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A Research Note on:

SWEDEN'S RESPONSE TO THE ENERGY CHALLENGE IN THE BUILT ENVIRONMENT

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ABSTRACT

International cooperation and exchange are being encouraged as a way to more successfully address complex problems such as the energy challenge. However, it is also recognized that what may be an appropriate solution for one country may not be appropriate for another. The purpose of this paper is to analyze Sweden's approach to the energy challenge in the built environment, to identify factors related to the alternatives chosen, and to gain insights as to how approaches may differ between countries. Information for the analyses was obtained from secondary sources and from personal interviews with Swedish researchers and policy makers. Various factors appear to affeect on policy decisions, which in turn are reflected in research priorities. Though countries may possess many similarities, the adoption of potential solutions needs to be considered in the context of the total environment.

INTRODUCTION

The energy scenario has had world-wide impact and will continue to do so in the years to come. Individual nations have designed and are re-designing their particular approach to energy-related problems and concerns. Appropriate alternatives selected by one nation may differ from those of another country as factors (i.e. values/goals, resources, current conditions, modes of operation, current leadership) influence direction and choice.

It is the purpose of this paper to present an overview of Sweden's approach to addressing its version of the energy crisis. The objectives are: 1) to describe Sweden's current situation with regard to energy use in the built environment; 2) to present Sweden's approach to the energy challenge; 3) to analyze Sweden's approach in terms of values/goals, natural resources, past decisions, modes of operation; and 4) to evaluate how and why approaches may be different/similar between nations. A comparison of differences/similarities in approaches between Sweden and the United States will be presented as an example.

It is important to undertake such an analysis for several reasons. First, it is easier to understand values, goals, and responses if they are seen in relation to environmental factors--factors that vary from one situation, or country, to another. Second, solutions/approaches may be transferable. In other words, a technology or management solution may be appropriate for countries other than the nation in which it originated. Likewise, one country can benefit by not

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repeating the errors discovered by another nation. Third, it is important to become increasingly aware of the international implications of actions within individual countries. A country does not operate in isolation. In countries where citizens have input into the decision-making for that country, it is important that they think with a global perspective as well as a local and regional perspective, especially with regard to energy directions.

METHODS

Information for the analyses was collected between July and November, 1985 while the author was on faculty development leave in Sweden. The Swedish Institute assisted in the design of this study. The Institute provided a comprehensive listing of: 1) current research projects and publications in energy-related areas; 2) government officials involved in energy policy, implementation and research-funding decisions; 3) individuals connected with local housing authorities; and 4) practicing architects. Names chosen for interviewing were selected to represent a cross section of research topics (conservation, user behavior, innovative energy sources, mechanical systems, housing design, impact of policies, policy decisions and directions) and a mixture of researchers, architects, government officials, and public housing managers. Those interviewed included researchers in energy-related areas at Lund University, the Royal Institute of Technology in Stockholm, and Stockholm University; architects involved in energy-related areas in Malmö, Göteburg, and Stockholm; government officials in the Ministry of Housing, the National Housing Board, the National Planning Board, and the National Council for Building Research; managers of public housing agencies in Gavle, and researchers at the National Swedish Institute for Building Research located at Gavle.

In conjunction with the interviewing process, information was obtained from current publications. Much of the research in Sweden is sponsored by the national government, which both funds the research and publishes the findings. Thus, most of the secondary sources were obtained from the Swedish Council for Building Research and the National Swedish Institute for Building Research. Monographs and working papers were obtained from those interviewed and from sources they identified.

While these two methods were deemed appropriate to address the objective of this paper, a word of caution is given. Official publications may tend to be somewhat biased so only the "best side" is presented. For publications written in Swedish, information was obtained from an English translation which was often abbreviated, summarized or reported in another source. Data from personal interviews may be somewhat biased as a result of the researcher's personal experiences, interpretation by the listener and problems of context. In spite of these shortcomings, it is believed that a realistic overview of Sweden's approach to addressing the energy crisis can be reported.

SWEDEN'S CURRENT SITUATION

Sweden is one of the world's highest per capita consumers of energy. Reasons for this include its high standard of living, the cold climate, and the needs of industry. In 1980, only one-fifth of Sweden's energy needs were supplied by indigenous resources. Imported oil accounted for 70 percent of the total energy supply. Sweden has no domestic oil or gas production. Coal and coke reserves are low. There is a uranium supply, but it is low grade. Thus, the uranium used to power Sweden's nuclear reactors is imported. In addition, long-range plans include the phasing out of Sweden's 12 nuclear reactors by the year 2010. Sweden has considerable peat, but this is used in only a limited way.

Forests are an important natural resource that provide approximately nine percent of Sweden's energy supply. Hydro-electric power, supplying approximately 13 percent of Sweden's energy, is the most important domestic source of energy (Olofsdotter, 1982).

The built environment consumes about 40 percent of Sweden's energy (Olofsdotter, 1982). On the whole, the Swedish housing stock is of good quality. From an international perspective, the housing has high energy standards due largely to a tradition of requirements for thermal insulation and technical methods. In 1982, 44 percent of all Swedish dwellings were in single- or two-family houses, while 55 percent of all housing units were in blocks of flats with at least three dwellings per building (Carlsson, 1984). The heated areas in residential buildings increased from 289 million m^2 (square meters) in 1960 to 381 million m^2 in 1982 as a result of the rapid growth of single-family homes during the 1970s. Thus, by 1982, 65 percent of the heated floor area was in detached houses and 35 percent was in apartment buildings (Carlsson, 1984).

Municipal districts, each with a popularly elected council that collects an income tax and operates such public services as schools, child and old-age care, utilities, housing and cultural and leisure activities, are responsible for supplying their inhabitants with electricity, gas, and sometimes, district heating. A district heating system is comprised of a communal heating plant that generates heat and transfers it through an underground system to users. In multi-family dwellings, heating costs are often charged in proportion to heated floor space rather than in proportion to consumption within the unit.

SWEDEN'S RESPONSE TO THE ENERGY CRISIS

Following the energy crisis in the early 1970s, Sweden's Parliament adopted an energy conservation plan in 1978 for the existing built environment. Its objective was to reduce energy consumption in the existing building stock by about 25 percent over a ten-year period. This plan was reviewed in 1981 and the goal was raised to 30 percent because rising energy costs made additional conservation measures necessary.

According to Olofsdotter (1982), the four primary goals established by the Swedish Parliament were:

1. All nuclear power plants should be closed down by the year 2010.

2. Dependence on oil should be reduced.

3. Considerable emphasis should be given to energy conservation.

4. Future energy supply should be primarily based on endurable and preferably renewable domestic sources of energy. Such targeted resources should also have the least possible environmental impact.

Sweden began to intensify research and development efforts in the energy area (Klingberg, 1982). Various agencies were delegated the responsibility for energy research. Energy research related to the built environment was the domain of the Swedish Council for Building Research (BFR).

While the Swedish Council for Building Research does not conduct research itself, it does distribute grants for selected research projects. In 1983/1984, universities and institutes of technology received 29 percent of the grant monies; private companies received 23 percent; other institutes were granted 17 percent of the monies; the National Institute for Building Research received 15 percent; state and local government were given 12 percent of the funds; and others received the remaining four percent of the grant money. The largest proportion of funding was for energy conservation. The second largest portion was for renewable energy sources (BFR, 1985). In the area of energy conservation, research supported by the BFR included the impact of human behavior on energy use and factors related to the efficiency of heating and transfer systems in buildings. BFR-supported research also examined the problems of indoor climate and the comparison and analyses of the impact of energy use in relation to the cost of different energy-conservation measures applied to existing housing stock.

In the area of renewable energy sources, research supported by the BFR focused on heat pump systems and natural heat utilization, investigation of the possibilities of surface earth, surface water, ground water, rock, outside air and solar heat, and the use of ground, rocks and water for energy storage.

Based on research findings, a report, *Energy 85, Energy Use in the Built Environment*, was compiled. The findings were synthesized to provide information for future decision-making. The information was organized to address Parliament's 1978 goals of 1) energy conservation, and 2) development of future renewable energy supplies. The research findings and the actions/decisions for the future they suggest are as follows:

Energy conservation and management. Human behavior has a considerable impact on energy use. A study of 78 technically identical single-family homes finds that energy use varies between 15,000 and 30,000 kWh/year. This wide variation is not significantly explained by the number of occupants, age, or disposable income, but is related to individual household habits such as indoor temperature settings and domestic hot water consumption (Lundström, 1982). It was suggested that technical systems be designed so that users understand them, are able to influence consumption, and have the ability to see the results (BFR, 1985).

Improvement and maintenance of existing heat production, distribution, ventilation and heat recovery equipment can result in potential energy savings of seven TWh/year (TWh=terawatt-hour or million million watts per hour per year) (Guidelines, 1980). Regular inspection and maintenance are needed. Calculation of maintenance costs should be included in the choice of new equipment (BFR, 1985).

Conservation measures applied to existing buildings have resulted in considerable energy savings, although the impact of the measure varies greatly from building to building because of the uniqueness of each building with regard to design, materials, orientation and geographic location (Anderlind and Norten, 1984; Hammarsten, 1980; Klingberg, 1984; The Industrial Group for Light Construction Engineering, 1982). To obtain the best combination of energy conservation measures, it will be necessary to develop accurate evaluative tools to measure the energy status of each building.

Research results and experience indicate that new buildings can be constructed that use very little energy. It is anticipated that energy consumption for space heating and domestic hot water production will be reduced from the current building standard of 120-130 kWh/m^2 to 80-100 kWh/m^2 by 1990. It is expected that continued technical development can further reduce energy use to 30-70 kWh/m^2 (kilowatt-hour/square meter or 1000 watts per hour per square meter) (Anderlind, Bankvall, and Munther, 1984). For best results, building techniques need to be compatible with manufactured housing techniques and be suitable for export. The techniques will need to address potential problems with radon decay products, moisture, mildew and accumulation of allergens (BFR, 1985).

Future energy supply. The energy policy of the Swedish Parliament states that future energy supplies should be based on endurable and renewable domestic sources of energy having the least possible environmental impact. Consequently, research and development has focused on energy-use systems incorporating solar hearing, heat pumps, and natural heat or energy storage. Within this context, new energy systems were identified and compared with conventional energy systems for use in single-family homes, apartment buildings and group-heating plants.

The future of heat pumps is good (BFR, 1985; Eriksson, 1984). Heat pumps are now competitive with oil and electric heating in single-family homes, and with electricity, oil and district heating in apartment buildings. In group-heating plants, heat pumps are competitive, particularly in larger systems. By 1990, the real cost of heat pump units is predicted to fall by 20-25 percent. The cost will be reduced even more if an export market is established resulting in economies of scale. Performance is expected to improve by 10-15 percent over the five-year period (BFR, 1985; The BFR Heat Pump Group, 1984).

The results are not as positive with regard to solar heating systems, although optimism exists as to their potential (Fredlund, 1985; Jilar, 1985). While costs of large solar collector apparatus and domestic hot-water heating systems for apartment buildings have been greatly reduced, continued research and development needs to be directed at further reducing costs. A reduction of 30-50 percent of current costs is needed to make solar group-heating plants, using seasonal heat storage, viable (BFR, 1985).

Research has been conducted on storage/extraction of heat in the earth, rock, and water (Gabrielsson, 1981; Swedish Council for Building Research, 1983). In Sweden, the winter days are very short. Thus, energy must be extracted from summer storage. Seen in a 20-year perspective, the potential recovery of heat from such methods can result in an amount of about 10-15 TWh/year. However, to achieve that potential, continued research and development, accompanied by full-scale experimental projects, is needed (BFR, 1985).

ANALYSES OF SWEDEN'S APPROACH

The Swedish selection of appropriate alternatives to reach their goal of reduced energy use appears to determined by a number of factors. For one, the absence of natural resources within the country limits viable alternatives. In the past, Sweden depended heavily on imported oil for its energy supply (In 1970, 75 percent of Sweden's total energy consumption came from imported oil. In comparison, imported oil comprises about 25 percent of total energy consumption in the United States) (BRF, 1985). Because of the uncertainty and volatility of the oil market, Sweden, by 1980, had reduced oil consumption to about 40 percent of total energy use.

Past resolutions set the stage for current decisions by eliminating some possibilities and supporting others. In Sweden, the design of heating equipment in multi-family housing has not included individual meters to record energy use. While other countries see individual metering systems as one way to influence energy use, such systems are not seen as a viable alternative for the Swedish system. Individual meters are considered too expensive to install and inaccurate in measuring individual energy use because of the heat transfer between walls, ceilings, and floors in multi-family housing. Individual heat pumps are considered by many Swedes as the way of the future. However, there is resistance from others, such as managers of district heating plants, who have made large capital investments in other methods of energy production and would suffer if their market is diverted to the use of heat pumps.

The Swedish value system contains a strong appreciation of the natural environment. This is also reflected in the alternatives chosen to address the energy problem. Through a public referendum, the people have rejected nuclear power as the energy source of the future. Conservation, solar energy, heat storage, and heat pumps have been chosen as the appropriate foci.

Sweden does not wish to lower its current standard of living with respect to comfort. Compared to many other countries (the United States included), Sweden has a high level of indoor comfort with relatively low energy consumption. Its approach to further reducing energy consumption has been to concentrate on technical measures rather than attempting to change consumer behavior. Sweden believes that economies derived from technical measures can be expected to be lasting economies, whereas those derived from change in human behavior (such as lowering the thermostat) may disappear if the price of energy drops.

In addition to the selection of viable alternatives, there is the need to select models for implementing the alternatives successfully. In Sweden, societal and research models emphasize co-operation. This concept is introduced early and re-inforced often in the public school system. In the development of energy systems, co-operation between industry, government, research institutes and universities is stressed. Such co-operation is seen as a way to accumulate valuable knowledge and to disseminate and export Swedish energy technology.

The Swedish model also emphasizes the importance of full-scale experimental building. Co-operative effort and experimental construction are considered the most important factors in insuring successful research and development results.

In Sweden, a holistic approach for potential solutions is stressed. Concentration on the development of efficient systems is considered essential. All measures (energy conservation measures, heat pumps, solar heating, rehabilitation) are to be implemented in a co-ordinated manner.

The collection of statistical data and the formulation of simulation models is strongly supported as a basis for decision-making. Likewise, initial training and on-going education for all workers and professionals is considered essential to realize the energy savings resulting from technical advances.

Sweden has a relatively centralized approach to energy research. The Swedish Council for Building Research distributes research funds for priority projects. The Council serves as the publishing mechanism for the results. It provides a central co-ordinating body that integrates the research findings and makes suggestions based on these findings. Such an approach has the advantage of focusing resources to meet objectives, but has the disadvantage of limiting the possibility of discoveries outside the realm of identified societal goals.

The Swedish government believes it is important to provide subsidies encouraging the adoption of new innovations. These innovations must be thoroughly tested and found viable before they are subsidized, however.

Swedish officials and researchers are confident that they will reach their goal for energy reduction. The Swedes have a tradition of setting relatively ambitious societal goals and then acomplishing them.

VARIATIONS IN APPROACHES: AN EXAMPLE

While there are world-wide forces (such as the energy crisis and other economic trends), there are nation-specific variables that dictate variations in the direction to address the common challenges. Thus, although one country can learn and benefit from the experiences and knowledge base of another country, appropriate adoption of these ideas, methodologies and technologies must be evaluated in terms of their appropriateness to the total environment within the adopting country.

For example, even though Sweden and the United States have many cultural, social, economic, and political similarities, subtle differences exist that influence the direction of energy policy and research. These differences include such factors as:

1. VALUES AND GOALS. In Sweden, there is general consensus that a top priority is the preservation of the natural environment. In the United States, there are many individuals who believe preservation of the natural environment is very important, but there are also many individuals who have goals (primarily economic growth and energy development) that compete with the preservation of the natural environment. In Sweden, nuclear power has been dismissed as an alternative, while in the United States, it is still considered a viable direction for energy production.

2. RESOURCES. The United States has a greater abundance of natural resources within its boundaries than does Sweden. Thus, while Sweden has emphasized conservation as a top priority, the United States has emphasized both conservation and increased production of oil and gas. Solar energy is considered more viable in parts of the United States than in Sweden. Certain geographic areas in the Unites States receive substantial amounts of solar energy during the winter months and do not need to store energy for transfer to winter use.

3. HOUSING PROCESS. In Sweden, it is possible to have greater control of the level of energy efficiency in housing because of more stringent national regulations. Greater energy control is possible in Sweden because most housing is built by a few (private) building companies than by thousands of builders as found in the United States. Energy systems for multi-family housing in Sweden are designed without individual metering systems, while individual metering systems are common in the United States in both single- and multi-family housing. Thus, the incentive for consumers to reduce energy costs by using less energy is not as successful in Sweden as in the United States. Sweden has a much larger proportion of its housing stock as rental property than does the United States. Energy conservation in rental property offers special and different problems from owned single-family homes because of separation of those who pay the costs and those who reap the benefits.

4. MODE OF OPERATION. Because of its tradition of planning and organization, Sweden appears to face problems with a longer

time perspective than is found in the United States. The United States depends more on marketplace adjustments to address ever-changing problems. Planning permits focus; marketplace adjustments produce diverse solutions.

CONCLUSIONS

To evaluate appropriate transfer of technology and modes of operation, the context of the environment in which the transfer will occur must be considered. For the successful transfer of ideas, methods and technologies between countries, there must be communication not only of ideas, methods and technology, but also values, goals, and environmental contexts. Today, with the recognized need to avoid costly mistakes, it behooves housing professionals to channel resources to obtain information that provides a comprehensive understanding of decisions in one's own country and in the countries with which exchange is likely to occur.

Transfer of information is easier between some countries than between others. For example, exchange between Sweden and the United States is easier than between some countries, as most Swedish researchers and policy makers have English as another language. Yet, even in Sweden, not all publications are written in English. Swedes, therefore, have easier access to United States information than Americans have to Swedish information.

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