the same way by all utilities. They are comprised of a fixed connection fee and a consumption fee. The fixed fee for district heating is based on the size of the heating system being supported. The consumption fee for both electricity and district heating comprises a fixed charge and a per kWh charge. Seasonal and hourly variations in the consumption fee for electricity have begun to be common throughout Sweden and are used for some district-heating rates as well.[154] Some electricity distributors offer reduced nighttime rates for the purpose of reducing daytime load peaks and "valley

† Oil prices are not controlled and follow the international oil market.

‡ Most of the municipal utilities in Sweden buy electricity rather than generating it themselves; they act as distributors to local consumers.

[153] Diczfalusy, 1987.

[154] *ibid.*

filling'' at night. Consumers can file grievances with the national electricity price regulating authority (prisregleringsnämnden) over issues regarding the fairness of rates.[155]

The national government in Sweden affects the overall prices paid by consumers for various energy products by manipulating energy taxes. In order to understand the current energy taxes in Sweden it is necessary to have some historical background.

From the 1940s until 1960, individual selective purchase taxes† were the most common form of product taxation in Sweden and were used to generate revenue. Selective purchase taxes affected a variety of products including tobacco, alcohol, and other ''luxury'' items. A general sales tax was also levied on some products. In 1960 the reach of the general sales tax was extended. Soon after, the entire issue of market taxation was taken up in the government and a unified consumption tax was explored. The new tax was expected to be a value added tax and to incorporate those items taxed under the sales tax. As a result of this investigation, a VAT was promulgated on January 1, 1969 to replace the previous sales tax.

Most of the products that were taxed with selective purchase taxes before the VAT was established in Sweden remained so after 1969, because one of the criteria for the design of the VAT was that it not lead to a sharp increase in the taxation of domestic product sales. As a result, most products that had been excluded from the general sales tax (including all energy products) were also excluded from the VAT.

The first general tax on *energy* in Sweden was promulgated in 1957 in the form of a selective purchase tax. This tax was applied to electricity, solid fuels, gasoline, ethanol, methanol, heating oil, and fuel oil. Domestic fuels (including peat and wood) have always been exempt from the general energy tax.‡ In 1964, the energy tax was broadened to include LPG used for motor vehicles.

The promulgation of the general energy tax in 1957 unified energy taxes. Separate taxes on gasoline, methanol, and ethanol had existed since 1929, and a tax on electricity had existed since 1951. The general energy tax remained relatively stable until the oil crisis in 1979. Since then there have been several significant increases in the tax rates on energy (1980, 1981, 1983, 1987), but the various energy sources have not been taxed equally. The largest increases have been applied to oil taxes.†‡ The first of these were clearly in response to the oil crises—an attempt to use taxation as an energy conservation policy tool. In 1981, the energy policy guidelines set forward by the Swedish government described taxation

155 *ibid.*

† A selective purchase tax is a tax on a specific product or set of products rather than an across-the-board tax on everything.

‡ They were, however, subject to value added tax from 1969 until 1983.

†‡ We have excluded taxes on gasoline—they have had the greatest increases—from our discussion, which is limited to energy sources used in the residential sector.

policy as the primary means of achieving the goal of reducing oil consumption by twelve million tonnes by 1990 (from 60% of energy supply to 40%). Taxation policy and conservation programs were intended to complement each other, although greater impacts were expected from the former.[156] In 1983, the Swedish parliament passed a bill that codified and broadened this policy. The bill called for energy taxation that encouraged fuel-switching away from oil and discouraged consumption. In addition the bill added requirements that the national balance of payments, energy supply security, employment, industrial development, and environmental impacts associated with the use of the various energy sources be taken into account in decisions regarding energy taxation. Consideration of the possibility of converting the general energy tax over to the VAT system was ended (at least for the time being - see below). Energy sources were to continue to be taxed with individual selective purchase taxes.

Although the trend in Sweden has been to tax energy products in a way that appears to follow the energy policy as it was stated in 1983, the *motivations* behind tax increases after 1983 are—unlike the Danish actions where a clear energy policy has been followed to the extreme—ambiguous. There is considerable debate in Sweden over whether the energy tax increases after 1983 were motivated *primarily* by energy conservation or revenue-generating demands.† Part of the reason for the lack of clarity may be the fact that decisions regarding the adjustment of energy taxes in Sweden are made in the Ministry of Finance rather than the Ministry of Environment and Energy. Regardless of the motivations behind the increases in energy taxes, the outcome has been to keep residential consumers' energy prices high, even after the oil price crash in 1985-1986. Decisions makers who believe in the conservation effects of high energy prices are likely to continue to support this taxation policy as efforts are made to replace the power generated by the nuclear industry.

Another important debate has been over whether or not energy products should be absorbed into the VAT system.‡ The "shoulds" and "shouldn'ts" of this debate are complex. However, the fact that energy has continued to be taxed separately rather than under the VAT system has enabled the government to easily manipulate energy taxes. Had this not been the case, the increases in taxes specifically on energy products would have required a revamping of the VAT system, or the establishment of new special taxes in addition to the VAT.

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[156] Energy Taxation Committee, Sweden, 1982.

† For an interesting argument, see "Moms på energi," Statens energiverk, Sweden, 1988.

‡ In 1979 the Swedish government gave an Energy Taxation Committee the task of exploring different ways of changing the energy tax and of describing the effects that could be expected. Incorporating the energy tax into the value added tax system was one of the criteria for acceptable proposals. The suggestions put forward by the committee in 1982 were criticized. As a result, the committee's findings did not lead to a change in the energy taxation system. The debate, however, continues. A new commission was appointed in 1987 to explore possibilities for incorporating energy taxes into the VAT system and supplementing them with selective taxes.

INFORMATION

The first two national energy conservation information campaigns in Sweden were carried out during 1973 and 1974 and were aimed at abating a crisis. Both were intended to produce short-term changes in the nation's energy consumption. One was a general campaign, administered by Överstyrelsen for ekonomisk försvar. The other specifically targeted electricity consumption and was run by Centrala Driftsledningen (CDL), later known as KRAFTSAM (Joint Council of the Major Swedish Electric Power Producers). CDL's electricity conservation campaign was carried out between November, 1973 and March, 1974. The campaign was begun because Swedish hydropower producers had experienced a dry year, which was made worse by an unusually cold winter that caused a heavy load on the electricity distribution net, and high oil prices (oil was used to back up the country's electricity supply, which was primarily hydro-based then). During the winter of 1973-1974, 20 percent of the electricity generated in Sweden was oil-based.[157]

In October, 1974, Energisparkommittén (ESK: the Energy Conservation Committee) was established to carry out an energy conservation campaign from December 1974 through April 1975. The committee was formed as part of the government's general change in tactic, moving from crisis intervention mode to the development of a distinct energy policy. The mandate creating ESK emphasized that the committee was to address energy conservation in general, not just oil conservation. And, although the mandate created the committee for a short period, the tasks and responsibilities defined for the committee were intended to encourage the adoption of measures that would produce sustainable energy conservation in the long term.[158]

ESK was made up of 15 members, including representatives of the ministries of Industry, Housing and Physical Planning, and Trade and was chaired by the Prime Minister's energy advisor (who was also the general director of Vattenfall).[159] Advisors to the committee represented a variety of government agencies as well as members of the business and construction communities. In June, 1975, parliament decided to maintain ESK and to expand its responsibilities. This decision came in conjunction with passage of the first national energy plan, and an effort to create a more permanent energy conservation policy.[160] ESK became the nation's central organization for disseminating information about energy. The primary task of the committee was planning and implementing energy conservation campaigns. The committee had several other ongoing responsibilities, including:

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[157] Vedung, 1986.

[158] Energisparkommittén, 1983.

[159] Vedung, 1986.

[160] Energisparkommittén, 1983.

- Supporting and coordinating the efforts of other authorities to disseminate energy-related information,
- Producing studies and information in support of legislation under consideration,
- Consulting with authorities and branch organizations in order to determine needs for expanding and speeding up the reporting/collection of energy consumption statistics,
- Together with Statens industriverk, following and analyzing energy consumption trends and making short-term forecasts of energy consumption,
- Studying possibilities for reducing energy consumption through technical and administrative measures.

In the beginning, ESK's campaigns were focused on general information to alter the public's energy-consuming behavior and to stimulate energy-saving investments.[161] ESK attempted to help household occupants reduce their energy use by increasing their knowledge/awareness of energy end uses and methods of saving energy. ESK information, therefore, contained both reasons for saving energy and technical methods for doing so. The three types of information that were central to ESK's campaigns were:

- Background information on the importance of conserving energy, from a societal perspective, including information on the environmental impacts of energy use, consequences of national dependence on imported oil, and the impact of that dependence on the nation's economy,
- Advantages, from private and commercial economic perspectives, of different energy-saving measures,
- Advice and suggestions on energy-saving measures and practical information for carrying them out.

This type of general information was distributed every winter from 1974-1975 through 1980-1981 by ESK in an attempt to motivate the public to save energy. Advertisements in newspapers, on billboards, on buses and on television were the primary vehicles for these campaigns. From the winter of 1975-1976 special brochures and leaflets were also used. These were aimed at target groups including SFD owners, owners and managers of multi-family buildings, tenants, tenant/owner group organizations, and car owners/drivers.[162] A magazine titled *Energy Conservation* was published four to six times per year starting in 1976, in order to reach special interest groups with influence on public opinion and decision makers.

In addition to carrying out general information campaigns, ESK was called upon by the parliament and various ministries to carry out several special campaigns with a variety of

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[161] *ibid.*
[162] *ibid.*

goals. One of these was the Seven Percent Campaign which was ordered by parliament on March 1, 1979. ESK was given two difficult tasks. The first was to reduce the nation's energy consumption by seven percent during the months of March through May (measured as 7% less than that of the previous year) by reducing the energy demand for space heating in buildings. The second was to evaluate the program's results. The latter was made especially challenging (or impossible) by two additional demands: the campaign was to start immediately and the evaluation was to be presented in preliminary form no later than May 15th, with a final report to be completed by the first of September. These dates eliminated any possibility of taking before and after measurements to help document the program's impact.

On March 5th, ESK went into action with an advertising blitz in all of the daily newspapers. While the program was in progress, several questions were added to ongoing opinion polls to try to gauge whether or not the campaign was influencing public opinion or behavior. There were no baseline data to compare with the results of the polls. Forty-nine percent of single-family homeowners polled, however, claimed to have reduced the indoor temperature of their homes. This was one of the main measures encouraged in the campaign. These responses may indicate that the campaign had some effect. Climate-corrected statistics of actual energy consumption in both single- and multi-family dwellings during the three months of the campaign indicate that the goal of a seven percent reduction in household energy consumption had been met in a significant fraction of the residential sector. There were significant savings made during the same period in the previous year as well, however. In all, the Seven Percent Campaign seems to have had some influence on the energy consuming behavior in residences. The extent to which the campaign was responsible for the savings during the three-month period, however, is unknown.

The general information campaigns aimed at broad energy consuming sectors gradually gave way to directed distribution of specific information. This information took on an instructive character, and demonstration material became an important part of ESK's work. The channels through which ESK distributed information also changed. Mass media advertisements were gradually de-emphasized and replaced with expositions, films, and brochures for select audiences. Cooperative work with other public and private organizations became important; experts and representatives from outside organizations participated in developing the committee's programs.[163] ESK made agreements with ~30 organizations in 1979 about which energy-saving measures should be promoted in which sectors. These organizations agreed to take responsibility for promoting some of the measures themselves.[164]

In 1979 ESK's national information efforts began to spread to local/regional levels. Local governments, under the Energy Conservation Plan for Existing Buildings, received

[163] *ibid.*

[164] *ibid.*

national funds to support advice/information/audit offices staffed with advisors who encouraged building owners to invest in energy-saving measures. ESK worked with local advisory offices, which incorporated ESK information materials in their services. ESK also supported local advisory offices by preparing special reports, organizing conferences, and consulting with local advisory employees. A special publication by ESK called "Meddelanden" was used to keep local advisors up-to-date on current issues.[165] Energy conservation buses manned with advisors from ESK made week-long visits to communities.[166]

In September, 1981 ESK was ordered to carry out a special information campaign in order to encourage owners and managers of multi-family buildings to adopt economically justifiable energy conservation measures. The campaign plans were presented in a press conference on October 23, 1981. The campaign activities outlined in that plan were carried out in January of 1982, and were to end in December, 1982.

The Multi-Family Housing Campaign is a good example of the developmental changes in ESK's information activities that are described above. The goal of the program—to produce long-term results through the adoption of energy conserving building retrofit measures—represented a big change from the goals of most of the earlier campaigns that aimed to produce short-term results through belt-tightening. Another difference from previous campaigns was the emphasis that was put on promoting only measures that were economically beneficial *for the consumer.* Although savings that benefited the community/society were still a goal, this goal was not verbalized in the campaign.[167]

The Multi-Family Housing Campaign's cooperative efforts between government and private institutions was important. ESK led the project, working with an advisory group that had representatives from SPV, Statens industriverk, BOS, and Kommunforbundet (the Swedish Association of Local Authorities—represents all kommuner) as well as a project group consisting of representatives of four housing organizations. HSB, Riksbyggen, Sveriges Fastighetsägares Riksforbund, and Sveriges Allmännyttiga Bostadsföretag represent more than 80 percent of all apartments in Sweden. They took primary responsibility for implementing the program by organizing local and regional conferences on energy conservation in multi-family buildings for their members, building owners and managers and other technical and decision-making personnel from related agencies. ESK oversaw their work by sending observers to all of the conferences. ESK information packets were used at the conferences along with each of the individual organizing institutions' information.

Between 1974 and 1982 ESK spent ~ 100 million SEK (in current SEK), roughly two-thirds of which went toward planning and implementing information programs.[168]

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165 *ibid.*

166 *ibid.*

167 Vedung, 1986.

168 Enegisparkommittén, 1983.

In July 1982, ESK's responsibilities for disseminating information were divided between BOS and Transportrådet (Swedish Board for Transport, TPR). ESK was disbanded completely on July 1, 1983 in conjunction with the creation of Statens energiverk (STEV). Half of the employees working under the Energisparkommittén moved into jobs in the information bureau of STEV.[169]

Although Energisparkommittén was responsible for distributing the majority of general information on energy conservation, many other agencies maintained information programs of their own, often linked to their own specific energy conservation programs. Information on subsidies that were available and eligibility requirements were provided by Bostadsstyrelsen. Bostadsstyrelsen and Statens planverk distributed information on standards, and regulations. Statens planverk also provided special training for professional groups interested in conserving energy in buildings. Information on measures for conserving energy in the industrial sector was provided by Statens industriverk. Since 1982, Konsumentverket has published the monthly magazine *Råd och Rön* (Advice and Findings) which gives information on the results of product tests performed at Statens Provningsanstalt. The energy efficiency of household appliances that have been tested is included in this publication.

Energisparkommitténs Annual Budget[170]

Fiscal Year	10e6 SEK
1974-75	4.7
1975-76	5.0
1976-77	5.3
1977-78	8.8
1978-79*	17.3
1979-80**	22.7
1980-81	17.0
1981-82***	17.7
Total	98.5

* including 2.5 in special funds
** including 6.4 in special funds
*** including 1.4 in special funds

In 1978, county governments began receiving national funds for establishing advisory services in their communities. Much of this money went toward providing home energy

169 Klingberg, August 1988.
170 *ibid.*

audits. In 223 out of a total of 279 kommuner (i.e., counties), audits were provided to homeowners upon request. In 156 of them, unsolicited audits were also offered to building owners. Government-employed auditors were used in 200 kommuner. The remainder used consultants or personnel hired in other job capacities. Of those kommuner with auditors, an average of 1.3 auditors/kommun were employed. Two thirds of the auditors had practical experience in construction. Fewer had practical experience in equipment installation. Audits required on average ~4 hours per SFD and 15 mins/apt in multi-family buildings.[171] During the fiscal years 1978-1979 through 1981-1982, 378 million SEK of national funding were spent on local information agencies (not including the cost of information materials provided by ESK). An additional ~90 million SEK of local funds were spent in such agencies during the same period.[172] The national funds that subsidized the community information/audit activities were eliminated on December 31, 1985. Although the intention of the program was to provide the impetus for local energy advisory services that would be run by the communities in the long term, most of the communities canceled their information services at that time. The national funding had been the critical link between the auditors and the communities. Most of the energy advisors took other jobs in local communities. Some of them went to work for municipal utilities. Only one third of the energy advisors who worked under the program are still energy advisors in communities today.[173]

One of the most important information programs implemented in Sweden, and the one information effort that can truly be seen as a program rather than a campaign, was the Energy-related Prototype and Demonstration Activities program (EPD) which was implemented from 1975 through 1982 as a cooperative effort between Bostadsstyrelsen, Byggforskningsrådet, and Bygginfo.† The EPD program began as a government-sponsored experiment in providing instruction in performing boiler adjustments. The first goal of the program was to produce ten-percent reductions in oil consumption by teaching building owners to carry out energy-saving adjustments to the air and flue dampers of boilers. The original experiment targeted property managers, boiler operators, chimney sweeps, and flue and conduit contractors.

Leadership for EPD came from a special EPD committee, comprised of representatives of the three institutions that initiated the program (BOS, BFR, Bygginfo), SPV, and Kommunforbundet. The latter was represented both directly by its own representative and indirectly by Byggtjänstföretag, of which it is partial owner. Several other institutions joined

[171] Bostadsdepartementet, 1980.

[172] Energisparkommittén, 1983.

[173] Klingberg, August 1988.

† Bygginfo was a private organization operated by Svensk Byggtjänst (Stockholm), Byggcentrum (Gothenburg), Skånsk Byggtjänst (Malmö), and Norrlands Byggtjänst (Umeå). These four organizations were in turn owned by branch and professional organizations of the construction industry.

the EPD program later, including representatives of ESK, Energihushållningsdelegation, and the Ministry of Industry. The program was implemented centrally through the energy department of Bygginfo.

The country was divided into five regions (north, middle 1, middle 2, west, and south) for implementation of the program. Six to eight instructors, each hired at 50 percent time, were hired in each region to give boiler maintenance seminars. At the beginning of each working season, instructors, who were professionals and engineers working in the field, were educated in both boiler maintenance techniques and teaching methods. Demonstrations took place in "EPD week"s in each region. Approximately 50 MFD owners and 200 SFD owners participated in each week long session.

Later the focus on boiler adjustments was expanded to include adjustments of entire heating systems, weather-stripping doors and windows, and adding insulation. Follow-up sessions to see if measures were adopted by workshop participants were held after the workshops. Measurements showed that an average of five percent savings were achieved in the boilers that were adjusted during the demonstrations. Of the boilers inspected in the demonstrations, 15 percent did not need adjustments, 25 percent were so bad that a adjustment could not help, and 60 percent were adjustable and needed adjustments.[174] During the first four years of the program (1975 - 1978), instructors visited 125 communities. About 25,000 people (~5 people/demonstration) participated in the program and about 10,000 boilers (including those of about 40 percent of the participants) were trimmed in demonstrations. Return visits showed that the remaining 60 percent of the participants' boilers were not getting trimmed, so the program developed EPD kits to leave in the communities so that participants could borrow them to trim their own boilers and might also do it with/for friends. Two hundred of these kits were left to be loaned out in approximately 110 localities. About 12,500 participants borrowed the kits and turned in reports of their results. Reported savings were somewhat higher than the five percent measured from demonstration adjustments.

In 1979, the EPD program turned over its demonstration and kit-loaning activities to community energy advisors, and began educating them. Local officials chose people to become EPD instructors. After the instructors were chosen (10-15 per community) they were educated by EPD in three-day seminars. About three weeks later, "EPD week" was implemented in each community with two days of information seminars and demonstration adjustments of approximately 30 boilers (first in special boiler rooms set up for demonstrations and after 1980 in houses of the program participants). Between 1982 and 1984 EPD published a quarterly magazine in order to spread the technical experience gained through the program amongst the local auditors.

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[174] Vedung, 1986.

SUMMARY

The Swedish government has used all of the traditional tools to encourage energy conservation in the residential sector. Essentially all of these efforts were focused on achieving two goals: ensuring the energy efficiency of the housing stock and equipment used to heat it, and encouraging fuel switching from oil to electricity. Residential energy conservation programs were used to achieve these goals by both encouraging investments in existing housing and influencing investments made in new housing. Heatpump sales seem to indicate that the government's influence in consumers' decision-making processes is strong.

Swedish construction standards for new buildings are by far the most demanding in world. The spurt of new housing construction in the late 1970s made the standards that much more important. But the building standards would not have been feasible without the home subsidies that provided funds for building homes of a quality that would otherwise have been unaffordable. The home subsidy program also contributed to the continuous stream of innovations in the construction industry that in many cases preceded the demands of the building code. National funds for R&D contributed to this development as well. By promising to cancel loans for projects that did not produce expected energy savings, the government eliminated the economic risk involved in testing experimental designs and technologies. National R&D funds for technology development helped to bring new products, such as residential heatpumps, onto the market.

These programs were implemented simultaneously in a market affected by dramatic increases in oil prices and low electricity prices. Taxation policies were used to accentuate these market trends, discouraging oil use and encouraging fuel switching to electricity. The relative costs of home heating oil and electricity were most important between 1981 and 1985, a period during which a large percentage of the residential sector switched to electricity for space and hot-water heating.

Most of the efforts to affect household energy consumption were aimed at the building stock. Appliances and behavior were largely ignored (exception by ESK's information campaigns). Tools for providing information to encourage behavior (both habit and investment) changes, such as mandatory individual heat-metering in multi-family buildings, appliance labeling, and detailed billing for energy consumed (the state-owned utility Vattenfall could have provided leadership in this area) were not used.

CONCLUSION

The comprehensiveness of the Swedish residential energy conservation programs in the area of building efficiency is notable. At the same time it made quantitative evaluations of any particular program or tool impossible. Nevertheless, the numbers that describe Swedish household energy consumption tell a story. Despite highly saturated household energy end uses and an extreme climate, household energy consumption in Sweden was low in 1973 compared to consumption in the other study countries and managed to decrease during the period between 1973 and 1986. There is no evidence to show that this resulted from belt-tightening or a reduction in the energy services provided in the sector. Improved efficiency is clearly the cause. The long-standing government interest in quality housing provided an infrastructure for making the reductions possible.

The government's ability to use that infrastructure by adding on to existing programs was important to the residential energy conservation programs. The adaptation of the building regulations and the home subsidy program are examples of this strategy. The same two programs can be used to demonstrate the remarkable level of coordination of the residential programs, despite the fact that there was no apparent centralizing force, like the AFME in France or the Energy Conservation Law in Japan, to tie them together. The consistent consultation with groups whos members represented a cross section of government and private interests in the development programs is the feature that seems to have produced this result. Nationally originating efforts to start new programs where infrastructures did not already exist were less successful. Attempts to instigate regional energy planning and local advisory/information programs provide good examples: in both cases the programs did not survive without national funds.

The public response to programs and program changes was rapid. The participation data on the special program of subsidies for energy conserving retrofits in existing housing, as the program went through many alterations, is the most dramatic example of this. This is clearly evidence of the government's ability to reach people with information. Although no equally dramatic evidence exists to show the impact of the general information programs, the data showing almost equal amounts of retrofit activity with and without subsidies could be seen as an indication that people received both the message that they should do something and the messages about what to do. Distinguishing the responses to government information from responses to price is, however, not possible.

Both savings and fuel switching between 1973 and 1986 were significant. Petroleum products' share of TPE was reduced from 73 percent in 1973 to 50 percent in 1986. This was mostly a result of fuel switching for end-uses rather than fuel-switching within electricity supply. The steady decrease in space-heating energy requirements in new single- and multi-family dwellings built in successive years from the early 1970s is well documented. Overall, household energy consumption dropped from 116.8 GJ/dwelling in 1972 to 92.2 GJ/dwelling in 1983 (21% decrease),† while the percentage of homes heated with electricity increased from 6.7 percent in 1973 to 27.3 precent in 1986.

† These values are climate corrected.

WEST GERMANY

BACKGROUND

During the 1960s the West German energy supply structure was in transition: imported oil was replacing domestic coal as the dominant energy source, and total energy consumption was climbing. The share of total primary energy (TPE) supplied by burning coal dropped from 75 percent in 1960 to 31 percent in 1973. Because coal is unsuitable for many of the end uses that induced the growth in energy demand during the period, and because extracting domestic hard coal was expensive, the trend away from coal was irreversible. Oil consumption increased, accounting for 55 percent of the total primary energy in 1973, up from 21 percent in 1960. With virtually no domestic oil sources, West Germany imported oil, 96 percent of which came from Middle Eastern countries in 1973. Natural gas consumption grew to 10 percent of TPE, supplied mostly by western european countries. Nuclear power had recently entered the picture and was supplying only one percent of TPE. Hydroelectrical resources produced a steady supply of approximately 5 MTOE per year (~2 percent in 1973), but there was no room for expansion.[175]

The escalation of oil prices in 1973 brought to the attention of West German policymakers the need to diversify the country's energy supply portfolio, both in terms of the types of fuels used and fuel sources. Market forces provided incentives for such diversification. The West German government established a policy acknowledging the power of the market, and determined to eliminate any barriers inhibiting its functioning to the fullest. At the same time, the government decided to encourage the use of domestic coal supplies by mandating that a given amount of power production be produced by domestic coal, and by subsidizing coal costs to iron and steel industries. The extra costs associated with using expensive West German hard coal in the steel and iron industries were and are borne by the state and federal governments. Increased electricity production costs have been shifted to consumers in the form of a 7.5 percent tax on electricity consumption. In 1985, 95 percent of the oil consumed in West Germany was imported, but only 60 percent came from the Middle East and 12 percent came from the North Sea. Eighty percent of electricity was being generated with domestic coal and uranium. Nuclear power plants accounted for eight percent of TPE in 1984, and natural gas was supplying 15 percent.[176] During the past three years, the political influence of the Green Party, which opposes nuclear power, has grown. This may inhibit future growth of nuclear power in Germany.

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[175] Röhling and Mohnfeld, 1985.

[176] *ibid.*

Residential energy consumption accounted for 29 percent of the total energy delivered in West Germany in 1973, second to industry, which accounted for 38 percent. Eighty-four percent of residential energy consumption went toward space-heating, and nine percent of the rest was used for heating water. Sixty percent of residential delivered energy was supplied using oil. Electrical appliances produced a relatively small share of the overall load. The refrigerator market was already saturated in 1973, but refrigerators' share of consumption continued to increase, which is one indication that they were increasing in size (old refrigerators may also have been plugged in in basements and "replaced" with new ones in the kitchen). The other major appliances had reached high saturation levels by 1982.[177]

The federal government's residential energy policy reflected the same general ideology as its broader energy policy. The government's goal was to seek out and eliminate market failures and to allow market prices to determine demand. Intervention, in the form of laws, subsidies, and information programs, was aimed at achieving this goal.

SIGNIFICANT INSTITUTIONS AND ORGANIZATIONS

National West German energy policy development takes place in a *Special Cabinet Committee on Energy,* which is responsible for energy policy review, evaluation, and (when necessary) revision (see Figure 6).

In keeping with the idea that the government should only intervene when the market fails and that the economy should otherwise be allowed to determine energy as well as other consumption matters, the *Federal Ministry of Economic Affairs* is responsible for establishing and administering German national energy conservation programs. The ministry acts under review and guidance from the Special Cabinet Committee on Energy. Although federal ministries in general have equal power, the Ministry of Economic Affairs leads, directs, and coordinates the conservation efforts of all other ministries.

The Federal Ministry of Research and Technology is responsible for R&D policy, administration, and evaluation. In addition, the ministry runs the *Nuclear Research Center,* where research and development projects in a variety of energy areas, including conservation, are carried out.

[177] Hildebrandt and Joerges, 1983.

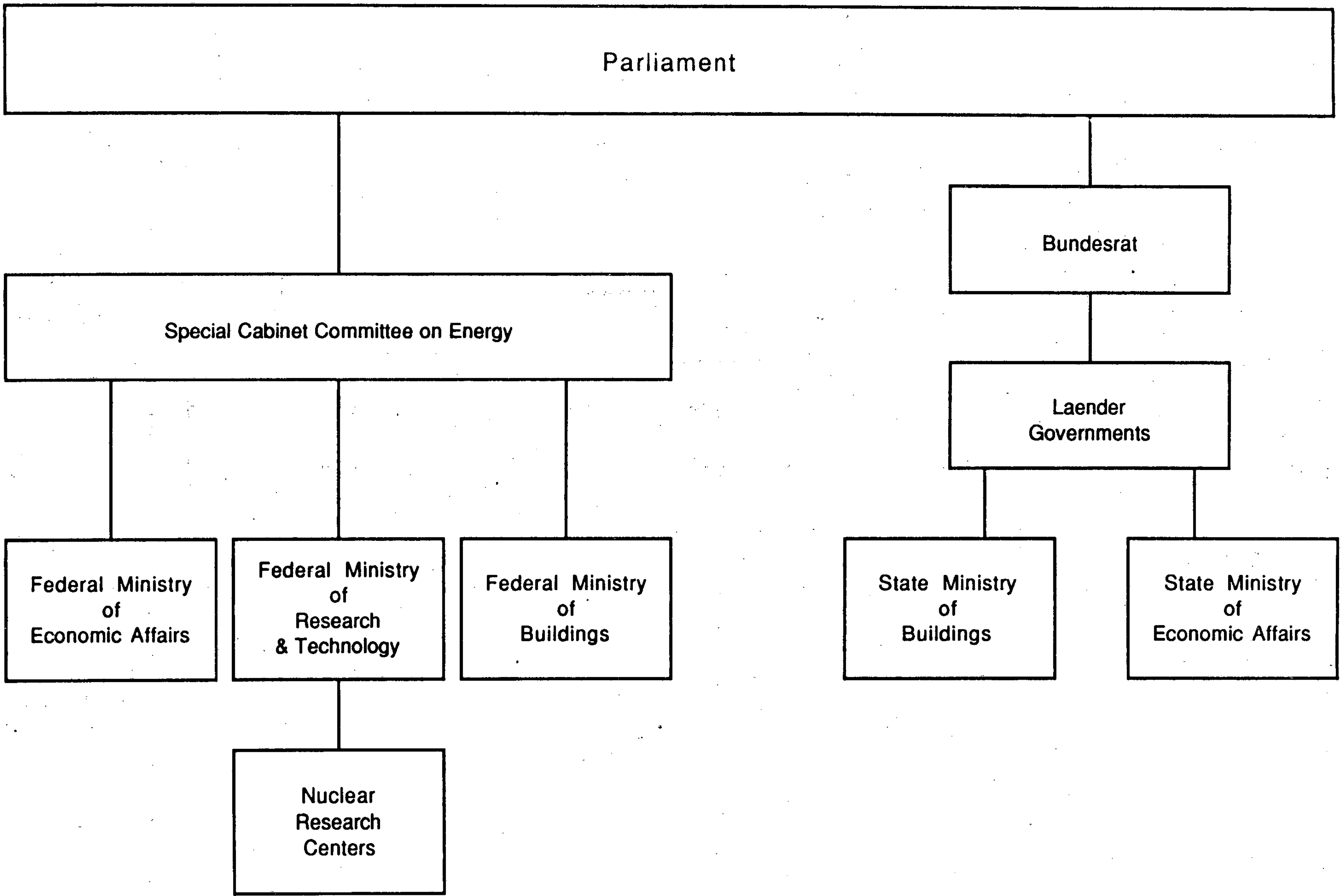

Figure 6
WEST GERMANY

The Federal Ministry of Buildings, under guidance from the Federal Ministry of Economic Affairs, established and periodically updates the national building standards. The ministry also shares with the Federal Ministry of Finance responsibility for controlling energy conservation investments in all federally owned buildings.

Regional ministries, which form the institutional structure of the *Länder* † governments, fulfill similar functions to those of the federal ministries. The *Bundesrat* ‡ is responsible for coordinating and monitoring the efforts of the Länder and federal governments. The Bundesrat therefore must approve the funding for all joint projects between the Länder and the Federal Ministry of Economic Affairs.

LEGISLATION

The official West German energy policy has been published since 1973 as the "Energy Policy Programme." This publication, which has been revised several times, provides the authority and guidelines for actions to be taken by the federal ministries, and calls for the involvement of industry and consumer organizations in policy and program development and implementation. Government goals are defined and prioritized, with emphasis on reducing the share of primary energy met by oil, diversification of energy import sources, promotion of energy conservation, and reduction of the negative environmental impacts resulting from energy use.

The federal government's role in achieving these goals is to: 1. allow the market function unhampered, 2. act to correct market failures/imperfections, and 3. act to stimulate programs which will be implemented, maintained, and developed further at the regional level. In the later versions of the "Energy Policy Programme," energy conservation is seen as having an important role in contributing to environmental protection as well as reducing the requirements for costly fossil fuels.

† Länder are regions with individual governments, similar to states in the USA.

‡ The Bundesrat is a body of Länder representatives similar to the Congress of the USA.

LAWS ESTABLISHING POLICY

The Energy Conservation Act (EnEg)† of July 22, 1976 gave the federal government the power to pass regulations establishing thermal requirements for the construction of new buildings, and efficiency and operating standards for space-heating, air-conditioning, and water-heating equipment. The act was amended in June, 1980, giving the government power to require individual, consumption-based billing for heating in multi-family dwellings and to establish minimum thermal insulation and heating equipment requirements in existing buildings. Based on the powers granted by this act, the federal government passed several laws, described in detail below.

The Modernization and Energy Conservation Act (ModEnG) was passed in July, 1978. This act provides the legal framework for instituting programs designed to subsidize retrofits that bring existing residential buildings up to the current building standard. The ModEnG was intended to work together with the EnEg. It established a program package through which subsidies were provided, using the regulations resulting from the EnEg as a basis for determining eligibility. The concepts of the act were brought to bear in the Bund-Länder-Programm described below. In practice, the act worked as a model from which the Länder governments produced spin-off energy conservation programs addressing needs particular to their individual communities. Two examples of such spin-off programs were; 1. the modernization program in Berlin, where special grants were made available to tenants in low-income areas, and 2. the Baden-Württenberg "Energy Conservation Program," which was aimed primarily at industry but provided low-interest loans to supplement national subsidies for energy conservation investments by homeowners.

The Income Tax Act (EStG) is part of the Income Tax Executive Order, passed in November, 1978. This act defines the legal structure for two types of tax incentives: depreciation deductions that could be taken without participation in a special program and special incentives like those provided under the Bund-Länder-Programm, which were available through June 30, 1983. The 1984 Tax Relief Act, passed on December 22, 1983, extended the availability of tax deductions for energy-related investments in owner-occupied homes through 1986, but restricted the eligible measures to installation of heatpumps, solar energy systems, heat-recovery equipment, wind power systems, biogas systems, and, under some circumstances, connections to district heating networks.[178] This extension of the tax incentives was a replacement of the subsidies that were previously available under the Bund-

† EnEg is an abbreviation of the German name for the act. Similar abbreviations for other acts are indicated in the text that follows. Equivalent full German names are found in Appendix A.

[178] Ministry of Economics, West Germany, 1984.

Länder-Programm.[179] In July, 1985, a new tax rebate program for modernizing heating equipment in owner-occupied dwellings was initiated.[180] These tax incentives are still offered, and are scheduled to continue to be available through 1991.

REGULATIONS

Standards for New Buildings

The Thermal Protection Regulation (WschV), was passed on August 11, 1977 and came into effect on November 1, 1977. This regulation lays out construction standards for all new residential buildings. The regulations were revised twice, in February, 1982, and again to take effect January 1, 1984. The latest revision resulted in more stringent thermal requirements for the construction of new buildings and for existing buildings that are being renovated (the latter includes cases in which one or more heated rooms are to be added and in which walls and/or ceilings adjoining heated and unheated spaces are to be replaced). The current standard requires that new residential buildings attain a given U_m value for the entire building envelope. The Federal Ministry of Economic Affairs publishes recommended k-values ($W/m^{2\circ}K$) for walls, roofs, and floors, which can be used to meet the overall building U_m value. These k-values range from 2.25 to 0.51 for floors, 0.53 to 0.37 for roofs, and go down to 0.36 for walls.[181] Double-pane windows are recommended. Local building authorities are responsible for enforcing the standard.

Operating Standards for Space Heating and Hot Water Production

The Regulation for the Management of Heating (HeizBetrV) was passed on September 22, 1978, and came into effect on October 1, 1978. The regulation requires monthly inspections and maintenance of all boilers with greater than 50-kW capacity. Due to this size stipulation, only large multi-family buildings were affected by the regulation. The law was amended in 1982, and the 50-kW lower limit was removed. The regulation now applies to all boilers, and compliance is monitored by: 1. chimney sweeps for boilers < 1MW; 2. regional authorities (Länder) for boilers > 1MW.

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179 International Energy Agency, 1987.

180 *ibid.*

181 Bundesministerium für Wirtschaft, 1983.

Standards for New Boilers and Hot Water Production

The 1978 Heating Equipment Regulation (HeizAnlV), amended in February 1982, gives efficiency standards for all new boilers with capacities greater than 4kW. In some cases, the revised version of the regulation applies to existing equipment. Local building authorities are responsible for enforcing the standard.

Individual Heat Metering in Multi-family Buildings

The Heating Costs Regulation (HeizkostenV) was passed on February 23, 1981 and came into effect on July 1, 1981 for all new buildings, requiring the installation of individual metering in new multi-family buildings and retrofit installation of meters in existing multi-family buildings. All affected existing buildings were required to comply with the regulation by June 30, 1984. There is no official controlling authority for this regulation. Instead the government expected that tenants would report building owners who did not comply with the law.

Note: Exceptions were granted for cases that would have required exorbitant investment costs, and for buildings with solar or waste-heat sources.

Regulation for Consumption-based Billing of Heating Costs

This regulation went into effect on June 22, 1979, requiring consumption-based billing of heating costs in all price-controlled and publicly assisted housing. This law was intended to set a precedent for and demonstrate the feasibility of consumption-based billing in private housing.

Heating Cost Regulation

Since February, 1981, consumption-based billing of heating costs in all privately financed housing units has been required.

Regulation on the Billing of Heating Costs

This regulation went into effect in 1984, requiring that between 50 and 70 percent of heating costs in all private housing units be billed in relationship to actual consumption.

Note: Without individual heat metering, this law would obviously have been impossible to implement.[182]

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182 Ministry of Economics, West Germany, 1984.

Appliance Labeling

A voluntary system for labeling household appliances with data on energy consumption was established in 1976. The program was intended to improve market transparency. Appliances currently covered by the program are electric and gas-fired ovens, refrigerators, and dishwashers. Imported appliances are not labeled, so their efficiencies are not provided to consumers shopping in the German market.

Appliance Efficiency Standards

There are no regulations determining appliance standards in Germany. Instead, on January 24, 1980, the Federal Minister of Economic Affairs extracted from manufacturers of household appliances a "Gentlemen's Agreement" to improve the efficiency of specific energy intensive products by up to 20 percent by 1985. The appliance efficiency goals have been increased voluntarily twice since 1980 by the appliance industry, in order to avoid government regulation. Measured reductions in energy consumption for German appliances in 1985 (over the 1978 values) were 27.7 percent for refrigerators, 17.6 percent for clothes washers, 28.9 percent for dishwashers, and 15.7 percent for electric ovens.[183] These efficiency improvements represent decreases in average annual consumption of a variety of models, weighted by the actual numbers and models of appliances sold.

PRICES AND TARIFFS

The German government has consistently followed a policy of non-interference with the energy market and has avoided regulating fuel prices. This policy was followed both when oil prices escalated in the early and late 1970s and during/after the oil price crash of 1986. Taxes are used, however, both for revenue generation and to support the German coal industry. All residential energy sources are subject to the 14 percent general VAT. Residential electricity customers pay an additional special electricity tax. The revenues from this tax are used to subsidize electricity generation in plants burning domestic coal, for which the price is higher than that of imported coal and/or oil. The amount of the tax varies by region and over time, but averaged approximately five percent between 1976 and May 1987. In June, 1987 the average special electricity tax rose to 7.5 percent.[184]

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[183] ZVEI, 1987.

[184] International Energy Agency, 1988a.

The Regulation for the National Electricity Rates (BTOElt), passed on January 1, 1974, codified the electricity pricing system for private consumers that had been in practice since the end of World War II. Under this system there are two tariffs, each consisting of a fixed charge based on the number of rooms in a dwelling and a commodity charge based on actual consumption. Tariff 1 has a lower fixed charge and a higher commodity charge than tariff 2. Although the actual commodity charges vary from region to region, tariff 1 and tariff 2 commodity charges always differ by 3 Pf/kWh within regions. One of the two tariffs is assigned to specific dwellings when electricity service is initiated. The choice between tariffs is based on the household's estimated future electricity consumption. The customer, however, is guaranteed to pay the lowest total annual price: at the end of each year, each customer's consumption is evaluated under both tariffs and a refund is issued if he/she has paid more than the smaller of the two costs. Total annual expenditures are paid in 12 averaged monthly installments. Because of this, customers do not see fluctuations in electricity prices that result from changing prices for the fuels used for electricity generation.[185] In addition to the two basic tariffs, there are two special tariffs. Customers who use less than 500kWh/yr (this usually applies to vacation homes) pay no fixed charge but pay a commodity charge that is approximately four times the average under the normal tariff system. Customers with electric heat storage systems can opt for an interruptable nighttime rate, with a fixed charge, and a commodity charge that is approximately half of the average commodity charge under the normal tariff system. This rate was established for the purpose of improving utility load factors by valley-filling at night.

SUBSIDIES

The "Bund-Länder-Programm," (also known as the "4.35 Billion DM Program"), established in 1978, provided grants and tax incentives for retrofits of owner-occupied dwellings. The program was aimed at providing subsidies for investments in energy conservation measures that would reduce energy consumption for space and hot-water heating. The program was intended to correct a market failure produced by the short-term view inherent in typical residential investment decisions. The legal framework for the program was provided by the ModEnG and EStG laws. The program was run jointly by the federal and state, or Länder, governments. The Länder funded 50 percent of the subsidies that were distributed in the form of grants. The federal government funded the remaining 50 percent of the grants and made up for the total revenue loss from tax deductions. Funds for both cases were provided

[185] Brand, 1988.

by diverting tax revenues.

Under the program, participants were allowed to choose between a grant and a tax deduction. Owner-occupants of dwellings built before 1978 were eligible for the grant/tax deduction for thermal improvements to the building envelope and/or improvements of heating systems. All owner-occupants were eligible for the grant/tax deduction for the installation of solar appliances, heatpumps, heat-recovery systems, and connections to district-heating grids. In order to qualify for either the grant or the tax deduction, owners were required to comply with regulations enforced under the auspices of the EnEg.[186]

The grant covered 25 percent of the costs associated with eligible investments costing between 4,000 and 12,000 DM per dwelling. Tax deductions of 10 percent of the investment costs, to be taken repeatedly over 10 years, replaced the normal tax deduction of two to five percent. In the case of the tax deduction there were no upper or lower limits on the investment amount. Applications to the tax portion of the program were to be made by no later than June 30, 1983.

The total government allocation for the grants (state and federal) was 2.34 billion DM. This amount was to be distributed on a first-come, first-served basis until the funds were exhausted. In 1978, 420 million DM of the funds for grants were distributed; the remaining amount was distributed in equal amounts between 1979 and 1982. The average subsidy was 2,881 DM per dwelling among the 1.51 million dwellings that took advantage of the grants.

There was no upper limit on the total government budget for the tax deductions. As of December 1982, 1.75 billion DM in tax deductions had been granted for retrofits of 0.92 million dwellings. The average deduction was 1,902 DM per dwelling.

The total government expenditure for the program, as of December 1982, was 4.35 billion DM distributed among 3.43 million homes. Most of the grants (92%) were used for improvements of the building envelope, with 77 percent of these going toward investments in double-glazed windows. The next largest portion of the funding was for improvements to heating systems (9%).[187]

INFORMATION

Although several of the federal ministries are responsible for publishing and distributing information regarding energy conservation in the residential sector, the Ministry of

[186] *ibid.*

[187] Fraunhofer Institute for Systems and Innovation Research, 1982, Annex.

Economic Affairs has been especially active in this area. It began providing such information in 1977 with the help of the Federal Press and Information Office, which is responsible for implementing and administrating the ministry's information activities. The ministry has used distribution of its own publications, radio and television spots, and public relations in the schools and commercial organizations as tools for reaching the public. The focus of the information disseminated has varied from general (stressing energy consciousness) to very specific (addressing individual issues and technologies like weather stripping and boiler maintenance).

Between 1978 and 1980, the Federal Ministry of Economic Affairs published a series of eight brochures on "problem areas concerning energy"[188] as part of their Bürger-Service (Citizen Service). Each brochure addressed a different subject and was aimed at a different target group. The brochures were distributed in energy information packets that were available, free of charge, upon request and at trade fairs and workshops. Comprehensive information on grants was also provided in the packets. The brochures were advertised in newspapers, on radio, and on television. Publications by the Stiftung Warentest (see below) also advertised the brochures.

In addition to distributing its own publications, the Ministry of Economic Affairs provides the primary funding for residential energy conservation projects within four organizations designed to meet specific information needs of consumers. In this way, the ministry delegates some of its information work, while maintaining control over the use of its budget. In more than one case, the government has taken advantage of existing organizations and thus avoided developing entirely new institutions. The organizations are run by boards whose members represent various factions of the community. The following is a description of those four organizations.

The *Stiftung Warentest* is a well-established independent foundation that evaluates a variety of products and services and publishes its findings in a monthly magazine and annual yearbook called *Test* (similar to the monthly magazine *Consumer Reports*). Special issues are also published intermittently. The Stiftung Warentest arranges seminars, provides information to educational institutions, and uses mass media to disseminate information.

In 1978 the Federal Ministry of Economic Affairs began providing special funds, allocated as part of the Bund-Länder-Programm, to the foundation. In exchange for this funding, the Stiftung Warentest performs specific tests related to the energy consumption and energy conservation factors associated with products such as space- and water-heating equipment,

[188] Hildebrandt and Joerges, 1983.

home insulation, and home appliances, and publishes the results in *Test.* By funding the Stiftung Warentest, the Ministry of Economic Affairs gained partial control over the content of *Test.*

The *Arbeitsgemeinschaft der Verbraucher* (AgV) is an association of approximately 300 organizations concerned with consumer interests.[189] The goal of the AgV is to strengthen the role of consumers in the economy by helping them to participate effectively in the marketplace. The primary function of the AgV has been to provide information and legal services to consumers.

In 1978 the Federal Ministry of Economic Affairs established a consumer energy advisory program that was implemented by the AgV and funded through the Bund-Länder-Programm. The goal of the program was to guide and stimulate consumer decisions regarding energy related investments. The Ministry of Economic Affairs selected topics covered by AgV energy advisory programs to complement the product testing done by the Stiftung Warentest. The AgV used Stiftung Warentest publications extensively when it counseled consumers about energy-related investments.

The AgV directs 11 regional bodies called Verbraucherzentralen der Länder, which implement the AgV's policies and administer local service centers. As of 1982, there were 120 such service centers contract with 150 professional advisors/consultants. In October of the same year, the AgV began to fund a mobile energy counseling service to reach consumers in rural areas.

The *Stiftung Verbraucherinstitut* develops and provides information and training to people and organizations who are links in the consumer information chain. Benefactors of the institute's services include professional consultants, educational institutions, journalists, teachers, etc.

As mentioned previously, information programs were carried out by several federal ministries in addition to the Ministry of Economic Affairs. An example of a publication from one program was a supplement to the Bürger-Service series, published jointly by the Federal Press and Information Office and the Federal Ministry for Regional Planning, Building, and Urban Development in 1980. The supplement was entitled, ''Energiesparbuch für das Eigenheim'' (''Energy Savings Book for the Homeowner''). It covered a wide range of household energy issues, including an explanation of the federal government's position on the Energy Conservation Act, the Bund-Länder-Programm, and energy use in homes.

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189 Joerges, *et al.*, 1982.

The *Bürger-Information Neue Energien* (BINE) was an information program that received 90 percent of its funds from, and was implemented by, the Federal Ministry for Research and Technology between October 1980 and December 1983. The remainder of the financing for the program came from fees for information packets which the program distributed for 10 DM each. The purpose of establishing the program was to provide specialized information on the application of energy-saving technologies in homes. Information on alternative energy sources and technologies such as solar, wind, and heatpumps was also provided. BINE claimed to be ''exclusively informational and neutral'' so as not to prejudice consumers. Information on government subsidies was included in the packets. According to Lutz Hildebrandt and Bernward Joerges, ''The information brochures are designed to be of greatest help to those people who already have some degree of competence in the area of energy conservation.''[190] The program was administered by the ''Fachinformationszentrum Energie, Physik, Mathematik'' in Karlsruhe, which is part of the Nuclear Research Center.

The Role of Utilities

In most cases in Germany, large, private, regionally-monopolistic producers, owned by shareholders, provide gas and electricity to local municipal utilities which are primarily distributional in nature. Although not funded by the government, electrical utilities have also played a role in providing energy conservation information to consumers. Utilities use information programs to help manage electricity loads by reducing peak demand while selling as much base-load power as possible. Much of the information is also used in pure marketing techniques that promote fuel switching to electricity and away from oil.

Blanket organizations have developed, encompassing many regional and local utilities as well as electrical appliance manufacturers and retailers, which work together toward accomplishing these aims (load management and increased sales) on a national level. One such organization is the Hauptberatungsstelle für Elektrizitätsanwendung (HEA). The HEA is a vertically integrated organization that provides information packages, consultant training, advisory services, links to consumer groups, a film service for public relations, and adult education programs. The HEA also provides information to the Stiftung Verbraucherinstitut and cooperates on joint projects with the Stiftung Warentest. As a marketing technique, the HEA provides information on the advantages of electricity over other fuels, and on the efficient use of electrical power. HEA programs are targeted at energy consumers in all sectors. For residential consumers, fuel-switching has been encouraged through the promotion of heatpumps and electrically powered hot water heaters. Although some of the actions of

[190] Hildebrandt and Joerges, 1983.

the HEA and similar organizations support the federal government's energy goals, the HEA and other utility organizations are concerned with sales rather than conservation. These organizations have campaigned for greater energy consumption through such actions as encouraging increased infusion of appliances in households, marketing them as modern, time-saving, devices.

RESEARCH AND DEVELOPMENT

Energy conservation research and development is carried out by the Ministry for Science and Technology and the Ministry for Regional Planning, Building, and Urban Development. Only a small portion of the budgets for energy R&D go toward energy conservation, and only a fraction of that money is for research affecting the residential sector. The Nuclear Research Center, which is controlled by the Ministry for Science and Technology, manages a program entitled, "New Energy Sources," which is devoted to developing "soft" energy production technologies. Results from this and other research are published in press releases, popular science magazines, and information brochures.

SUMMARY

West German residential energy policy is built on the premise that governmental intervention is appropriate only where the market fails. Actions taken by the government have primarily been regulatory. National building construction standards came into effect in November, 1977. Individual heat metering in multi-family buildings has been required since July 1981 for all new buildings and since June 1984 in existing buildings. Requiring individual heat metering made it possible to also require consumption-based energy billing. Consumption-based billing was established in three steps during a period of five years. It was first required in public housing, in June, 1979. As of February, 1981 all privately financed buildings had to meet the requirement. Consumption-based billing was extended to cover all private housing in 1984 (coinciding, necessarily, with the individual heat-metering requirement).

Individual heat metering and consumption-based billing laws were adopted in order to create a clear economic relationship between energy consumption and costs in consumers' private economies. This philosophy is only partially reflected in West German energy pricing policy: electricity prices are based partially on actual consumption and partially on the number of rooms in a given dwelling. Fuel prices are not regulated, but taxes are applied to oil in order to encourage fuel switching.

The efficiency of oil-burning boilers was also addressed by the West German government with regulations. Two laws requiring inspections and efficiency adjustments for large existing boilers and minimum operating standards for new boilers came into effect on October 1, 1978. Both laws were amended in 1982 to include small boilers.

Appliance manufacturers avoided regulation by entering into "gentlemen's agreements" with the government. The first of these was in 1976 and provided for energy consumption data labeling on domestically produced household appliances. Imported appliances are not labeled. In 1980, West German appliance manufacturers agreed to improve the energy efficiency of specific household appliances by up to 20 percent by 1985. This target has been raised twice since the original agreement was made.

Grants and tax incentives were used to promote investments in retrofit measures in the existing housing stock, where market incentives were not perceived as sufficient. These subsidies were offered under the "Bund-Länder-Programm" which was established in 1978. Under this program, 4.35 billion DM were distributed among 3.43 million homes during a five-year period. Seventy-seven percent of these subsidies were used for investments in double-glazed windows.

Extensive information programs have been supported since 1977. This support has ranged from direct distribution of information by government bodies to subsidy of private consumer publications and consumer organizations. The distribution tactics of government-supported information programs indicate that these efforts were aimed at providing information where the market for it exists, rather than attempting to inform consumers who are not normally reached by existing market mechanisms.

CONCLUSION

Residential energy conservation policies and programs in West Germany were not aimed at radically altering the energy market. They were instead intended to enhance, and remove barriers to, existing market incentives for reducing energy consumption.

Although the precise impact of governmental intervention in the sector is unknown, actual changes in consumption of energy in the aggregate, and of specific fuels, can be seen between 1972 and 1983. Total residential delivered energy increased consistently between 1972 and 1979. Part of this growth can be attributed to the increased saturation of central heating, which climbed from 49 percent of households in 1972 to 67 percent in 1979. Energy consumption for space heating can be expected to increase approximately 30 percent when conversions to central heating are made.

Between 1980 and 1983, a continuous drop in household energy consumption occurred. Delivered oil/dw-DD (dwelling, degree day), the use of which came under regulation during this period, dropped 9 percent. Natural gas delivered/dw-DD dropped 6 percent over the period while consumption of solid fuels increased 7 percent. Some unreported increase in the burning of wood is also likely, which may have contributed to the drop in oil and gas consumption. Total energy delivered dropped from 83.3 GJ/dwelling in 1972 to 81.6 GJ/dwelling in 1983† (3.7% decrease). This small decrease in energy consumption supports the participation data on retrofits under the Bund-Länder-Programm, which indicate that major thermal adjustments of the building stock were not made.

† These values are climate corrected.

TOOLS

The programs we have studied were implemented by governments operating in the context of market economies. In this comparative section, the tools used by governments for the purpose of influencing residential energy consumption are aggregated in terms of their intended effects on the energy and energy-related (end-use devices, efficiency improvement investments, etc.) markets. The program tools which are described, and the comparisons of the ways in which they have been used, are presented in three groups; those which fix the market, those which change the market, and those which alter the make-up of items on the market.

This typology is useful because it introduces the assumptions made by government decision-makers regarding why consumers are not behaving as desired (lack of knowledge, lack of motivation, lack of funds, etc.) and the rationals behind choosing between program tools. The typological categories are not mutually exclusive, however. Because consumer behavior is usually determined by several interrelated factors, the most effective programs are often those which use a combination of tools from some or all of the categories, each in ways that mutually support the others.

PROGRAMS WHICH FIX THE MARKET

Government decision-makers in the countries we have studied have consistently implemented programs that are designed to fix the residential energy market. Such programs are designed based on the perception that consumers are not acting with economic rationality and are not doing so because market imperfections exist (consumers are assumed to be inherently market responsive). Government decision-makers have attempted to identify specific areas where market imperfections have existed and to correct them.

Information

Lack of information is the most commonly identified imperfection in the residential energy market. The perceived lack of information is often seen as the cause of residential consumers' inadequate market response. Information programs are intended to address this failure, with the expectation that doing so will change consumers' behavior (i.e., make them more market responsive). The two general types of consumer behaviors that are targeted by residential energy conservation information programs are:

a) investment behavior

b) habits (adjusting thermostat levels, turning off lights, etc.)

Information aimed at investment behavior is used to help consumers buy a given service with less energy/money. Information aimed at habits is often used for the same purpose (as in the case of information on product maintenance). In addition, information aimed at changing habits is used to encourage consumers to adjust their demand for a given service in relation to its market price and/or in relation to costs that are external to the market (lost opportunity costs, environmental and social costs, etc.).

Campaigns

Most of the efforts by the governments of the study countries to distribute information took the form of campaigns. Information campaigns formed the backbone of the Japanese government's residential energy conservation program. Large scale campaigns were also important in Denmark, France, and Sweden. The nature and degree of specificity of information distributed in campaigns depends both on the type of behavior being targeted and assumptions as to what information is missing and thereby inhibiting consumers' market response (what do consumers know/not know?). Survey data can be an effective source of information to program designers faced with making these kind of assumptions. In Sweden, the energy conservation information program went through a clear evolutionary process, starting at a very general level and becoming more targeted and specific over time.

The degree of specificity of information distributed, and the level of distribution (to everyone *vs.* to target groups) are directly related. In most cases, the level of distribution chosen is dependent on the type of information to be disseminated. General information is most commonly distributed broadly whereas more specific information is distributed to smaller, select audiences. The choice of specific target populations for the distribution of information depends on assumptions regarding which consumers are most likely to benefit from/respond to the information. The problem of making these assumptions is often avoided by distributing information only when it is solicited, as was the case for much of the information distributed in West Germany. Sometimes broad advertizing is used as a marketing tool for encouraging the solicitation of specific, targeted information.

Channels

Because assembling and broadly distributing information requires an extensive infrastructure or network, several of the study countries chose to use large, centralized agencies for the administration of information programs. The extent to which these agencies were capable of delegating their responsibilities to dispersed parts of an existing infrastructure and use them as information channels determined the extent to which information reached both specific target groups and the general public. In contrast, the West German government gave responsibilities for information programs to a diverse and decentralized group of institutions, and tended to rely on proven information channels, both public and private, for reaching the public. Involving private institutions, such as the Stiftung Warentest, had an added advantage in that private institutions provided channels that consumers already trusted as useful information sources. In Denmark, France, and Sweden, local governments played an important role in channeling information, using federal funds to support local and regional information centers and provide advisory services.

Special Information Programs

In a few cases, the governments of the study countries have gone beyond campaigns and used other methods of reaching the residential consumer with energy-related information. One of these methods is product labeling. Mandatory product labeling has been used in the case of household appliances in some states in the U.S., in France, and in Japan, and a voluntary program for labeling domestically-produced appliances is used in West Germany. In Denmark and France, labels are used in conjunction with the sale of residential buildings. In both countries, the home labeling programs are integrated with the national building code. In Denmark, labels identify buildings that meet the code and, for those that do not, measures needed to retrofit the building. In France, special honorary labels ranging from two to four stars are given to buildings that exceed the code.

Tools such as regulation and price manipulation have also been used indirectly as channels for distributing information. In France, the regulation requiring thermostat settings to be set no higher than 19°C was clearly an information program: while the law was not practicably enforceable, and was therefore not viable as a regulation, it was used to send a loud message to the public that indoor temperature levels were important for energy conservation. In Denmark and Sweden, energy taxation fulfills a secondary goal of informing the public that energy conservation is still an important long-term issue despite low market prices that the governments perceive as temporary.

Supporting Other Programs

One of the most important roles of information programs is to support and encourage participation in other programs. It is impossible to achieve adequate participation levels in any program if the public is not aware of its existence. Information programs are also important for informing the public about changes and adjustments to other programs that take place over time. The swift participant response to changes in the Swedish subsidy program (as demonstrated in fluctuations in program participation) clearly showed that the government had created an effective communication channel to the public.

Regulations

Regulations have also been used to remove perceived imperfections in the residential energy market. Requirements for individual heat-metering and boiler inspections are two examples of this usage of regulations as program tools. Individual heat-metering requirements establish an economic link between multi-family dwelling occupants and the energy they consume for space heating. Multi-family dwelling occupants who do not pay heating bills that are directly associated with the heat they use cannot correlate their space-heating energy consumption to energy prices in general, and have no incentive to modify their energy-consuming behavior when energy prices change. Individual heat-metering regulations were introduced in Denmark, France, and West Germany in order to remove this barrier to market responsive consumptive behavior from the residential energy market.

Boiler inspection regulations can also be seen as tools for eliminating market imperfections. In most of the study countries, boiler inspection requirements were already in force before 1973 and were used to ensure the safety of boiler operations. These existing boiler inspection requirements provided a useful infrastructure for implementing inspection requirements designed to improve boiler performance from an energy consumption point of view. The justification for such requirements is that the owners/operators of boilers do not have the information or skills necessary for ensuring the energy-efficient performance of their equipment. Neither do they have the information that regular boiler maintenance can improve the performance of their equipment, thereby reducing their energy consumption and expenditures. Boiler inspections provide both of these missing pieces of information.

Some boiler-inspection regulations go beyond this information-providing role and require efficiency adjustments to be made based on inspection findings. Such regulations are markedly different than those discussed previously, in that they are not based on the assumption that consumers are inherently market responsive. By implementing such regulations, policy-makers take the risk out of making this assumption and actually circumvent the the consumer's decision-making process in the energy market.

The EPD information program in Sweden addressed the operating efficiency of boilers in a different way: the program sought to inform boiler owners/operators of the benefits of regular boiler inspections and maintenance and to teach them how to perform the inspections and adjustments themselves. Measurements showed that the energy efficiency of boilers inspected and adjusted under this program improved five percent on average. The program reached only roughly two percent of the oil-fired boilers in single-family dwellings in Sweden in the first four years of implementation, however, which is presumably significantly fewer boilers than the inspection regulations passed in the other countries reached.

PROGRAMS WHICH CHANGE THE MARKET

In some cases, consumers are perceived as responding to the energy market but the resulting behaviors are not seen as satisfactory from the government's point of view. When less energy consumption or more investments are desired, governments can intervene and change the market by introducing subsidies and/or manipulating the total price (market price plus tax) that consumers pay for the energy they buy. Subsidies are generally introduced when adoption of energy conservation measures are desired but lack of capital and/or adequate financial incentive is seen as a barrier to consumer investments. Pricing and tariff schemes can dampen consumer expenditures in cases where consumers' demand for the energy they buy is price-elastic.

Subsidies

Residential energy conservation subsidies give consumers a stronger incentive to invest in upgrading the physical characteristics of their building or its heating equipment in order to yield lasting reductions in energy requirements. The countries in this study used tax benefits, grants and low-interest loans to subsidize energy conservation measures (see Table 21). But even in those cases in which the same measure was employed in different countries, the different program terms and implementation methods could mean very different effects. To consider these differences, we turn to some underlying issues in the design of the programs.

Subsidy programs are typically more controversial than other conservation programs because they distribute public funds widely throughout the economy, benefiting some groups more than others. Subsidy programs are therefore normally conceived with several issues in mind. One of these is *efficiency* (i.e., could the program achieve the same results with less money?). Others are *equity* (i.e., is the program fair? who benefits? who pays?), and *effectiveness* in achieving the overall objectives established (i.e., did program participants take measures which in fact yielded the intended results?) These issues are not independent and distinct, but rather interact and interfere with each other. In many respects, the ways in which governments have chosen to structure their residential energy conservation subsidy programs can be seen as different responses to these three fundamental issues.

Table 21. Subsidies

	Denmark	France	Germany	Japan	Sweden	U.S.
Roof/attic Insulation	G	G/T/L	G or T	L	G/L	G*/T/L*
Wall Insulation	G	G/T/L	G or T	L	G/L	T/L*
Glazing	G	G/T/L	G or T	..	G/L	T/L*
Infiltration	G	G/T/L	G or T	..	G/L	G*
Efficient Furnaces	G	G/T/L	G or T	L	..	T/L*
Fuel Switching	G	G/T/L	G or T	..	G/L	..
Heatpumps	G	G/T/L	G or T	..	G/L	T
Solar Heat	..	G/T/L	G or T	L	G/L	T/L*
Heat Recovery	..	..	G or T	..	..	..
Audit	G	G/T	..	..	..	(RCS)

Notes:
Table concept after A. Ketoff.
G: grant; T: tax benefit; L: loan; *: income qualifications
For Denmark, measures refer to post-1980 programs.

Approaches to Efficiency: Type of Subsidy and Free Ridership

Economic efficiency is an important theoretical criterion for maximizing welfare. In lay terms, it is also a common measure of performance. Conservation programs can be compared in terms of three aspects of efficiency.

The first of these is efficiency in the sense of getting the most results (i.e., the most investment in energy conservation) with the least public expense. The main way to address efficiency in this sense is through the form of the subsidy itself. Different subsidy mechanisms imply different levels and kinds of costs to the public. Most countries used more than one subsidy mechanism (see Table 21). Denmark is the exception: it relied exclusively on grants to subsidize residential conservation at the national level. Japan used only loans, but its efforts to subsidize improvements to the thermal performance of residential buildings were so minimal as to hardly rate discussion anyway. Germany gave participants the choice of a grant or tax deduction. Sweden offered both grants and loans (with incidental tax deductions on loan interest). the U.S. relied mainly on tax incentives, but introduced limited grant and loan programs for low-income groups.Only France made extensive use of all three subsidy mechanisms.

Of the different types of programs, grants and tax incentives have similar features from an efficiency standpoint. Each is a direct transfer of income. In the case of tax incentives, however, the amount of the transfer, either in absolute terms or relative to the total conservation investment, may depend on the marginal tax rate of the applicant. If the tax incentive takes the form of a deduction from taxable income, the size of the income transfer (or equivalent grant) obviously depends on the marginal tax rate which would otherwise apply to the recipient of the subsidy. On the other hand, if the incentive is treated as a tax credit, then it is independent of the individual's marginal tax rate. The latter case is similar to a grant, which is also independent of the applicant's income.

These alternative treatments of tax incentives can be distinguished in terms of efficiency (their equity implications will be discussed below). A tax deduction provides a greater subsidy to high income households, who will have a higher marginal tax rate in a progressive tax system. It can thus be argued to be less efficient because it is providing more support precisely to that portion of the residential sector which would otherwise be most likely to take conservation measures anyway. High income households not only have the most discretionary income to devote to investments such as improved energy efficiency, but also stand to capture more of the benefits directly because they use more energy than other households.

In France and in the U.S., tax incentives suffered from this inefficiency. However, this issue was addressed in France by the conversion of the deduction to a tax credit in 1982. Because 25 percent of the eligible expenditures could be claimed, this change increased the effective grant (income transfer) for those households whose marginal tax rate was less than 25 percent and reduced it for those with tax rates above 25 percent. This was consistent with program efficiency: one would expect to have to provide a larger subsidy to those with lower incomes in order to stimulate discretionary actions (even those in their own self-interest) because of the high opportunity costs of discretionary funds for this group.

Loans are by definition repaid (otherwise they are grants). Even with interest subsidies, they therefore require fewer public resources than direct grants or tax incentives. The effective subsidy involved in a loan program is the difference between the terms of the public loan and what could be obtained from commercial sources. Some loan programs can indeed contain substantial subsidies especially at high interest rates.† For example, the Swedish program for loans to install new and renewable energy systems in multi-family housing provided (for a short period) complete forgiveness of all interest and principal repayment for up

† Note that at high real rates of interest, even subsidized loans may be unattractive, prompting authorities to increase the absolute level of subsidy.

to 10 years. On a large loan, this could amount to a very large sum. The Japanese subsidy program, on the other hand, offered small loans only on terms so close to those of commercial lenders that the program was not widely used.

Efficiency, in the sense of getting the greatest mileage from the subsidy dollars, is traded off against effectiveness, which can be thought of as achieving the desired outcomes. The more attractive an incentive becomes, the more likely consumers will adopt it, but the higher the public cost. Each country weighs the benefits of the program against its costs in public resources. If there are few social benefits then the individual is expected to bear most of the costs and capture most of the benefits. The greater the social benefits, the greater the willingness of the government to bear a larger proportion of the costs, and, presumably, to tolerate so-called "free riders" who would have contributed to the social benefits by making conservation investments even without the subsidy.

In Japan, the effective level of subsidies was very low. This suggests that the government placed a low value on social benefits, and judged instead that the homeowner would capture most of the benefits of reducing heating requirements (or increasing comfort) by improving the home's thermal performance. Sweden, Denmark and France, at the other extreme, all placed very large sums of public money into energy conservation subsidies, suggesting their policy authorities placed a high value on the social benefits of conservation.

There is a second sense in which programs may be compared from an efficiency standpoint. Administrative efficiency means reducing the expenditures on program administration while still achieving acceptable results. Clearly there is a trade-off between administrative efficiency and the prevention of fraud and abuse. To ensure that the measures which have been partially paid for by the public are in fact installed may require costly inspections or audits. The most common solution to the administrative efficiency issue is for a new government energy conservation program to take advantage of an existing bureaucracy which is already adept at dispensing forms and information, and at verifying and approving applications according to prescribed criteria. Sweden and France adopted this approach, as subsidy programs were folded in to other on-going efforts of various bureaucracies (local governments, housing agencies, etc.). Sweden used local government building inspectors as a way to conduct spot checks on subsidy recipients. Denmark, on the other hand, accepted a very costly administrative infrastructure in the interest of achieving very effective results. Denmark created a whole new cadre of trained auditors and inspectors in the private sector. Audits were required by legislation (and for a time, also completely subsidized) as prerequisites to obtaining the subsidies.

The final sense in which efficiency plays a role in differentiating conservation programs is the sense of economic efficiency. Economists would argue that subsidies for energy conservation investments in homes are only justified if the social benefits of reduced energy use exceed those captured by individual consumers. Determination of these social benefits is susceptible to a number of value judgements related to hard-to-quantify factors, such as the social costs of dependence on imported oil, the probability of supply disruptions in the near or foreseeable future, and the income effects of energy price increases on different portions of the population. The countries in this study reveal, through the political choices made in establishing their subsidy programs, different valuations of the social benefits of residential energy conservation.

From an economist's perspective, the socially efficient allocative outcome is only achieved under conditions of external social benefits when an appropriate subsidy is provided to individual consumers. In other words, in the absence of subsidy, energy conservation investments will be less than the efficient optimum. The objective is to set the subsidy level so as to yield the socially-optimal amount of energy conservation investment. If policy makers actually proceed according to this criterion, then the level of subsidy chosen reflects (politically-determined) social preferences and therefore the economically efficient level of energy conservation investment.

Interestingly, when the issue is viewed from the standpoint of economic theory in this way, the free ridership question vanishes. The fact that some consumers would have been willing to make conservation investments at a lower level of subsidy (or even none at all) is no longer an issue. If consumers undertake conservation investments in response to energy prices and the cost of the investments, and if subsidies are intended to reduce these costs and hence to stimulate more investment, it is clear that regardless of the cost of the conservation measures, there will be some consumers who would have undertaken such measures even if the costs had been higher. The point of economic theory is that the subsidies affect the marginal level of conservation investment, and increase it to a socially optimal level. It is this level which is important, not the obvious fact that, regardless of prices and subsidy levels, there will always be some consumers who would take action anyway. Thus, an economic analyst might look at the free rider question quite differently than an "efficiency expert" simply counting government expenditures. In fact, an economic analyst might well argue that so-called "free riders" are irrelevant. If there are real social benefits of energy conservation, and these are captured in the subsidy, then anybody who undertakes conservation investments should receive full compensation for the social benefits created as a result, in order to ensure that each individual undertakes conservation investments to the socially efficient level (i.e., that point at which the private and social benefits equal the opportunity costs).

In the countries examined in this study, there was relatively little concern with free ridership. It seems plausible to suggest that there were two reasons for this lack of concern. One was that in those countries with a high level of subsidy for conservation investments (Denmark, Sweden, France), there were large perceived social benefits to conservation, and that therefore the rationale of economic theory, as outlined above, prevailed. The other reason, particularly in the case of Denmark, is that the effectiveness of the results was perceived as more important than the efficiency of the program delivery mechanism, so the free rider issue never arose.

Approaches to Equity: Subsidy Structure and Eligibility

The equity issue has to do with which groups benefit from a program. Benefit incidence depends both on eligibility as well as on those elements of program structure that are used to make the subsidy more attractive to particular groups. It could be argued that if the objectives of the program were to save energy, then it shouldn't matter where the energy came from. But in practice it is clear that subsidy programs in several countries were intended to reach certain portions of the housing sector, in part because of equity objectives.

In particular, a significant concern in France, Denmark and Sweden has been structuring subsidies to reach the multi-family portion of the housing stock. This group is typically hard to reach because households themselves lack the incentive to reduce energy consumption if they do not pay their energy bills directly. Even when there is separate metering of energy use, residents have limited ability to modify the physical equipment in order to reduce energy use. On the other hand, when building owners can simply pass rising energy costs through to tenants in the form of rent increases, they also have limited incentive to invest in conservation measures. Homeowners, however, pay their own energy bills directly and directly capture savings from energy conservation investments. Because tenancy is correlated with lower income levels, the issue has distributional implications.

Sweden addressed this issue by limiting the extent to which energy cost increases could be passed along to tenants. This gave building owners a strong incentive to make efficiency investments. Sweden provided the same amount of funding for units in multi-family housing as for single-family units. In a large building, this meant that the potential grant available to the building owner was very large, in relation to the relative costs of the work (for example, the costs of connecting a 200-unit building to the district heating system were not 200 times the costs of connecting a single-family house). Because the building owner did not have the same tax advantages to borrowing money in Sweden as the single-family home-owner, authorities found that many building owners used only the grant portion of the Swedish subsidy, and did not bother with a loan. However, although it was not used extensively by landlords, the availability of a subsidized loan for up to 100 percent of the costs of improvements in Sweden did permit the participation of low-income home owners who otherwise would have been unable to provide their share of the required investment. Sweden also offered need-based conservation financing to specific disadvantaged groups, such as the elderly and handicapped.

This approach was significantly different from that adopted by France, where the grant programs were structured to provide a higher proportion of funding to public housing and low-income households, and where some special funding sources in fact existed specifically for such households. The multi-family housing sector was reached through a special effort funded by the central government (FSGT) and directed to public housing (low-income and cooperative housing) throughout the country under the coordination of the National Association of Public Housing Organizations.

Denmark tackled the multi-family housing question by making conservation grants more generous for that sector. Denmark also allowed municipalities to undertake loan programs to further assist disadvantaged groups who otherwise might not be able to take advantage of the national grants. These local programs could provide fully guaranteed loans to the elderly, disabled or widows for up to 100 percent of costs.

The U.S. demonstrated an explicit concern for reaching low income households with conservation measures through the Weatherization Assistance Program. Unlike the other countries, which modified the terms of their programs to favor low income groups, the U.S. developed a major program dedicated solely to low income households. The Weatherization Assistance Program reached about 12 percent of the eligible households in its first seven years, providing funds to states to enable direct installation of energy conservation measures in low income households at no cost. The program has unfortunately been troubled by high costs and uncertain savings.[191]

The issue of income and the incidence of conservation subsidies is most important in relation to programs whose benefits were transferred through the tax system. In France (initially) and Germany the highest income groups were doubly favored by the tax incentives for conservation investments (an option under the German program). First, it was more likely that high-income groups would have the discretionary funds needed for their share of the costs (this also applies in the case of Denmark). Then, because some portion of these costs was deductible from taxable income, those with the highest marginal tax rates gained the greatest cash benefit in the form of lower taxes. In the U.S. tax deduction scheme, program requirements (principal residence only eligible; long tax form required) demonstrated a bias

[191] Clinton, Geller, and Hirst, 1985.

towards higher income groups to begin with, in addition to the effects of marginal tax rates.[192]

Differences in program structure can be gauged in part if we consider the program participation rates by housing tenure category in France and Sweden. In 1984, questionnaire results in France indicated that 74 percent of all households in which energy efficiency improvements (including fuel switching) had taken place during the previous year were single-family houses. In Sweden, over the lifetime of its energy conservation subsidy program (1974-1983), almost 80 percent of the number of units which were approved for funding were multi-family, and the proportion of multi-family participation in the program increased steadily. While the two numbers are not directly comparable, they give an indication of fundamentally different responses.

Approaches to Program Effectiveness: Eligible Measures and Participation

If energy conservation subsidies are to ensure that energy is saved, then programs must ensure that building improvements are technically adequate (i.e., effective). Otherwise, the public might pay for measures that do not save energy. To restrict the measures eligible for subsidy, all countries in this study adopted approved lists of technically-appropriate conservation or fuel substitution measures. Some lists were more restrictive than others. By listing only a small number of eligible improvements, an agency could ensure that only measures with widely applicable and significant conservation benefits were subsidized. However, a short list of eligible measures excludes all the exceptional and unusual cases from consideration.

Of the countries in this study, Japan had the most restrictive list of measures eligible for subsidy. Homeowners could receive special loans only for insulation and installation of a solar hot water heater, while apartment owners could receive loans for space and water heating systems as well as passive solar heating in addition to the measures available to homeowners.

A more costly and sophisticated approach to ensure effectiveness of subsidized measures is to link them to pre-investment audits, whose recommendations would limit the range of eligible measures in each individual case. Among the different countries in this study, it is clear that Denmark went farthest in linking audits directly to the subsequent subsidy of conservation measures. The first round of conservation grants in Denmark were found to have been devoted to measures of limited significance from an energy conservation standpoint, but of cosmetic importance to the appearance and value of the property. As a result, a

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192 *ibid.*

requirement linking the grant to an energy audit by a qualified professional was initiated in 1978. In Denmark's comprehensive 1981 legislation, a short list of specific eligible measures was also introduced, further restricting the range of potential investments which would receive public subsidy. The audit/inspection requirement was expanded to include a post-investment "heat inspection report" as well as the pre-retrofit audit. The evolution of Denmark's grant program demonstrates a mounting concern with effectiveness.

Another case was that of France, which introduced a similar requirement linking its grants to an audit in 1979. Audit procedures were subsequently improved and became the object of separate financial support. Audits sponsored in part by AFME were made a prerequisite for grant funding from other agencies. However, there was never a requirement that only measures recommended by the audit would be funded.

The German subsidy program appeared to be relatively insensitive to the notion of effectiveness. Although the program, like the early Danish and Swedish grants, was extensively used for cosmetic investments, no attempt was made at restructuring it to address concerns about what measures the subsidy funds were spent on. The types of building improvements eligible for funding were not tightly controlled with an eye to most effectively improving energy efficiency. As a result, the bulk of the funds in Germany went to the installation of new double-pane windows, with relatively small overall energy conservation consequences.

Sweden, by contrast, revised its program repeatedly, altering terms of eligibility to include or exclude measures which were particularly adapted to current policies. After the first three years of the program, for example, oil furnace exchange became ineligible for subsidy, and heatpumps were added. Renewable energy sources of different types were added later, and terms were made especially attractive for them. The list of measures eligible for funding in Sweden, and the amounts which would be paid for each, was very detailed. Such detailed lists offered program administrators some control over the measures undertaken, but also gave enough flexibility for owners of single- and multi-family buildings to identify some measures from the list which were attractive for their buildings.

But technical appropriateness is not the only aspect of effectiveness: a program must also attract a high degree of interest and participation. One element of an attractive program may be the flexibility it offers homeowners to make a variety of different improvements. But, as we have seen in the German case, too much flexibility can lead to ineffective investments. The most important element of program attractiveness is probably the amount of subsidy. However, the greater the subsidy, the greater the efficiency penalties (see above), so program designers must balance their concerns.

The most appealing subsidy program from the standpoint of consumers would have been Sweden's, which offered a relatively large grant for 35 percent of total costs, and a low-interest loan for the remainder. The loan interest was also deductible for tax purposes. However, possibly because Swedish were already relatively efficient, the participation rate in its programs was less than in Denmark's 1980 grant program, in which over 100,000 grants were distributed (and the funds exhausted) in only 4.5 months. Part of the success of the Danish program may have been due to a tripling of the maximum grant from what had been previously available.

At the other extreme, the Japanese program was unattractive because it offered only loans of limited amount, for a small number of upgrading measures, at near commercial terms. Under these circumstances, its limited popularity (and hence, effectiveness) is no surprise.

Program attractiveness (and effectiveness) depends in part on the government's promotional efforts—the visibility of the program to the public. It might be expected that subsidy programs could best be promoted and recognized by the public if they were offered through a single, well-recognized public authority, with local access for inquiries and applications, and consistent program terms. However, none of the countries studied could be said to represent this ideal. In all cases, the constraints of existing institutions and the knowledge gained with experience meant that either a large number of different agencies became involved, or that programs went through a series of rapid, and often significant changes in their criteria and terms.

France is an interesting example of a conservation program which started off as an initiative of the national government, manifested through subsidy programs offered by a number of fragmented agencies. However, as the programs evolved, the evident need for more co-ordination between agencies was expressed, and delivery mechanisms and promotional effort were decentralized to the level of the regional and municipal governments. The role of the AFME shifted from providing grants for energy conservation measures to subsidizing audits and information services in support of grants offered by other agencies. The Villes Pilotes program was the logical culmination of this shift: a local promotional and program delivery mechanism to coordinate access to diverse national subsidy programs.

All of the countries studied except Japan eventually involved local or regional governments with their national subsidy programs. In Sweden and Denmark, municipal offices were used to administer the grant applications. In Germany the state governments contributed funds to the program and in France the municipal and regional governments were invited to contribute promotional and administrative support, as well as joint funding. U.S. programs for weatherization assistance and conservation loans were implemented through state governments, and typically involved municipal agencies and community groups. Thus, in all of the examples of large-scale, popular subsidy programs, the advantages of local commitment and involvement in program delivery were recognized.

There remains the issue of the contradiction between achieving program effectiveness by fine-tuning subsidy terms and conditions, and pursuing effectiveness through offering a consistent, highly-visible and recognizable program to the public. It would appear that while Denmark and Sweden, in particular, were notable for the frequent changes to the structure of their subsidy programs, the rapid response of applicants to shifts in program details (increase/decrease in grants, application deadlines, etc.) suggests that consumers were generally aware of the programs and the changes being made. In these cases, the variability of program terms was not a problem because there were good channels of information to potential applicants. The program fine-tuning undertaken in each case probably added to its effectiveness rather than confusing consumers.

Finally, it should be acknowledged that the discussion to this point has been framed around the notion of effectiveness solely in terms of reducing energy use. In fact, both France and Sweden (and, to a lesser extent, Denmark) explicitly used their subsidy programs as tools to encourage fuel substitution. In Sweden, the installation of district heating connection equipment (e.g., heat exchangers, valves, controls, connection service charges) was the largest category of subsidy expenditures in the multi-family building sector for many years. With the French subsidies, almost as much money was spent on substitution from solid fuels or oil to natural gas or electricity as on insulation.

Many techniques were used to control subsidy program effectiveness. Denmark's final program, linking grants to pre- and post-retrofit audits in order to meet the national requirements for a "heat inspection report," went farthest to ensure that technically correct measures were both identified and implemented by subsidy recipients. France also made widespread use of audits in connection with subsidies for conservation measures. Sweden, Germany and Japan relied on more or less detailed lists of technically acceptable retrofit measures. Germany's was the most flexible and undemanding of these lists and was not evaluated or revised during the course of the program. of measures.

Conclusions

Some common lessons emerge from the experiences examined. Each of the countries concluded at an early stage that in order to get something accomplished, they would have to be prepared to disburse public funds. The implication, in countries that chose grant or tax incentive schemes, was that the social benefits of energy savings were large enough to justify public subsidy. Having made this fundamental decision, these countries appear not to have been concerned with the "free rider" issue at the stage of program design. A theoretical justification for this position can be argued, particularly if the issue is perceived and analyzed as one of serious market failure due to positive externalities. With changing perceptions of the role of government and the legitimacy of government intervention to address issues of market failure, this perspective might be difficult to sustain, but it offers one explanation for the historical lack of concern.

In countries that implemented a subsidy program (i.e., excluding, for practical purposes, Japan) program efficiency and effectiveness were improved by modifying the terms of the program. France, Sweden and Denmark all improved their programs' effectiveness by modifying them, while Germany made no changes to their program, which was largely ineffective in reducing energy use. Sweden and Denmark also demonstrated the value of publicizing and promoting their programs well: in spite of a series of successive changes in subsidy structure and/or eligibility rules, participation in their programs was high and applicants were responsive to the changes.

The experiences of Sweden, Denmark and, to a lesser degree, France, also demonstrate that conservation incentive programs can reach the rental, multi-family sector. These three countries adopted different strategies for addressing this sector, but all recognized it as posing a special equity problem. France, with a large public housing sector, directed special funds and attention through national organizations to this portion of the housing stock in particular. Sweden provided 35 percent grants to multi-family building owners, who had a double incentive in that they were restricted by national legislation from passing along the full amounts of energy cost increases in rents. Denmark, on the other hand, offered incentives for owners of multi-family buildings which were more generous than those for single-family homeowners.

Experience with tax incentives suggests that while these will attract attention, the incentives may not reach their targets. Only France appears to have been concerned enough about this effect to deliberately change its tax incentive program so as to make its effects more equitable—i.e., by changing it to a tax credit instead of a tax deduction.

For reasons of administrative efficiency and program effectiveness, all of the countries except Japan took advantage of local agencies to help administer and deliver the program of national subsidies. This development is particularly significant because it emerged independently, in a variety of very different programs and in different forms, after several years of experience in each country. The incentive for the creation of the programs is national, related to the macroeconomic and social costs of dependence on oil imports, so there are clear reasons for the origin of the initiative at that level. Experience suggests that there are also good reasons for involving local government in program development and implementation.

In general, the structure of subsidy programs in the different countries studied depends on where the countries have aligned themselves along the efficiency/effectiveness trade-off axis, and on the range of possibilities dictated by social preferences as expressed through the political process. The variety of experiences suggests that many different approaches are feasible. Sweden, Denmark and France, with quite different subsidy programs, were able to elicit substantial energy use intensity reductions in the residential sector.

An interesting trend should particularly be emphasized here. In Sweden, Denmark and France the conservation subsidy programs became, over time, more and more closely linked to the broader activity within the housing sector aimed at housing renovation and rehabilitation. There are efficiency, equity and effectiveness reasons for adopting this approach. Adding energy conservation improvements into a program that funds various building improvements not only reduces administrative overheads through joint application and information/promotion efforts, but also reduces the costs of the conservation investments themselves when they can be included with other complementary rehabilitation work at the same time.

In countries in which a substantial proportion of the housing stock was built before 1960, the need for housing rehabilitation programs, particularly intended to help landlords upgrade the stock of rental housing, is widely recognized. Such rehabilitation work may be very comprehensive, involving a wide range of electrical, plumbing and structural improvements as well as energy conservation measures to bring the building up to current standards. Such work cannot be undertaken without a complete and thorough inspection, often required both before and after the work to verify compliance with building regulations and grant requirements. Thus, coupling energy conservation subsidies with housing rehabilitation can address equity objectives because of the importance of rehabilitating older rental housing, and can improve the effectiveness of conservation subsidies by making it easier to incorporate energy audits into inspections which would be required anyway. This trend directly connects residential energy conservation to housing programs and the agencies which support them.

Finally, an obvious distinction should be drawn. The fundamental thrust of the programs in France, Germany, the U.S., Sweden and Denmark was toward improving the efficiency of space heating energy use in the residential sector, either because that portion was the most important component of sectoral energy/oil use, or because that portion of sectoral energy use demonstrated the greatest potential for efficiency improvement. Completely different conditions prevailed in Japan. Space heating was not a major concern there, and the Japanese adopt a different perspective completely on indoor comfort. Consequently, this discussion has little to say about the Japanese approach to subsidies for reducing space heating. However, Japan did provide subsidies to support industrial research and development in the area of household appliances, including heating appliances. This could be thought of as an ''upstream'' approach to residential energy use efficiency. The advantage of this approach is that it encouraged technological advances in appliance manufacturing which could eventually yield lower energy consumption in the household without the consumer having to do anything except buy a new appliance. This way, instead of trying to reach a huge target audience of diverse households, with different interests and priorities, the government was able to concentrate on a small number of industrial firms, with similar interests in technical advances and improving the competitiveness of their products. The Japanese strategy may be of increasing interest as diminishing returns limit the prospects for more gains in space heating efficiency in some of the countries in this study.

In summary, some lessons may be drawn from the diversity of experiences described here. First, conservation subsidies have been delivered under a variety of different institutional structures, and even changing structures within the same country. The important thing is that programs have evolved to become more effective and efficient with time. The involvement of local and regional governments in program delivery and adaptation is a consistent theme in each country with a major subsidy program. The evidence from European countries suggests that there are a number of ways to structure conservation subsidy programs to make them attractive to the multi-family sector, although the U.S. programs did not adopt these. Finally, there is evidence in several countries of a link between conservation subsidy programs and broader housing rehabilitation programs to enhance their efficiency, equity, and effectiveness.

Prices and Tariffs

Pricing tools are used by governments to manipulate the total price that consumers pay for goods and/or services.† These tools include: implementing, eliminating, or changing a tax; manipulating a tariff structure; or charging a base price not equal to marginal cost. Pricing tools are among the most powerful instruments of government policies for promoting energy conservation in the residential sector. They are also the most controversial and therefore are subject to severe political/social constraints. Other important contextual factors such as the economic structure and status of the country limit the feasibility of implementing pricing

† In this report we focus on residential customers and the total prices they pay for various types of energy. Total price is the sum of the market price of the energy source (most commonly light fuel oil, pipeline gas, and electricity in the residential sectors of the countries we have studied) and any taxes (including VAT) and/or fees that are levied on it.

tools.

The motivation for and the use of pricing tools vary among the countries we have studied. In each country, pricing tools have been used to meet at least one of the following goals: promoting energy conservation, raising revenues (without an energy conservation objective), or encouraging fuel switching. In most of the study countries, energy pricing policy has been designed to generate revenue; promoting conservation and encouraging fuel switching have been secondary goals. Generating revenue and promoting conservation may or may not be compatible goals. A tax that is designed for the primary purpose of generating revenue may promote energy conservation and/or encourage fuel switching. A value added tax (VAT) is an example of a pricing tool used for tax revenue maximization; a tax that is designed for the primary purpose of encouraging energy conservation may, however, generate progressively less revenue as consumers respond by reducing energy consumption. Therefore the goals of a government's energy pricing policy and their prioritization must be well defined before a pricing tool(s) is chosen. In practice this is often difficult because the government institutions that are responsible for pricing policies and those that are responsible for energy policies (ministries of finance and ministries of energy, for example) operate independently and may have conflicting goals.

Pricing tools have several advantages over other policy instruments for encouraging energy conservation. One advantage is that it is often easy to target a particular group of consumers with pricing tools (i.e., taxing or structuring a tariff to affect only subgroups of the customers in the energy market). Pricing tools are attractive to policymakers because the tools' administrative costs are small compared to costs of other policy instruments. In fact, pricing tools are often used to generate revenue that far exceeds the cost of administering the tool. In addition, pricing tools are implemented through a direct channel to consumers: the consumer's energy bill.

Energy bills can also be a barrier to the effectiveness of pricing tools, however. In most of the study countries, consumers do not receive their energy bills often enough to respond quickly to policy signals sent out through changes in prices and tariffs. In addition, customer bills are often calculated using estimates of consumption based on that of previous billing periods rather than on actual consumption for the current billing period and/or bills may be averaged for consumption over long time periods. The United States is the only study country where consumers receive an energy bill on a frequent basis (monthly or bi-monthly), and the bill corresponds to the actual consumption during the respective billing period. Without this kind of frequency and connection to actual energy consumption, pricing tools may not result in changes in residential customers' energy-consuming behavior.

The greatest difficulty in implementing pricing tools lies in determining, without knowing the targeted consumers' price elasticities of demand, the optimal total price that will achieve a policy goal(s). The problem of optimizing pricing tools is also complicated by the fact that they can cause feedback effects on the consumption of other goods and services in the economy: when total energy prices increase (or decrease) without corresponding increases (decreases) in household disposable income, consumers' ability to buy other goods and services in the economy is reduced (increased).† Using pricing tools can also cause equity and efficiency problems; they tend to be regressive because low-income households spend a larger portion of their income on heating than richer ones.[193] As energy prices increase, this relationship is exaggerated, and the economic burden on low-income households can become extreme.

Potential Impacts Of Pricing Tools On Residential Energy Consumption

The fundamental assumption behind the implementation of pricing tools for the purpose of encouraging energy conservation (discouraging energy consumption) is that an increase in total energy price will cause consumers using that particular energy source to decrease their consumption of it. In addition, if the pricing tool is used to change the relative prices among energy sources, the change may be expected to induce consumers to switch energy sources (fuel switch). Given these assumptions, the degree to which the implementation of a pricing tool can be expected to affect total residential energy consumption depends on several contextual factors. The first of these is the fraction of the country's total residential energy demand that is supplied with the energy source in question. Table 22 illustrates the energy source shares for the residential sector in each of the study countries. Table 23 shows the energy sources used for electricity generation. Increases in the price of oil in 1973 had a greater impact on residential consumers than decreases in and after 1986 because oil provided a smaller share of the energy consumed in residences in the mid- to late 1980s than it had in the early 1970s. An extreme example of this took place in Sweden, where the share of energy in the residential sector provided with oil dropped from 70 percent in 1973 to 27 percent in 1986. The potential impact also depends on: residential energy customers' ability to substitute consumption of a given fuel with other fuel sources, customers' willingness to accept reduced comfort, and/or customers' willingness to invest in or adopt measures to improve the efficiency with which they use energy. These factors determine the consumers'

† The tax structures in most industrialized countries are complex. We are examining energy taxes in a partial setting; i.e., it is beyond the scope of this paper to examine taxes on other goods and services that may coincide with energy taxes in the respective economies of the study countries.

193 Vine and Reyes, 1987.

price elasticity of demand.

Table 22. Residential Energy Consumption by Energy Type
in Percent

	Oil		Pipeline Gas*		Electricity	
	1972	1985-86	1972	1985-86	1972	1985-86
Denmark	71	51	2	6	8	17
France	56	36	11	25	7	20
Germany	58	49	10	26	11	16
Japan	47	46	23	19	22	32
Sweden	70	27	1	5	14	36

* Includes natural and city gas.
Totals may not total 100 percent because of the omission of the solid fuels and district heating categories.

Table 23. Electricity Generation by Fuel Type[194]
in Percent

	Oil		Natural Gas	
	1973	1985-86	1973	1985-86
France	39	2	5	1
Germany	14	12	12	8
Japan	63	29	4	21
Sweden	19	4	0	0

Totals may not total 100 percent because of the omission of several fuels.

Framework In Which Prices Are Determined

Residential energy prices vary widely among countries and energy sources. Even within countries, there are often large regional variations in the prices of specific fuels. Market prices for residential energy products are determined by both external and internal factors. External factors are those over which the government of a country has little or no control. Two of the most important external factors in determining residential energy market prices are the international market prices of imported fuels and the exchange rate.

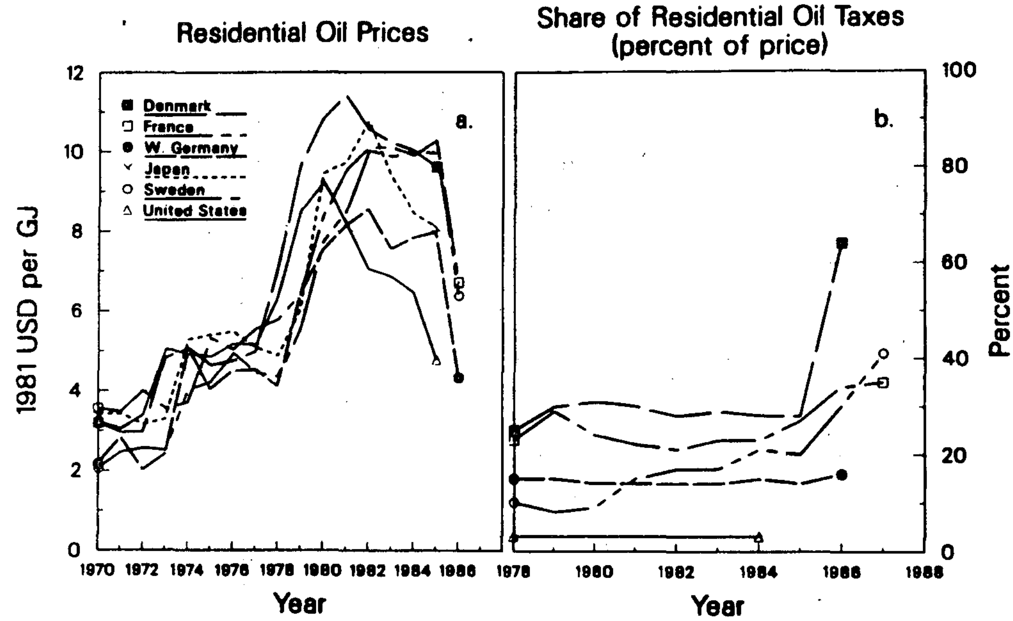
In countries that rely heavily on imported fuels, policymakers cannot control the market price of the imported fuel. This problem has been most evident in the case of oil prices, which are determined by international trade. Natural gas prices are determined by international contracts among distributors, pipeline companies, and producers. Natural gas prices

194 Hawk and Schipper, 1988.

tend to fluctuate less than oil prices, however, because gas contracts usually cover longer time periods. In some countries, natural gas prices are linked to oil prices through either parity or index pricing schemes. In West Germany, for example, "following a traditional policy of the gas industry, natural gas prices are indexed to oil prices."[195]

Fluctuations in exchange rates affect residential energy prices when a country relies on imported energy sources. From 1981 to 1985, the U.S. dollar (the currency in which oil is traded) was very strong compared to other currencies. Fuel oil prices in most of the study countries continued to rise after the world oil price began to decrease in 1982 because the value of the U.S. dollar was increasing at a rate that more than offset the dropping oil price. Residential fuel oil prices in these countries continued to rise accordingly (see Figure 7(A)). In the mid-1980s the reverse of this trend occurred: the drop in the world oil price was magnified/reinforced because the value of the U.S. dollar relative to the currencies of the study countries was falling.

Figures 7(A) and 7(B)



Even in the face of changing international fuel prices, however, pricing tools can be used to control the prices that consumers pay; taxation can keep prices high, and ceilings can keep prices low. The political and economic consequences of such market interventions, however, are significant. As part of an aggressive policy to discourage increases in energy consumption, the Danish government raised the tax on oil when the world oil price dropped in 1985-86; the government has raised the tax again several times since in an attempt to hold

[195] International Energy Agency, IEA/SLT (87)33, 1987.

the overall price at pre 1986 levels. Whether or not the Danish government will be able to maintain this policy over a long period of low oil market prices is an important issue in Denmark today. The Danish government has also used pricing tools to control the price of residential natural gas, which has been possible because Denmark's domestic natural gas resources are owned by the national government. The price controls are used to ensure that residential natural gas prices are kept below oil prices on a heat equivalent basis.[196] In France, natural gas resources are also monopolized by the national government.

An important national policy in the United States kept the price of natural gas at the wellhead down after 1954. This policy played a large role in keeping residential natural gas prices low after 1973 and especially after 1979. Over the past decade, however, these controls were gradually removed. The Japanese government imposed price ceilings on oil products until 1982. Although technically every country in Europe has some kind of price control system, only Japan and the U.S. imposed significant lower-than-market prices on household fuels. These policies helped to insulate consumers from the large price increases of the 1970s.

A government's traditions and laws with respect to market intervention are the most important internal influences on the extent to which pricing tools are used to control the base prices of energy sources. The wide variation in these factors is clearly evident among the study countries. The U.S. government, for example, intervenes less in its country's energy market than the government of Japan does in its energy market. Electricity prices in the study countries are set almost exclusively in free markets by publicly and privately owned utilities. The ability of national governments to use pricing tools to control the base price of electricity is therefore limited.† The general trend in the electric supply industry is toward decontrol and privatization, and the willingness of governments to intervene in electricity pricing has been declining.

Taxation

Taxes can be assessed as either ad valorem or unit taxes. Ad valorem taxes are assessed as a percentage of the net sales price. Ad valorem taxes permit equal rates to be applied to different fuels, which maintains a uniform tax rate. The German government charges a special ad valorem electricity tax, the revenue from which is used to subsidize electric utilities that burn domestic coal. In general, however, ad valorem taxes have been used less frequently than other types of taxes in the countries we have studied. Unit taxes are applied at a given

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196 *ibid.*

† The government-owned national electric utility (Electricite de France) in France is an exception to this rule.

rate per unit consumed. In Denmark, France, and Sweden, unit taxes are assessed on both oil and electricity.

General taxes (taxes placed on all goods and services) reduce the disposable income of all consumers. By decreasing the buying power of consumers, general taxes tend to reduce overall consumption, including consumption of energy products and services. Thus energy conservation is an indirect result of the application of general taxes. Likewise, general *energy* taxes (those placed on all energy sources) tend to discourage the consumption of energy and energy services.

Specific taxes are those placed on one or more but not all goods and/or services. Specific energy taxes (ad valorem and unit) promote conservation (i.e., discourage consumption) of specific fuels, and can induce fuel switching. Specific taxes also alter the distribution of income among households; e.g., if a tax is imposed only on one fuel, households that use the fuel are penalized in relation to households that do not. Specific energy taxes cause both income and substitution effects, except when applied equally to all energy forms, in which case only income effects occur. Unequal taxation among energy sources can trigger fuel switching if the use of a pricing policy tool alters the overall energy price and makes one energy source more expensive relative to the others. The relative tax burdens (excluding VAT) for oil and electricity in both 1978 and 1985-86 in each of the study countries are illustrated in Table 24. Oil and electricity were treated fairly equally in 1978, but by 1985-86 oil use was strongly discouraged in Denmark, France, and Sweden. Natural gas and renewable fuels are not taxed above VAT in any of the countries studied.

Table 24. Treatment of Energy Sources
Tax in Percent - excluding VAT

	Oil		Electricity	
	1972	1985-86	1972	1985-86
Denmark	11	56	11	38
France	10	22	6	7
Germany	4	4	6	7
Japan	n/a	n/a	4	4
Sweden	14	41	14	21

Value added taxes (VAT), which are assessed as a percentage of the net price, are the most widely used taxes in European countries. Value added taxes are applied at each stage of the production process. In the case of fuel oil, for example, VAT is applied to the price of oil when a refinery sells oil to a pipeline company or distributor. When the pipeline company or distributor sells the oil to a heating company, VAT is again applied to the price of oil. Finally, the heating company sells the oil to the consumer and the consumer pays VAT based on the price of the oil. At each stage, the price (and theoretically the value) increases, causing the revenue generated by the VAT to increase, because the VAT is based on a percentage of the price. In practice, the VAT affects only residential consumers because at every other stage the cost of the tax is passed on in the price of the product to the next stage. Value added taxes are used on most goods and services. In Sweden, energy prices are not subject to VAT but are taxed under a specific tax structure. in Table 25 the VAT rates (in percent) for 1978 and 1986 for each of the study countries that apply VAT to energy products are listed.

Table 25. Value Added Taxes[197]
in Percent

Country	1978	1986
Denmark	18	22
France	18	19
Germany	12	14

Fees

In some countries, fees have been charged instead of or in addition to taxes. The revenue generated from these fees is usually earmarked. Swedish consumers were previously charged fees, the proceeds of which went to special funds such as the oil substitution fund, the oil exploration fund, and an environmental fund for research toward reducing the environmental impacts of coal burning. Such fees were incorporated into special energy taxes in July, 1986, the proceeds from which are no longer earmarked. The Danish government currently charges compulsory storage fees for light and heavy fuel oils, gasoline, and diesel (25 DKK/tonne, 41.72 DKK/tonne, 0.8 DKK/m^3, 4.10 DKK/m^3 respectively).[198]

Earmarking funds raises some questions regarding economic efficiency: earmarking may introduce rigidity. For example, sometimes the revenue generated through earmarked taxes and fees exceeds the amount required for the associated fund or goal, and the surplus revenue cannot be used elsewhere because it is earmarked. Revenue generation through earmarked taxes and fees has a political advantage, however: voters will often accept fees designated for specific purposes more readily than they will accept non-earmarked ones.

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[197] International Energy Agency, 1988b.

[198] Eklund, 1988.

Tariffs

Tariffs, a method of calculating price, are most commonly determined by utilities and are therefore beyond the reach of national government policy. We have found no tariffs, however, that contradict national energy policy. Utilities use a variety of tariff schemes, both for load management and, in utilities where capacity is an issue, to encourage electricity conservation. Time-of-use (TOU) rates are used to provide different electricity tariffs dependent on the time of day and/or the season during which the electricity is consumed. Because the metering technology required to charge TOU rates has been expensive, these rates are more commonly applied to industrial customers than residential customers in the study countries. TOU rates are becoming more common in the residential sector, however, as these technologies become more advanced and less expensive. Special nighttime electricity tariffs encourage the use of heat storage systems. Both of these rates are used to smooth out electric utility load curves.

The electricity tariff structure in France provides the only important example, in the countries we have studied, of a nationally established tariff that encourages energy conservation. As mentioned previously, the French government is the monopoly owner of the nation's electric utility, EdF. This gives the French government considerably more control over the pricing and tariff structure of electricity sold in France than the other study countries' governments have.† EdF offers three electricity tariffs to its residential customers. As is common in most utility tariff structures, all three of the EdF tariffs are composed of both a subscription charge and a consumption charge. However, the subscription charge for all three tariffs is based on the kW capacity required by the customer, which is an unusual arrangement. The more capacity customers require, the more they must pay. For electrically heated homes, this policy encourages more efficient building construction. Tight electrically heated homes require less kW capacity for space heating than loose ones. Tight homes also have more pronounced peaks in their load curves, however, since their electricity requirements tend to peak dramatically on the coldest days of the year. In order to lessen this seasonal peaking effect, EdF offers a special tariff—the EJP tariff. Residential customers on the EJP tariff pay less for their electricity in the "off season" but must either switch to another fuel for space and/or hot-water heating (done automatically in response to a line pulse signal) or pay extremely high electricity rates on the coldest days of the year.

These tariffs represent an interesting case of clashing national energy policies: the national policy to encourage electric space heating in the residential sector and the policy

† Although the largest electric utility in Sweden (Statens Vattenfall) is also government owned, the utility sets both its tariffs and its prices autonomously.

represented in the increasing kW subscription charge to encourage energy efficiency. The EJP tariff can be seen as a creative measure in response to the negative side effect of the interaction between these two policies (the extreme peak in the load curve).

Changes In Energy Prices And Taxes And Their Impacts On Consumers

When consumers face an increase (or decrease) in total energy costs, the change distorts their budget. When the total price of an energy source is increased, consumers cannot purchase the same quantity of goods and services as they have purchased in the past. Often, consumers will reduce their consumption of the product whose price has been increased. The degree to which consumption will be reduced is dependent on consumers' price elasticity of demand.

Between 1973 and 1982, oil prices increased much faster than disposable income in each of the countries. In West Germany, oil prices increased four times as much as disposable income between 1973 and 1983. The resulting income effect was clearly one of the most important determinants of household energy consumption during the period, and motivated a great deal of the energy conservation and fuel substitution that took place in the study countries. By the time oil prices began to drop in 1982, many residential energy customers had switched from oil to other fuels, and many of those who were still consuming oil were consuming smaller quantities because they had adopted energy conservation measures. These factors lessened the reversal in the income effect that would otherwise have taken place as oil prices decreased. Despite this fact, the governments of some of the study countries feared that decreasing oil prices would cause increased oil consumption and have a negative effect on national energy conservation efforts. These fears became even more intense as oil prices plummeted in 1985 and 1986. The Danish government has used aggressive taxation policies, especially after 1985, to keep residential oil prices artificially high and eliminate the possibility of such a reversal. The French and Swedish governments have also increased their taxes on residential fuel oil. In 1987, 41 percent of the Swedish oil price was tax.

Figures 7 through 9 illustrate the changes in energy prices and taxes for each country.† These figures show the differences in the total residential prices and the proportion of

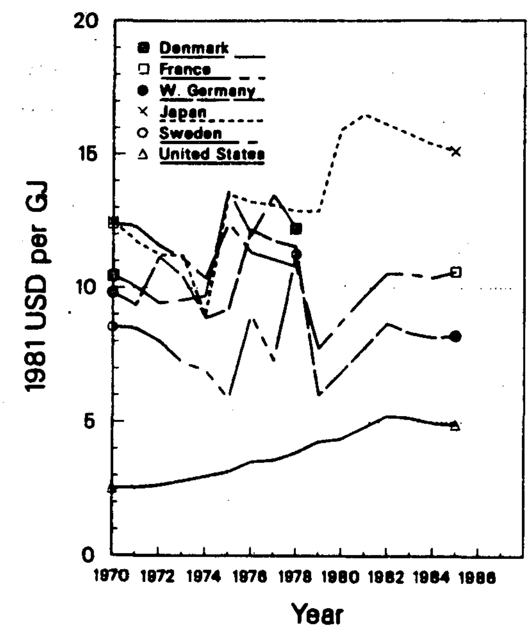
† Most of the price and tax data used in this chapter are from "Energy Prices and Taxes, Fourth Quarter 1987," International Energy Agency (IEA), Paris, 1988. Consumers may face a number of different fuel prices, especially for natural gas and electricity. For these fuels the average unit value is used. For Denmark, the electricity price data correspond to the average price for SFD without electric heating.

taxes among the study countries.† The share of the total residential oil price attributed to taxes varies from zero in Japan to more than 64 percent in Denmark (see Figure 7(B)).

Residential natural gas prices are shown in Figure 8. Natural gas prices have varied less over time than oil prices have. In the early 1980s, natural gas prices were competitive with oil prices on a heat equivalent basis in France, West Germany, and the United States. After the drop in oil prices in 1985-86 this relationship reversed. Of all of the study countries, Japan has had the highest gas prices (all of the gas used in Japan has been city gas (made in part from LNG)). The United States has had the lowest residential natural gas prices (more than three times cheaper than city gas prices in Japan), partially because of its domestic supplies and partially because of policies (such as the price ceiling described earlier) designed to promote its use.

Figure 8

Residential Gas Prices

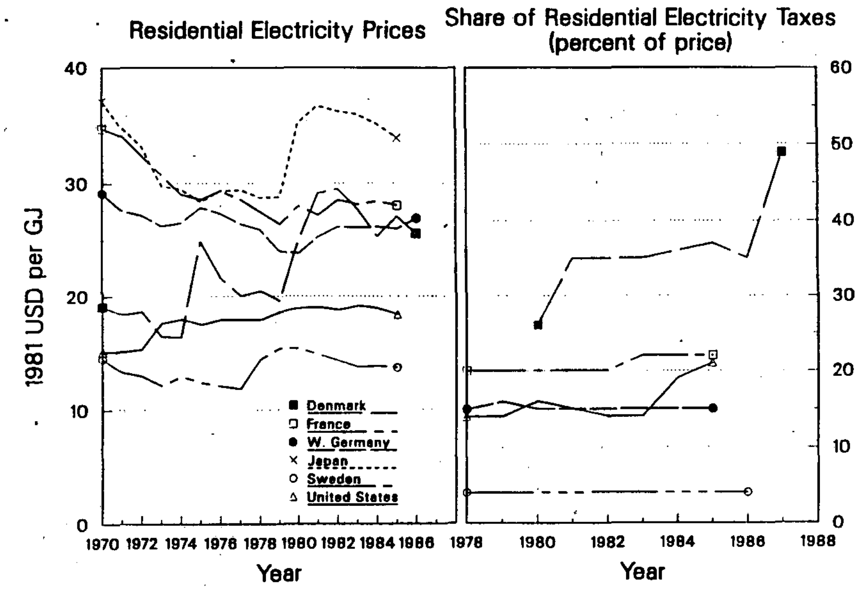


Residential electricity prices are higher than both residential oil and natural gas prices in every country except Sweden, where electricity was less expensive than oil on a heat equivalent basis between 1981 and 1985. Sweden has always had the lowest electricity prices, and Japan's are the highest (see Figure 9(A)). Electricity taxes have remained fairly

† The prices are shown in 1981 U.S. Dollars. The exchange rates used for the conversions are as follows (per 1USD): 7.1234DKK, 5.4346FF, 220.5400yen, 5.0634SEK, 2.2600DM. Source: "International Financial Statistics Yearbook," series RF, International Monetary Fund, Washington D.C., 1988

constant in every country except Denmark. (see Figure 9(B)).†

Figures 9(A) and 9(B)



Conclusion

Pricing tools have been used to varying extents in the study countries. The motivations behind the use of these tools has also varied greatly. The Danish government has implemented the most aggressive pricing policy, primarily using taxes. The Swedish government has done so to a lesser degree. The French government used both taxation and tariffs as pricing policy tools. West Germany and Japan have not used pricing or tariff measures. Most pricing tools were used after 1980, especially after residential oil prices fell in 1985-86.

What was the impact of pricing policy on residential energy demand and conservation? Although one cannot separate the effects of different price increases in each country, energy consumption per dwelling for space heating fell the most in the three countries that taxed oil heavily, Denmark, France, and Sweden. In each of these countries, energy consumption per dwelling in 1986 was below the 1973 levels. In West Germany and Japan, by contrast, energy consumption per dwelling was higher in 1986. In addition, the share of dwellings using oil for space heating fell far more in the first three countries than in the latter two. The use of pricing policies in Denmark, France, and Sweden clearly accelerated energy conservation and fuel switching from oil to natural gas and electricity in existing dwellings and promoted the use of the latter two fuels in new dwellings.

† Denmark is the only study country for which electricity price and tax data beyond 1985 are available.

PROGRAMS WHICH ALTER THE MAKE-UP OF ITEMS ON THE MARKET

The range of possible consumer investment decisions is always bounded by the items available on the market. Because of this, the market itself determines both the maximum and minimum efficiencies that a residential consumer can buy when investing in an energy-consuming end-use device. There are several tools that governments can use to intervene in the market and alter the make-up of products available to consumers. These tools can be used both in programs that remove the most inefficient products from the market and programs that add new, more efficient, products to the market. The funding of research, development, and demonstration projects is one important way that governments have attempted to get more efficient products onto the market. In Japan and West Germany Gentlemen's Agreements with appliance manufacturers have also served this purpose.

Both of these strategies broaden the range of items available on the market in a positive way, from the standpoint of energy efficiency. They do not, however, produce any guarantees as to the efficiency of products that consumers buy. Because consumers' decision-making processes when buying appliances and homes involve many parameters (size, options, color, price), energy efficiency is often a minor determinant of the products that are actually sold on the residential market. To do this in a way that consistently reaches all consumers and guarantees that all new products sold will perform with at least a minimum energy efficiency requires regulation. Laws that regulate the production of appliances and the construction of buildings are used to eliminate inefficient products from the market, thus creating minimum *standards* for the range of items available to consumers.

Mandated Efficiency Standards

Standards affect the marketplace in two somewhat different ways. Some standards divide the supply of homes or appliances on the market into those that already meet the standard and those that do not. This division often occurs when there is a wide distribution of efficiencies of building-related components or systems on the market, such as with the quantities of insulation in new homes or efficiencies of new electric appliances. Standards mandate increases in thermal insulation levels over those currently employed in new construction *on the average*, but a sizeable minority (or in some cases a majority) of homes usually comes close to or exceeds these requirements. Manufacturers of products that employ technologies with inferior efficiency characteristics must improve the technologies or stop selling their products.

Some standards require new approaches to design or require new kinds of energy-saving components. They may specify an uncommon component or technique (heat recovery in homes, for example), because the level of performance required can only be achieved using this new technique. Mechanical ventilation in tightly-built homes is a good example of a technique that was introduced in a minority of homes in Sweden and Denmark in the 1970s but is now necessary in new single-family dwellings in Sweden, which are built so tightly that a forced-air exhaust system is needed to maintain indoor air quality. In the extreme, standards can require development of entirely new technologies. Mandating extremely efficient refrigerators, for example, could lead to wider adoption of the rotary compressor, which is used in a minority of refrigerators today, as well development of an evacuated panel, essentially a refrigerator cabinet that contains a double wall with a vacuum between the walls. No manufacturer has successfully employed this panel so far. The proposed ban on certain refrigerants could lead to the use of substitutes that cause the refrigerator to use more energy. To compensate for this extra energy use, manufacturers may have to accelerate the development of evacuated panels or other energy-saving technologies.

Building codes or regulations are, of course, nothing new. In every country we have studied, national and local authorities have regulated building construction practices, and often technologies are installed in buildings to raise health or hygiene and safety standards. Most regulations specify minimum or maximum values of particular parameters that describe the building and its components, or require certain kinds of services to be available when the building is built (such as sewage). Sweden, for example, already required some thermal insulation in homes before 1973 to prevent moisture buildup on the inside of exterior walls. And most countries regulate appliances and combustion equipment. The insulation properties of a gas cooking stove (for fire safety), its ventilation to the outdoors (health and hygiene), and its placement in the kitchen (for fire safety) are all regulated.

Standards serve several important purposes. First, they require certain properties or features of structures or equipment that that might be absent if not required, either because the builder/manufacturer wants to save money, or the buyer does not see the value of these features. Sometimes the standards reduce externalities, such as emissions from chimneys, or even fire risks. Standards also assure the buyer/consumer/occupant that the house (and its components) or piece of equipment meets certain minimum levels of quality, safety, and performance, levels which the buyer/consumer/occupant cannot independently measure. The ultimate effect of standards is to change the technologies used in making homes or products, technologies that buyers/consumers/occupants themselves may never see or even be aware of.

Governments use energy standards to accelerate the reduction of energy use for key end uses, such as space and water heating. These standards usually require investments in energy-saving technologies that might not otherwise be made. Accelerating the reduction of energy use is particularly important if the national valuation of saving energy is greater than that seen by the individual manufacturer, builder, buyer, or occupant/user. Although the efficiency improvements required by standards result in lower energy use and operating costs for occupants of new homes, these improvements must be made by the builders or manufacturers, usually before the buyer or user enters the picture. Why these opportunities are not available to most homebuyers or purchasers of equipment, or why the marketplace itself fails to stimulate all parties to exploit these opportunities where and when available is beyond the scope of the present discussion.† But the end result is that the market for technologies that boost energy efficiency is weak, which creates a vicious circle. Producers of energy-using goods notice the weak market for efficiency, so they invest less in developing, producing and marketing technologies that are more efficient. Governments have recognized this situation and intervened by imposing standards or raising levels of efficiency required by existing standards on homes, and in some cases, on equipment and electric appliances. These standards or regulations lead directly or indirectly to the appearance of new products or technologies on the market that meet the standards.

It is important to distinguish between standards that affect energy use in *new* homes and equipment and in *existing* homes and equipment. Growth in the housing stock since 1973—representing 15-20 percent of homes that existed in 1988—has caused the portion of residential energy consumed in buildings built since 1973 to be significant. If thermal standards had led to a 25 percent savings in these new homes (compared with energy use in homes built before 1973), the savings in 1988 could have been as great as 5 percent of total residential energy use for space heating. Many building codes also regulate equipment use for space and water heating. Because the stock of heating/hot-water equipment and electric appliances grows and turns over more rapidly than the housing stock, the adoption of policies that affect energy use in these systems can also have a significant impact on residential energy use. In 1988, homes built before 1973 accounted for roughly 80 percent of the energy used for space and water heating in the residential sector. If standards or other regulations pass over these buildings, important opportunities for accelerating energy savings may be missed. Thus it is important to consider approaches to boosting efficiency in new *and* existing homes, as well as new (and existing) equipment. In the following sections, we review regulations that

† See Schipper, 1976, Krieg, *et al.*, 1980, and Ruderman, *et al.*, 1987, for discussions of market imperfections.

applied to new homes and equipment, as well as to existing homes. We focus on how such regulations affect these end uses, and discuss electric appliances briefly as well.

New Homes: Thermal Regulations

Most countries regulate heat loss in new homes, either by thermal standards published in building codes, or by other regulations, such as the Wärmeschutzverordnung in Germany. Table 26 shows the k-values for maximum permitted thermal conductivity (for single-family dwellings) in effect in 1988 in the countries we studied. The table also shows the successive changes that led up to these values. Current requirements in every country are far stronger than those in effect in 1973. Present standards for most building components require thermal conductivities that are about 50 percent lower for most building components than those in force (or common practice) in 1973. In general, changes in these requirements were made in two or three steps between 1973 and the present.

The thermal standards in the table fall into two generic groups representing overlapping or complementary approaches. Standards in Denmark and Sweden are *prescriptive*. They specify minimum (or maximum in some cases) values for energy-related parameters for all important building components. The building code in each country contains a general statement requiring "good energy economy" in the home, indicating that the goal of the standards is not simply to insure that components meet or exceed certain thermal transmission requirements, but that the overall impact is to reduce energy demand. Indeed, tradeoffs among the values of these parameters are allowed (up to a point specified for each component) that do not raise total heating energy requirements. The Danish code, for example, gives a simple formula (Heat loss = A + B x Floor Area) to simplify the comparison of alternative approaches.

The second type of thermal standard, the performance standard, specifies the overall energy performance of the building shell, giving values of thermal resistance or conductivity that apply to the entire structure or to large components, such a standard may even specify design energy budgets for given model homes. The codes in France and Germany are *performance* oriented. For example, the maximum k-value of a wall and window together is specified in the German regulations. The k-values shown in the table for Germany and France are typical choices for individual components in single-family dwellings. In both countries, the surface-to-volume ratio of the house is important in determining insulation requirements as well, which means that the overall shape of the building affects the permitted heat losses. This performance approach was used in the development of the standards once proposed for the U.S., the *Building Energy Performance Standards* (BEPS).

Table 26. Comparison of Residential Building Codes[199]

K-Values in W/m^2-° C for Single-Family Dwellings*

(Degree-Days Base 18°C shown for each country)

COUNTRY	WALL	ATTIC, ROOF	FLOOR	WINDOWS (PANES)	SOURCE
DENMARK (3122 DD)					
1972	0.6 - 1.3	0.45	0.45	3.6 (2)	
1979	0.3 - 0.4	0.2	0.3	2.9 (2-3)	BR 77
1984**	0.3 - 0.4	0.2	0.3	2.9 (2-3)	BR 84
FRANCE*** (2522 DD)					
1974	1.05	0.5	0.9	(2)	G = 1.6 W/m^3-°C
1982	0.7	0.3	0.82	(2)	G = 1.0 W/m^3-°C
1985	0.65	0.3	0.45	(2)	G = 0.65 W/m^3-°C
W. GERMANY (3113 DD)					
Pre-1978	1.57	0.57-0.9	N/A†	N/A	DIN 4108 (Eurima)
1978	0.81	0.55	N/A	N/A	WschV 1977 (Eurima)
1984	0.38	0.28-0.3	N/A	(2)	WschV 1982 (Eurima)
SWEDEN (4167 DD)					
Pre-1972****	0.69	0.39	0.43	3.0 (2)	SBN 67
1977	0.3	0.2	0.30	2.0 (3)	SBN 75
1984**	0.17	0.12	0.20	2.0 (3)	ELAK; Homes with direct resistance heat only

* Units shown are metric units; R = (5.9/k). Degree days refer to 18°C, in heating season, and are taken from LBL data base.

** Applies to "low energy homes" in Denmark and homes heated by direct resistance heating in Sweden; in both cases, mechanical ventilation is virtually required.

*** France - Typical solutions for the region H1: Lille-Paris-Lyon.

**** Actual practices (Schipper, *et al.*, 1985) were 0.35, 0.28, 0.30, and 2.7 in 1973.

† Not applicable.

The levels of thermal conductivity in Table 26 imply important changes in building techniques relative to pre-1973 practices. Walls were solid or hollow with no insulation before 1973, but now insulation is required. Builders in France and Germany, where masonry construction dominates, must enlarge the cavities between double walls in order to make room for more insulation, or they must find better insulation materials, or learn

[199] Sources: Denmark: Bygreglement, 1972; 1979; 1984. France: AFME; and Ministry of Environment and Housing; ISI Karlsruhe. Germany: Wärmeschutzverordnung, 1976; 1982; DIN, 4108. Sweden: SBN 67; SBN 77; SBN 85 (ELAK).

techniques for putting insulation on the outside of single brick or stone walls. Even where insulation requirements have been increased beyond already high values, ie., Sweden and Denmark, builders have had to develop new techniques to reduce the marginal cost of increasing insulation. One such technique was the development of I-beam-shaped studs to replace conventional studs that come in prescribed widths. These new studs come in continuous depths, so they can be cut larger to exactly match the thickness of insulation in a wall. In countries where window glazing had been ignored in building codes, minimum thermal efficiencies are now imposed. Single glazing has been replaced by double glazing, and, in Sweden, double by triple.† This improvement requires different framing techniques, because the new windows are thicker. In all, present thermal requirements imply considerably different building practices from those common before in all countries.

Windows are usually dealt with explicitly in the regulations. Most regulations limit the area of windows to some fraction of floor area or outside wall area. This limitation can be exceeded, however, as long as the extra heat loss from added window area is compensated for by improvements in other parts of the building. Regulations do not actually specify the number of panes of glass that are required, but give an overall transmission value that in most cases clearly corresponds to 2 or 3 panes. This value includes the contribution of window frames to overall heat losses, insuring that the insulating properties of good glazing are not short-circuited by poor window frames. Such a requirement illustrates the importance of the *functional* approach: the goal of the standard is to reduce heat losses, not simply to require that a certain component have a certain characteristic, like the number of panes of glass.

In most countries thermal requirements depend on choice of heating fuel and/or the geographical location of the building. For example, new homes using electricity for space heating must meet somewhat more stringent thermal requirements than other homes. The ELAK Code in Sweden[200] requires significantly greater insulation levels (see Table 26) for homes that cannot easily switch away from electricity because they are built with direct acting resistance heat instead of electric boilers with hydronic distribution. In practice, most

† Double glazing is still not required in new construction in England (except where window area is unusually large), and is not commonly found in new homes. Ironically, double glazing is very popular as an expensive retrofit. This is a clear example of a market failure, because the technology of double glazing is widely available and would cost less to install when the home was built than it does as a retrofit. Making double glazing mandatory in new construction would save consumers money. In Denmark and Germany, strengthened requirements for lower heat transmission in windows caused double glazing to replace single glazing in the substantial number of homes that were still equipped with single glazing in the early 1970s.

[200] Schipper, Meyers, and Kelly, 1985.

builders follow the ELAK code for all houses in order to avoid the complications of building homes with different amounts of insulation. In France, homes with electric space heating must be built with more insulation than homes heated with other fuels. In Denmark, homes built to a specified high level of performance (meeting maximum air leakage rates, low thermal conductivity standards, and featuring mechanical ventilation as well) are exempt from the general fuel-choice requirements of the regional heat plan. In many regions of Denmark, employing this high level of insulation is the only condition under which electricity (or oil) may be used for space heating. Finally, location, (ie., climate) is reflected in the standards. Insulation requirements in France are more strict for homes built in the north than in the south, in response to the harsher northern climate. This is also the case in Sweden, but most builders adopt the stringent requirements of the north for all homes, in order to reduce production costs by consistently building to only one level of insulation. The BEPS in the U.S. were to have used this approach, taking into account differences in fuel prices as well.

Some countries strictly regulate natural ventilation or air leakage. The 1975 Swedish code placed maximum air leakage values on major components, and recommended overall maximum air changes per hour (ACH; 3 ACH for 1- or 2-story detached homes, fewer for taller buildings) after 1978. But to maintain air quality and reduce the risks of indoor moisture and mold build-up, minimum ventilation requirements of 0.5 ACH (averaged around the year) were introduced. Mechanical ventilation has become necessary to control the flow of air. A cooking hood with a fan-driven exhaust to the outside is also required. The net effect of these requirements is to reduce the total heat loss from ventilation. The 1980 "ELAK" code in Sweden specified lower natural air leakage rates than the previous code permitted (0.5 ACH), and mandated mechanical ventilation in homes built to satisfy this code. (German authorities are now considering this step.) Thus the standards both anticipate an important opportunity for energy conservation and deal with some of the problems that tapping this conservation resource might cause.

New Equipment and Electric Appliances

Governments have traditionally regulated many properties of new space- and water-heating equipment for reasons of fire safety and hygiene, as well as to insure that new homes could be properly heated. In most countries, building regulations govern space- and water-heating equipment, i.e., combustion and distribution system function (e.g., heat water to a certain temperature), placement, insulation, and serviceability. Building regulations in Sweden and Denmark require duct insulation, accessibility for testing of stack gases, gauges, and other features that insure that the *system* of house plus heating device functions efficiently; however, there is no direct requirement that a boiler meet a certain efficiency. The Swedish approach is to treat equipment explicitly in building codes. In Denmark, the building code refers to existing standards (promulgated by government or professional bodies different from building-code authorities) that effectively raise energy efficiency of equipment. (This approach is favored by many states in the U.S., which adhere to the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standards or those promulgated by other recognized groups.) In Germany, a law separate from the building code (the Heizungsanlageverordnung) stipulates minimum levels of rated efficiency for combustion equipment. The new U.S. regulation, the National Appliance Energy Conservation Act (NAECA), will apply to all new gas- and oil-heating equipment, and to water-heating equipment as well. These independent, direct regulations are advantageous because they apply to all new heating equipment, not just that installed in new homes, i.e., they affect the replacement market. In Denmark, France, and Sweden, the efficiency of replacement equipment is not regulated directly. But an independent regulation on equipment might be problematic, because builders or consumers, focusing only on the choice of heating equipment, might not take in to account what will be most efficient for their particular building.

It is important to note that Denmark, France, and Sweden place equal emphasis on the technical specifications of components of equipment *and* their functional installation in the building. For example, the location of the boiler in the building, and its accessibility for purposes of monitoring and maintenance are specified by the building codes in all three countries. And in Denmark and Sweden controls that allow the occupant to regulate heat are required. The Swedish code even requires that "instruction manuals for the proper running and maintenance of the installation" be supplied with the installation. These regulations recognize the importance of function, not simply particular design parameters related to energy efficiency.

The regulations discussed so far deal with equipment and structures that account for 75-85 percent of energy used in homes and nearly all of the fossil fuels consumed in homes. Electric appliances and electric or gas cooking stoves account for an increasing share of household energy use, now between 10 and 20 percent. Measures improving their efficiency could significantly affect residential energy use.

Nevertheless, there have been virtually no energy standards imposed on electric appliances or stoves in European countries or Japan. Instead, there have been a series of agreements between industry and government that established efficiency goals. (These "gentlemens' agreements" are reviewed elsewhere in this report.) In the U.S., minimum efficiency standards for appliances were stipulated by Congress in the 1970s, but not signed by the president until 1987. International trade in appliances, and the need for countries' products to be equally competitive, is cited as the reason why no country in Europe—particularly a member of the EEC—could impose efficiency standards on appliances. However, in the U.S.

the desire to harmonize individual state regulations caused the appliance industry to support national appliance-efficiency standards.

Existing Buildings and Equipment

As noted in the introduction, existing or "older" buildings (ie., those built before new or strengthened regulations aimed to improve energy efficiency took effect in the 1970s) consume nearly 80 percent of all energy used in homes today for heating and hot water. Intended to encourage energy conservation, regulation of these buildings has focused on requiring individual metering of apartments, as well as improved heat controls and boiler maintenance. These regulations have mostly been aimed at larger boilers and apartments although in Denmark and Germany regulations apply to individual homes as well. These regulations fill a gap left by a market imperfection: landlords, who can pass energy costs on to tenants through rent charges, have no incentive to improve thermal comfort (or reduce costs) for tenants. Regulations "remind" building owners or operators (including occupants) about the benefits of more efficient energy use and reduced emissions. Finally, they help create a market for specialized control and metering technologies.

Regular boiler maintenance is required in most countries. This is particularly important in apartment buildings, where owners/operators have little incentive to save energy, or where investments only pay off if applied to the entire building. Most countries, therefore, require regular maintenance of boilers above a certain capacity; Denmark requires that even smaller boilers serving individual homes be inspected annually. Chimney sweeps carry out these inspections. This important group already bears responsibility for fire-safety and emissions-related inspections of boilers in many countries, so the efficiency-related boiler maintenance does not necessarily add extra visits to their rounds, only extra work. Together with requirements for individual metering and individual controls, requirements for boiler maintenance eliminated an important market imperfection for those living in apartments. The need for accurate metering caused several companies to improve the quality of heat meters and lower their cost, removing a technical barrier to accounting fairly for the use of heat and hot water in individual apartments.

None of the governments in this study regulate maximum indoor temperatures or other aspects of comfort in homes. When energy supplies were uncertain, there was an attempt during France to specify "correct" temperatures, but this regulation was not enforced. (There were similar regulations in the late 1970s for public buildings in many countries, including the U.S.) But governments have avoided directly restricting individuals' own freedom to choose their levels of indoor comfort. (Most building codes require that the size of heating plants be sufficient so that, together with the required levels of insulation, a *minimum* temperature can be maintained.) In fact, the imposition of requirements for individual metering and controls probably *increased* indoor comfort (per unit of money spent).

Governments have done little to require retrofit measures that increase the efficiency of building shells. This is regrettable, because such regulation would accelerate the development of low-cost techniques for retrofitting walls and windows. Denmark requires a certificate of energy efficiency before a house can be sold but does not require that measures recommended by the energy auditor be carried out. Germany requires that buildings be brought up to current standards if they are renovated. Although subsidy programs encouraged many owners to improve their buildings (see the subsidy chapter in this report), there are still many buildings—as many as 1/3 of all apartments in Denmark—that are significantly less efficient than officials believe is reasonable.

Energy Savings from Efficiency Standards

It is clear from Table 26 that great improvements in thermal properties of new buildings, compared with pre-1973 practices, were called for through changes in building codes. The differences between succeeding sets of requirements imply a sudden improvement in construction practices after imposition of each new set. In fact, improvements were probably more gradual, with many builders adopting more efficient practices even before standards were imposed. This means that the differences between earlier and later requirements in any single country, as portrayed in the table, overstate the actual change that was caused by the codes (assuming there was no cheating on requirements). This is particularly true in Sweden.† More important, comparison of estimates or measurements of heating energy use in homes built before and after efficiency standards took effect or were tightened show that the homes built after standards took effect used significantly less energy for space heating than homes built previously (See Schipper, Ketoff, and Kahane, 1985).‡ Some reductions in energy use are a result of using more efficient heating equipment, which is encouraged indirectly or mandated by other regulations. Thus it appears that broad goals of thermal and equipment standards in building codes and in other regulations have been achieved. While

† The difference between 1977 requirements and 1972 practice in Sweden was relatively small. In Schipper, *et al.*, 1985, the increment between the new code (SBN 75, in force in mid-1977) and actual construction practices in the year preceding it was found to be small because construction practices had improved steadily over several years. (See also, Schipper, 1984.) That is, regulations codified existing practices. However, the 1984 ELAK code required levels of insulation that were uncommon when the code was first proposed in 1980.

‡ Because there is some evidence that comfort (ie., temperatures, heating hours) improved in better insulated homes, the observed reductions in heating energy intensity imply slightly greater relative improvements in thermal integrity, with the difference in the relative changes accounted for by greater comfort. By the same token, improved indoor temperature must be scored as an achievement in itself, particularly in the case of Britain, where comfort in the early 1970s was low by European standards.

codes have not necessarily *caused* all of the improvements in efficiency or comfort, the improvements suggest that at least the goals of the codes have been met.

It is hard to measure how much the operating efficiencies of new space- and water-heating equipment have improved. The strengthened regulations on equipment components (such as insulation on pipes) and function (such as combustion efficiency) affect other parts of the heating system, as well as the performance of the entire house as a system. Improvements in the energy efficiency of this system are reflected in the drop in consumption for main space- and water-heating fuels as noted above. In the case of electric appliances, there are no national standards yet in any country except the recently enacted ones for the U.S. But appliances sold by national marketers in states like California after strong state energy efficiency standards came into effect in 1977 were more efficient than those sold elsewhere, as evidenced by the "* Not for Sale in California" notes attached to the least efficient models shown in national catalogs. And surveys from California's Pacific Gas and Electric Company taken in 1985 show that newer homes use less electricity for major household appliances than older ones. This suggests that the specifications of the California standards were met, and the goal of saving energy was accomplished.

Other Impacts of Energy Efficiency Standards

The imposition of energy efficiency regulations has had a wider impact than is measured by the reductions in energy use noted above. Codes have led to reductions in the costs of many energy-saving technologies. This effect was important both in Germany and France, where thermal practices were very inefficient before 1973. As the demand for double or triple glazing increased, production costs fell. Faced with regulated construction practices, the industries that supply equipment and housing components aimed to lower costs of implementing the required energy-saving measures. Dr. H. Ehm, Bundesbauministerium,[201] has pointed out that, in Germany, material supply companies and builders alike learned to produce new materials more cheaply and deploy them at less cost after standards were enacted. He suggested that strengthened building codes in Germany have stimulated this development. The codes led to improved construction practices, which in turn led to lower construction costs for energy-saving measures in new homes. In Sweden, where efficiency was (and remains) greater than in any other country, regulations have stimulated the market for ventilation and heat recovery, as well as the I-beam studs referred to previously. By 1984, seven competing kinds of I-beam constructions were available. Ultimately, then, energy efficiency standards have an important impact on the marketplace. A guaranteed market for efficiency rewards

[201] Ehm, 1987.

innovative manufacturers, suppliers, and builders, by assuring that their markets will not be undercut by competitors whose products are less efficient and therefore can be sold for lower initial cost. These changes in the shape of the market for energy saving technologies may be one of the most important achievements of efficiency standards.

More stringent thermal standards have also had an important effect on comfort. More efficient homes have lower operating costs, which could lead to somewhat higher indoor temperatures and hot water use. In most countries, this effect is small, because the level of indoor comfort in centrally-heated homes was high in 1973. But in England, authorities have found little reduction in gas use in new homes compared with older ones. Instead the gains in efficiency have been taken back as significant increases in comfort, and observed as more uniform heating of the house (made possible by good insulation), expanded hours of heating, and, of course, higher indoor temperatures. It could be argued that this increase in comfort would have been obtained eventually, but through greater use of heating fuels instead of insulation. The effect observed must still be considered a positive benefit of the imposition of standards, however.

Issues

Two important issues emerge from the review of energy efficiency standards: cost effectiveness, and the problem of acceptance of standards by those who produce the affected homes and equipment.

The cost effectiveness of required energy efficiency measures is an important criterion in the design of energy-related aspects of the building codes (or other efficiency regulations) in each of the countries. Methods and assumptions (including important factors such as the acceptable payback period and assumed interest rate) for evaluating the cost effectiveness of measures varied from country to country. There are few detailed cost-benefit studies documenting the economic payback associated with the quantity of thermal insulation required by individual standards. The consensus among experts we met with in Germany,† as well as studies of Denmark,[202] and Sweden,[203] was that requirements are "cost effective" with the mortgage as the boundary condition for interest rate and payback. Despite the long-term cost effectiveness of energy-efficiency measures required by standards, however, the economic drawback of increased construction or production costs is significant from both the builder's

† See, for example, Deutsches Institut für Wirtschaftsforschung, 1985. Energiesparmassnahmen im Raumwärmebereich auch bei sinkenden Ölpreisen noch vertretbar? **Wochenbericht**, Nr. 44/85, 31 Oct.

202 Schipper, 1983.

203 Schipper, Meyers, and Kelly, *op. cit.*

and consumer's points of view.

One concern often raised is that the additional costs of energy-efficiency measures compete for available capital with other uses of new-home funds. A clear example of this is in public cooperative housing in Denmark, where total construction costs (per square meter) are fixed by law without consideration for energy efficiency investments. In Sweden, housing authorities addressed this problem with a unique program of home loans, which finance efficiency measures, including those that exceed the basic requirements in the building code.[204] The program began in the 1950s for apartments and 1960s for single-family dwellings. The *combination* of codes and home loans was probably the reason for the high thermal integrity of homes in Sweden built before 1973, and the continued improvement in homes built subsequently as well. Put simply, the program insures that all installations required by the code are supported explicitly by the state loans. Additional amounts of insulation, or other measures (for example, a hot-water heatpump instead of an ordinary water heater) can also be funded with loans at the same terms and interest rate as the rest of the house. This approach satisfies both builders and buyers.

In other countries, no program finances or directly subsidizes the extra costs of required efficiency measures, although some countries' programs support the purchase of high-efficiency boilers, heatpumps, or other "experimental technology". Sweden's loan system reflects a major difference in political-economic philosophy from others'. German officials pointed out that measures that are required by the government cannot, by law, be supported financially by the government.† This distinction means that the first cost for building a new, energy-efficient home that meets government requirements will be higher than that for a pre-requirement home, at least until the construction industry learns new, low cost ways of saving energy. Initially, the incremental costs of meeting efficiency standards are a major obstacle to their acceptance by the construction industries in countries that do not choose the Swedish approach.

Do lower oil prices in the late 1980s undermine the cost effectiveness of the increased conservation required by codes designed in the early 1980s? The reduction in construction costs to meet improved thermal requirements in new homes may have offset the impact of some of this price decrease.‡ The incremental cost of meeting the increased thermal

[204] Schipper, Meyers, and Kelly 1985, *op. cit.*

† Ironically the words in German corresponding to the terms "required" and "supported" are "gefordert" and "gefördert."

‡ Deutsches Institut für Wirtschaftsforschung, *op. cit.*, estimated that most of the 1977 and 1984 required measures in Germany were economic with falling oil prices, although they did not foresee the crash that occurred in 1986.

requirements in new homes has apparently decreased as the building industry has gathered experience in meeting stiffer thermal requirements. This means that the new techniques developed in the 1970s and 1980s could remain competitive with significantly lower energy prices. And the incremental costs of meeting efficiency requirements include the sunk costs for initial learning and tooling. These are now essentially paid. Thus present requirements are probably still cost effective.

Building shell requirements can cause real changes in construction practice only if these changes are accepted by the construction industry. How rapidly builders respond depends in large part on the degree of cooperation between builders and housing authorities. The thermal requirements of all codes we studied were developed through government-industry negotiations. In many cases the new goals were first tested through competitions or trial houses, construction of which was supported by authorities. Such projects were widely publicized in France, Denmark, and Sweden, for example. Their success gave builders and suppliers, as well as future homeowners, confidence.

Cooperation between the housing industry and government was not new in 1973. In some countries, this cooperation enhanced the ability of housing authorities to codify requirements for energy-saving measures, which was a new area for regulation as far as housing authorities were concerned. In Sweden, and to a certain extent in Denmark, however, the housing authorities already played an active role in developing affordable housing. The investments made by public authorities in district heating systems in both these countries before 1973 suggest that affordable comfort, supported by local energy rather than housing authorities, was a part of this development. The housing authorities' mandates to improve energy efficiency in new homes fitted this goal well. Not surprisingly, the thermal performances of new homes in Sweden and Denmark have been the best among the study countries. Clearly the organizational structure of the energy and housing authorities in a country, and their relations, play a major role in the government's ability to implement building efficiency standards.

Many important properties that affect the energy efficiency of equipment have been regulated for decades. Committees to deal with important aspects of each piece of equipment (fire safety, insulation, etc.) have existed for a long time, and have defined channels for government-industry cooperation. Moreover, many pieces of equipment are produced by large, multinational companies, which are better prepared than small builders to respond to regulation. Indeed, in some countries (notably Great Britain, as well as in some states in the U.S.), energy suppliers take an active role in the development and strengthening of industry-wide standards as well as in the testing and even marketing of more efficient equipment. Individual equipment is also easier to test than entire houses. This means that manufacturers have a better opportunity to test a variety of options for meeting new requirements, and to see the results quickly. As a result of pre-existing relationships between equipment suppliers and government, which are born of a tradition of regulations (in most study countries), new regulations on equipment for space and water heating met with little resistance by suppliers.

Britain deserves special note. In Britain, the 1981 *Energy Conservation Act* was supposed to specify minimum thermal efficiency standards for most combustion equipment. However, voluntary programs run by the existing British Standards Institution were judged satisfactory, so no standards were implemented. This example illustrates the importance of using existing organizations and their standard-setting procedures to further energy efficiency goals. Virtually all new construction (and most boilers) are built for gas-fired heating in Britain. British Gas, which has a monopoly on gas distribution, is also a leader in sales of gas-burning equipment, and tests equipment as well, making it easy for their company encourage the development of very high-efficiency ("condensing") boilers. Thus Britain already had a single "authority" that could regulate equipment efficiency, or at least encourage purchase of more efficient equipment through its sales outlets. In other countries, the authority for each of these procedures is spread among many overlapping institutions. Efficiency standards, however, can strengthen the interaction among these institutions by clarifying energy-efficiency goals toward which all relevant institutions can work.

In the case of electric appliances, the resistance to efficiency standards in Europe was a result of a sensitive situation. The chief reason that standards were not imposed, at least in EEC countries, was the political difficulty of promulgating a standard that would be acceptable in all countries. In theory, a standard in one EEC country is a potential restraint of trade. Therefore, only a community-wide standard could be acceptable. But this would require agreement on procedures for testing and labeling, not a simple matter in the EEC. EEC directives pertaining to labeling of electric ovens were issued in 1979, but directives for to refrigerators and freezers, clothes washers, and dishwashers have been "discussed" since 1980 with no agreements as of early 1988.[205] The problem of accuracy and interpretation of test results (for labeling, etc.) was resolved in 1986, but the technical difficulties in actually choosing specific standard requirements were only overcome for refrigerators and freezers, which may become subject to standards in the future. The difficulty with clothes washers and dishwashers is that it is practically impossible to define the "output," or services delivered, against which to measure energy consumption. Clothing and eating habits differ from country to country, and so, therefore, do the ways of washing. Thus it is possible to reduce energy use, but at some point this could reduce the cleanliness of clothes and dishes,

[205] Leydon and Repoussard, 1988.

as an expert from Philips pointed out.[206]

Reasons for rejecting appliance efficiency standards in Sweden are somewhat different than elsewhere. Authorities at the National Consumer Protection Board[207] argue that improvement in energy efficiency of electric appliances has been good enough to make standards unnecessary. The board also argues that standards would impose a burden on smaller manufacturers. The board notes (in arguments similar to those put forward within the EEC) that Sweden should not in practice set up a potential barrier to trade by imposing standards on equipment that is traded internationally. Finally, in the 1970s, it was also seriously argued in Sweden[208] that so much of the waste heat from appliances helps satisfy space-heating requirements that the economic benefits of saving electricity used in appliances are significantly lessened. For all these reasons, Sweden has not imposed efficiency standards on electric appliances.

Summary and Conclusions

The goals of energy-efficiency standards for new homes and equipment have been realized. Evidence also suggests that the imposition of standards has accelerated the development of new technologies and their transfer into the marketplace. For space-conditioning equipment, standards in most countries highlight many subtle facets of the relationship among the equipment, the building, and the function itself (which is to deliver thermal comfort) that would otherwise be ignored in the construction process. In addition, the reduced heat losses mandated by standards decreases the uncertainty facing an engineer who is trying to size a new heating system for a building. This decrease reduces the need to oversize building systems to meet an unusually heavy load on a very cold day, for example. And tight, well-insulated buildings need heat during fewer hours of the year, which increases the seasonal efficiency of heating equipment, causing it to operate more steadily in fewer, colder hours, with fewer cycling losses. These improvements might not have been realized without well-defined goals for reducing heating needs, which were specified in efficiency standards.

In addition to requiring uniform thermal quality in new buildings and equipment, energy-efficiency regulations create a climate in which innovators are rewarded. Moreover, strengthened building codes are a signal, representing both minimum values that consumers can expect, as well as providing an index against which builders can measure their work. Builders in Sweden, for example, always refer to the extent to which their houses exceed

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206 Stavast, 1985.

207 Horovitz, September 1987. Also Horovitz, 1987 and 1988.

208 Schipper, Meyers, and Kelly, 1985, *op cit.*

code requirements. Builders in Denmark whose homes have a projected heating demand below a certain level may label their homes "lavenergihus" (low-energy house), and these are exempt from the fuel-choice requirements of the regional heat plan. This was still a selling point in 1988. As a result of standards, both the producer and the consumer can count on a more uniform and higher quality product than was on the market before 1973.

In the final analysis, efficiency standards alter the make-up of technologies on the market. But they also signal to consumers and producers the "right" level of energy efficiency, and give assurance that products that meet the standards achieve the "right" levels of efficiency. Most governments perceive that the social benefits of reducing energy use are greater than the benefits to individual building owners and occupants. Moreover, it could be argued that the individual benefits of increased energy efficiency are greater than the increased costs, but consumers are prevented from capturing these benefits because of market imperfections. Energy-efficiency standards address these issues by establishing a uniform method of accounting for energy concerns in new buildings and in new equipment. In this way, the efficiency requirements set a norm for construction practices or efficiency levels. Even if some unregulated construction would have been as good as or better than that required by regulation, there would not be a norm against which to measure. Furthermore, regulations protect consumers, assuring that they receive a minimum level of quality (with regard to thermal integrity) when they buy new homes. This is important because most consumers have no way of determining for themselves the thermal integrity of a home for sale. The case is even more extreme for renters because building owners are usually more interested in first cost than in operating costs (usually paid by tenants) or comfort. The few regulations that cover operation of existing buildings support development and deployment of technologies that landlords (and many homeowners) would never have demanded. The regulations also helped support the investment that many societies have made in know-how, i.e., professional boiler and system maintenance.

CONCLUSIONS

PROGRAM DESIGN AND DEVELOPMENT: GUIDELINES FOR CREATING PROGRAMS THAT WORK

The response of individuals, households, and institutions to residential energy conservation† programs (i.e., the potential impact of each program or policy) depends on many factors. Households' primary motivation for saving energy is economic. Individuals/households try to reduce their total energy expenses by reducing the cost of acquiring energy services and/or reducing the amount of energy services they consume. The attractiveness of measures aimed at achieving either of these goals depends on the amount of energy (or energy service) consumed, the price of energy, and the various measures' costs. The cost of adopting conservation measures depends on characteristics (size, age, operating condition, etc.) of the energy-consuming end-use devices in use (homes, appliances, and space- and hot-water conditioning equipment).

Large homes, poorly insulated homes, and homes with inefficient space-heating equipment are prime targets for energy conservation programs. The stock of oil-heated homes in central Europe and Denmark fit these criteria in 1973. Households where indoor temperatures and/or hot-water use is high, where electric appliances are large, and/or where large families live are also good targets, because total energy expenditures in such homes tend to be large. This situation characterized residences in the United States and Sweden in 1973. However, while Swedish homes were the most thermally efficient in the world in 1973, those in the United States were relatively leaky. Although residential energy consumption in these two countries developed in different directions after 1973, energy savings were achieved in both cases.

Households that heat to relatively low indoor temperatures or heat intermittently and only in individual rooms are less likely to participate in residential energy conservation programs. Japanese homes fit this description in 1973. In Japanese homes, and in homes elsewhere that were still heating with stoves (homes in West Germany and France in particular), energy consumption for space heating did not drop dramatically after 1973 (except during

† In all of the countries considered in this report, energy conservation was equated with oil conservation between 1973 and 1986. The experience gained through the energy/oil conservation programs implemented in these countries, however, are generalizable and can be applied to programs aimed at conserving other fuels or products.

short periods of very high prices and uncertain fuel—particularly oil—availability) because households were in the process of attaining higher and more uniform indoor temperatures (i.e., greater comfort). Conversions from stoves to central-heating systems increased energy consumption in many homes. The number of homes with central heating in France and West Germany virtually doubled between 1972 and 1986. In West Germany, rising household incomes allowed central-heating systems to penetrate the home-heating market so rapidly that the share of homes heated with oil (the most readily available fuel for central heating) increased until the early 1980s. For the same reason, kerosene retained its place as the primary heating fuel in Japan as well.

The primary space-heating fuel source in use and the options available for fuel-switching also affect participation in residential energy conservation programs. Homeowners heating with natural gas in the United States were shielded to some extent from the rapid increases in energy prices in 1973 and 1979. Homeowners in Sweden had the alternative of fuel-switching to cheap electricity (between 1981 and 1985). But the bulk of the homes in the study countries were faced with dramatic oil-price increases and had only two options for reducing their energy expenditures: reducing their level of comfort, or increasing the efficiency of their energy use.† Homeowners in this position had great incentive to adopt energy conservation measures and participate in energy conservation programs.

While these contextual factors affected program participation and the adoption of energy conservation measures, the impacts of these programs and measures on total residential energy consumption in each country were obscured by evolutionary changes in the structure of residential energy use that were taking place at the same time. Most of these changes were driven by rising household incomes. Because centrally-heated homes use, in general, twice as much fuel as homes with individual room stoves, the conversion of homes using individual room stoves to central-heating systems was significant enough in West Germany and, to a lesser extent, in France to offset energy savings from conservation measures adopted in homes that already had central heating.‡ In addition, new homes, although better insulated, tended to be larger than the existing housing stock in all of the study countries. Thus the amount of heated space per household increased. A similar trend took place in the case of household appliances: although the efficiency of new appliances was improving in each of the countries, the large growth in appliance ownership in France, Japan, and West

† Oil was the dominant space-heating fuel in Denmark, France, Japan (kerosene), Sweden, and West Germany in 1973.

‡ Much of the conversion to central heating accompanied the rapid abandonment of coal and other solid fuels, although wood has remained an important secondary space-heating fuel in parts of the United States, Sweden, and France.

Germany, as well as the fact that larger and more complex appliances were being bought, offset efficiency gains. For example, the efficiency of most new refrigerators (measured in liters cooled per kWh of electricity consumed) increased, but the cooled volume of newly purchased refrigerators and the number of energy-consuming features they contained (such as freezer compartments) increased as well. Most new homes also contained central, rather than individual point-of-use, water-heating systems. The aggregate effect in countries experiencing significant structural changes was often that energy consumption for space heating remained relatively constant, or increased.

Changes in the size of households also affected residential energy demand in a very important way. The average size of households declined, in some countries by as much as 15 percent, between 1972 and 1986. This caused the number of homes, heating devices, appliances, etc., per capita to increase. All else being equal, reductions in household size tend to reduce energy needs per household (particularly for water heating and cooking), but the decline in energy consumed per household is more than offset by the increase in the number of households per capita. Reductions in household size invariably, therefore, cause the total amount of energy consumed in the residential sector to increase.

These examples show that contextual factors, described both in terms of physical characteristics and trends toward structural change, define the appropriate energy conservation measures that can be promoted in any given case. Examining context is the first step in conservation program design.

The second step in conservation program design is choosing the right tool or combination of tools for the task of promoting the measures identified in step one. Determining which is the "right" tool or set of tools for the task also depends on several interacting factors. The most important of these are legislative constraints (political, ideological, and budgetary), implementation constraints (the availability of infrastructure and the relationships between key institutions), and requirements for the predictability and sustainability of program results.

All of the political and ideological constraints to residential energy conservation policies and programs differ from government to government and over time. Some of these are easily identifiable by government decision makers, and thereby avoidable. These most obvious constraints provide "first-cut" criteria for eliminating unviable tools from those being considered. For example, laissez-faire policy in West Germany precluded aggressive intervention in the residential energy market. In Japan, policies aimed at producing continued improvements in the standard of living were seen as constraints to the range of tools that were viable for conservation programs.

The "second-cut" criteria for choosing tools are usually budgetary. Policy-makers set budget limitations based on their own answers to the question "How important is the problem?" and choose among tools by answering the question "How much money do we have to spend?" The question of "What should we spend it on?" is the logical extension of this economically based decision-making process.† Some programs, such as subsidies, are inherently fiscally-intensive. Others, such as regulations, can be implemented with very low costs to the government but may produce high costs to consumers affected by the policy. All programs involve income redistribution to some extent, in the sense that they create new expenses in one area and benefits from those expenditures in others. Where government budgets for conservation programs are limited, this concept can be used as the basis for forming synergistic policies for providing program funding: revenue generating programs (taxes and fees) can be used to fund revenue demanding programs, such as subsidies. With only a few exceptions, however, the revenue generating conservation programs in the countries we have studied have not ear-marked the funds to be recycled into other conservation programs. Programs that have large income-generating effects and do not provide guidelines for the redistribution of the funds they collect (i.e., where revenue is thrown indiscriminately into the national fiscal pot) can cause harmful distortions of national economies and can limit governments' ability to alter or reverse their revenue generating policies in the future. Such is the case in Denmark, where the national economy has become severely dependent on income generated through taxes on energy.

In addition to legislative constraints, there are other less obvious constraints to the feasibility of implementing programs that should not be overlooked. These constraints are often directly related to the type of tool being considered. As a policy-maker or planner it is important to recognize these constraints and to account for them when choosing amongst program tools.

The relationships between actors, both public and private, that are responsible for designing, implementing, and responding to national programs are important determinants of the success or failure of programs. Regulatory programs aimed upstream (at manufacturers) require good cooperative relationships between the government and the industries they affect. Sweden provides a good example: the process used for developing and implementing building codes there is a success story largely because such relationships have been addressed and used to enhance the regulatory process. Strong relationships between

† In some cases the answer to the question "How important is the problem?" and other concerns, such as equity issues, preclude the use (or at least the exclusive use) of economic criteria for choosing amongst program tools. This is often the case when social benefits cannot adequately be included in, or outweigh the results from, common cost-benefit analyses.

government and the appliance industries in Japan and West Germany made gentlemen's agreements aimed at improving appliance efficiencies possible. The perceived lack of such relationships between the government and the housing construction industry in Japan limited the extent to which the Japanese government was able to influence the energy efficiency of new homes. The cooperation of industry can often be enhanced through research, development and demonstration (RD&D) programs, as in the case of the H2E85 and Bâtiment Econome programs that preceded changes in the building code in France. The failure of the United States government in its attempt to implement mandatory national Building Energy Performance Standards in 1980 provides a good example of what can happen when governments attempt to design and implement such regulatory legislation without first gaining the support and cooperation of industry factions.

Institutional relationships also determine the extent to which different programs can be coordinated. Cooperative interaction between agencies in Denmark made the pooling of efforts toward the common goal of reducing space-heating requirements in existing buildings possible.

The availability of infrastructures for implementing programs is more important for the use of some tools than for others. Strong infrastructures are most important in the case of information programs. Such programs require an extensive network of effective institutional channels. These channels are necessary for determining the type of information that will be of most use to program participants, for assembling the most up-to-date and useful information on any given subject, and for effectively disseminating the information to the target population. A wide range of public and private institutions provided an effective infrastructure for disseminating information in West Germany. Existing programs and regulations can also be seen as useful sources of infrastructure for energy conservation programs. The home loan system in Sweden and boiler inspection regulations in several countries are examples where existing programs were successfully piggy-backed by new energy conservation programs.

Using existing agencies and programs as opposed to creating new ones is advantageous for several reasons. Creating infrastructural institutions is costly and time consuming, and it is difficult to ensure their effectiveness. By accessing existing institutions, both public and private, time and expense can be held to a minimum and the risk of creating ineffective agencies is reduced. In addition, many such institutions are already trusted by the public as information sources. Efforts to create new agencies are particularly problematic when they involve stimulus at the national level for creating agencies meant to function at the local/regional level. We have described several cases of programs in the study countries where new infrastructures were created for the purpose of implementing specific programs.

Among these are the the EPD program in Sweden and the Energy Consultant's Register in Denmark. Both of these programs were aimed at creating agencies for distributing information. In each case, the agencies proved unsustainable when funding at the national level was removed. The creation and subsequent collapse of such infrastructures can cause other important negative side-effects, such as the unemployment of displaced and isolated labor forces created under programs.

The aforementioned constraints determine the feasibility of using the various available tools in residential energy conservation programs. They provide very little information, however, about the outcomes that various program tools can be expected to produce. The "final cut" in choosing program tools should incorporate criteria based on requirements for the predictability and longevity of program results. Some tools produce "predictable" results and participation rates, whereas others have higher levels of uncertainty. In addition, some of them produce "permanent" savings while others produce short-term savings which are easily reversible in the long-run. Different tools are, therefore, appropriate to different conditions and goals.

Information campaigns aimed at changing consumers' energy consuming habits are the least predictable of program tools and tend to produce the least permanent results. In some cultural settings, advice from the government about "good" and "bad" behavior is widely accepted by the public and can be used to produce short-term behavioral changes. This can be particularly useful in times of crisis, when immediate and large-scale reductions in energy use are required. Information campaigns were used successfully toward these goals in Denmark, Japan, and Sweden following the oil price shocks in 1973 and 1979. In other settings, such campaigns can backfire and cause long-term negative impacts for the success of energy conservation. Jimmy Carter's famous "put on a sweater" speech in 1977 is seen by many experts as having had this effect: instead of rallying the American public around common energy conservation goals this speech taught the public to equate energy conservation with sacrifice rather than efficiency. Even in countries where changes in energy-consuming habits have measurably reduced residential energy demand (for example, Denmark), the results are temporary; habit-based savings are often replaced by efficiency improvements, and tend to reverse as demands for energy services increase. Information programs aimed at encouraging investments in energy efficiency are equally unpredicatable as campaigns aimed at consumer habits, but the measures adopted by participants produce more permanent savings.

Subsidy programs can be seen as attempts to design investment-related information programs with less participation uncertainty: consumers are advised to make certain investments, and their acceptance of that advice is given motivation through carrot dangling. This method can be very effective in both ensuring broader participation than can be expected from information programs and in providing the subsidy-offering body control over the measures adopted by program participants. The latter factor can be used to influence the longevity of savings resulting from program participation. As mentioned previously however, subsidy programs are expensive to implement, and participation is constrained by the amount of money that the government is able/willing to spend: as each subsidy offered increases in value the number of interested participants grows, but the rate at which the program budget is exhausted increases as well. Thus it is difficult to reach large cross-sections of residential energy customers with subsidies without spending vast amounts of public funds.

Programs that change the total price that consumers pay for energy by manipulating base prices or supplementing them with taxes or fees produce broad participation, but the effect they have on energy consumption is not easily predictable. The impact of higher energy prices on consumption depends on consumers' price elasticity of demand, which is difficult to estimate *before* a program or pricing policy is implemented. Economists' estimates of consumers' price elasticity range from very low (i.e., close to zero) to more than one (i.e., a 1% increase in the price of a given energy type leads to a greater than 1% decline in demand). The uncertainty produced by this problem can be reduced by raising total price to extreme levels, thereby assuring response by the bulk of the consuming population. Such policies have successfully hindered growth in energy consumption in Denmark. In countries where there are large disparities in income levels, however, such pricing schemes are likely to produce equity problems: energy expenditures of the poor, who do not have the resources necessary for improving the efficiency of their energy use, will rise to disproportionate fractions of their total income, whereas achievement of the desired response will be unpredictable among the rich, whose energy consumption is largely price inelastic. In addition, pricing policies alone provide no certainties as to the longevity of savings they produce: the government has no control over whether consumers respond by belt-tightening (thus producing highly reversible savings) or by investing in efficiency. Nevertheless, pricing policies in Denmark, France and Sweden have had impressive short-term effects: high prices maintained through taxes have held consumption down. In countries where such policies have not been not implemented, such as Japan and West Germany, residential energy consumption has increased as prices on the world oil market have gone down.

Although often difficult politically to implement, enforceable regulations that provide minimum efficiency standards for new homes, space-conditioning equipment, and appliances are the broadest reaching and most predictable tools for encouraging residential energy conservation. Because most of these products have long life-times, such regulations also produce savings that are not easily reversed. In addition, the costs associated with implementing and enforcing these regulations are usually small and marginal, since most countries already regulate such products for purposes of safety and hygiene.

Most of the problems associated with the use of each individual program tool can be avoided or alleviated by using a combination of tools aimed at achieving individual energy conservation goals. Response to information programs can be strengthened through the use of subsidies, just as participation in all programs can be maximized through effective information dissemination. Subsidy programs can be funded through revenue-generating programs, and subsidies can be used to influence consumer-investment decisions made in response to rising energy costs. Minimum efficiency standards for the energy-consuming end-use devices that consumers buy can be achieved through the use of regulation. And the acceptance of regulations can be enhanced through RD&D programs. Continued RD&D and the adoption of known efficiency measures can be encouraged through subsidies. And subsidized RD&D programs can be used to enhance relationships between public and private institutions. In short, the most effective residential energy conservation programs are designed using a variety of tools synergistically.

PROGRAM EVALUATION: WHERE DOES IT FIT IN?

The last but far from least important aspect of successful residential energy conservation programs is program evaluation. It is beyond the scope of this project to discuss methods for performing useful program evaluations. Our "guidelines" would be incomplete, however, without a brief discussion of the role of evaluations in enhancing the effectiveness of residential energy conservation programs. Program evaluations are important both as part of the implementation process (i.e., de-bugging in a dynamic situation) and after programs are completed (i.e., enhancing the learning-curve effect). Evaluations played an important role in optimizing the Swedish home energy subsidy program, for example, and are currently a widely-sought-after commodity in countries considering the development of future residential energy conservation programs.

The current demand for well-designed and well-implemented evaluations of previous programs is difficult to meet. Although program evaluations have become more common in the United States, they are still relatively sparse in other countries (with the exception of Sweden). This is due in part to institutional barriers to program evaluation. One of the most significant institutional barriers to program evaluations is the fear of annihilation. When the agencies responsible for implementing programs fear that criticism may lead to loss of program funds they are not likely to evaluate their own programs, or cooperate with outside evaluators. This has been particularly true for energy conservation programs, which have been difficult to fund in many countries. Even in cases where some initiative toward self-evaluation is taken, the results are often inadequate because planning and funding for evaluative efforts are seldom integrated into program design.

After programs have been completed, the agencies responsible for their implementation are usually focusing on programs that are current and/or looking forward and planning future programs. Thus time and resources are not available for concentrating on the past. Even when these barriers are removed, the information that is required to adequately evaluate programs is not usually available: comprehensive evaluations require a considerable amount of data collection, before, during, and after the program being analyzed is implemented. This requires considerable advance planning. It is essential, therefore, that consideration of the requirements for providing useful evaluations become part of the program design process.

REFERENCES

AFME, 1981. Methods for Impact Analysis of Information Campaigns Led by the AFME in the Residential Sector. Paris, France (mimeo report).

AFME, May 1982. Aides Financières dans l'Habitat - Chez Vous, la Maitrise de l'Energie est Entre Vos Mains, Paris, France (brochure, in French).

AFME, 1984. Aides Financières dans l'Habitat - Rectificatif a l'Edition de Mai 1982, Paris, France (in French).

AFME, 1985. Maitrise de l'Energie - Lettre d'Information de L'Agence Francaise pour la Maitrise de l'Energie, no. 21, printed in *Le Monde, April 10, 1985*.

AFME, 1986a. Rapport d'Activité 1985, Paris, France (in French).

AFME, 1986b. Un Premier Bilan: 1982-1985, Un Programme pour l'avenir: 1986-1990, Paris, France (in French).

AFME, 1987a. Rapport d'Activité 1986, Paris, France (in French).

AFME, October 1987b. Etude sur l'Evaluation des Actions Villes-Pilotes en Matière de Promotion du Diagnostic thermique, Déjà Effectués ou en cours dans les Etats membres de la CEE: Parti 1 -- La France, Rapport Final, France (in French).

AFME, 1987c. Les isolants: produits et fabricants, Paris, France (brochure, in French).

AFME, 1987d. The French Experience in Energy Management: Energy Data from 1973 to 1985, Paris, France.

AFME/EPERE, December 1985. Energy Management in France, Paris, France.

AFME/EPERE, 1986a. Maitrise de L'Energie Dans Les Pays Industrialisés, Paris, France (working document, in French).

AFME/EPERE, May 1986b. Effort et Moyens Mis En Oeuvre pour la Politique de Maitrise de l'Energie dans Cinq Pays Industrialisés, N. 86.119, Paris, France (in French).

AFME/EPERE, 1986c. Evaluation des Effets de la Deduction Fiscale sur l'Investissement de Maitrise de l'Energie des Menages, n/86-175/1, Paris, France (in French).

Agency of Natural Resources and Energy, MITI, March 1986. "Energy Fact (sic) in Japan," Japan.

Angioletti, R., April 1988. "Les Consommations d'Electricité Specifique dans le Secteur Residentiel et Tertiaire", in Bulletin de l'Habitat et Tertiare--AFME, no. 7, pp. 8-15, Valbonne, France (in French).

Assembleé Nationale, 1985-86. Rapport d'Information...sur le bilan de la politique de maitrise de l'énergie, Assemblée Nationale, 1re session ordinaire de 1985-86, No. 2985.

Beaud, P., October 1987. "Un Peu d'Histoire", Bulletin de l'Habitat et Tertiaire--AFME, no. 5, pp. 13-19, Valbonne, France (in French).

Bostadsdepartementet, 1980. "Program för Energihushållning i Befintlig Bebyggelse: Betänkande från Energihushållningsdelegationen," *Statens offentliga utredningar,* Stockholm, Sweden (in Swedish).

Bostadsstyrelsen, 1975. "Energisparlån och bidrag," Stockholm, Sweden, (in Swedish).

Bundesministerium für Wirtschaft, January 1983. "Wärmeschutz bei Gebäuden: Wärmeschutzverordnung vom 24. February 1982," Bonn, West Germany (in German).

Byggforsningsrådet, 1984. "Bostadsstyrelsens lån- och bidragsgivning till energisparåtgärder i bostäder mm," R134:1984, Stockholm, Sweden, (in Swedish).

Carlsson, Lars-Göran, 1989. "Energianvändning och strukturomvandling i byggnader 1970 - 1985," Byggforskningsrådet R22:1989, Stockholm, Sweden (in Swedish).

Centre Scientifique et Technique du Bâtiment (CSTB), 1982. Le Programme National Francais d'Economie d'Energie dans l'Habitat Neuf Construit à Partir de 1985, CSTB, France (mimeo, in French).

Charbonnier, S., Ministère de l'Equipement et du Logement (MEL), Direction de la Construction, Paris, France, priv. comm., February 9, 1988.

Dallaporta, J. P. and P. Herant, April 1988. "Nouvelles Reglementations Thermiques", Bulletin de l'Habitat et Tertiaire--AFME, no. 7, pp. 3-8, Valbonne, France (in French).

Dallaporta, J. P., October 1987. "Des Stats, des stats, oui mais....", Bulletin de l'Habitat et Tertiaire--AFME, no. 5, pp. 33-36. Valbonne, France (in French).

Danske Elværkers Forening, February 1987. "Elforsyningens tiårsoversigt, 1976-85," Frederiksberg, Denmark (in Danish).

Debergue, G., October 1987. "Quelques chiffres", Bulletin de l'Habitat et Tertiaire--AFME, no. 5, pp. 37-38, Valbonne, France (in French).

Debergue, G., AFME, priv. comm., July 4, 1988.

Diczfalusy, Bo, 1987. "Energipolitikens Vardag: Hur är energipolitiska temperaturen i Sveriges kommuner?," AB Svensk Energiförsörning, Sweden (in Swedish).

Economic Planning Agency, Japan, 1987. "Statistical Yearbook of Japan," Prime Minister's Office, (in Japanese).

Ehm, Dr. H., Bundesbauministerium, Bad Godesburg, W. Germany, priv. comm., 1987.

Eklund, Erik, May 1988. Beskattningen av energi i utlandet, Statens Energiverk, Stockholm, Sweden (in Swedish).

Energisparkommittén, 1983. "Information som styrmedel," SOU1983:34, Stockholm, Sweden (in Swedish).

Energy Conservation Center, 1979. "The Law Pertaining to the Rationalization in the Use of

Energy," Law No. 49, 1979, Japan, translated by JEPIC and ECC.

Energy Conservation Center, 1984. "Energy Conservation in Japan, Fiscal Year 1983," Tokyo, Japan.

Energy Conservation Center, 1985. "Energy Conservation in Japan, 1984," Tokyo, Japan.

Energy Conservation Center, May 1985. "Activities in FY 1984," Tokyo, Japan.

Energy Conservation Center, 1986. "Energy Conservation in Japan, 1985" Japan.

Energy Design Resources Inc., May 1986. "Japan's Manufactured Housing Capability: A Review of the Industry and Assessment of Future Impact on the U.S. Market," prepared for the U.S. Department of Energy, Washington D.C.

Energy Taxation Committee, Sweden, 1982. "Skatt på Energi," Sweden (in Swedish).

Finney, Peter, former employee of Statens planverk, Stockholm, Sweden, priv. comm., August 1988.

Fraunhofer Institute for Systems and Innovation Research (ISI), December 1982. "Evaluation of Energy Conservation Programmes in the EC Countries," Karlsruhe, Germany.

Fraunhofer Institute for Systems and Innovation Research (ISI), December 1982, Annex. "Evaluation of Energy Conservation Programmes in the EC Countries, ANNEX: Description of Energy Conservation Programmes," Karlsruhe, Germany.

Garand, G., 1988. priv. comm., interview with G. Garand, ANAH, July 4, 1988.

Gilbert, Sylvain and Michel Guenot, (P. L. Debomy, ed.) undated. La Tarification `a Electricite de France - edition 1985, Direction de la Distribution, EDF-GDF, France (in French).

Guyot, G., October 1987. "Enquetes et Resultats sur les suites Donnees aux Diagnostics Thermiques", Bulletin de l'Habitat et Tertiaire--AFME, no. 5, pp. 30-32, Valbonne, France (in French).

Hawk, Dianne and Lee Schipper, 1988. "The Role of Oil in Electricity Generation in Five European Countries: Past, Present, and Potential," LBL-25674, International Energy Studies, Lawrence Berkeley Laboratory, California, U.S.A.

Hildebrandt, Lutz and Bernward Joerges, 1983. "Consumer Energy Conservation Policies and Programs in the Federal Republic of Germany," in *Consumer Energy Conservation Policies (CECP)*, CECP Technical Reports Volume IV, IIUG, Berlin.

Horovitz, Autur, September 1987a. "Elanvändning för hushållsapparater," Konsumentverket, for Statens energiverk, Sweden (in Swedish).

Horovitz, Autur, Konsumentverket, Sweden, priv. comm., 1987.

Horovitz, Autur, Konsumentverket, Sweden, priv. comm., 1988.

Industridepartementet, 1974. "Energi 1985 2000," *Statens offentliga utredningar,* 1974:64, Stockholm, Sweden (in Swedish).

Industridepartementet, 1975. "Så ska vi planera energihushållningen i Sverige," Sweden (pamphlet, in Swedish).

The Institute of Energy Economics, January 1983. "Energy in Japan," Bi-monthly report No. 61, Tokyo, Japan.

International Energy Agency, March 1987. "Government Organizations and Programmes with respect to Energy Conservation in IEA Countries," IEA/SLT (87)33, Paris, France.

International Energy Agency, 1988a. "Energy Prices and Taxes, Third Quarter 1987," Paris, France.

International Energy Agency, 1988b. "Energy Prices and Taxes, Fourth Quarter 1987," Paris, France.

International Energy Studies, March 1987. "Evolution of Residential Energy Demand in OECD Countries, Part One: 1970 - 1984 Data Base," LBL-22267, Lawrence Berkeley Laboratory, California, USA.

Joerges, Bernward *et al.*, October 1982. "Consumer Energy Conservation Policies - A Multi-national Study, Fourth Interim Report," IIUG, Berlin.

Ketoff, Andrea, Sarita Bartlett, Dianne Hawk, and Stephen Meyers, July 1987. Residential Energy Demand in Six OECD Countries: Historic Trends and Future Directions, LBL-22642, International Energy Studies Group, Lawrence Berkeley Laboratory, California, U.S.A.

Klingberg, Tage *et al.*, December 1982. "Consumer Energy Conservation Policies in Sweden," Statens institute för byggnadsforskning, Gävle, Sweden.

Klingberg, Tage, Swedish Building Research Institute, Gävle, Sweden, priv. comm., August 1988.

KRAFTSAM, 1987. *Elkraftförsörning i Sverige 1986* , Sweden (in Swedish).

LeVaillant, Patrick and Genevieve McInnes, 1981. "Sommaire - Annexe 1: Les politiques d'économies d'énergie mises en place depuis 1973 dans les différents pays", France (mimeo, in French).

Leydon, K. and J. Repoussard, Energy Directorate, EEC, priv. comm., 1988.

Leyral, R. and E. Monnier, 1983. Consumer Energy Conservation Policies and Programmes in France, CECP Technical Reports Vol. V., International Institute for Environment and Society, Berlin (IIUG, WZB).

MEL, 1988. "L'adaptation de la Réglementation Thermique Applicable aux Logements Neufs", Rencontre CEGIBAT, May 19, 1988.

Meyer, Niels I. and Jørgen S. Nørgård, February 1987. "Alternative Energy Plans for Denmark," Energy Group, Physics Laboratory III, Technical University of Denmark, Lyngby, Denmark.

Ministère de l'Equipement et du Logement (MEL), 1987. Données economiques et financières sur le logement, no. 138. Paris, France.

Ministry of Economics, West Germany, October 1984. English translation and summary of the annual Energy Status Report.

Ministry of Energy, Denmark, December 1986. "Energy in Denmark, Status Report on Energy Planning 1986."

Ministry of Housing and Physical Planning (Bostadsdepartementet), Sweden, 1978. "How much energy will we save in ten years? Summary of the Swedish Government's proposed energy conservation plan for sic$," Stockholm, Sweden (pamphlet).

National Building Agency, Sweden, June 1982. "Energy-conserving Measures in Buildings, A Survey of the Danish Energy-saving Program in the Ministry of Housing 1975 - 1987," prepared for an U.N. Seminar in Gävle, Sweden.

National Energy Administration, Sweden, 1988. "Energy Research 1987-1990," 1988:3, Stockholm, Sweden.

Nordic Statistical Secretariat, 1985. "Yearbook of Nordic Statistics, 1984," Stockholm, Sweden.

Nørgård, Jørgen S., September 1986. "Technologies to Increase End-Use Electricity Efficiency," Energy Group, Physics Laboratory III, Technical University of Denmark, Lyngby, Denmark.

Observatoire de l'Energie/Direction générale de l'Energie et des Matières premières, 1986. Tableau des Consommations d'Energie en France, Ministère de l'Industrie, des Postes et Téléphones et du Tourisme, France (in French).

Olive, Gilles, December 1986. Dossier sur l'Evolution de la Politique Nationale d'Economie d'Energie dans le Secteur du Bâtiment, Habitat HPE, France (in French).

Olive, Gilles, August 1984. "Industrial Policy for Energy Saving New Housing", American Council for an Energy-Efficient Economy, Proceedings - 1984 Summer Study, Volume J, pp. J84-91, Washington, D.C.

Perkins, Frances, November 1985. "Japan's Energy Policies -- Their Evolution and Implementation," Institute of Energy Economics, Tokyo, Japan.

Pinta, J. C., 1987. La Tarification de l'Electricité en 1987, Electricité de France -- Service d'Etude et de Promotion de l'Action Commerciale, Paris, France (in French).

Plan Construction et Architecture, April 1987. "Le Programme Bâtiment Econome: Note de Presentation", Paris, France (in French).

Plazy, J. L., October 1987. Repartition des Frais de Chauffage, Bulletin de l'Habitat et Tertiaire--AFME, no. 5, p. 7.

Röhling, Eike and Jochen Mohnfeld, December 1985. "Energy Policy and the Energy Economy in FR Germany," *Energy Policy.*

Sagawa, Naoto, 1984. "The Japanese Energy Conservation Policy and It's Effects on Energy Demand Structure," unpublished paper.

ScanTest, Danish Energy Agency, 1974. "Befolkningens energisparebestræbelser, November 1974," Copenhagen, Denmark (in Danish).

Schipper, Lee, December 1982. "Residential Energy Use and Conservation in Denmark: 1965-1980," Lawrence Berkeley Laboratory, California, U.S.A.

Schipper, Lee, December 1983. "Residential Energy Use and Conservation in Denmark," *Energy Policy.*

Schipper, Lee, Andrea Ketoff, Stehpen Meyers, and Dianne Hawk, September 1986. Electricity and the Home: an International Overview of Trends, LBL-21187, Lawrence Berkeley Laboratory, California, U.S.A.

Schipper, Lee, Andrea Ketoff, and Adam Kahane, 1985. "Explaining Residential Energy Use by International Bottom-up Comparisons", *Annual Review of Energy,* 10:341-405.

Schipper, Lee, Stephen Meyers, and Henry Kelly, 1985. "Coming in from the Cold," Seven Locks Press, Washington D.C.

SOFRES, September 1985. Maitrise de l'Energie 1984 - Rapport Synthetique, Sema-Metra, Montrouge (in French).

Statens energiverk, 1986. "Förtida avveckling av kärnkraften i Sverige," 1986:10, Stockholm, Sweden (in Swedish).

Statens energiverk, 1988. "Energy in Sweden 1988 Facts and Figures," Stockholm, Sweden (pamphlet).

Statens Vattenfall, Sweden, priv. comm., 1985.

Statistiska Centralbyrån, 1986. "Energy Statistics for one- and two-dwelling houses in 1985," Stockholm, Sweden.

Statistiska Centralbyrån, 1987. "Energy Statistics for one- and two-dwelling houses in 1986," Stockholm, Sweden.

Statistiska Centralbyrån, 1987. "Energiförsörjningen fjärde kvartalet 1985 och 1986 samt åren 1985 och 1986," report no. E 20 SM 8702, Sweden (in Swedish).

Stavast, L., Head of Consumer Affairs, Phillips NV, Eindhoven, priv. comm., 1985.

Swedish Council for Building Research, 1985. "Energy 85, Energy Use in the Built Environment," D1:1985, Stockholm, Sweden.

United Press International, September 1986. "Survey Ranks Denmark as Best Place to Live," article reprinted in the San Francisco Chronicle.

United States Department of Energy, 1984. Residential Conservation Service Evaluation Report, Washington D.C.

Vedung, Evert, 1986. "Informativa Styrmedel: Hur Svenska Staten Oevertalt Folk att Hushålla med Energi," Uppsala, Sweden (in Swedish).

Vine, Edward and Imelda Reyes, September 1987. Residential Energy Consumption and Expenditure Patterns of Low Income Households in the United States, LBL-23994, Lawrence Berkeley Laboratory, California, U.S.A.

Walker, J. A., T. N. Rauh and K. Griffin, 1985. "A Review of the Residential Conservation Service Program", *Annual Review of Energy,* 10:285-315.

Widegren-Dafgård, Karin, Ministry of Environment and Energy, Sweden, priv. comm., October 1988.

ZVEI, 1987. "Energieinsparung bei Elektrogeräten," (in German).

Överholm, Egil, Swedish Council for Building Research, Stockholm, Sweden, priv. comm., 1988.

APPENDIX A

LIST OF ABBREVIATIONS

ACH	Air Changes per Hour
AEE	Agence pour les Economies d'Energies (Office of Energy Conservation, France)
AFME	Agence Francaise pour la Mâitrise de l'Energie (French Agency for Energy Management)
AFME/EPERE	AFME/Service Evaluation, Planification, Etudes et Recherches Economiques (Evaluation, Planning, and Economic Studies Service, Department of AFME, France)
ANAH	Agence Nationale pour l'Amélioration de l'Habitat (National Housing Rehabilitation Agency, France)
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers (USA)
AgV	Arbeitsgemeinschaft der Verbraucher (Consumer Federation, Germany)
BEPS	Building Energy Performance Standards (USA)
BFR	Byggforskningsrådet (The Swedish Council for Building Research)
BINE	Bürger-Information Neue Energien (Energy Information Service, Germany).
BOS	Bostadsstyrelsen (The National Housing Board, Sweden)
BTOElt	Bundestarifordnung Elektrizität (Regulation for the National Electricity Rates, Germany)
Bo	Bostadsdepartementet (Ministry of Housing and Physical Planning, Sweden)
CDL	Centrala Driftsledningen (previous name for KRAFTSAM, Sweden)
CSTB	Centre Scientifique et Technique du Bâtiment (Building Science and Technology Center, France)
DD	Degree-Day
DDE	Direction Départementale de l'Equipement (the local building and equipment standards office, France).
DKK	Danish Crown(s)

DM	German Mark(s)
E	Energy
ECC	Energy Conservation Center (Japan)
EEC	European Economic Community
EJP	Electricité Jour de Pointe (''peak day'' tariff, France)
ELAK	Elanvändnings Kommittén (Electricity Use Committee, Sweden)
EPD	Energiinriktaprototyp och demonstrationsverksamhet (Energy-Related Prototype and Demonstration Activities program, Sweden)
ESK	Energisparkommittén (The Energy Conservation Committee, Sweden)
EStG	Einkommensteuergesetz (Income Tax Act, Germany)
EUR-10	The European Economic Community (official name of the Common Market) which consists of ten countries: Belgium, Denmark, France, Italy, Japan, Luxembourg, Netherlands, Portugal, Spain, and West Germany
EdF	Electricité de France (French Electric Utility)
EnEg	Energieeinsparungsgesetz (Energy Conservation Act, Germany)
FF	French Franc(s)
FSGT	FF Fonds Special de Grands Travaux (Special Major Project Funds, France)
FY	Fiscal Year
GJ	Gigajoule
GWh	Gigawatts per hour
GdF	Gaz de France (French Gas Utility)
HDD	Heating-Degree-Days
HEA	Hauptberatungsstelle für Elektrizitätsanwendung (West German electric use information agency)
HPE	''Haute Performance Energétique'' (High Energy Performance Labeling Program, France)
HeizAnlV	Heizungsanlagen-Verordnung (1978 Heating Equipment Regulation, Germany)

HeizBetrV	Heizungsbetriebs-Verordnung (Regulation for the Management of Heating, Germany)
HeizkostenV	Heizkosten-Verordnung (Heating Costs Regulation, Germany)
IEA	International Energy Agency
JIS	Japanese Industrial Standards
KBS	Byggnadsstyrelsen (The National Board of Public Building, Sweden)
KOV	Konsumentverket (The National Swedish Board for Consumer Policies)
KRAFTSAM	Samarbetsorganisation för elkraftproducenter (Joint Council of the Swedish Electric Power Producers)
KTOE	Thousand Tonnes of Oil Equivalent
Kcal	Kilo-calories
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
M	Million
MEL	Ministère de l'Equipement et du Logement (Ministry of Equipment and Housing, France)
MELATT	Ministère de l'Equipement, du Logement, l'Aménagement du Territoire et du Transport (Ministry of Property Management, Housing, and Transport, France)
MFD	Multi-Family Dwelling(s)
MITI	Ministry of International Trade and Industry (Japan)
MTOE	Million Tonnes of Oil Equivalent
MUL	Ministère de l'Urbanisme et du Logement (Ministry of Urbanism and Housing, France)
MW	Megawatts
ModEnG	Modernisierungs-und-Energieeinsparungsgesetz (Modernization and Energy Conservation Act, Germany)
NAECA	National Appliance Energy Conservation Act (USA)
OECD	Organization for Economic Cooperation and Development

PAH	Primes à l'Amélioration de Habitat (Program for Housing Rehabilitation, France)
PALULOS	Primes à l'Amélioration des Logements à Usage Locatif (subsidy for non-profit, low-rent social housing, France)
PCA	Plan Construction and Architecture (France)
Pf	German Pfenning(s)
R&D	Research and Development
RCS	Residential Conservation Service (USA)
SBN	Svensk Byggnorm (Swedish Building Code)
SEK	Swedish Crown(s)
SFD	Single-Family Dwelling(s)
SIB	Statens institut för byggforskning (The National Institute for Building Research, Sweden)
SP	Statens provningsanstalt (The National Testing Institute, Sweden)
SPK	Statens pris- och kartellnämnd (The State Price and Cartel Agency, Sweden)
SPV	Statens planverk (The National Board of Physical Planning and Building, Sweden)
STEV	Statens energiverk (The National Energy Administration, Sweden)
STU	Styrelsen för teknisk utveckling (The National Swedish Board for Technical Development)
TOE	Tonnes of Oil Equivalent
TOU	Time of Use
TPE	Total Primary Energy
TPR	Transportrådet (Swedish Board of Transport)
TWh	Tera-watt-hours (10^{15} watt-hours)
UNOHLM	Union Nationale des Organisations Habitation à Loyer Modiré (National Association of Public Housing Organizations, France)
USA	United States of America
U_m	Mean U-value

VAT	Value Added Tax
W/m^2 °K	Watts per square meter degree Kelvin
Wh/yr	Watt-hours per year
WschV	Wärmeschutzverordnung (Thermal Protection Regulation, Germany)
ZVEI	Zentralverband der Elektrotechnischen Industrie e.V. (Association of Electric Appliance Manufacturers, Germany)
dw	dwelling
kW	kilowatts
kWh	kilowatt-hour
yr	year

APPENDIX B

GLOSSARY OF TERMS

Climate-corrected	Refers to energy use statistics that have been adjusted to reflect long-run average weather.
Combi	Combination refrigerator/freezer.
Contextual aspects	Refers to the setting into which conservation programs were introduced.
Cooling degree-days	A measure of cooling requirements based on the deviation of the average daily temperature above 18°C (a day with an average temperature of 21°C has 3 cooling degree-days).
Delivered energy	Energy delivered to the building site for consumption.
Downstream channels	Direct linkages between the government and the public.
Elasticity of energy demand	The relationship between energy demand and change in income or price of energy.
Energy conservation	Actions that result in lower use of energy generally or of particular fuels.
Externalities	Impacts of using energy sources that are not internalized in the price.
General energy taxes	Taxes placed on all energy sources.
Heat-equivalent basis	A means of comparing energy forms (or their price) based on their energy content.
Heating degree-days	A measure of heating requirements based on the deviation of the average daily temperature below 18°C (a day with an average temperature of 12°C has 6 degree-days).
Hydronic distribution	A heating system that uses piped water to distribute heat in a building.
k-value	A measure of thermal conductivity.

Kotatsu	A small, electric heater common in Japanese homes.
Program impacts	Specific, observable outcomes of programs.
Tools	Refers to regulations, aids and incentives, and deterrents, as in "policy tools."
Unit tax	A tax calculated on quantity as opposed to price.
Upstream channels	Linkages between the government and key enterprises who in turn interface with the public.
U-value	Rate of heat flow through a material per hour per area per °F.
Value-added tax	A tax on the value added to a product at each stage of processing or fabrication.

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