Thailand's demand side management initiative: a practical response to global warming

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Introduction

Today, Thailand's power sector accounts for nearly 33 per cent of the country's total carbon dioxide (CO_2) emissions. During the next decade, the power sector will surpass transportation as the major source of CO_2 emissions in Thailand. By the year 2011, we project that the sector will account for 43 per cent of Thailand's CO_2 emissions.

To keep up with the rapidly rising demand for electricity, the Electricity Generating Authority of Thailand (EGAT) is planning to more than triple its capacity over the next fifteen years, from 10,000 to more than 30,000 megawatts (MOO) by 2006. Most of the new plants being built will burn lignite and coal. This trend will lead to greatly increased emissions of carbon dioxide and other greenhouse gases.

Here we focus on the potential for reducing CO_2 emissions in the power sector, since this is one of the most rapidly growing sources of such emissions in Thailand. It is also the sector for which there are the best data on costs and associated CO_2 reductions. The cost of conserved carbon (CCC) for residential electricity conservation measures ranges from negative US$155 to positive $41 per tonne of carbon as CO_2 equivalent in the year 2001. The average CCC for a comprehensive electricity conservation effort covering all subsectors (industrial, commercial, and residential) may be even lower, around negative $190 per tonne of carbon.

At present, there are inadequate data to enable similar analyses for the transportation and industrial sectors. In the future, work needs to done to apply the principles used here to perform analyses of the technical potential and cost feasibility of CO_2 reduction measures in the transportation and industrial sectors as well.

We also describe the crucial role that the multilateral development banks can play in providing the financial, technical, and policy support necessary to seriously address the problem of growing CO_2 emissions in rapidly industrializing countries.

Even if current predictions of global temperature rise are overstated, the economic impacts of continued high rates of growth in energy use worldwide will be untenable. The World Bank estimates that developing countries will require an average of US$100 billion annually just for capital expenses in their power sectors alone during the next decade. The amount needed over the next three decades is an estimated $4 trillion. Foreign exchange currently pays for about 38 per cent of these capital expenses. Yet only $10-12 billion per year is expected to be available from multilateral and bilateral agencies, the main providers of foreign exchange for electricity supply projects (Philips 1991). A shift to cleaner, cheaper fuels and improved energy efficiency will reduce the debt burden of developing countries, and thus yield additional societal benefits besides just reducing emissions of greenhouse gases.

Shift in Thai CO_2 emissions

Thailand is not currently a major contributor to global warming, in terms of emissions of carbon dioxide and other greenhouse gases. The World Resources Institute has estimated that Thailand emits 1.2 per cent of the world's total of greenhouses gases (125 million of a total of 10.6 billion tonnes of C annually as CO_2 equivalent (SKI 1992)). In 1987, Thailand emitted 1.3 tonnes of carbon per capita, matching the world average (SKI 1992). By 1990, Thailand's CO_2 emissions had declined to about 0.98 tonnes of carbon per capita (TTCGE 1991).

Increases in CO_2 come from two major sources: deforestation, which increases CO_2 emissions directly and also reduces the uptake of CO_2 from the atmosphere; and fuel combustion, which emits CO_2 directly into the air. In the past, deforestation was by far the largest cause of Thailand's CO_2 emissions. As Thai forests are depleted and energy use increases, however, fossil fuel combustion will rapidly become the dominant source. In the near future, as Thailand's economy expands and its burning of fossil fuels grows, so too its contribution to global warming will increase. The U-shaped curve of total CO_2 emissions implied by Figure 11.1 tells the story.

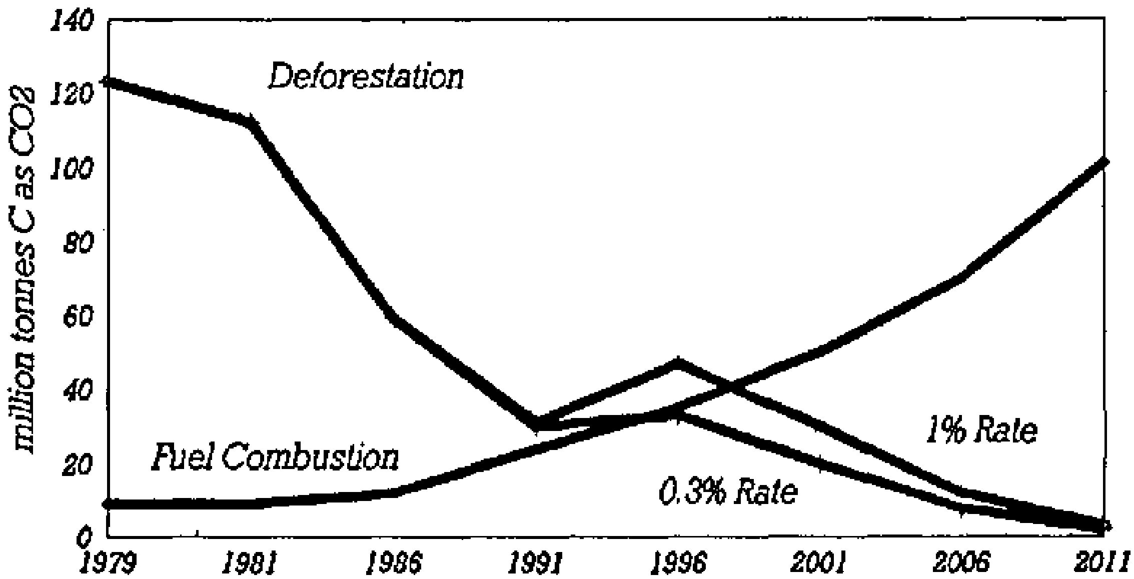

Figure 11.1 Thailand's net CO_2 emissions from deforestation and fuel consumption

In Thailand, the ratio of CO_2 emissions from deforestation to emissions from fuel consumption has declined dramatically from 13.7 in 1979 to nearly 1 in 1991. CO_2 emissions from fossil fuels are expected to rise fourfold over the next 20 years, to 100 million tonnes by 2011.

The transition from deforestation to fuel consumption as the main source of CO_2 emissions is a possible pattern that will occur in other countries with formerly abundant forest reserves - that are on the road to industrialization. The drop in the amount of CO_2 released due to deforestation in Thailand's case has two primary causes: reduction in the amount of remaining forests and the nation-wide logging ban instituted by the government in January 1989. The large increase in fuel consumption will come from two main sectors: transportation and power. This chapter focuses on the potential to reduce greenhouse gas emissions from the rapidly growing power sector.

Thailand's policy responses to global warming

During the preparations for the United Nations Conference on the Environment and Development (UNCED) in Brazil in June 1992, Thailand's government showed significant interest in international environmental issues, and particularly in addressing global warming. In addition to hosting a series of high-level international conferences on the environment, the government attempted to identify the most effective response strategies at its disposal for dealing with climate change. Thailand's national report to UNCED concluded that the country's most significant contribution will be a comprehensive set of energy conservation programmes that, if aggressively pursued, could reduce projected increases in Thai CO_2 emissions from the power sector by more than 2.5 million tonnes of carbon annually over the next decade (TTCGE 1991).

Thailand's energy picture

The agency responsible for setting the direction of Thai energy policy is the National Energy Policy Council (NEPC), a cabinet-level committee that sets the policies governing fuel and electricity. The operating arm of the NEPC is the National Energy Policy Office (NEPO), which is under the Office of the Prime Minister. NEPC is responsible for overseeing the kingdom's three electric utilities, the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA).

EGAT is a state-owned enterprise that produces virtually all of Thailand's electricity. MEA and PEA distribute electricity provided to them by EGAT. They are state enterprises under the direction of the Ministry of Interior.

The agency charged with taking the lead on energy conservation and renewable energy activities is the Department of Energy Development and Promotion (DEDP), which is under the Ministry of Science, Technology and Energy. In summary, NEPC and NEPO develop energy policies and the electric utilities; DEDP, and other institutions (for example, the Petroleum Authority of Thailand) are responsible for implementing those policies.

Thailand's primary energy use grew at an average annual rate of 13.4 per cent between 1985 and 1990. The rapid, sustained growth is due to the overall pace of growth of the economy and expansion of industrial, construction, and transport activities. The Seventh Economic Plan projects an economic growth rate of 8.2 per cent from 1992 to 1996. It is expected that energy demand will grow at an even faster rate, for example 10.3 per cent in the power sector (NEPO 1991).

Transportation accounts for the largest share of primary fossil fuel demand at about 30 per cent, followed closely by the power sector (29 per cent) and the industrial sector (20 per cent) (see Figure 11.2). Energy use in the power sector is rising faster than energy use for transportation, however. By 2006, power generation will account for some 37 per cent of Thailand's primary fossil fuel demand, compared to 35 per cent from the transport sector (TDRI 1991). To keep up with the rapidly rising demand for electricity, EGAT projected in 1990 that its installed capacity in the year 2006 would have to reach 24,900 (EGAT 1990). The estimate was recently revised upward to more than 30,000 MW (EGAT 1992).

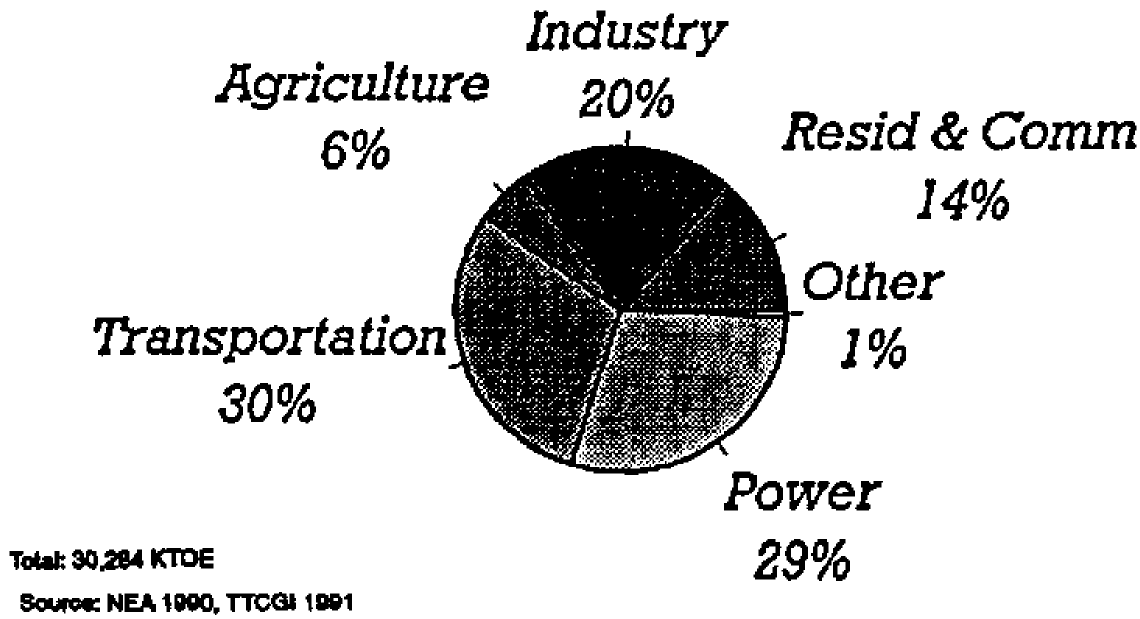

Figure 11.2 Thailand's primary fossil fuel demand, by sector

Sources of CO_2 emissions

Petroleum is the largest fuel source in Thailand, accounting for 56 per cent of primary energy demand. Most of this fuel is used in the transportation sector, which contributed 40 per cent of Thailand's CO_2 emissions in 1991. The next largest sources of CO_2 emissions are the power sector (33 per cent) and industry (15 per cent). During the next decade, the power sector will surpass transportation as the major source of CO_2 emissions in Thailand. By the year 2006, we estimate that the power sector will account for 43 per cent of Thailand's CO_2 emissions from fuel consumption (see Figure 11.3).

Thailand's policy is to promote the use of domestic energy resources in order to reduce the burden on the country's balance of payments. Domestic energy resources comprise gas, lignite, biomass (including fuelwood) and hydropower. The use of fuelwood and hydropower is unlikely to grow significantly, due to the government's efforts to encourage reforestation and to growing public opposition to the building of dams.

The implications of this strategy of relying on domestic and inexpensive energy resources can be seen most clearly in the power sector. In 1991, oil and natural gas together accounted for 66 per cent of electricity generation. By 2006, a complete shift will have taken place. Oil and gas together will account for just 36 per cent of primary energy supply to electricity generation, while coal and lignite will make up 55 per cent. Lignite is readily and cheaply available in Thailand. Coal, while not mined locally, is available in the region (from Australia and Indonesia) and its price is expected to remain stable because of the large available resources.

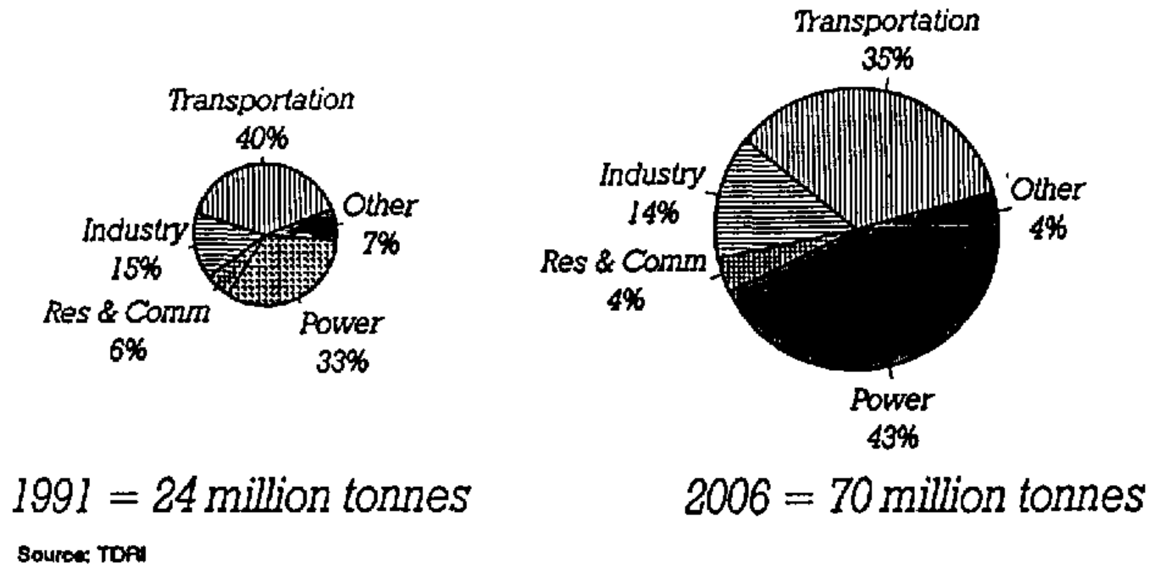

Figure 11.3 Thailand's CO_2 emissions by sector, 1997 and 2006

In the power sector, where most of the lignite and coal is used, consumption will rise more than fourfold - from 11.6 million tonnes in 1991 to 49 million tonnes annually in 2006 (EGAT 1990). In Figure 11.4, we show the dramatic shift in fuel mix that will occur in the energy and power sectors. Two 1,000-MW nuclear plants are scheduled to come on line in 2006, with four more units following soon thereafter.

End-use energy efficiency policies

Considerable scope exists to improve end use efficiency in Thailand's energy consumption. Recent studies have estimated that, in the power sector alone, efficiency improvements could reduce the projected growth in demand by 2535 per cent over the next decade (Monenco 1991, IIEC 1990). Similar improvements can be made in thermal (non-electric) energy use in factories, but this area has not been adequately studied.

Thailand is currently pursuing two main initiatives to improve end-use energy efficiency: an energy conservation law and a utility-run demand side management (DSM) programme.

The Energy Conservation Promotion Act

The National Assembly passed Thailand's first-ever energy conservation law in February 1992. The Energy Conservation Promotion Act gives the Department of Energy Affairs (DEA, formerly the National Energy Administration), the power to issue an energy code for new buildings. Initially, the code will be voluntary, and developers of new buildings will be encouraged to abide by it. The code will establish minimum performance levels for the insulating properties of building materials and glazing, and will recommend levels of lighting and energy intensity.

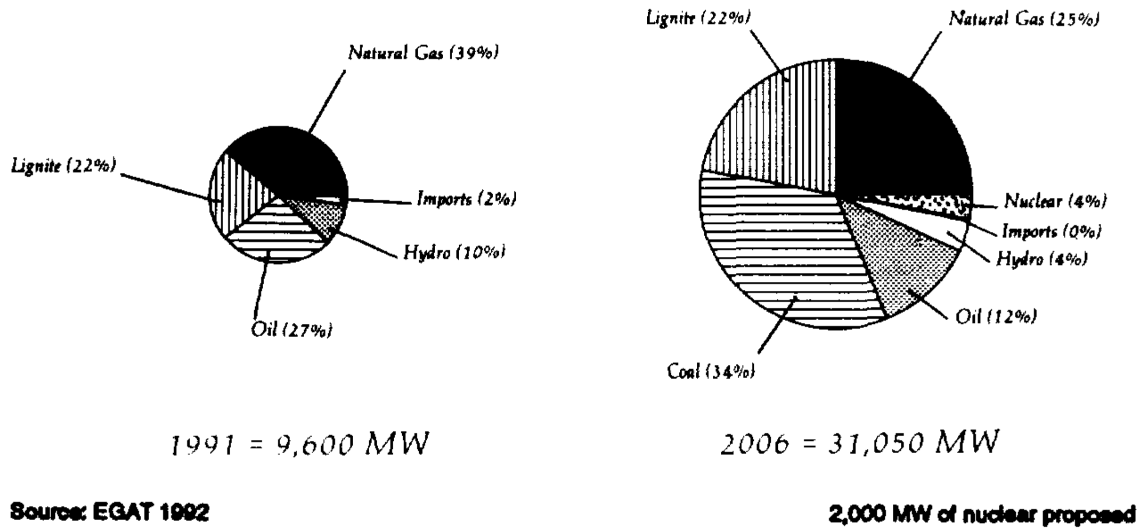

Figure 11.4 Thailand's electricity production by fuel type, 1997 and 2006

At the same time, the law will require the owners of large buildings and factories (with power demand of more than 2,000 kW) to appoint an energy conservation manager and to submit a comprehensive energy management plan to DEA. The owners will have three years to submit the plan; if they fail to do so, they will receive a surcharge on their electric bill. In its initial stage the requirement to submit an energy conservation plan will apply to 220 large industrial facilities and 60 buildings.

The Energy Conservation Promotion Act also empowers DEA to establish minimum efficiency standards for electric appliances and energy-consuming equipment. It is likely that these standards will be coordinated with the efforts of the Thailand DSM Office to set minimum energy efficiency requirements for its various programmes.

Finally, the law also establishes the Energy Conservation Promotion Fund, which will be available for energy conservation and renewable energy projects in all sectors. The cabinet has recommended that the initial amount in the fund be US$60 million. Thus there will be two major sources of funds for end-use efficiency projects in Thailand: the Energy Conservation Promotion Fund (for all sectors and fuel types) and the DSM programme, described below (for electricity measures).

The demand side management programme

In November 1991, the Thai government approved a five-year Demand Side Management Master Plan that will allocate US$188.5 million to the purchase of energy-efficient equipment in the commercial, industrial, and residential sectors. The plan calls for the three utilities (the Electricity Generating Authority of Thailand - EGAT, the Provincial Electricity Authority - PEA, and the Metropolitan Electricity Authority -

MEA) to establish jointly a Demand Side Management Office, which will operate a comprehensive set of energy conservation programmes (Cherniack and du Pont, 1991).

Both the Energy Conservation Promotion Act and the DSM Master Plan will bring about efficiency increases in all sectors and help to reduce Thailand's CO_2 emissions substantially. In the case of the DSM, no central government monies need to be allocated for the CO_2 reduction measures, since the cost will be borne by utilities, just as they currently bear the cost of building power plants. The following section describes the principles of DSM, how it is being applied in Thailand, and the potential for reducing CO_2 emissions from the power sector.

When it passed its DSM Master Plan in November 1991, Thailand became the first Asian country to incorporate energy efficiency formally into its power planning process. Top management at the Thai electric utilities, with some prodding from the National Energy Policy Council, decided to spend money to produce energy efficiency as a future resource for the electric power system. The Thai DSM initiative was inspired by a decade of experience with DSM at more than 500 American utilities. These utilities now spend US$1.2 billion annually, and have sponsored 1,400 different DSM programmes (see box).

The role of demand side management

International commitment is growing to sustainable development at the local and national levels in a wide variety of social and economic conditions. Three important criteria for establishing sustainable development in the power sector are efficiency in electricity generation, transmission and distribution; efficient use of electricity; and renewable energy resources, with emphasis on solar (thermal and photovoltaic), wind (mechanical and electrical) and biomass (small and large scale).

The major components of end-use efficiency in the power sector include the principles of integrated resource planning and demand side management. These principles are the fundamental basis for sustainable energy planning in the power sector.

Integrated resource planning (IRP) is an effort to fully integrate both supply and demand-side options into a utility system expansion plan that provides reliability, lowest total system cost, and acceptable levels of risk. It is a rational enhancement to the least-cost generation planning framework that has governed utility expansion planning worldwide for decades and been promoted by the Bank and other multilateral lenders. What distinguishes IRP from current power system supply planning is that conservation - the efficient end-use of electricity competes directly with generating resources for consideration in meeting a utility's future load growth requirements. Both supply and demand are considered formally in the utility planning and resource acquisition process. IRP can also be called least-cost utility planning (LCUP) since it describes the truly lowest cost system for meeting all electricity service needs in society.

Demand side management (DSM) can be defined as the systematic effort by the electric utility to influence the timing and magnitude of customer electricity use in order to optimize power system operation and planning. DSM includes tariff pricing mechanisms, load management techniques and increased efficiency in all end-uses of electricity. An integrated resource plan typically includes a comprehensive demand side management plan that is implemented by the utility to create the least-cost operation and expansion of the power system

Beginning in the United States in the early 1980s, electric utilities began the most advanced work in the world on developing demand side resource options for their electric power systems. In North America, where most DSM work to date has taken place, more than 500 utilities have sponsored DSM programmes; these included 1,000 programmes for residences and 400 programmes for commercial and industrial buildings.

Carbon dioxide emissions from electricity generation are exported to rise dramatically in the US during the next 20 years, increasing by 68 per cent between 1990 and 2010. As a share of emissions from fuel combustion, CO_2 emissions from the power sector will rise from 31.5 per cent to 39.4 per cent during this period (Foruqui and Haites 1991). DSM programmes have the potential to reduce electricity use in the year 2010 by 20 per cent (Hirst 1991). They also have the potential to reduce projected emissions of CO_2 from the power sector by up to 18 per cent (Faruqui and Haites 1991).

Because the cost of most energy conservation measures is typically less than the cost of building new power plants, the adoption of DSM measures by a utility actually saves money (that is, produces a net benefit). This means that the net cost of conserved carbon for DSM measures is negative in most cases. One US study estimated that about 23 per cent of US carbon emissions in 2010 could be eliminated at a negative cost of conserved carbon, and that up to 39 per cent of emissions could be eliminated if all the conservation measures were adopted. The most expensive of the conservation measures would have a net cost of conserved carbon of just US$43 per tonne of carbon (Atkinson et al. 1991).

In Table 11.1, we list the estimated programme costs and savings associated with the Thai DSM effort. These programmes will provide financial incentives for customers to purchase energy-efficient equipment. The utilities compare the cost of purchasing electricity savings to the cost of building new power plants. Only measures that cost less than the cost of building new generation capacity are included in the programmes. The average long-term cost of savings from all of the DSM programme measures is US$0.017/kWh (see Figure 11.5). When these costs are compared to EGAT's adjusted long-term cost of US$0.0621kWh (see below) to produce new electricity supply, it is clear that the least-cost investment for the utilities is in energy efficiency.

Thailand's five-year plan aims to save an estimated 238 megawatts (see Figure 11.5). Although this is a pioneering effort for an Asian utility, the US$188.5 million allocation represents just a small portion of the estimated US$36 billion that the Electricity

Generating Authority of Thailand will need for its capacity expansion programme over the next decade (EGAT, 1992). In fact, capital constraints are one reason that EGAT stands to benefit from an aggressive DSM programme.

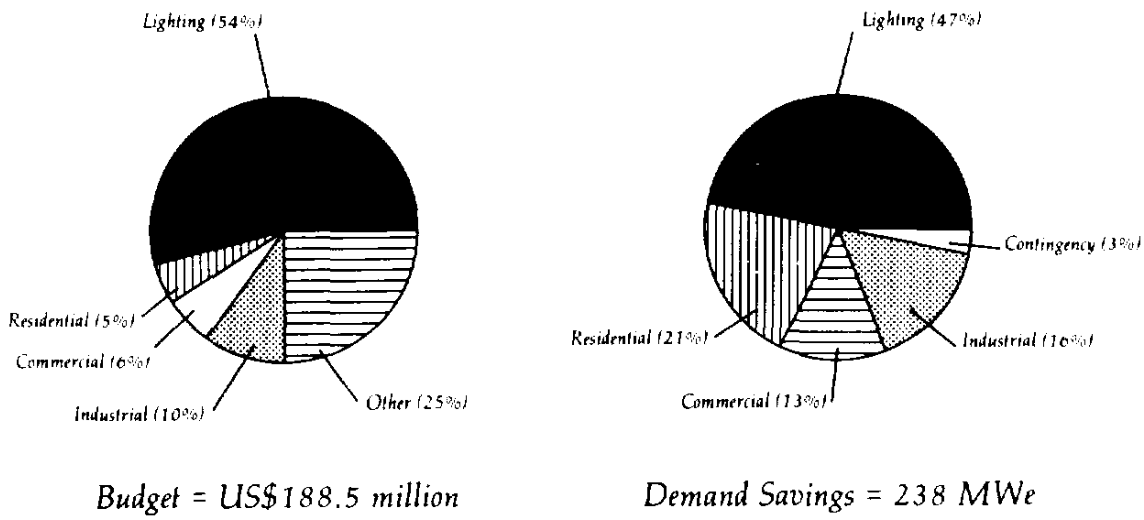

Figure 11.5 Thailand's power sector, 5-year DSM budget and demand savings

Table 11.1 Thailand's proposed demand side management programmes

Programme	**Peak savings (MWp)**	**Energy saved (GWh/yr)**	**Cost ($m)**	**CSE (cts/kWh)**
Lighting	133	677	101.0	2.2
Residential refrigerators	28	186	6.0	0.4
Residential air conditioning	23	117	3.0	0.3
Commercial programmes	15	180	12.0	0.8
Industrial motors	30	225	19.0	1.1
Contingency	9	42	11.5	3.6
Whole programme	238	1,427	188.5	1.7

Notes
EGAT estimate combining New Commercial Building Design Programme with Peak Shaving.
Whole programme budget includes laboratory and testing, consulting, training, programme administration, and public relations.

CSE (cost of saved energy - (CRF* DSM Cost)/(GWh/yr saved)	EGAT LRMC = 4.2 ct
CAP (cost of avoided peak) - DSM cost/kWp saved	EGAT new capacity =

CRF = capital recovery factor

0.147 CRF lighting	0.117 CRF commercial
0.131 CRF refrig	0.131 CRF motors
0.131 CRF A/C	0.131 CRF contingency

Source: International Institute for Energy Conservation, 'Thailand: Promotion of Electricity Energy Efficiency. Final Report of Pre-investment Appraisal,' report to World Bank/Global Environment Facility & United Nations Development Programme, Bangkok, 1993.

On average, the DSM options outlined in the five-year Master Plan will provide MW savings at a cost of less than half the cost of building new capacity. The 238 MW is just the tip of Thailand's iceberg of efficiency potential, however. Studies conducted by various Thai agencies and outside consultants of Thailand's electricity end uses have identified an achievable DSM potential of at least 2,000 MW over the next decade (Monenco 1991, IIEC 1990). This represents nearly 20 per cent of EGAT's planned system expansion, which can be avoided at half the cost of new capacity. An aggressive, 10-year DSM effort to save 2,000 MW of peak demand would yield EGAT US$2.9 billion net savings in capital costs for system expansion (see Table 11.2).

Costs and benefits of the DSM master plan

Traditionally, the external costs associated with power production have not been accounted for in the tariff structure. These externalities are the cause of damage to the environment and human health in Thailand and surrounding regions from the normal operation of power plants that burn fossil fuels such as oil, gas, coal, and lignite. By not including these externalities in the cost of electricity, power system planners are assigning a

Table 11.2 Thailand's capital investment choices

	10-year achievable DSM potential	= 2,000 MW
	2,000 MW of power plants[a]	= US$4.5 billion
minus	2,000 MW of DSM	= US$1.6 billion
equals	10-year DSM net cost savings	= US$2.9 billion
Other major infrastructure projects		
	Second stage expressway	= US$1.2 billion
	Nation-wide sewage treatment	= US$2 billion

a The cost of 2,000 MW of delivered power is calculated based on a 15% reserve margin and 14% power transmission and distribution losses. It is equivalent to 2,817 MW of installed capacity.

This table contains the cost savings accrued by EGAT, government-run utility, for investing in an aggressive 10-year DSM plan. These cost savings are compared to similarly-sized investments that the Thai government is planning for other large infrastructure projects. EGAT plans to add 13,100 MW over the next decade at an approximate cost of US$19.7 billion. The cost of new capacity is US$1,600/kW, while DSM measures for Thailand cost US$800/kW on average (source du Pont and Biyaem 1992). value of zero to the environment. Many state and national governments have recognized this fact and have begun to add an externality surcharge to the tariff. As of mid-l992, the Thai government had not yet established an environmental resource accounting method that could be applied to the power sector. The DSM Master Plan assigns the following credits to DSM measures in comparison to supply side power generation options: 14 per cent for transmission and distribution losses, 15 per cent for the reserve margin, and a 15 per cent environmental credit.

EGAT's long-term avoided cost for new power plants is US$0.0431kWh. After factoring in the recommended credits, EGAT's adjusted avoided cost is US$0.062/kWh. DSM measures will be judged cost-effective if they cost less than this amount. At present, Thailand has no formal environmental regulations that can influence the choices made by utility planners. Clearly, the establishment of an environmental accounting system could allow Thai planners to assess the environmental benefits of demand side management.

CO_2 reductions from the DSM Plan

In order to assess the CO_2 benefits of DSM, it is necessary to use a detailed model that relates the energy savings from each DSM measure to the actual operation and fuel mix of the generating plants in the power system. To date, this analysis has only been carried out for Thailand's residential sector.

Utility system planners from the Tellus Institute in Boston conducted a workshop in May 1991 with the System Planning Department of EGAT and staff from Thailand's National Environment Board. Using power system data supplied by EGAT, and cost and savings data provided by a residential DSM assessment for Thailand, the workshop team quantified the environmental benefits of the combined DSM measures for the residential sector (EGAT 1991, Bartels 1991, Parker 1991). The benefits occur when the utility burns less diesel for peaking plants and less coal and lignite for base-load plants. The savings occur when the utility defers or avoids the need to build future power plants.

The system planners used the Energy Conservation Model (ECO), which is a computer software package that calculates the costs, resource impacts, and environmental externalities of demand side management programmes. It also determines the revenue and rate impacts of the programmes. Data on residential conservation measures were input from the Parker (1991) study of residential electricity use in Thailand, the most complete analysis of energy conservation potential in this sector. The simulation assumed eight different conservation programmes were run over a ten-year period (one rural and one for Bangkok) for each of four major electricity uses: cooling, lighting, refrigerators, and cooking (rice cookers).

The costs of residential efficiency improvements were based on data collected in Thailand during 1991 (Parker 1991). These costs were used to calculate the cost of saved energy for each technology or package of measures (Parker 1991, Cherniack and du Pont 1991). The costs of conserved carbon (CCCs) were then calculated based on the costs of saved energy for the measure, the utility's adjusted long-run marginal cost of production, and the CO_2 reductions derived using the ECO model. This method for calculating CCCs is explained in Akbari and Rosenfeld (1990).

Figure 11.6 shows a supply curve of conserved carbon for the Tellus/ EGAT workshop. The cost of conserved carbon (CCC) ranges from negative US$155 to positive $41 per tonne of carbon as CO_2 equivalent in the year 2001. A study of the CO_2 emission reduction potential from conservation measures in US homes found a range of CCCs of negative US$92 to positive US$43 per tonne of carbon (Atkinson et al. 1991). Table 11.3 compares the two studies.

As explained in several other sources, negative costs of conserved carbon are common for most energy conservation measures. In fact, they benefit, rather than burden the economy (Akbari and Rosenfeld 1990, Atkinson et al. 1991). The Tellus numbers indicate an energy savings potential of more than 3,200 gigawatt hours (GWh) in the residential sector by 2001. The associated CO_2 reductions from the residential subsector could total 1 million tonnes of carbon (as CO_2) by 2001. This figure is 5 per cent of projected CO_2 emissions from the overall power sector in 2001.

Since the residential sector accounts for only 25 per cent of Thailand's electricity demand, it stands to reason that additional CO_2 reductions (beyond the 1 million tonnes for the residential sector) from commercial and industrial conservation measures will be substantial. These data have not been analysed yet in the Tellus (or any other) model, but a rough estimate can be made by assuming that Thailand's achievable 2001 DSM potential of 2,000 MW (11,500 GWh) is spread evenly across the EGAT fuel generation mix through the year 2001.b

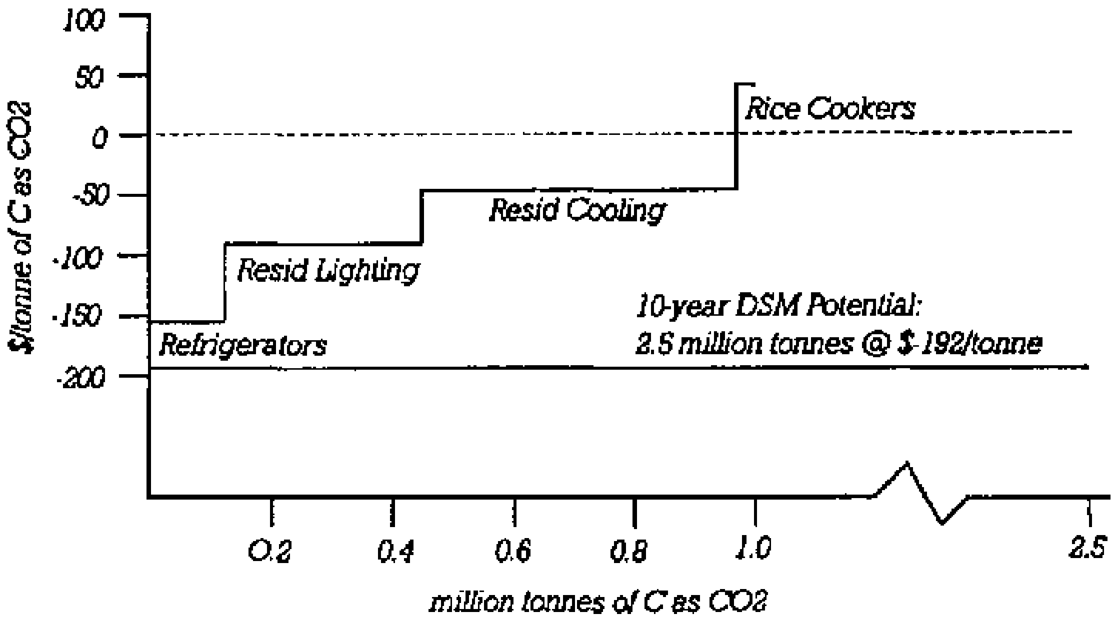

Figure 11.6 Carbon abatement curve for Thai residential sector, 2000

This 'back-of-the-envelope' analysis yields a CO_2 reduction of about 2.5 million tonnes of carbon annually, or 13 per cent of CO_2 emissions from the overall power sector in 2001 (Monenco 1991, IIEC 1990, Busch 1990, Parker 1991). The average cost of conserved carbon for DSM measures in all sectors is about negative US$1901tonne of carbon.

Table 1 1.3 Comparison of CCCs for residential electricity conservation measures (US $/tonne carbon)

End use	United States	Thailand
Lighting	-92.2	-96.2
Refrigerators	-30. 1	-155
Space conditioning	+9.9	
Air conditioning	-	-44.5
Water heating		
Rice cookers	-	+40 7
Other	-36.9	

Source: Atkinson et al 1991

Why should other developing countries adopt DSM?

The benefits of DSM programmes and integrated resource planning (IRP) are substantial, especially given the rapidly growing demand for electricity by all sectors of the economy in many developing countries and the rising capital and environmental costs of meeting the demand. The search for mechanisms to reduce global CO_2 emissions makes DSM an even more attractive policy for governments and utilities in developing countries. Briefly, the benefits of DSM are:

• It enables utilities to operate at the lowest possible cost of production. This cost minimization keeps tariffs stable and under control. Net system benefits will increase because investments in needed new power plants are avoided for as long as possible or avoided completely. Also deferred or avoided are transmission system expansion, operation, maintenance and fuel costs.

• End-use efficiency reduces customers' bills. This leaves everyone with more money which can be spent in other parts of the economy. Foreign debt obligations for power plant construction can be reduced also leaving additional funds for other infrastructure development priorities.

• Demand side management reduces the uncertainty in projecting future electricity demand because a portion of the expected load growth is managed through efficiency programmes.

• Investments in efficiency can be made in smaller amounts and adjusted more quickly to meet changes in demand. Therefore, the risk of underbuilding or overbuilding new power plants is reduced. The use of expensive capital is optimized.

• Integrated resource planning reduces social conflict over natural resource utilization because fewer power plants of any type have to be sited.

Other Asian developing countries are also exploring the feasibility of implementing DSM programmes on a large scale. Tenaga Nasional Berhad (TNB), the private power utility that serves Malaysia, has about 3,650 MW peak demand which is expected to grow to around 5,500 MW in 1995. The DSM project proposed by TNB, which began in 1992, is to conduct a smallscale test of commercial building retrofits. Several buildings will undergo 'super retrofits.' after the retrofits, the project team will monitor the end uses of electricity in these buildings and compare these results to monitored use in a group of control buildings.

The purpose of the test will be to document the capacity and energy savings acquired by replacing standard ventilation and air conditioning equipment, inefficient lighting systems, and other end uses with more efficient technology. A second objective is to expose the TNB staff to the analysis, development, and monitoring of DSM projects. The TNB staff will be trained in the fundamentals of DSM project development and operation.

The role of the multilateral development banks

Developing countries must seriously address the issue of climate change. To do so, they will require monetary as well as technical assistance from the developed countries, as promised in the Climate Change Convention. The most appropriate vehicle for funnelling funds into worthy CO_2 reduction schemes is the multilateral development banks (MDBs), which largely shape investments in the power and transportation infrastructures in developing nations.

With energy investments averaging more than US$5 billion per year (over $3 billion for The World Bank alone), MDBs are the world's most important sources of capital for energy investments in developing countries and Eastern Europe. Through their economic advice, loan conditions, and investments in both energy-producing and energy-consuming sectors, these banks shape energy development and consumption in these countries. They also strongly influence the investment priorities of bilateral and multilateral assistance agencies, commercial banks, and other investors. Thus, energy investment in many countries turns to a great extent on the decisions of these banks.

The MDBs cannot single-handedly effect a transition in developing countries to a greater emphasis on energy efficiency; government, industry, and financial institutions in these countries must be full partners. The banks, however, because of their vast influence on the countries' investment policies, can be leaders in this transition.

Energy service needs should be met by evaluating both new supplies and demand-side efficiency improvements, and selecting from among the options according to cost. This is called an integrated, least-cost planning approach. For the electric power sector, loans should be based on the lowest cost methods of delivering electricity services, either by improving the efficiency with which these services are provided or by increasing the supply itself. The same integrated least-cost approach can be applied to oil, gas and water resources.

To accelerate their learning process in this area, the multilateral development banks need to initiate a series of demonstrations of implementation strategies. In the past, owing to the uncertainty of success, the banks have concentrated on studies of the potential for efficiency improvements, possible institutional frameworks for administering energy efficiency programmes, and the barriers to energy efficiency. Such studies should continue, but actual implementation and demonstration programmes in developing countries are the only way to understand the problems and to develop solutions.

The experience in Thailand can serve in some regards as a model for the MDBs in establishing demonstration energy efficiency projects in the electric power sector. Initial reaction from The World Bank to the Thai DSM plan has been favourable, and it has also granted approval in principle for US$15 million in loan funds to supplement the Thai DSM effort. These funds will be administered through the Global Environment Facility. An additional US$25 million soft loan has been offered to the Thai DSM effort, pending appraisal, by the Japanese Overseas Economic Cooperation Fund.

It is also encouraging that The World Bank has begun active pursuit of options for funding small-scale energy conservation and renewable energy projects. The Bank's FINESSE project studied the technical and financial potential for funding such projects in four Southeast Asian countries: Thailand, Malaysia, Indonesia, and the Philippines (World Bank 1991). As a follow-up to the initial FINESSE workshop, The World Bank has established an Asia Alternative Energy Unit. The Asian Development Bank has also shown interest in allocating loan funds for renewable and energy conservation projects. The latter institution is also implementing the UNDP study of least-cost greenhouse gas reduction strategies in Asian developing countries, including Thailand.

Conclusions

To avoid the sort of impacts estimated in the box opposite, all nations will have to find ways to reduce their contribution of greenhouse gases. The Climate Change Convention signed in Rio places the onus on everyone to limit carbon dioxide emissions, although the developed countries are expected to take the lead. While the implementation of this agreement is not yet clear, we have argued in this chapter that industrialized and developing nations can significantly contribute to efforts to halt global warming at relatively low cost at least at the outset of such a programme.

Thailand's CO_2 emissions from fuel combustion will double over the next decade, from 24 to nearly 50 million tonnes annually. An aggressive demand side management effort in the power sector could reduce emissions by 2.5 million tonnes annually by the year 2001. The average cost of conserved carbon for these measures would be about negative US$1901tonne.

Thailand's nascent efforts in the area of electricity conservation can provide lessons for other developing countries. Clearly, in order to initiate effective DSM efforts in developing nations, industrialized nations will have to provide significant technical and financial assistance. Prime vehicles for providing this assistance are the multilateral development banks, which already shape the power infrastructure in developing nations. The banks must internalize the concepts of integrated resource planning and demand side management if they are to play a positive role in this regard. They will then be in a sound position to introduce loan recipients to these techniques and to assist them in developing national strategies for energy efficiency and carbon conservation.

Climate change impacts in Thailand

In Thailand, the warming under GISS 2 x CO_2 climate la climate model scenario run assuming a doubling of CO_2 levels] is equivalent to a 3°C to 6°C increase in current mean annual temperature, a projection that is broadly in agreement with other GCMs [general circulation models]. There are, however, substantial differences between GCMs concerning changes in precipitation, which vary widely from normal but generally show a reduction under the GISS 2 x CO_2 scenario. Northern Thailand may be drier in most of the months except in July which is currently a dry period and this would appear to benefit cropping. However, August and September would experience only between 73 per cent and 89 per cent of present rainfall. Other GCMs, however, do not indicate such a reduction in rainfall and it is important to emphasize this uncertainty. Under the GISS 2 x CO_2 scenario winters are also drier but as very little rain is normally expected during that time of the year the adverse implications may be less.

Two particular aspects of the Thai economy were studied with respect to potential impacts from these projected changes in climate effects on rice production in Ayuthaya Province and effects of sea-level rise in Suratthani Province.

The CERES model was run for a 25 year set of daily climate variables (19641988). Model outputs for the current climate substantially exceeded observed values for transplanted rice and were lower than expected for yields of direct seeded rice. It was not possible, however, to conduct an adequate validation of the model and to re-tune it to observed data for Thailand. As a result, the consequences should be treated with caution.

The results indicate that under a change of climate projected for a doubling of CO_2 main crop rice cultivation in Ayuthaya Province would increase in the order of 8 per cent. These benefits would, however, be, in most cases, quite marginal because they are substantially less than the existing year-to-year variation. The modelled yields were also characterized by marginally greater yield variations. Off season rice, planted from mid-December to early February, exhibits a 5 per cent increase in average yield under the GISS 2 x CO_2 climate with concurrent increases in variation of 3-40 per cent. However, little value can be placed on these results because of lack of model validation. Indeed the results are not consistent with those for Chiang Mai which were validated against observed data, and which indicate a decrease in rice yield of about 5 per cent under the GISS 2 x CO_2 scenario.

Thailand has approximately 2940 km of coastline, much of which contains important economic activities such as shrimp farming and rice farming. The study considered the potential impact of a 0.5 m and 1 m rise of sea levels in the Suratthani Province in southern Thailand. This region is characterized by a sand dune line which may mark an ancient shoreline and has a consistent elevation about 1 m above present sea level. It was therefore used as an indicative boundary to the area potentially affected by a 1 m sea level rise. The suggestion is that 7400 ha (37 per cents of the study area would be affected by inundation under a 1 m sea level rise. About 4200 ha of productive agricultural land and large numbers of shrimp ponds would be lost.

Excerpt from M Parry, A Magalhaes, Nguyen H Ninh, The Potential Socio-Economic Effects of Climate Change, A Summary of Three Regional Assessments, UN Environment Programme, Nairobi, 1991, p 19.

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