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Prepared for

WORKSHOP ON ENERGY CONSERVATION POLICY AND MEASURES FOR ENERGY DEMAND MANAGEMENT

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1 Introduction

The purpose of this paper is to address a few key policies for achieving significant building energy conservation in developing countries. The paper highlights important needs to be met in developing strategies to implement the policies.

The ASEAN† region provides the setting, with its rapid economic growth and hot, humid climate. Within the region, industrialization and urbanization processes are creating a growing demand for energy, particularly oil and electricity. Annual consumption of commercial energy has increased at a rate of over 5 percent in most countries and electricity growth has been above 10 percent per annum. Despite their economic growth, ASEAN countries face severe economic stringencies and difficult resource and budgetary constraints. Energy expenditures and investments constitute a major share of total national budgetary and investment expenditures—generally close to 25 percent.

Energy conservation in buildings is important to the national economies of the region. In the developing countries, including ASEAN, energy conservation has had a lower priority than in the industrial countries. Moreover, energy conservation in buildings has been neglected in the national conservation plans that have been developed. This oversight is significant, for commercial buildings now consume well over one-third of all electricity in the ASEAN region, and will account for approximately 40 percent of the demand for additional electrical generating capacity in the near future.

2 Significant Building Energy Conservation Is Possible and at Low Cost Compared with New Electricity Generating Capacity

Real tradeoffs exist for ASEAN countries between investing in new power generating capacity and investing in building energy efficiency. Implementing cost-effective conservation measures in buildings produces a significant reduction in expenditures on electricity.

In developing effective energy policies, investment in energy conservation can be treated as if it were the same as investing in power generating capacity. New power generating capacity may cost $1500/KW, when all costs are included. Building energy conservation may cost $300-400/KW saved. This is less than one-fourth of the cost of new power generating capacity.

This potential has caused utilities in the United States, such as Pacific Gas and Electric, San Diego Power and Light, the Bonneville Power Administration, and Northeast Utilities, to invest in energy conservation and to provide energy conservation services to customers.

Within ASEAN, large commercial buildings in urban areas are prime targets for effective energy conservation investments. A number of factors contribute to this. There are relatively few large buildings. The energy source is virtually totally electricity (predominantly for cooling, lighting, and equipment). Each building is a large consumer. Energy conservation measures applied to them can have large impacts on national economies.

At relatively modest costs (compared with the alternatives), the following building energy conservation potentials are attainable:

† ASEAN (Association of Southeast Asian Nations) is comprised of Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Of the six countries, only Brunei did not participate in the ASEAN/USAID Building Energy Conservation project discussed in this paper.

- 40% to 50%+ reduction in energy consumption of new buildings
- 15% to 25% reduction in energy consumption of existing buildings
- Shift of electricity demand for buildings from day to night, thus improving the load factor on electricity-generating equipment for some ASEAN countries.

If policies are implemented to achieve these targets, the results are substantial reductions in electricity expenditures. Presently, more than one-third of all electricity generated in ASEAN is consumed in commercial buildings. Research on building energy use in ASEAN suggests that "near term reductions in energy use can amount to 160 million dollars (US) per year in the near term . . , 320 million dollars per year in the intermediate term, and one half billion per year in the longer term. These benefits will accrue both to the nations as a whole in the form of reduced oil imports, improved balance of payments, and reduced need for capital investment in power plants as well as to the individual building owners in the form of reduced electricity bills."

A number of related benefits occur. Electricity generating capacity is freed for use by other sectors of the economy because of the reduced demand for additional electric power from buildings. Money otherwise spent for new power plant construction can be shifted to other national priorities, and the debt burden reduced. Balance of payments are improved. Also, more efficient electrical generation yields lower cost goods and more competitive prices for export of national products. Because electricity in ASEAN is generated primarily from oil, reducing electricity use reduces oil use, and about 45 percent of the cost savings from reduced electricity use is from reduced oil use. [USAID, 1985]

3 Social, Institutional, and Financial Barriers to Energy Conservation in Buildings

Are there strong current factors that constrain energy conserving design practices? There are indeed a number of significant barriers to building energy conservation within developing countries. Some of these barriers are also present within the developed countries, but are exacerbated within the developing countries. Some important barriers are summarized below. Also, at least one other paper presented at this conference contains a good summary of such barriers to building energy conservation (Mustapha, 1987).

3.1 Lack of Information Within the Building Community

The most important barrier to energy conservation in buildings in developing countries is the lack of information among all members of the building community. Few architects, engineers, and builders are familiar with important energy-efficient design technologies and design procedures. Also, relatively few courses or other sources of information on the subject are available.

Within the ASEAN countries, for example, with the exception of Singapore, there has been insufficient expertise and equipment to conduct energy audits or to measure the effects of conservation measures. This lack of information severely restricts appropriate policy-making in the public sector and rational decision-making in the private sector.

3.2 Lack of Experienced Government Personnel

A related barrier is the severe shortage of government personnel with an adequate base of building energy expertise to develop government conservation programs. Until this expertise base is adequately expanded, lower level personnel cannot be mobilized to perform energy audits or to enforce energy building codes. Further, this expertise is a prerequisite to effective government cooperation with the private sector in increasing building energy efficiency.

3.3 Lack of Government Infrastructures

Even when personnel experienced in energy efficiency are present within governments of developing countries, the lack of proper government organization can hamper the development or implementation of energy programs. Often this can compound the problems of implementing building energy conservation policies.

An example of this barrier is seen in most ASEAN countries. To properly develop building energy policies, good data on building construction practices, energy use, and energy conservation potentials must be available. These data rarely exist, and if they exist, they are sparse. Also, there are no government structures for gathering, storing, maintaining, and disseminating the data. Thus, a government wishing to implement policies to promote energy conservation in buildings has a dual problem. The government must not only implement a building energy data gathering activity, but it must also create the government institutional and legal structures that can permit the data program to occur.

3.4 Increased Construction Costs

Generally, energy-efficient building design increases building construction costs. Energy efficient building equipment and systems are routinely more expensive than energy-inefficient alternatives. Typically, the relative cost of energy-efficient equipment is even higher in developing countries. Thus, in general the potential for increasing the initial cost of constructing buildings is a barrier to building energy conservation. While economic conservation measures assure that higher initial costs will be offset by reduced fuel costs, the imposition of additional expenditures on buildings may be difficult to bear in many developing countries. This has proved to be the general case in ASEAN countries. To overcome such obstacles, "demonstration" building construction projects are needed to prove that conservation measures pay off. Such demonstration programs are discussed later in this paper.

There are, however, some important exceptions to this general condition. An important objective in energy-efficient building design is to achieve reductions in building fuel costs at no increase in building construction cost, or even with a decrease in building construction costs. This is usually accomplished by designing in such a way that increased construction cost for one building subsystem (say, lighting) permits a decrease in the construction cost of another building subsystem (say, air conditioning). Careful building construction cost accounting can demonstrate that downsized cooling equipment from energy-conserving lighting and envelope designs can result in lower total building first costs *and* significant energy conservation at the same time.

There are many examples of such cost tradeoffs among building subsystems in the developed countries. However, this process requires a fairly high level of energy conservation design skills, procedures, and communication within a building design team. As mentioned above, this skill level usually is not present within the design communities of developing countries.

3.5 Perceived Lack of Importance of Energy Conservation

Often, energy conservation is not perceived as a high priority objective to building owners and operators. This can lead to pervasive energy wasting habits. For example, some ASEAN buildings are operated routinely with opened doors between conditioned and unconditioned spaces. This can increase the load on the air conditioning by as much as 25 percent. Also, buildings throughout the ASEAN region are kept colder than is necessary for comfort. (Ironically, cooling systems designed to keep buildings at low temperatures actually can consume more energy when the buildings temperature is raised without reoptimization.)

3.6 Trends in Building Design Practices

The relatively recent introduction of certain western architectural features has led to the decreased use of several traditional, and very energy-efficient, ASEAN building design practices. Two examples of traditional architectural forms in the ASEAN region that contribute to energy efficiency are natural ventilation and the use of external sunshades over windows.

The traditional design practices can be both cheaper and more energy-efficient than some new practices now in vogue. For example, traditional envelope construction within the ASEAN region includes brick and stucco walls with external shading devices to protect the glass from direct solar rays. This traditional wall construction is not only less expensive than the currently fashionable western curtain wall construction, but it is significantly more energy-efficient because it results in lower heat gains to the building interiors than does curtain wall construction. The traditional wall construction also produces improved comfort conditions for building occupants near the walls because of the reduced solar heat penetration and reduced glare.

4 Energy Policies and Implementation Needs

We now turn to our main topic, an assessment of policies and implementation needs for promoting energy conservation in commercial buildings in ASEAN. In this paper, we consider nine different policies that can contribute significantly to achieving cost-effective levels of energy consumption in buildings. We explain the context of the policy, the current status in ASEAN (as best we know it), and our assessment of additional efforts that could assist in the achievements of the policy goals.

4.1 Building Energy Standards and Guidelines for New Buildings

4.1.1 Importance of Energy Standards

Building energy standards can be very effective implementation strategies for energy conservation. Studies of energy standards implemented in developed countries indicate that they can produce energy reductions of the order of 20 percent to 40 percent or more.

As noted, the buildings sector is diffuse. It is characterized by a plethora of decision-makers involved in the building design and construction process, each focusing on particular interests. Even so, a common thread runs through the entire process. This is the existence of building codes and standards. Virtually all countries have some form of codes and standards, in large part because of the need to establish some uniformity on such diverse activities. Building codes, traditionally aimed at assuring health and safety in buildings, also constitute a vehicle for bringing about improvements in energy efficiency.

4.1.2 Background - Effectiveness of Energy Standards in Other Countries

Building energy standards form important elements of energy policy in numerous countries in Europe, the Americas, and the Pacific. A partial list of countries with energy standards for commercial buildings includes the U.S., Canada, England, France, Germany, Sweden, Denmark, Norway, Switzerland, Australia, New Zealand, and Singapore. In many cases, the countries listed (and others as well) have standards applicable to both new and existing buildings.

Available information about the experience of these countries indicates that such energy standards have been effective in reducing unnecessary energy costs and have not presented unusual difficulties in implementation. As a result, a number of countries are now engaged in their second or third update of building energy standards.

For example, in the U.S., the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) developed a voluntary energy standard in 1975 (ASHRAE 90-75). This standard was estimated to produce energy reductions of 40 percent from pre-1973 oil embargo commercial building designs [A. D. Little 1976] and energy reductions of 25 percent to 40 percent from typical mid-1970s buildings designs [AIA 1980]. In the late 1970s and early 1980s, all 50 states in the U.S. adopted some modified form of this standard into mandatory state energy codes, usually for new buildings and for major retrofits. Often, codes and standards for existing buildings were based on modifications of ASHRAE 90-75.

Currently, ASHRAE is developing separate major revisions to the standards for commercial buildings (ASHRAE 90.1P) and for residential buildings (ASHRAE 90.2P). It has been estimated that the proposed ASHRAE 90.1P standard for commercial buildings will produce an additional 10 percent to 20 percent energy reduction from the requirements of the 1980 version [Crawley and Briggs 1986]. Major portions of the proposed draft standard 90.1P for commercial buildings have already been adopted in at least one state code (Massachusetts), even before the standard has received final approval by ASHRAE. Several other states are also considering adopting portions of ASHRAE 90.1P.

4.1.3 Status of ASEAN Standards Development.

Singapore is the only ASEAN country that has implemented a building energy standard. This standard was implemented in 1979 [PWD 1979]. This standard adapted the requirements of ASHRAE 90-75 to the needs of Singapore's climatic conditions and construction practices. In developing the standard, Singapore accomplished considerable original work in developing overall thermal transfer value (OTTV) concepts to reduce heat gains through building envelopes. Singapore also focused on lighting and air conditioning standards and implementation aids to facilitate use of the standard, including the production of a valuable handbook [PWD 1983]. Singapore has been analysing ways to improve the stringency and implementation of its standard, and plans to have a proposed revision to its existing standard prepared in the spring of 1988.

Malaysia is presently studying the idea of incorporating an energy efficiency standard into its set of building codes. Malaysia's proposed standard is the result of analyses conducted since 1986, with assistance from LBL as part of the ASEAN/U.S. Agency for International Development (USAID) Building Energy Conservation project [Kannan 1987; Deringer 1987; and Busch 1987]. This proposed standard is estimated to reduce new building energy use by about 20 percent.

Because this is Malaysia's first building energy standard, the intent of the energy criteria is to eliminate the most energy-intensive design practices while not adversely impacting construction practice. The effort strove to keep the standard as simple as possible in order to encourage its acceptance by the Malaysian building design community. The proposed standard constrains only the most important energy factors: solar load on the building envelope, energy use by and heat gain from lighting systems, and the efficiency of the air conditioning system.

The proposed Malaysian energy standard for new commercial buildings is an initial effort. After several years' experience has been gained, energy criteria may be considered for operation and retrofit of existing Malaysian buildings.

Thailand is just beginning an assessment of an energy standard for new buildings. The energy conservation provisions of the proposed Malaysian standard have been expanded and revised to produce a first draft of a proposed standard for Thailand. The draft Thai standard incorporates both proposed requirements and recommended guidelines in one document. A substantial appendix has been developed that documents example calculations for a typical building.

A version of this Thai draft standard is now being modified with the intent of serving as a "model energy standard" for all ASEAN countries. On completion of this "model energy standard," Indonesia and the Philippines are expected to begin a process of evaluating their plans for the development of standards and guidelines.

4.1.4 Needs

This strategy is not completed with the adoption of a new standard. Supporting actions are needed to ensure proper compliance and enforcement. Otherwise the standards are not likely to be effectively implemented.

The enforcement of building codes and standards typically occurs at the local level. Thus, the ASEAN countries that implement energy standards will need training programs for building code officials. Such training programs have been essential to the successful implementation of building energy codes and standards in the developed countries.

Training will also be needed for architects and engineers to ensure proper compliance with the new standards. The effort will require the publication of guidelines or manuals of recommended practice that can assist building designers and code officials to understand the implications of various energy strategies in specific building design situations. A trend in the U.S. is to provide microcomputer programs to facilitate the task of code compliance.

4.2 Energy Audits and Retrofits for Existing Buildings

4.2.1 Importance of Audits and Retrofits

The greatest near-term impact on electricity use in the commercial sector can be obtained by auditing and retrofitting existing buildings. Even in the rapidly growing commercial building sectors within ASEAN countries, new buildings add less than 10 percent of space to a country's building stock each year. Conversely, a major audit and retrofit program can potentially address a substantial proportion of a country's building stock in a short time.

The accumulation of data from a series of energy audits and retrofits of existing buildings represents a valuable resource for policy-making in developing countries. The energy audits provide policy-makers with information about the levels of energy efficiency of the existing building stock within the country. This information is sorely lacking in all ASEAN countries, with the possible exception of Singapore. Likewise, information about retrofit costs and energy saved can provide policy-makers with an indication of the potential benefits of further audit and retrofit programs.

4.2.2 General Audit and Retrofit Procedures

The energy audit is a method to determine which energy conservation actions are most cost-effective. An energy audit will provide information on lighting, air conditioning and ventilation equipment, water heating equipment, window characteristics, etc. One of the first steps is usually to improve the operation and maintenance of equipment and to initiate a program of energy awareness and management for each large business. These low-cost actions alone can often reduce electricity use by 10 percent or more. Some examples of energy retrofits for existing buildings are the installation of sun shades to reduce solar gain, the use of timers to control lighting and air conditioners, substitution of more efficient fluorescent lamps for existing lamps, and installation of more efficient chillers and fans.

A primary purpose of an energy audit is to decide what low or no-cost actions can be taken and which building components need alteration to improve energy efficiency. To achieve these objectives, possible conservation measures need to be ranked in terms of benefit-to-cost ratio or other economic indicators. This is usually done by using an energy analysis tool in conjunction with an economic analysis, often by computer analysis.

4.2.3 Status in ASEAN Countries

To date, relatively few detailed energy audits have been conducted. For example, in Malaysia only four detailed audits and less than thirty summary audits of buildings have been conducted. Only the four detailed audits provide sufficient information to assess conservation potential.

Within the USAID-sponsored ASEAN Building Energy Conservation project, a series of two-week courses have been conducted to train government, university, and private sector personnel in energy auditing procedures and techniques. These courses have been held in Indonesia, Thailand, and Malaysia to date. The most recent course was held in September, 1987, in Malaysia. The courses included hands-on experience with a new, simplified energy analysis program, ASEAM2, developed by the U.S. Department of Energy (US DOE). Copies of the microcomputer tools were provided as part of the course, along with documentation of energy audit procedures. Also, a complete set of building energy monitoring equipment is presently being shipped to each country for use in very detailed analyses of energy use.

Several of the ASEAN countries that have received this training are planning to carry out building energy surveys. The results of the surveys will be used to assemble a data base on building energy use.

4.2.4 Needs

The in-country skills for conducting energy audits as a basis for appropriate retrofits is extremely limited. The most pressing need is to develop an energy audit service industry within each country. This would consist of people with the training and experience to conduct detailed energy audits, and with access to the analysis tools and the monitoring equipment needed as well. The training, tools, and equipment made available to date are probably not sufficient to assure that such an industry is initiated.

There is also a need to spur the formation of markets for energy audits. Currently, private sector building owners are not aware of the benefits of audits and retrofit actions. A possible way to demonstrate these benefits is through a government-sponsored program. For example, a government could support a series of demonstration energy audits performed at no charge to businesses or building owners involved. These audits should include economic calculations such as payback period and benefit-to-cost ratio for each suggested conservation measure. The program could provide feedback to building managers and owners about benefits of conservation measures, and might include limited economic subsidy for retrofit actions taken. After the initial subsidy to get the program started and demonstrate its benefits, one would hope that such programs would be self-sustaining.

Another means of providing a market for energy auditing skills is through a program of energy audits for government-owned or -leased buildings. Such a guaranteed market would undoubtably spur the private sector to develop energy audit/retrofit capabilities.

4.3. Energy Pricing

4.3.1 Background

Energy pricing is a key issue not only for energy use in buildings but for all sectors. Numerous social, political, and economic factors influence the energy pricing policies followed in the ASEAN countries. Energy prices that are consistent with long-run energy costs will tend to foster efficient use of energy. If energy prices are significantly subsidized, then society will *necessarily* underinvest in efficiency. Even with prices related to costs, there are significant barriers and market imperfections that reduce investment in efficiency, as we have seen in §3.

4.3.2 Key Issues of Energy Pricing in ASEAN

In buildings, one is primarily concerned about electricity prices. Electricity prices vary considerably among the ASEAN countries. In 1982, the lowest electricity prices in the region were in the Philippines (about 6 U.S. cents per kilowatt hour) and the highest were in Malaysia (9.5 U.S. cents per kilowatt hour) [Siddayao 1985, p. 31].

The key issue is not, however, the absolute value of electricity prices or even the relative value among the countries. Rather, there are two critical issues that need to be addressed: (1) to what degree do current electricity prices reflect the cost of power (either embedded costs or long-run marginal costs) and (2) to what degree does the *structure* of existing electricity prices correspond to short-run marginal costs?

The first issue has significant bearing on the effectiveness of both the market and government programs to bring about conservation investments. Unfortunately, obtaining good information about electricity price subsidies is very difficult. The denial of loans from international lending agencies (e.g., to Indonesia in the recent past) because of apparent subsidies of electricity prices has made the issue particularly sensitive.

The second question—concerning the relation between the electricity pricing structure and short-run marginal costs—is not nearly so difficult to answer. The relationship is generally poor. Time-of-use rates are applied only to large industrial users in Singapore, Malaysia, and Thailand and not at all to commercial customers. In the Philippines, time-of-use rates do not exist for any customers. Only in Indonesia do time-differentiated rates apply to the commercial sector, with an on-peak rate about 60 percent higher than the off-peak rate. The Indonesian rate structure is intended to reflect the short-term marginal costs of supply [Wyatt and de la Moriniere 1986].

This issue of time-differentiated rates is a very important one for the building sector. Storage of "coolth" in the form of cold water or ice is an extremely effective way of reducing peak power demands in those areas where building and electric utility system peaks are coincident. For Singapore, Malaysia, and the Philippines, commercial building and utility system peaks do in fact overlap. (In Thailand and Indonesia, the residential load is of greatest concern during peak hours.) Thermal energy storage and other load-shifting technologies for commercial buildings could yield substantial benefits in reducing growth of peak loads and thus deferring capital investments in new generating capacity (without reducing electricity services). However, because of the lack of time-differentiated rates to the commercial building sector in these countries, there is *no* incentive for load shifting technologies. This is a significant problem, retarding the introduction of highly cost-effective technology in buildings as well as adding to the already existing strains on the electric utility system.

4.3.3 Needs

There have been various studies of energy and electricity pricing within ASEAN. Because of the critical importance of pricing policy to effective energy conservation programs, continued attention to this issue is merited. The greatest need is for careful empirical studies quantifying short and long-run marginal costs and identifying subsidies within the energy (for commercial buildings, electricity) pricing system. We recognize that such studies are often sensitive. Nonetheless, any efforts which improve information in this area are useful.

A more focused effort that is very much needed is an analysis of short-run marginal costs as a basis for developing time-differentiated rates for commercial buildings. As noted above, this effort could encourage use of load-shifting technologies in buildings where they are not now used. We believe that a modest scoping effort would demonstrate that the benefits from accurate time-of-day tariffs for buildings could be significant.

4.4. Research and Development

4.4.1 Background

Not surprisingly, the greatest research and development efforts on energy efficiency in buildings have been done in the developed world. This means that most of the research has concerned buildings in climates very different from that of the ASEAN region. Probably the two leading countries in building efficiency R&D are the U.S. and Sweden. It is not surprising that the Swedish research is concerned with protecting building occupants from cold exterior environments. The emphasis on research in the U.S. has also been on cold climates, in spite of the fact that a significant portion of that country is in moderate to hot climate regions. Only in the past several years has there even been a conference concerning energy use in hot, humid climates in the U.S.

The relative paucity of research on building energy conservation in hot, humid climates is compounded by the fact that many new, large commercial buildings in ASEAN are transplants from colder climates. That is to say, the design principles applied to new buildings in ASEAN are often those developed for very different climates. Thus, many of the new buildings (particularly the large skyscrapers) that are claiming the skylines of ASEAN cities are designed to fit well into New York City or Chicago; traditional architectural practices, often developed over many years to take advantage of local climatic conditions, are in many cases losing favor to more "modern" design practices.

In short, because relatively little is presently known about the design and operation of buildings for energy efficiency in hot, humid climates and because current design trends may lead away from efficiency in many cases, there is a considerable need for research in this area.

4.4.2 Status Of R&D On Energy Conservation In ASEAN Buildings

Each of the ASEAN countries has some research on energy conservation in buildings. In Singapore and Thailand, the major research efforts are in universities. In Malaysia, research in building energy conservation is just beginning, also primarily at universities. In Indonesia, research has been underway for many years, at a few universities and, more recently, at some research institutions. In the Philippines, university research has been combined with a strong government effort to keep abreast of the lastest technological developments, primarily from other countries.

In spite of these efforts, the overall R&D activity in the ASEAN region is limited. Typically, only a handful of researchers in each of the countries is actively engaged in full-time research on energy use in buildings. The major focus of the research is on studies of effects of radiation on buildings (Singapore, Thailand, and Indonesia), energy auditing of buildings (Philippines, Malaysia, Indonesia, and Thailand), energy monitoring (Singapore and Thailand), computer simulation research (all of ASEAN except Brunei), and passive solar design (Philippines, with growing interest in the Philippines and Thailand). Little research has been devoted to new product development (with the possible exception of the Philippines) and much of the research is in relatively early stages in many of the countries.

4.4.3 Needs

Both the USAID and the Australian funding have supported ASEAN research efforts in the field during the past several years. Some new funding may be available in the future from Japan. Germany and Sweden have also provided support for research activities. In spite of these efforts, the active research effort in the field is at early stages and needs considerable encouragement and support. The greatest needs are support for (1) building energy simulation research, both to continue to develop expertise with ASEAM2 and to make certain that the research results contribute to the education of the building community, (2) development of energy audit expertise and improved audit procedures, (3) research on daylighting design, air conditioning efficiency, natural ventilation, lighting, and related high payoff technologies, and (4) the transfer of the results of this work to the broader design and practitioner community. It is particularly valuable that research be supported at universities, as this will greatly increase the knowledge imparted about building energy conservation to current and future students, many of whom will work in fields where they can practice what they have learned.

A small activity that could substantially enhance the ongoing building energy research efforts would involve training ASEAN graduate students and other researchers in developed countries. Because there exists a nascent building energy research activity in ASEAN, ASEAN students trained in developed countries would be able to return to their countries and directly use the knowledge gained. A small program (e.g., two to five two-year training grants in building energy research per ASEAN country) would have a major impact on the long-term vitality of building energy research activities in the region.

4.5 Government Buildings

4.5.1 Background

In all major countries in the world, governments own and therefore have full control over significant numbers of buildings. This fact, combined with the difficulty of inducing the private sector to invest in more energy-efficient buildings, has led to the suggestion that the government demonstrate energy efficiency in its own buildings, thereby serving as an example for private investors as well as benefiting the national treasury.

4.5.2 Status of Energy-Efficient Government Buildings Programs in ASEAN and Elsewhere

This deceptively simple idea has seen relatively little success anywhere. In the U.S., the U.S. Department of Energy has long supported a federal buildings activity entitled the Federal Energy Management Program (FEMP). FEMP is designed to encourage (or require) contractors to apply life-cycle costing techniques to all new and some existing federal buildings. In practice, FEMP has often had difficulty in improving the energy efficiency of government buildings. For example, federally-assisted housing consumes significantly more energy (per capita or per square foot) than comparable private housing [Greely, *et. al.*, 1987]. On the other hand, individual agencies of the U.S. federal government, such as the U.S. Postal Service and the U.S. Navy, have been very successful with their building energy conservation programs.

Efforts have been made in several ASEAN countries to improve the energy efficiency of the government building stock, with as mixed results as in the U.S. The initial effort in Indonesia to promote energy conservation in commercial buildings dealt with government buildings. Very little success was obtained, in large part because of lack of resources and expertise at the time. In Thailand, an energy conservation committee was set up to investigate energy efficiency in government buildings; however, considerable difficulties may be expected because of the existence of air conditioners that are officially prohibited in many government buildings. It will be extremely difficult to study energy use in government buildings when the occupants and building managers do not want official records to show the existence of technical violations of rules. In Singapore, no real distinction has been made between government and private commercial buildings, as all buildings must comply with the building energy standards. We are unaware of any special efforts to date in Malaysia and the Philippines to deal with federal buildings.

4.5.3 Needs

It is probably too early to determine the needs within ASEAN in the area of government buildings. If one or more countries establish strong commitments to improve the stock of government buildings, it would be appropriate at that time to assess the likely success of the program and the assistance that would most support it.

4.6 Demonstration Programs

4.6.1 Background

Demonstration projects can be a highly-successful way of convincing a skeptical community (of professionals or of the general public) that a new idea or a new technology works. Demonstrations of energy-efficient buildings can be successful in this regard, particularly if various displays and exhibits are combined with the building to describe and educate people about what has been done and the results obtained.

4.6.2 Status in ASEAN

Energy-efficient demonstration buildings have not yet been attempted widely in ASEAN. In fact, the authors are aware of only one such building in the entire region: the Center for Non-conventional Energy Development (CNED) Complex at Quezon City in the Philippines. This building complex was constructed to reduce solar heat gain, take advantage of prevailing breezes (natural ventilation), use sunlight in place of artificial light where possible, and use other passive and some active solar devices. The building combines interesting design features with energy conservation measures. Various research studies have been performed on the building and it is open to the public.

The Philippines is also initiating a project funded by USAID to demonstrate new, commercially available energy conservation technologies. This project (Technology Transfer for Energy Management, TTEM) will provide subsidized loans for such technologies. One or several of the projects will likely be the demonstrations of technology for energy-efficient buildings.

4.6.3 Needs

There is a strong need to demonstrate to a skeptical (and typically cautious) building community the effectiveness of several relatively new technologies for improving energy efficiency in commercial buildings. Probably the foremost need concerns new techniques for daylighting in buildings. Daylighting has the potential for reducing energy use in a typical building in ASEAN by 10 to 20 percent, at very low incremental first cost. However, there is presently no building in all of ASEAN that employs modern daylighting technology! There exist various concerns about the practicality of the technology; also, information about the design and installation of daylighting systems is virtually nonexistent in ASEAN at this time. A well-designed demonstration project in several countries, combined with high-quality information, could go a long way to overcome concerns about daylighting and to bring about significant commercial activity over the next decade or so.

Other advanced technologies for improving energy efficiency of buildings (e.g., natural ventilation, advanced lighting systems, effective use of heat exchangers, novel humidity control devices, high-efficiency motors, improved fan and pump designs, more efficient chillers, cool storage and other load-shifting technologies, radiant barriers) could also benefit significantly from demonstration projects.

The process of establishing demonstration programs could be enhanced through highly-focused seminars with key trade associations (representing various aspects of the building community). If co-ordinated with other programs (e.g., low-interest loans) to reduce risks to builders of innovative, energy-efficient buildings, such seminars have the potential to spur important progress.

4.7 Electric Utility Conservation Programs

4.7.1 Background

The electric utility is directly affected by the energy characteristics of buildings. If new, inefficient buildings are constructed, electricity demand grows faster than otherwise. ASEAN countries are already experiencing very high growth in electric power needs.

Because of high costs of new power, electric utilities in the U.S. have become intimately involved in designing and implementing a very large and diverse array of programs to promote energy conservation. Examples of such programs include zero interest loan programs (for residential homeowners), rebate programs for efficient appliances, residential weatherization, subsidies for efficient lighting systems in residential and commercial buildings, and low-cost energy audits, to name but a few of these programs. Utilities in the U.S. spend literally billions of dollars improving the energy efficiency of the building stock. Such investments are generally fully justified by the reduction in expenditures on new generating capacity; otherwise, they would not be approved by the utility regulatory commission.

4.7.2 Status of Utility Conservation Programs in ASEAN

The U.S. is the only country in which many electric utilities have actively and aggressively promoted programs to reduce energy use. Very little in this regard has been done in ASEAN (or elsewhere, for that matter). At least one utility in ASEAN, the Public Utility Board of Singapore, has publicized the benefits of energy conservation. But active programs with the utility paying for a portion of energy conservation investments of electricity consumers do not exist.

4.7.3 Needs

There is a need to determine the costs and benefits of ASEAN utilities' developing and implementing active demand-side programs. Because the idea of a utility playing an active role in moderating demand has not yet had any attention in ASEAN, a serious analysis of the pros and cons of such activities among ASEAN utilities could have a substantial impact. To be successful, such an effort would need to be strongly analytical. It would have to be performed collaboratively with a utility to obtain meaningful data as well as to engage key individuals within the utility in the issues. This type of analysis activity, if done very well, has considerable potential for effecting major policy reforms.

4.8 Public Information

4.8.1 Background

The information requirements and the different audiences needing to be reached to effect a successful energy conservation program for commercial buildings is enormous. Building owners need to know what works and what doesn't. Architects and engineers need to understand basic principles and how to apply them to the building type and location of interest, as well as details of design, performance, and cost of a myriad of design options, conservation technologies, etc. Government officials need to know much of this information and more to decide what constitutes good public policy. As important as the quantity of this information is the need for quality: decisions involving substantial investments (often required to improve the efficiency of buildings) are made only if the information is *credible.*

4.8.2 Information in ASEAN

There is a lack of high-quality credible information on energy conservation opportunities in commercial buildings in ASEAN. First, as noted previously, research on what makes sense in ASEAN climates is sparse, so that the knowledge base is limited at present. Second, the topic of energy conservation in buildings has heretofore received little attention in government circles. Thus, the governments (often the source of credible information on topics like this) have not been especially active. Third, the private sector has also not been active, limiting information from this source. Finally, only a handful of faculty at universities throughout ASEAN actively work in areas of energy conservation in buildings. Thus, few students are acquainted with the field.

There are some notable exceptions. As noted earlier, Singapore has published a handbook and conducted numerous seminars on the OTTV standard for commercial buildings. Not only is the handbook valuable in implementing the standard; it is also a valuable educational tool for individuals interested in understanding many of the factors that influence building energy use in a hot, humid climate.

Nonetheless, the state of information on the topic is limited. One example stands out: while a number of faculty members in architecture departments in Thailand have expressed interest in teaching a course in energy-conscious design, no such course is presently offered because there does not exist a textbook on the subject in the Thai language.

In general, Thailand and Indonesia are the most removed from good information sources about energy conservation in buildings. Singapore and the Philippines have the most readily available information, with Malaysia in between. However, because (as noted previously) much of the information that is available is relevant to cooler climates, applicability of information from the U.S. or Great Britain (the two primary sources) is often limited.

4.8.3 Needs

The universities need a high-quality textbook on energy-conscious design (for architects) and equipment (for engineers). Handbooks for designing, constructing, and operating buildings are needed. Information of a more general nature, to motivate and educate the public, is badly needed in most of ASEAN. Relatively modest projects to provide much-improved public information on energy conservation opportunities in buildings in ASEAN could enormously enhance the efforts in the region, particularly as there is such a paucity of credible information at present.

4.9 Strengthening Public and Private Capabilities

4.9.1 Background and Importance

In both the public and private sectors, people who are knowledgable and experienced in building energy conservation are in very short supply. Also, every energy implementation strategy mentioned above involves some government action. However, in most cases government institutional arrangements do not exist to provide proper vehicles for action. This requires that governments accomplish dual tasks for any implementation strategy: they must set up the institutional structure for accomplishing the strategy and attempt to implement the strategy at the same time.

It is not possible to directly assess the energy savings that will directly result from improved personnel and institutional capabilities. Yet, the availability of these capabilities is crucial to the success of virtually all of the strategies mentioned in this paper. In this sense, strengthening public and private capabilities crosscuts all other implementation strategies and is extremely important.

4.9.2 Status in ASEAN

There are training activities regarding energy conservation in buildings in ASEAN but these are sporadic and very limited. The USAID-sponsored ASEAN project on energy conservation in buildings provides some significant training in multiple aspects of the subject. A number of bilateral programs as well as the Australian-sponsored ASEAN project have given training in energy auditing and, through the Australian program, building energy simulation modeling. There is also some continuing education at several of the major universities throughout the region in building energy related material.

Institutions to implement any of the policies in §4.1 to §4.8 are not fully developed in most of the countries. Two areas in the countries leave considerable scope for strengthening: the energy policy apparatus (as it relates to energy conservation policy in general and building energy conservation policy in particular) and offices for implementing policies. While there is not uniformity among the countries, all except Singapore need to combine a strong governmental commitment to building energy conservation policies with substantial training and manpower development to achieve significant policy objectives.

4.9.3 Needs

Training: The level of training related to building energy conservation could easily be expanded by several orders of magnitude. A comprehensive manpower development program is crucial to influencing the processes of building design and building operations. A comprehensive program should include skill-building for government policy-makers, government personnel responsible for building codes and standards, design professionals and educators.

Government policy-makers: They need to acquire the skills to perform the economic and policy analyses to support appropriate conservation measures. For example, various training programs at the Asia Institute of Technology (a Southeast Asian regional university located in Bangkok) could be expanded further, including an additional short course in energy management. Such training may include energy planning methodologies, organizational aspects of energy management, energy information system design and operation, topics in energy economics, industrial energy auditing, field audit training, case studies work, implementation of energy conservation measures, retrofitting, bioenergy conversion, etc. Regional workshops also can be provided to review and assess progress in energy planning in the region.

Government personnel responsible for building codes and standards: Officials from government public works departments must receive professional development training in energy conservation to be able to properly implement the improved energy efficiency design criteria for buildings embodied in revised building codes and standards.

Practicing architects and engineers: Architects and engineers are especially important targets for energy manpower development programs. Most professionals practicing today were trained in an era of cheap energy. Thus, unfortunately, most building design professionals in business today do not understand the basics of energy-efficient building design. Energy conservation workshops, like those discussed above for government officials, would help build skills. The courses would need to start with basic energy concepts and advance to more sophisticated concepts. An important mechanism is designing and presenting such courses in cooperation with architectural and engineering societies.

A precedent for this important type of manpower development has been established in a developed country. In the U.S., the American Institute of Architects (AIA) designed a series of three two-day workshops on energy conservation principles and techniques. While the AIA funded much of the course development from professional dues, some funding support was provided by the US DOE. Energy-knowledgeable architects and engineers were trained to teach the course. The courses were provided in the early and mid 1980s to several thousand architects and engineers in the U.S.

From experience with this training program in the U.S., it was found that it is important to include in such classroom training the opportunity to incorporate analysis of actual building designs being developed within practitioners' offices. Without such discussion and feedback, it has proven very difficult to apply lessons learned in classroom situations to design procedures within a design office.

Educators: Finally, similar professional development programs and courses are needed for educators, who will prepare new students to enter the building industry workforce. Such professional development could include the production of course curriculae. In the U.S., the US DOE funded the development of such a university course in passive solar design. The course was developed at the University of Pennsylvania for use by other universities. While it is a valuable course for heating climates, its applicability to ASEAN cooling-dominated climate conditions is limited. However, the concept of developing a cooling climate oriented course is very applicable.

5 Conclusions

In summary, significant potentials exist for energy conservation in buildings within the ASEAN region. If reasonable levels of energy conservation can be achieved, important benefits will be gained. Building owners will gain via improved building cost-effectiveness. Building occupants will gain via improved amenity and comfort. National economies will gain in reduced energy expenditures and improved energy efficiency.

This paper has described several key conservation policies. Implementation strategies have been described, including the needs, constraints, and barriers that confront implementation. The development agencies from several countries are working with nations of the ASEAN region on efforts in support of the policies described in this paper. UN ESCAP has an opportunity to follow these developments, and to judiciously select to support strategies than can attain significant advances toward implementation of the key conservation policies discussed.

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REFERENCES

Busch, J.F. and Deringer, J.J., 1987, "A building envelope energy standard for Malaysia." ASHRAE Far East Conference on Air Conditioning in Hot Climates, September 3-5, 1987, Singapore.

Kannan, K.S., 1987, "Development of energy conservation guidelines for Malaysian buildings." Presented at the ASHRAE Far East Conference on Air Conditioning in Hot Climates, September 3-5, 1987, Singapore.

PWD, The Development and Building Control Division, Singapore. 1979. "Singapore Standard CP 24, Code of practice for energy conservation in building services."

PWD, The Development and Building Control Division, Singapore. 1983. "Handbook on energy conservation in buildings and building services."

Universiti Teknologi Malaysia (UTM), Unit Penyelidikan Dan Peeundingan. November 1986. "Guidelines for energy conservation, Final report."

ASHRAE Standing Standard Project Committee 90.1. 1986. Draft Standard 90.1P, "Energy efficient design of new buildings except low-rise residential buildings." September 16, 1986 draft version.

Deringer, J.J., Busch, J.F., Hall, J.D., Kannan, K.S., Levine, M., and Turiel, I., "Energy and economic analysis of commercial building standards in Malaysia." Presented at the ASHRAE Far East Conference on Air Conditioning in Hot Climates, September 3-5, 1987, Singapore.

Little, A.D., "Analysis of the Impacts of ASHRAE 90-75," 1975.

AIA Research Corporation, "Analysis of ASHRAE 90-75R," 1980.

Crawley, D. and Briggs, R., "Energy Impacts of Proposed ASHRAE 90.1P," ASHRAE Journal, 1986.

Misuriello, H.P., Fireovid, J.A., and Hsieh, H.W., "Microcomputer and diagnostic instrumentation applications for commercial building energy audits in tropical climates." Presented at the ASHRAE Far East Conference on Air Conditioning in Hot Climates, September 3-5, 1987, Singapore.

Ullah, M.B., Rao, K.R., and Tan, S.O., "Computer-based instrumentation and energy analysis of a large office building in Singapore." Presented at the ASHRAE Far East Conference on Air Conditioning in Hot Climates, September 3-5, 1987, Singapore.

Turiel, I., Curtis, R., and Levine, M., "Parametric energy analysis in support of Singapore energy conservation standards." Presented at the ASEAN Conference on Energy Conservation in Buildings, May 29-31, 1984, Singapore.

Levine, M., Curtis, R., and Turiel, I., "Policy recommendations for reducing energy use in commercial buildings in ASEAN." Presented at the ASEAN Conference on Energy Conservation in Buildings, May 29-31, 1984, Singapore.

USAID, Project Paper Asia Regional, ASEAN Energy III Energy Conservation and Management, April, 1985

Turiel, I., ''Energy Conservation in Commercial buildings, Thailand, (Draft)'' Lawrence Berkeley Laboratory, 1986.

Wyatt, E., Lawrence Berkeley Laboratory and de la Moriniere, O., Agence Francaise pour la Maitrise de L'Energie (AFME),''The feasibility of commercial building thermal energy storage in ASEAN countries (second draft)'' 1986.

Mustapha, Ismail bin, ''Energy conservation policy and measures for energy management in Malaysia,'' UN ESCAP, August 1987

Siddayao, Corazon Morales, ''Criteria for energy pricing policy,'' 1985, p. 31.

Greely, K. M., Mills, E., Goldman, C. A., Ritschard, R. L., and Jackson, M. A., ''Baseline analysis of measured energy consumption in public housing,'' LBL-22854, January 1987.