Renewable IPPs for Southeast Asia

Final Report

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List of Acronyms and Abbreviations

ADB = Asian Development Bank
AWEA = American Wind Energy Association
BOO = build-own-operate
BOT = build-operate-transfer
BTO = build-transter-operate
CO_2 = carbon dioxide
DSM = demand-side management
EGAT = Electricity Generating Authority of Thailand
EGCO = Electricity Generating Company, Plc.
ESCO = energy service company
FGD = flue gas desulfurization
GDP = gross domestic product
GMS = Greater Mekong Subregion
GW = gigawatt
GWh = gigawatt-hour
HP = horsepower
IEA = International Energy Agency
IPP = independent power producer
KW = kilowatt
kWh = kilowatt-hour
MW = megawatt
MWh = megawatt-hour
NEB = National Electricity Board of Malaysia
NEPO = National Energy Policy Office of Thailand
NFFO = Non-Fossil Fuel Obligation system
NGO = non-government organization
NO_X = nitrogen oxides
O&M = operation and maintenance
PPA = power purchase agreement
PURPA = Public Utility Regulatory Policies Act of 1978
PV = photovoltaic
RFP = request for proposal
SE Asia = Southeast Asia
SO_2 = sulfur dioxide
SPP = small power producer
TWh = terawatt-hour
USAID = the United States Agency for International Development
VAT= value-added tax

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1 Introduction

The world is facing its toughest environmental challenge to date. Governments and scientists alike have agreed that the problem is real, and serious. Organizations as diverse as Greenpeace and the World Bank agree that the world needs to pursue a fundamentally new energy direction based on energy efficiency and renewable energy. However many believe that the transition may be too costly for the world's economies. The Renewable IPP concept seeks to illustrate the practicality and affordability of an alternative approach that could be implemented today.

This report investigates the economic and environmental advantages of IPPs based on renewable energy and energy efficiency, compared to IPPs that are powered by fossil fuels. This will be done by selecting an energy mix of renewable energy and energy efficiency, based on a cost and resource mix for a Southeast Asian country, and then comparing the economic costs and environmental impacts of this "Renewable IPP" to those of a fossil fuel-based IPP.

Independent Power Producers were originally conceived as resellers of cogenerated electricity and other small-scale power resources.[1] But a 1988 report[2] for the (U.S.) National Association of Regulatory Utility Commissioners specifically addressed the ability of conservation and load management programs[3] and renewable energy developers to bid as independent power producers. As experience was acquired, the possibility of financing and building large central generating facilities using non-utility private companies gained credence.

The legal and regulatory structures of the power sector of most countries in this region have had to be modified to both allow and encourage private investment. A first step in this mobilization is already occurring, as the region's governments begin to allow Independent Power Producers (IPPs) to enter the market.

The combined opportunity for private power generation from IPPs and the recognition of the possible cost competitiveness and environmental and economic benefits of renewable energy and energy efficiency suggest the viability of a new form of energy supply enterprise: the Renewable Independent Power Producer (Renewable IPP). The Renewable IPP concept could be implemented either through market-driven bidding processes as those used in North America, or through policy support mechanisms similar to the "feed-in" laws found in several European countries. The idea proposed in this report is to apply the IPP concept to the provision of efficiency and renewable resources in Southeast Asia by inviting bids from a full spectrum of efficiency and renewable energy service providers. This will allow the private sector to provide the least-cost solution to meet the energy needs of the market.

A Renewable IPP would supply cost effective energy and efficiency benefits using the best renewable energy and energy efficiency technology available for each country or region. A

[1] PURPA established a class of non-utility generators made up of small power producers and cogenerators who became known, following the parlance of the Act, as "qualifying facilities."
[2] Duan et al. (1988)
[3] Conservation and Load Management Programs (C&LMP) are more familiarly known as Demand-Side Management (DSM).

Renewable IPP would operate a power generation facility that would be based on a synergic mix of renewable energy, cogeneration, and demand-side management resources combined into an optimal and cost effective resource package. Ideally, the Renewable IPP would maximize the use of the lowest cost renewable or energy efficiency resource for each country or region and gradually add more expensive power options.

The Renewable IPP enterprise would build and operate a package of multiple renewable energy and energy efficiency resources as a single project, thereby gaining the benefits of having a system-wide integrated resource which would incorporate load shape flexibility not available to each resource segment alone. In this regard, because of its distributed nature, the resource would potentially supply power into the grid at multiple points, yet be financed and operated as a single project.

The power plant proposed and analyzed here mimics the resource proportions in the Philippine Energy Plan, in order to typify a Renewable IPP. That is, it is composed of half renewables and half energy efficiency. The exact energy mix for a Renewable IPP in a given country, of course, would depend on that country or region's resource availability.

This report presents a market-based policy framework for promoting renewable energy and energy efficiency as a primary solution for Southeast Asia's energy future. It carefully demonstrates that Renewable Independent Power Producers (IPP) can provide a significant power resource at a competitive cost, while dealing with the increasingly important issues of economic development and environmental degradation in Southeast Asia

2 Background

Prior to the economic crisis which has affected the region since mid-1997, electricity demand and consumption in Southeast Asia was growing at a rapid pace. This growth is now expected to be slower in the short term, leading to a temporary power glut in some countries. However, Asian economies are expected to eventually recover, and when they do, the trend of rapid growth in energy demand will resume. The need to construct power plants to meet this growing demand is the driving force behind many regulatory and institutional changes that are transforming the electricity sectors of most countries in Southeast Asia.

Conventional methods of power generation require fossil or nuclear fuels. For the most part, these fossil and nuclear fuels are obtained from outside the Southeast Asia region, making the region as a whole dependent on fossil fuel imports. This dependency weakens the energy security of the region since changes in fossil fuel trade patterns and prices can have many negative economic, political, and social implications. Thus it is important for the region to develop its indigenous energy resources, especially renewable resources such as solar, wind, biomass, and small hydro in order to alleviate the dependency on fossil fuels.

Building the renewable energy infrastructure necessary to enhance regional energy security will require large amounts of investment capital. During this period of economic crisis, it will not be possible for governments or multilateral lending institutions to provide all the necessary funds. Mobilization of private sector participation in the process will thus be vital.

A first step in this mobilization is already occurring, as the region's governments begin to allow Independent Power Producers (IPPs) to enter the market. Until recently, the electricity generation market has been a government-dominated field. However, legal and regulatory structures in many countries in the region are being, or have been, modified to make it attractive for IPPs to proliferate. As IPPs enter power markets, they often compete with state-owned utilities, encouraging governments to improve the competitiveness of the power sector. Governments often use liberalization mechanisms such as price and volume deregulation, industry restructuring, and privatization.

To date, nearly all of the IPP activity in Southeast Asia has focused on large-scale, fossil-fuel-based projects. However, the introduction of IPPs in the region could also allow a chance to develop supply electricity resources that are based on renewable energy resources as well as improved energy efficiency. This report investigates the economic and environmental advantages of IPPs based on renewable energy and energy efficiency, compared to IPPs that are powered by fossil fuels. This will be done by selecting an energy mix of renewable energy and energy efficiency, based on a cost and resource mix for a Southeast Asian country, and then comparing the economic costs and environmental impacts of this "Renewable IPP" to those of a fossil fuel-based IPP.

2.1 Economic Developments and Outlook

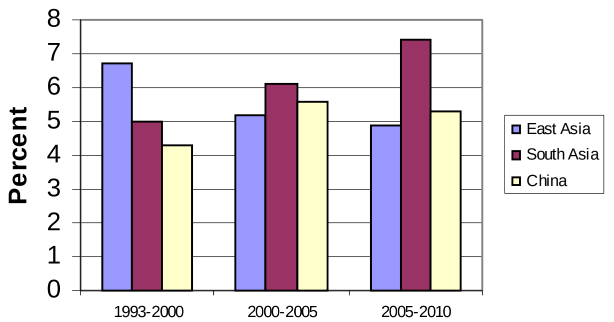
The crisis affecting the region began with the devaluation of the Thai Baht in mid 1997. This devaluation was a result of the country's high current account deficit, large short-term capital inflows and a speculative "bubble" (fueled largely by investment in real estate) that burst. Thailand's economic growth fell sharply, and present expectations are that the Thai economy will contract by around 5 percent in 1998, followed by marginal growth beginning in late 1999.[4] Other countries within the region also face a similar prescription for either contraction or severely dampened economic growth. However, the situation is extremely volatile and the short to medium term outlook for growth in the region is generally pessimistic. If the Japanese yen continues to decline against the dollar, export competitiveness of the region would be undermined and local currencies would be further weaken. The PRC currency (including that of Hong Kong) is also under pressure and another round of currency devaluation would severely test financial systems throughout Southeast Asia.

Loss of investor confidence in Southeast Asia has resulted in a sharp drop in foreign direct investment. This will slow down economic growth and growth in electricity demand, while also delaying project implementation. Most governments have had to cut their budgets, tighten monetary policy and raise interest rates. Many domestic firms are finding it difficult to survive, especially those burdened with debt denominated in foreign currency. Credit is limited, and imports of intermediate goods are now more expensive. The result of all this has been higher inflation and unemployment, accompanied by severe social consequences and political instability.

[4] Rockett and Wilson (1998), p. 3.

In the long term, however, there are reasons for optimism. The economic crisis has forced countries of this region to reform their financial and banking sectors, as well as other areas critical to economic and social stability. Former centrally planned economies are continuing to make progress in their transition to more market-based economic systems. Southeast Asian countries have industrious and reasonably well-educated labor forces, and the region is well endowed with natural resources. There is a strong foreign presence in the region that provides access to management skill, and technology know-how. When the economies and markets settle, foreign investment will also play an important role in the economic recovery.

Figure 2.1: Pre-Crisis Projections of Electricity Generation Growth Rates



Source: International Energy Agency (1997)

While it is too soon to forecast the medium- to long-term economic prospects for the region, its strengths suggest a resurgence of growth once the crisis has passed, although probably at lower levels than those prevailing before the crisis. The pre-crisis projections of electricity generation growth rates for Asia are shown in Figure 2.1.

The eventual resumption of economic growth will bring with it a rapid resumption in the growth in electricity demand. This projected resumption of growth must be anticipated and needs to be prepared for now in order to avoid shortages in electricity generation capacity later. To illustrate the point, stagnation in the demand in Thailand for two years would only result in short-term deferral – and not eliminate the need for - of about 1,500 MW of additional capacity.[5]

2.2 Liberalization and Independent Power Producers

Since the early 1990s, fundamental changes have occurred in the electricity supply industry in industrialized countries. These changes were enacted due to an increasing dissatisfaction – often on the part of industry - with power industry performance and the perception that electricity prices were too high. Asian governments have recently joined the ranks of those seeking to reform their power sectors, but for slightly different reasons. Unlike industrialized nations, Asian countries have experienced rapid GDP expansion and even more rapid growth in electricity demand. However, tightening government budgets, combined with low electricity prices, and cross-subsidies between sectors, and increased skepticism on the part of international lending institutions, have made it clear that traditional state-owned utilities alone will not be able to finance future power demand while maintaining or improving their standard of service. Initially, Asian governments tried to address the problem by inviting foreign investors to build, and in many cases operate and maintain, independent power projects as a supplement to state-owned generation; but there was also a recognition that public utilities were not performing optimally.

[5] Rockett and Wilson (1998), p. 9.

Utility performance in Asian countries has been found to lag far behind industrialized country standards. A recent study comparing the technical efficiency of utilities in 27 developing countries between 1975 and 1990 found that the Electricity Generating Authority of Thailand (EGAT) and Malaysia's National Electricity Board (NEB) rank 14th and 18th respectively, a long way short of best practice. [6]

Reforms of the structure and ownership of Asian power markets first arrived as foreign investment in the form of independent power producers (IPPs). IPPs have been invited by Asian governments due to the inability of their own state-owned utilities to adequately finance the rapid expansion in power generating capacity. Governments have also provided a number of crucial incentives for foreign investors, and established administrative procedures for solicited and unsolicited bids from investors. Incentives include exemptions from import duties, favorable tax regimes, government guarantees regarding repatriation of investment and profits, land use rights and easier employment of foreign nationals.

The administrative procedures focus on rules for project tendering, approval and selection, and the conditions under which supply licenses are issued. Solicited bids for capacity typically comprise a competitive tendering process. Regulations and/or licenses also often specify the type of IPP. Build-Own-Operate (BOO), Build-Operate-Transfer (BOT) and Build-Transfer-Operate (BTO) schemes are the most common. They may also contain provisions regarding procurement of primary energy sources and government-specified priorities for projects using certain (often indigenous) types of fuels, the projects' environmental performance, and even specify a model power purchase agreement and a grid code.

So far, several Southeast Asian governments have established a legal framework to support IPPs. Some examples of legislation include Regulation 02.P/03/M.PE/1993 and its amendments in Indonesia, Executive Order 215 of July 1987 and Republic Act 6957 and its amendments in the Philippines, and the May 1994 guidelines for purchase of power from IPPs as well as the 1995 Power Purchase Solicitation Document in Thailand.

Another reform that is taking place in the effort to improve performance is the privatization of state-owned utilities. One study carried out in Sweden, for example, found that labor productivity in privately owned utilities remained high, whereas it deteriorated considerably over the course of two decades in state-owned companies.[7] Taking into account that privatization also generates resources for government budgets that can be allocated to other economic development goals, privatization has become a major priority for some countries in the Southeast Asia region. Table 2.1 summarizes the privatization plans of some Southeast Asian governments. The information indicates that Asian governments are taking a cautious approach towards privatization. Nevertheless, privatization plans are being developed in conjunction with restructuring, which is important in order to avoid issues such as preferential treatment of state-owned (or formally state-owned) companies over IPPs and new entrants.

In 1995, Singapore was the first Southeast Asian nation to privatize its generation, distribution and energy trading functions in a new competitive environment. Two generating companies were formed: Power Senoko Ltd. and Power Seraya Ltd. The Power Grid Ltd. and Power Supply Ltd. were also formed primarily to handle energy distribution, trading and customer

[6] Yunos et al. (1996)
[7] International Energy Agency (1997), p. 61.

service functions. Malaysia and Indonesia have also moved towards privatization of their electricity supply industries through the participation of IPPs.

Table 2.1: Summary of Privatization Plans in Asian Countries

	Company to be Privatized	Target Date	IPPs ?	Wholesale Competition
Indonesia	Generation: Max. 40% of PLN's successors Genco 1 Genco 2	After 1998	Yes	No
	Transmission: Grid extension	time horizon not determined		
Philippines	Generation: NPC privatization through genset divestiture, geothermal and hydro to remain under gov't control	time horizon not determined	Yes	No
	Transmission: Possible	time horizon not determined		
	Distribution: New private entry	time horizon not determined		
Thailand	Generation: EGAT's successor, EGCO, is already under majority private ownership and further privatization is planned	In progress	Yes	No
	Transmission: Admission of "Strategic Partners"	After 2000		

Source: International Energy Agency (1997)

In Thailand, the impact of the 1997 Baht devaluation has caused EGAT's financial position to deteriorate due to foreign-denominated debt on its investment projects. This in turn has increased the pressure for EGAT to privatize and inject new capital into the country.[8] The National Energy Policy Office (NEPO) has estimated that the privatization of state-owned enterprises in the energy sector would generate US$ 2.7 billion for Thailand in 1999. For example, the sale of a 14.9% stake owned by EGAT in the Electricity Generating Company Plc. (EGCO) to China Light & Power is expected to bring in US$ 240 million.[9]

The Philippines' power sector is also moving toward restructuring. The Omnibus Electric Power Bill was resubmitted to Congress in July 1998 and would in its current form open the generation sector to competition by splitting the National Power Corporation into several generation companies. Countries like Laos, Myanmar and Vietnam have just relaxed their control over the power sector, but few private power projects are either in operation or in the pipeline.

2.3 Market Trends

As mentioned earlier, electricity demand growth is expected to resume in Southeast Asia once the region's economy recovers. Before the current economic crisis, this growth was forecasted to require a capital expenditure in the order of US$ 90 billion or more over the period of 1997-2005 for the development of generation, transmission and distribution infrastructure.[10] Table 2.2 shows the installed generation capacities of Southeast Asian countries.

[8] Piyasvasti Amranand (1998)
[9] Asian Institute of Technology (1998a), p. 8.
[10] AEEMTRC (1998), p.1.

Table 2.2: Installed Generation Capacities of ASEAN Countries

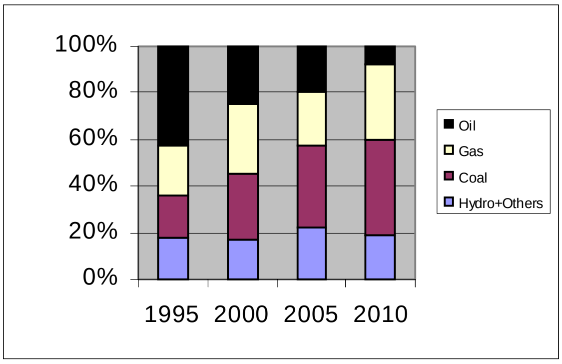
ASEAN Country	Installed Capacity (GW)	Electricity Production (TWh/yr)	Consumption per capita (kWh/yr)
Brunei (as of 3/98)	0.7	2.0	7,407
Indonesia (as of 12/97)	19.0	75.0	370
Laos (as of 12/97)	0.2	1.0	90
Malaysia (as of 6/97)	12.6	48.0	2,200
Myanmar (as of 6/98)	1.0	4.0	56
Philippines (as of 12/97)	11.6	40.0	594
Singapore (as of 12/97)	5.5	25.0	7,936
Thailand (as of 9/97)	17.0	93.0	1,324
Vietnam (as of 6/98)	4.8	19.0	247
Total	**72.4**	**307.0**	Avg. **2,247**

Source: AEEMTRC (1998)

The domino effect of the financial crisis in the region has resulted in a regional recession. Power supply is now in surplus. As for new power development, many private power projects are now on hold, subject to further review, or up for rescheduling. However, as mentioned earlier, electricity demand is expected to resume its rapid growth rate once the region's economies have recovered, and the pace of power development will again have to keep up with the increasing demand. There is evidence indicating that coal will become the predominant fuel for future power plants once power development in the region resumes its previous rapid growth.

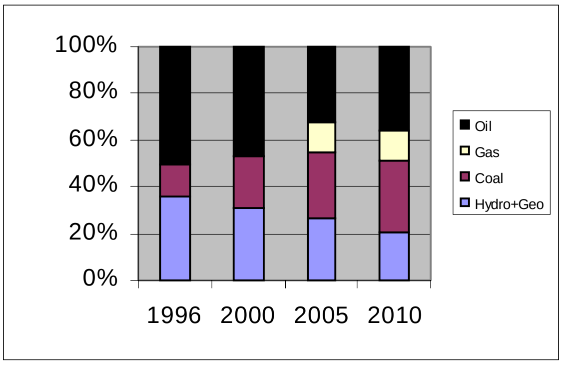
The projected fuel mix of installed generation capacity of various Southeast Asia countries during the period 1995 – 2010 is shown in the following figures.

Figure 2.2: Indonesia's Generation Capacity by Fuel Types



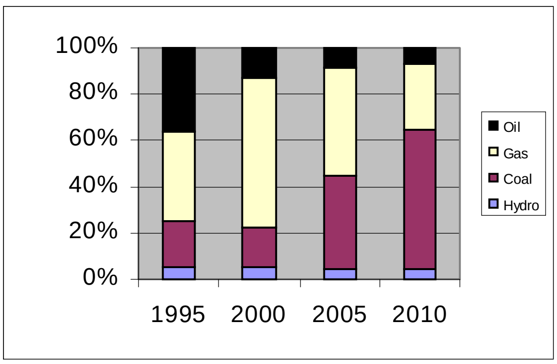
Source: International Energy Agency (1997)

Figure 2.3: Philippines's Generation Capacity by Fuel Types



Source: Lefevre et al. (1997)

Figure 2.4: Thailand's Generation Capacity by Fuel Types



Source: International Energy Agency (1997)

Indonesia, Philippines and Thailand are among the largest consumers of electricity within ASEAN. The general trend of energy mix in the generation capacity of these three Southeast Asian countries is that coal will become the most used fossil fuel, while the shares of gas and oil will slowly decline. In fact by the year 2010, it is projected that coal will hold an average share of 51 %, while gas and oil will hold 28 % and 21 % respectively of all fossil fuels used in generation.[11] The power

[11] This was calculated using data from Figures 2.2, 2.3 and 2.4 *for fossil fuels only*.

development outlook for Indonesia, the Philippines and Thailand suggests that the share of hydro, geothermal and other renewable energy resources are not likely to increase significantly over the time period 1995 – 2010. It is also important to note, however, that the amount of power plants based on all types of fossil fuels is expected to increase in *absolute* terms.

IPPs will finance and install much of the future increase in generation capacity. For example, based on the latest Philippines Energy Plan, more than 90 GW of capacity additions are planned by 2025, and a large portion of this will be open to the private sector.[12] However, the effects of the economic recession will cause most governments in this region to delay the construction of additional power plants since peak power demands have contracted from the levels of the previous year. In Thailand, the government is deferring power purchases from independent and small power producers, as well as reducing output from some of the existing plants. In 1994, the government awarded contracts to seven IPPs to construct power plants. However, five of the seven licensed IPPs have agreed in principle to delay the start-up of their sales to EGAT by one to two years. At least six small power producers (SPPs) projects where concession was awarded to private investors have been cancelled as the bidders were no longer financially strong enough to undertake them.[13] EGAT and the government energy authorities have already decided to further delay soliciting purchases from IPPs and SPPs until 2000 or 2001.[14]

[12] AEEMTRC (1998), p. 9.
[13] Pokwamdee (1998)
[14] Yuthana and Kositchotethana (1998)

3 Finance Systems for Conventional IPPs

Independent Power Producers, private organizations selling electricity to electric utilities and occasionally directly to customers, are a relatively recent addition to the electricity supply system. Historically, electric utilities were considered natural monopolies, and were often vertically integrated; the utility owned everything from the fuel supply, to the generation source, to the transmission and distribution lines.[15] As various abuses of the monopoly occurred, the assumption of a natural monopoly was periodically re-examined and portions of the system were separated. In the U.S., the PURPA legislation of 1978 required utilities to purchase electricity from independent sources.[16] From this beginning, the concept of having separate companies compete to generate power for sale to utilities and customers has spread internationally.

Independent Power Producers were originally conceived as resellers of cogenerated electricity and other small-scale power resources.[17] But over the next ten years other resources both large and small appeared to fit the PURPA concept. A 1988 report[18] for the (U.S.) National Association of Regulatory Utility Commissioners specifically addressed the ability of conservation and load management programs[19] and renewable energy developers to bid as independent power producers. As experience was acquired, the possibility of financing and building large central generating facilities using non-utility private companies gained credence.

Asian utilities are in the midst of a widespread and comprehensive process of reform. For example, the Electricity Generating Authority of Thailand is on a tight timeline of restructuring and privatization. EGAT's restructuring follows the "corporatize : privatize" model -- that is, its initial efforts were to restructure administrative systems and to identify and track cost centers. This was followed by the formation of business or profit centers. In Thailand, this has included spinning off a generating company, the Electric Generating Company Limited, which has purchased some of EGAT's generating resources and is participating in EGAT's IPP program.

To match the requirements of the reforms, utilities have been encouraged by bilateral and development and finance organizations to embrace private sources of technology, capital, and expertise. As a result, policymakers in India, Indonesia, Malaysia, Philippines, and Thailand have established frameworks for the solicitation of power from IPPs. The following table displays the country status of IPPs.

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[15] Garfield and Lovejoy (1964), p. 15.

[16] The Public Utility Regulatory Policies Act of 1978 (PURPA). Passed over 20 years ago it still draws strong opinions. The American Wind Energy Association says that PURPA "made possible the renewable energy development of the 1980's." In sharp contrast, the PURPA Reform Group whose members are all electric utilities, announces on their web page "PURPA's 20-Year Legacy of High Electricity Costs Why, After 20 Years, PURPA Still Is Creating New Problems."

[17] PURPA established a class of non-utility generators made up of small power producers and cogenerators who became known, following the parlance of the Act, as "qualifying facilities."

[18] Duan et al. (1988)

[19] Conservation and Load Management Programs (C&LMP) are more familiarly known as Demand-Side Management (DSM).

Table 3.1: Status of IPPs in Southeast Asian Countries

Country	Number of IPP/SPPs	Power Resource (MW Planned/committed/built)	Comments
Indonesia*	IPP: 14	IPP: 7,701 MW committed	Most projects placed on hold due to current economic crisis.
Malaysia**	IPP: 9	IPP: 3,100 MW built; 5,900 MW committed	Some projects placed on hold due to current economic crisis.
Philippines***	Not available	IPP: 5,368 MW installed; 4,691 MW committed; 600 MW planned	Philippines IPP models have received world recognition due to impressive track record.
Thailand****	IPP: 7; SPP: Firm = 34 Non-firm = 22	IPP: 5,944 MW committed SPP: 347 MW built; 1,800 MW committed	Some projects commission date delayed due to current crisis; Thailand is the only SE Asia country with a SPP program.
Vietnam	None	-	Policy reforms to allow IPP are underway.

* Source: United States Energy Information Administration (1998)
** Source: AEEMTRC (1998)
*** Source: AEEMTRC (1998)
**** Source: Electricity Generating Authority of Thailand (1998)

Some countries in the region have also developed a framework for Small Power Producers (SPPs) to promote the use of renewable resources for electricity generation. Thailand has over 45 SPP operators with contracts to supply 1,800 MW. As of July, 1998, 20 SPPs had come on line with a capacity of 347 MW.

3.1 Financing of Conventional IPPs

The magnitude of investment required to meet future growth in electricity demand in the Southeast Asia region is very high. The traditional means of financing of the power sector has come from the government and loans from multilateral and bilateral lending organizations. However these institutions have become hard pressed to provide all the capital needed, and consequently causing institutional changes to attract private capital through privatization and IPPs.

To date, the development of IPP legislation has been the predominant method of increasing private-sector participation in electricity supply and finance in the region. Private companies build and operate power plants and then sell that output to the primary national electricity supplier. The contractual agreements with the state-owned utility companies have typically been under either a Build-Operate-Own (BOO) or Build-Operate-Transfer (BOT) schemes. In the latter scheme, after some pre-defined period of operation, the plant is transferred to the state utility at nominal or zero cost. It may be argued that IPP projects have been the dominant avenue for private-sector participation in the power sector because their participation has required the fewest changes to existing institutional structures and regulations. The state utility company may operate largely as before, and treat IPPs as merely a different way of procuring generation capacity.

The conditions for investment by private firms (domestic or foreign) must be such that an investor can be reasonably assured of obtaining a satisfactory return on that investment. In order to meet these conditions, the legal and regulatory structures of the power sector of most countries in this region have had to be modified to both allow and encourage private investment. This process began in the Philippines with Executive Order No. 215, issued in 1987, and in Thailand with "Regulations for the Purchase of Power from Small Power Producers", published in 1992. Both of these laws allowed small-scale electricity producers and industrial cogenerators to sell electricity to the state-owned monopoly utilities. The Philippines later implemented legislation allowing IPPs in 1991 (Republic Act 6957), and Thailand's relevant IPP legislation was approved in 1994.

A variety of tax and other incentives have been established to improve the potential financial performance of private investments. Those relating to income taxes and importation duties are summarized in Table 3.2.

Table 3.2: Income Tax and Importation Incentives for Investors in Private Power

	Indonesia	Philippines	Thailand
Income Tax	no special treatment, except for geothermal projects	6 year tax holiday	3 to 5 year tax holiday; accelerated depreciation
Import Duties on Capital Equipment	total exemption; deferral of VAT and sales taxes until plant operation	total exemption; simplified procedures; includes spare parts and supplies	44.45% on capital equipment for plants less than 10 MW; 12.35% for greater than 10 MW

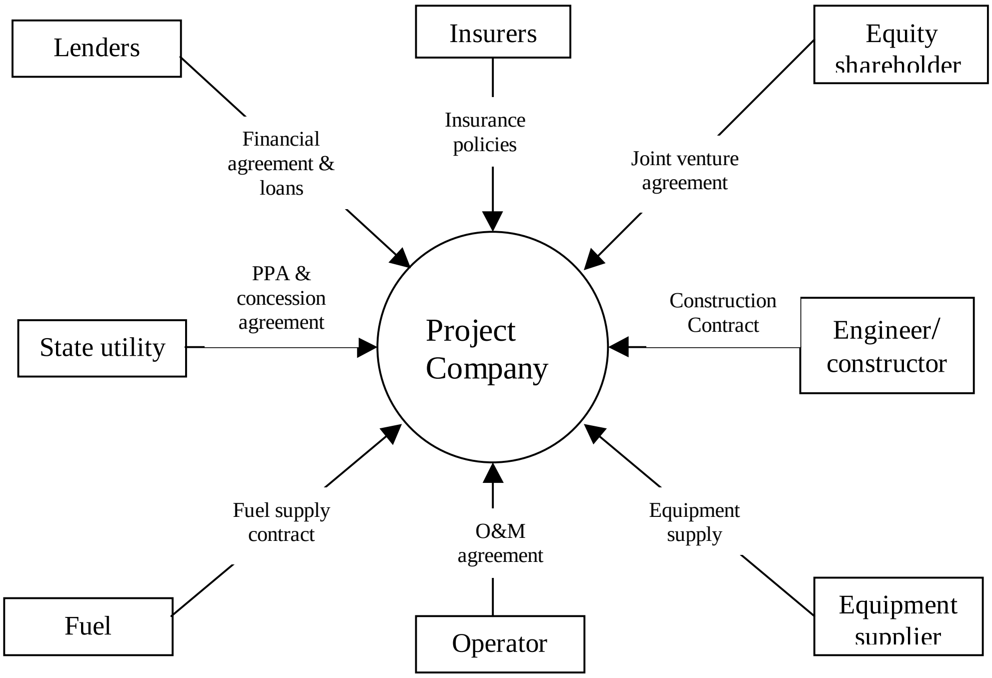
Source: International Energy Agency (1997)

IPPs in the region usually involve a consortium consisting of a specialized IPP developer, a primary energy supplier, an electrical equipment supplier, and additional foreign and local partners. The consortium typically forms a project company and develops specific project proposals in cooperation with equipment suppliers, fuel suppliers, lenders, and other parties. If the project is selected by the state utility, a power purchase agreement (PPA) is negotiated to fix the terms of purchase of the electricity by the utility. Figure 3.1 summarizes the principal parties involved in implementing an IPP project and the essential contracts involved.

Every fossil fuel project has different costs depending on factors such as its size; location; fuel supply cost and availability; country risk profile; sponsor company profile; the strength of its power purchase agreement; the ability of the energy buyer to accept and pay for the energy over the long term (20 years); the distance and cost of transmission and distribution; the availability of financing; debt and equity for the project; the strength of the construction contractor building the plant; among other considerations. The number of variables that potentially impact any given power project makes it difficult to generalize about project costs. However, two useful rules of thumb are that (a) to be competitive, power produced by an IPP costs about $US 1 million per MW, and (b) the IPP investment should be able to produce a rate of return in the range of 15%-20%. These are some of the basic criteria an IPP would have to meet to be competitive in the private sector and to qualify for private sector financing.

Typically, a minimum of 20 to 30 percent of the capital needed to construct and start-up an IPP project is obtained as equity contributions from the project owners and shareholders, while the remainder is debt.[20] An important financial goal of the project company is to isolate the financial risks of the project from the consortium's parent companies. This is usually done through "limited recourse" financing. In this type of financing, lenders to the project can expect repayment of their investments primarily through the cash flows arising from the project itself, and there is limited recourse for payment from the parent companies. This limits potential losses of the consortium members to their equity contributions and any additional construction, operation or credit support they have to provide in order to obtain financing.

Figure 3.1: Principal Parties and Contracts in IPP Projects



Source: International Energy Agency (1997)

In order to attract equity and debt financing to IPP projects, it is essential to minimize the risk of poor financial returns or excessive costs. One of the most difficult risk to manage is that of unforeseen changes in policy by local or national government. The risk arises not only from changes in the immediate structure and regulation of the power sector, but also in financial policies and in other areas that can have a potential impact on the profitability of the project. Exchange rate risk can also be significant, since loans are typically denominated in foreign currencies while revenue from electricity sales is in the local currency. The previously mentioned effects of the 1997 currency devaluation in many Asian countries on planned IPP projects exemplify this point. Other issues involving the project's fuel supply and the stability of its sponsor or construction contractor can critically impact the project's economic viability and financeability.

The power purchase agreement (PPA) is the most important contract for obtaining project financing. The PPA defines which parties bear the costs arising from the occurrence of unforeseen risks. It typically has provisions that define whether or not increases in the price of certain inputs to the power plant may be passed through to the electricity purchaser (in most

[20] International Energy Agency (1997), p. 85.

cases, the state utility). For example, increases in the price of fuel, the cost of compliance with changing tax and environmental laws, and general inflation are commonly covered in PPAs.

PPAs may also address the issue of what is commonly referred to as "take or pay" minimum amount of power to be purchased. This is the minimum amount of the total full-capacity production (kWh) on which the payments to the power producer are based, regardless of the actual level of electricity production, and is what makes the PPA financeable. Separate payments may also exist for generation capacity. Some selected PPA characteristics of the largest electricity consuming countries in the region are shown in Table 3.3.

Table 3.3: Selected PPA Characteristics

	Indonesia	Philippines	Thailand
Preferred concession type	BOO; BOT for geothermal	BOT	BOO
Fuel price pass-through	Yes	Yes	Yes
Other pass-throughs			
Environment	Yes		
Tax	Yes		Negotiable for each PPA
Exchange rate	Yes	Yes	
Evaluation of proposals	Government committee	Government/Utility committee	Government committee
Minimum billable production	Typically yes	0% for long-term contracts; 50% for 5 year contracts	Non-firm contracts for < 5 years Firm contracts for > 5 years
Sovereign guarantees	No	Yes for some	No

Source: International Energy Agency (1997)

Apart from the usual risks that have been discussed, there may be other risks that go well beyond the ability of the state utility and the PPA to fully mitigate. In this case, sovereign guarantees have been an important issue in financing IPPs in many countries in the region. Sovereign guarantees are agreements by a government to assume responsibility for maintaining long term payments under a PPA if the state utility cannot.

3.2 Other Financial Considerations

The impact of the power project on the environment can also be an important consideration to project financiers. For example, the Nam Thuen hydroelectric project in Laos has faced considerable criticism from non-governmental organizations (NGOs) and environmentalists inside and outside the region due to its potential to impact ecosystems, deplete forests and require the resettling of large numbers of local people. Lenders, including the Asian Development Bank (ADB), have become wary about financing the project, and are now more cautious about requiring that power projects satisfy all relevant domestic environmental laws and minimum World Bank Standards. The ADB and other development banks have established policies on financing that require a review of given a project's environmental performance.

Externality costs of fossil fuel IPP projects are traditionally not included in the financial cost-benefit calculations for a given project.[21] However, as these costs begin to be included the

[21] A detailed discussion of externality costs is given in Section 5.2.3.

historically understated costs of a fossil fuel project will rise and the real costs of a sustainable energy project will decline. In a recent study, the World Bank found that, once the costs of pollution and carbon emission of their power generation projects were included in the project expenses for projects constructed and funded over the past 10 years, the net present value of many of those projects potentially became negative. This means that normally, under private sector financing criteria, the projects should not have been financed. Furthermore, the externality costs will become a significant cost factor for projects in the future as awareness of global climate change and environment costs grow.

To date, the majority of capital for the financing of IPPs in the region has come from foreign investors. However, from the viewpoint of foreign investors, local equity participation is seen to reduce the risk associated with investing in the project. One barrier to obtaining domestic capital is the limited size of domestic capital markets such as the stock markets, bond markets and commercial banks. The underdeveloped capital markets are caused by the predominance of state enterprises in economic activities. Consequently, state interventions in credit allocation via national banks, distortion of interest rate policies, and other government policies have limited the development of domestic capital markets. For example, interest rates were controlled in Thailand until 1987.[22] The result of such an unclear policy framework is that it has limited the ability of investors to mobilize private capital in sufficient amounts from domestic sources. National governments and utilities have therefore sought foreign capital as the primary source of finance for power sector development.

It has been a common practice for IPP project sponsors to take relatively low equity positions in projects in order to limit their financial risks. The objective is to shift much of the project risk to the lenders. However, as institutional reforms and regulatory frameworks come into play, the political risks will be seen to decrease, and it is likely that project developers will be prepared to provide a greater proportion of equity to projects. The evolution of a policy and institutional framework that accommodates private participation often takes time to reach a stage that inspires investor confidence. Figure 3.2 shows the development of the IPP industry in the United States. It took nearly a decade from the initial passage of the Public Utilities Regulatory Policy Act (PURPA) to withstand legal challenges and utility intransigence and to realize major growth.

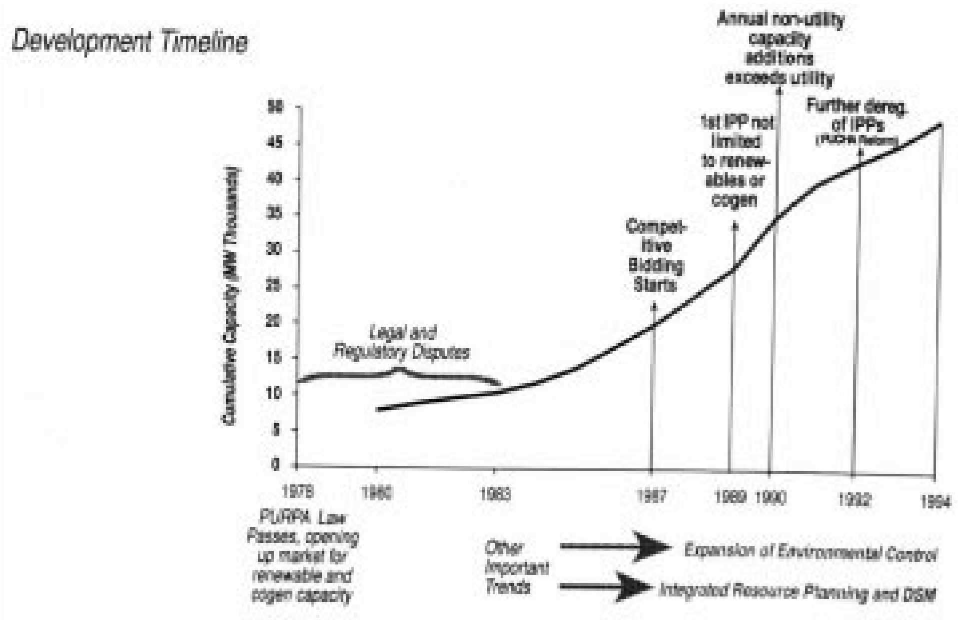
The combined opportunity for private power generation from IPPs and the recognition of the possible cost competitiveness and environmental and economic benefits of renewable energy and energy efficiency suggest the viability of a new form of energy supply enterprise: the Renewable Independent Power Producer (Renewable IPP). A Renewable IPP would supply cost effective energy and efficiency benefits using the best renewable energy and energy efficiency technology available for each country or region. A Renewable IPP would operate a power generation facility that would be based on a synergic mix of renewable energy, cogeneration, and demand-side management resources combined into an optimal and cost effective resource package. Ideally, the Renewable IPP would maximize the use of the lowest cost renewable or energy efficiency resource for each country or region and gradually add more expensive power options.

This facility would need to be economically competitive and to earn a market rate of return in order for it to compete with traditional energy sources and to be financeable. Based on the

[22] International Energy Agency (1997), p. 90.

increasingly competitive economics of renewable energy as costs decline, the recognition of the benefits of energy efficiency, and the recognition of the real financial costs associated with fossil fuel generation externalities, a Renewable IPP will become increasingly feasible over the short to medium term. At the very least, least-cost combinations of renewable power and energy efficiency should increasingly be able to compete with traditional energy generation.

Figure 3.2: U.S. Independent Power Framework[23]



[23] Source: Baughman and Buresch (1994), p. 12.

4 The Renewable IPP Concept

In this section, we introduce the Renewable IPP concept along with a possible energy mix for the Renewable IPP using a representative mix of resources drawn from an actual energy plan for a Southeast Asian country. We then examine the available "green" resources that can be used as alternatives to conventional fossil fuel-fired power plants in Southeast Asia.

4.1 Renewable IPPs for Southeast Asia

The Renewable IPP concept could be implemented either through market-driven bidding processes as those used in North America, or through policy support mechanisms similar to the "feed-in" laws found in several European countries (see Section 4.1.2).

Beginning with the Public Utilities Regulatory Act of 1979 and extending to the demand-side management bidding programs of the mid 1980s, alternatives to utility constructed power plants have grown phenomenally in the U.S. The utilities have been using a request for proposals (RFP) process to solicit competitive bids from independent power producers to provide demand-side (i.e. energy-efficiency or load management) and renewable resources. These bidding programs have led to the development of more than 1,500 MW of efficiency alone in the U.S.[24] More recently, the State of California procured more than 500 MW of new renewable power in a competitive auction in which they provided incentives of just 1.1 to 1.3 cents per kWh.[25]

The idea proposed in this report is to apply the IPP concept to the provision of efficiency and renewable resources in Southeast Asia by inviting bids from a full spectrum of efficiency and renewable energy service providers. The request for bids could have a minimum price floor, or could provide a modest subsidy in order to ensure the healthy development of renewable energy resources. This will allow the private sector to provide the least-cost solution to meet the energy needs of the market.

With one very notable exception, South East Asian utilities and governments have yet to effectively pursue the acquisition of efficiency and renewable resources.[26] In a recent report to the Philippine Government, Winrock International summarized the opportunities most governments in the region are failing to deliver on:[27]

> "With an aggressive and cost-effective national program of energy efficiency and demand-side management, coupled with serious and sustained support for the development of indigenous renewable resources, the same national economic growth targets might be met with less than half the currently projected generating capacity

[24] Hinge (1998)
[25] Tutt (1998)
[26] The Electricity Generating Authority of Thailand is operating a very large and very successful DSM program which in its pilot phase is targeting 300 MW and 1450 GWh with a 5 year budget of US $190 million. Thailand also has created an energy efficiency and renewable energy investment fund of nearly US $300 million. The DSM program is funded primarily from Thai funds, and the efficiency and renewables fund is financed from a domestic tax on petroleum products.
[27] Weingart (1998)

additions, and with over half of all electricity produced from domestic renewable energy resources, instead of from imported fossil fuels."

Governments and utilities persist in missing these economic and environmentally beneficial opportunities.

- Wind energy has become competitive with conventional sources in many situations and, for instance, India has solved dispatchability issues through system storage policies.
- Small scale renewable facilities offer advantages such as distributed generation and lack of transmission requirements. Their aggregate system characteristics can be quite advantageous, yet they are universally treated as separate small resources and not fully credited for such benefits.
- Renewable energy has fewer overall negative impacts on the environment than conventional energy sources. However, the economic and social benefits produced by renewables have not typically been included in power project evaluations or comparisons.
- Demand-Side Management has been proven to be cost-effective, reliable, plentiful, and to have positive system characteristics. Yet aside from Thailand, no Southeast Asian entity has made any comprehensive or effective effort to exploit this potential.

The fundamental reason is that governmental and utility institutions are primarily committed to power generation and energy supply expansion; the acquisition of cost-effective efficiency and renewable resources is a much lower priority for these institutions.

We propose to solve these barriers by removing the green resources (renewable energy and energy efficiency) from reluctant utilities and ineffective governments. The development of environmentally clean and modern power resources would be kicked-started by an extension of the IPP concept. The resource developers would essentially be Renewable IPPs, which would respond to solicitation for bids for energy resources from utilities and governments.

4.1.1 What Would It Look Like ?

In part the answer would depend on the direct needs, costs and resources of the soliciting utility. If the utility needs a baseload resource, the Renewable IPP would create a mix of resources whose combined load characteristics would match the utility baseload requirements and provide the economically and environmentally lowest cost solution. If the utility is seeking a peaking resource, the Renewable IPP would dispatch a resource whose combined load characteristics included renewable resource generation during peak times, perhaps through biomass based co-generation, solar, plus low-cost peak time energy conservation through air-conditioning and lighting efficiency measures.

There are two possible models of the Renewable IPP depending on the degree of deregulation in the electricity market. The first is that of individual single technology Renewable IPPs and the second is that of a larger Renewable IPP controlling a mix of resources. These are discussed in more detail in the Renewable IPP Operations section of this report.

4.1.2 Why Now ?

Climate change
The world is facing its toughest environmental challenge to date. To solve the climate change challenge is not simply a matter of cleaning a watershed, protecting an endangered species, or even reducing acid rain, difficult as those improvements have been. Global climate change requires global cooperation on a scale never before experienced. Governments and scientists alike have agreed that the problem is real, and serious. At the Kyoto climate summit, industrialized countries agreed to reduce the amount of carbon dioxide and other greenhouse gases in the atmosphere. But crucial details are still under being tested and negotiated

Organizations as diverse as Greenpeace and the World Bank agree that the world needs to pursue a fundamentally new energy direction based on energy efficiency and renewable energy. However many believe that the transition may be too costly for the world's economies. The Renewable IPP concept seeks to illustrate the practicality and affordability of an alternative approach that could be implemented today.

Scientists estimate that we can only afford to release a limited amount of carbon into the atmosphere, otherwise, we pass the "safe" limits of climate change. At this point climate change may happen too fast and ecosystems would be unable to adapt.

If the world continues burning fossil fuels at present levels, the "safe" limit of 1 °C will be reached in just 40 years. That is why the Renewable IPP opportunity is an important step to start reducing carbon dioxide emissions immediately and prepare for an orderly phase out of fossil fuels.

Challenge of restructuring and privatization
As mentioned earlier, there is a wave of electricity reform and restructuring sweeping the electric utility industry in both industrialized and developed economies. The types of electricity sector reforms can be classified into four broad areas: commercialization, privatization, restructuring (unbundling), and retail competition.[28] There have been a number of studies of the impacts of these reforms on energy efficiency and renewable energy programs. These studies have reached a similar stark conclusion: that unless efficiency and renewables are explicitly concluded in the development of the reform legislation, funding for, and investment in, efficiency and renewable energy resources falls off drastically. This is because the fundamental goals of utility privatization and restructuring to improve the short-term efficiency of utility operation (without accounting for the longer term or overall costs) do not address the primary market and policy barriers to the widespread implementation of renewable energy and energy efficiency.

The most comprehensive recent study on this topic examined the effects of electricity sector reforms in six countries: Argentina, Chile, New Zealand, Norway, the United Kingdom, and the United States.[29] The study only looked at efficiency and did not look at the impact of

[28] Clinton and Kozloff (1998)
[29] Ibid. The full results of this study are reported in detail in a three-volume set published by USAID (1998a, b, and c).

reforms on renewable energy development. The study found that end-use efficiency was totally ignored in the deliberations on short-term power sector reform in four countries and was included only as an afterthought in two countries. It also found that utility funding for energy-efficiency efforts diminished as the perceived benefits declined and that only the largest commercial and industrial users who are fully aware of the cost savings are served by energy service companies (ESCOs).[30]

Another study examined the impact of electricity sector reforms in Europe.[31] It compared the development of cogeneration, wind energy, and demand-side management in the Netherlands, Denmark, Germany, and the United Kingdom. Like the previously cited report, this study found that funding for both renewables and efficiency efforts tended to drop off as electricity sector reforms were enacted. The study also concluded that without significant regulatory support, investment in wind energy and DSM efforts would likely diminish substantially. The authors pointed to two exemplary policies in the United Kingdom that are playing an important role in supporting renewable energy and energy efficiency.

In the UK, "Standards of Performance" require companies to undertake projects to save more than 6,000 GWh of power during the period 1994 to 1998. This is financed by a fixed levy charged to captive end users and coordinated by the national Energy Saving Trust.[32] Similarly, renewable energy activities are supported by the Non-Fossil Fuel Obligation (NFFO), a levy that was set up in the early 1990s to support the nuclear power industry, but which has since been shifted largely to support renewable energy development.

In Germany, perhaps the first and foremost regulatory support for renewable energy is the Renewable Energy Feed-In Tariff (REFIT) contained within the country's Electricity Feed Law (EFL). The REFIT specifies the price at which German utilities must purchase all power from renewable generators; and this price is tied to the residential electricity tariff. Wind generators receive a payment of 90% of the residential tariff, amounting to a payment of 0.1721 DM/kWh in 1996. At the May 1998 exchange rate of 1.76 DM / US$, this would be equivalent to 0.098 US$/kWh, approximately 10% higher than the payment for wind provided in Denmark. The extra costs of purchasing this wind power compared to conventional electricity are passed on to electricity customers of the local purchasing utility, causing higher electricity prices in areas with substantial wind energy development. This is changing, however, to uniform funding by consumers throughout the country to reduce regional funding inequities.[33]

4.1.3 Renewable IPP Operations

There are two possible models of the Renewable Independent Power Producer depending on the degree of deregulation in the electricity market. The first is that of individual single technology Renewable IPPs and the second is that of a larger Renewable IPP controlling a mix of resources.

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[30] Clinton and Kozloff (1998), p. 6.20.
[31] Slingerland (1998)
[32] Ibid., p. 6.250-6.251.
[33] Redlinger (1998), p. 24.

Single technology Renewable IPPs would provide power as produced (for wind or solar for example) or on demand for controllable renewables (such as biomass and small hydro). The power management to produce a coherent base-load power supply for the Renewable IPP mix would be undertaken by the regional utility or grid operator. This is similar to developer projects as implemented in Europe.

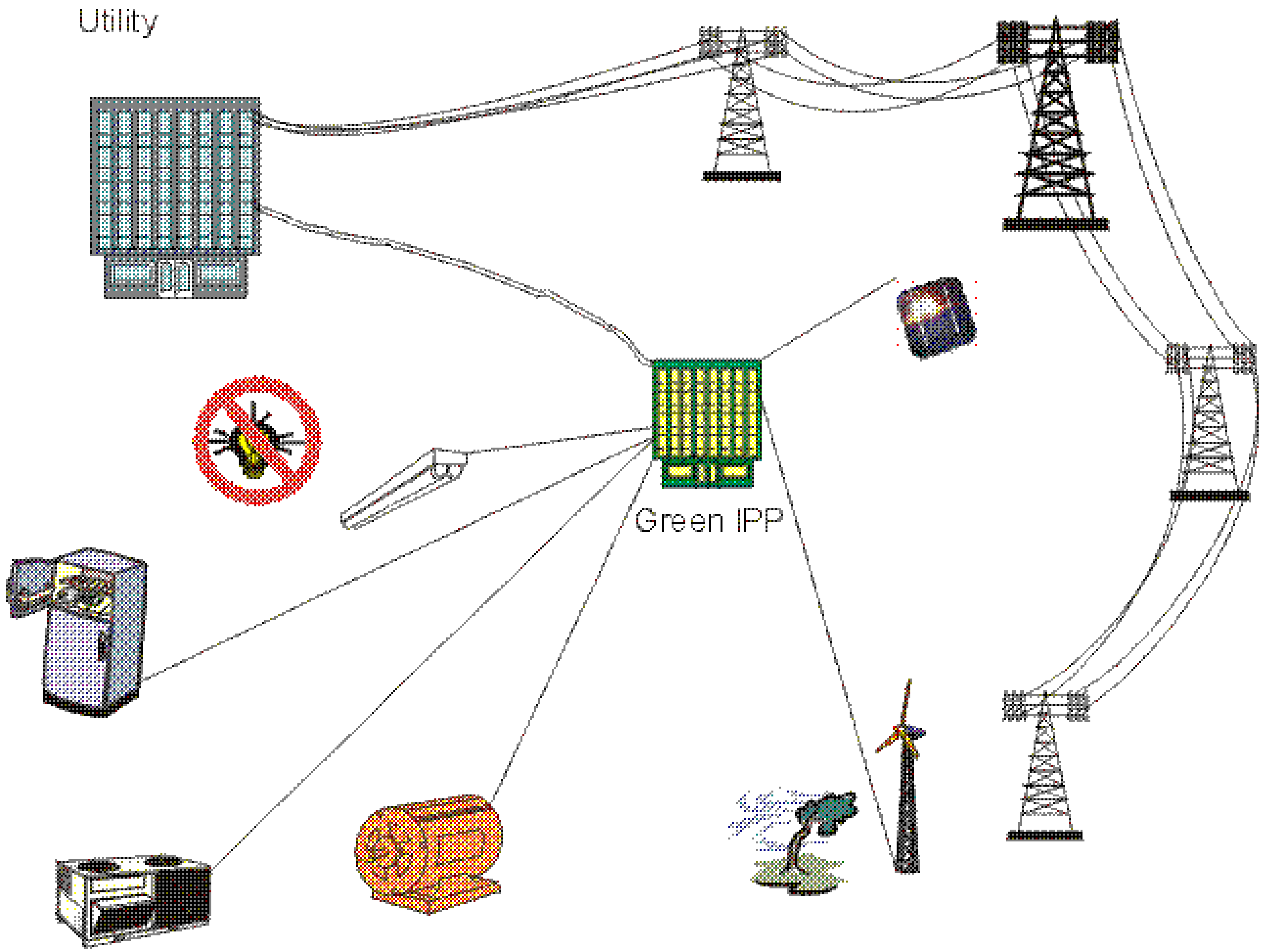
Mixed technology Renewable IPPs would own and control a mix of resources and provides power on demand to the grid operator. This type of Renewable IPP would mimic the operations of a typical generation facility.

Thus the Renewable IPP enterprise could build and operate a package of multiple renewable energy and energy efficiency resources as a single project, thereby gaining the benefits of having a system-wide integrated resource which would incorporate load shape flexibility not available to each resource segment alone. In this regard, because of its distributed nature, the resource would potentially supply power into the grid at multiple points, yet be financed and operated as a single project. Figure 4.1 illustrates this point.

A single project operation mode may be important to the concept because it presents to the purchasing utility a single resource dispatch. This prevents the utility from discounting the dispatch and availability characteristics of the Renewable IPP. Similar research in Thailand for a renewable resource pricing policy by Rambøll, a Danish consulting company, IIEC and others revealed that renewable resources in aggregate possess a very positive availability profile. Yet because the purchasing utility does not consider the resource as aggregate, each individual resource availability is considered in setting the price the utility is willing to pay. This price in Thailand is significantly lower than that which might otherwise be paid for the resource if aggregated.

However, the two models for the Renewable IPP differ only in where the power management takes place. There is no difference in the quality or quantity of the power to the grid.

Figure 4.1: Operation of a Renewable IPP



4.1.4 Solutions Already Proven

Much progress has been made over the last two decades in improving the technology, reliability, cost-effectiveness, and overall understanding of renewable energy and energy efficiency. In this section we review the policy solutions which have proven to yield results for energy efficiency and renewable resources. These policy solutions will need to be put into place more widely so that the Renewable Independent Power Producer concept can successfully and effectively work.

Policies have had to be adapted or revised to realistically reflect the changed needs of the market place. As electric and other utilities came into being, the concepts of monopoly and competition were refined to reflect new understandings of what would be necessary for these public services to flourish. The concept of a natural monopoly came into vogue. As the beneficial impacts of utility acquisition of energy efficiency as an energy resource came to be more fully understood, the concept of Integrated Resource Planning was created and widely adopted. These and many other concepts have turned into innovative policy initiatives which have changed overtime to adapt to new circumstances and provide new solutions.

Now we are again faced with challenging new circumstances. Driven by economic and environmental issues ranging from global market competition to global climate change, a few policy exemplars need to be replicated so that we can effectively demonstrate energy supply solutions on a cost and environmentally effective basis.

Reliable power purchase contracts are one of the most critical requirements for the successful development of energy projects, both renewable and efficiency bidding based. Creating reliable independent power markets has been the foundation of every successful renewable energy strategy. The most famous example of this may be the 1978 PURPA law in the United States; but other countries such as the United Kingdom, Denmark, Germany, and India have all developed rules providing guaranteed power purchase agreements for renewable electricity. Resource bidding provides similar transparency and clarity for efficiency projects.

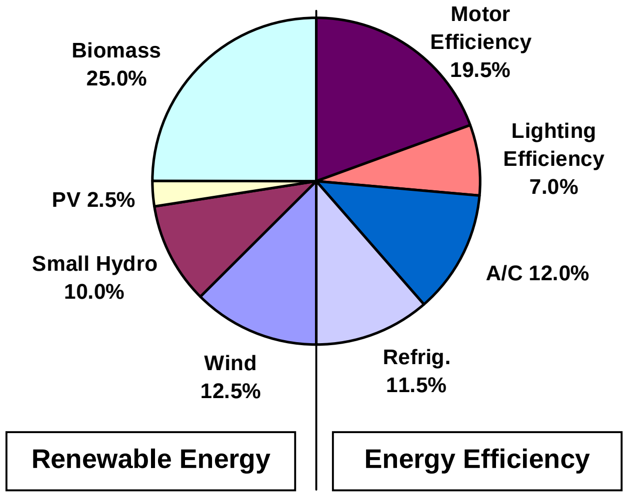
In some cases, a consumer may desire to use renewable energy, but the location of the renewable resource (e.g., biomass or wind) may require transmission. In other cases, a customer may wish to purchase its power directly from a private renewable generator. In either case, such arrangements would not be feasible unless the utility’s transmission grid can be used to transmit, or “wheel”, the power from the generation site to the consumer’s site. Wheeling provisions allow such private transmission over utility lines by paying a utility fee. Wheeling provisions for renewable energy have been implemented in India. Wheeling provisions for aggregate energy efficiency resources have been developed by the Bonneville Power Administration in the U.S. through their “billing credit” policy.

4.2 Possible Energy Mix of a Renewable IPP

The Philippines makes a good case study for the application of the Renewable IPP concept because it demonstrates a cost effective model for long term energy planning. The Philippine Energy Plan (1996-2025) places a high priority on developing indigenous resources. It also specifically addresses the inclusion of renewables and energy efficiency in the national energy resource portfolio. In 2010 for example, renewable resources are projected to provide over 700 MW of energy for the country. Similarly DSM is to provide over 700 MW.[34] Given these projections, the creation of a conservative 150 MW Renewable IPP through a bidding process by the year 2002 would be a reasonable step to take toward accomplishing the Philippine national energy goals.

The power plant proposed and analyzed here mimics the resource proportions in the Philippine Energy Plan, in order to typify a Renewable IPP. That is, it is composed of half renewables and half energy efficiency. The exact energy mix for a Renewable IPP in a given country, of course, would depend on that country or region's least cost resource availability. The following pie chart displays the technologies included.

Figure 4.2: Energy Mix of Renewable IPP



4.2.1 Description of Energy Mix

Because there is an actual nationally adopted plan that explicitly includes energy efficiency and renewable based generation, our mix is designed to fit the actual goals of the Philippines. Where the Philippine National Energy Plan proposes to rely on demonstration projects to achieve nearly 700 megawatts from these resources, we propose a firm scheme for direct acquisition.

The resource proposed for the first Renewable Independent Power Producer transaction is 150 MW that consists of equal parts energy efficiency and renewable based generation. The energy efficiency component is divided in to three key approaches, increasing the efficiency of energy used by electric motors in the industrial and commercial sectors, increasing energy efficiency in lighting in all sectors, and implementing minimum energy efficiency standards on equipment. The renewable energy component is composed of wind generation, small hydroelectric (mini and micro hydro), a photovoltaic application and biomass based cogeneration.

This resource mix would help the Philippines move toward its national targets for renewables and efficiency, using a market-based mechanism that will be cost competitive with traditional

[34] Philippine Department of Energy (1996)

energy generation resources. This is true even though there are some relatively high cost resources in the mix (e.g. photovoltaics). The Renewable IPP can produce cost-competitive and environmentally sound electric resources because it blends some more expensive renewable resources with some very inexpensive end-use efficiency resources.

4.2.2 Renewable Energy Resources

The Southeast Asia region has many indigenous and renewable energy resources. Some examples of these resources are: solar, wind, hydro, biomass, and geothermal energy. However, many governments in the region have structured utilities and other infrastructure based on fossil fuel resources, and much of the renewable energy resources remain yet to be developed.

Solar energy is a resource that is virtually available in unlimited supply. Although the technologies available to tap solar energy are already commercially available, the main constraint lies in the relatively high cost of photovoltaic and solar thermal electric equipment. Since solar thermal electric technologies require direct sunlight, another problem is that many parts of the region have overcast skies for long periods during the year.

Wind energy is currently being studied in order to obtain the most detailed information regarding its real potential in this region. Preliminary assessments seem to suggest that the wind energy potential may not be as high in some parts of the region as compared to other parts of the world, but is a viable and low-cost energy supply option.

The hydroelectric potential is also high in Southeast Asia. Excluding the former Soviet Union but including China, Asia has the highest potential in the world.[35] Hydro is the most developed resource used for electricity generation as compared to other renewables in the region. Further growth is expected, as there is still a large hydroelectric potential especially in the Greater Mekong Subregion (GMS) countries. The Table 4.1 shows the estimated hydroelectric capacity.

Table 4.1: Estimated Hydroelectric Resource of GMS Countries

Country	Total Exploitable Resources (TWh/yr)	Developed Resources (TWh/yr)
Cambodia	41	-
Lao PDR	102	1.1
Myanmar	366	1.1
Thailand	49	4.6
Vietnam	82	5.8
Yunnan Province of China	450	7.9
Total	**1,090**	**20.5**

Source: Asian Development Bank (1995)

It can be observed that only about 2 percent of the exploitable hydroelectric potential has been developed in the GMS region. The estimated potential will decrease if social and environmental issues such as population relocation and reservoir filling are taken into account. However, in view of the future need of more electrical energy in the region, the potential is still very large. Hydro is also valuable in that it can provide baseload and load-following capabilities.

[35] Johansson, et al. (1993), p. 75-77.

Biomass materials have been traditionally used as fuel for cooking and other heating needs. Since the economy of Southeast Asia is based on agriculture, there are large amounts of crop residues available for use as fuels for electricity generation. Some examples of crop residues available in the region are: rice husk, bagasse, coconut husk and shell, and wood. It has been estimated that about 890,000 GWh worth of energy is recoverable from crop residues in Asia (excluding China). Furthermore, if assuming that three-fourths of the milling and manufacturing wood wastes and one-forth of the forest residues are recoverable, another 610,000 GWh can be obtained.[36] These figures are the highest among the developing world.

Geothermal energy contributes to a small but significant component of the electricity mixes in countries of the region. At the present, there is a combined installed capacity of 2.9 GW, which represents 35% of the worldwide installed capacity. Within the next 10 years, the combined capacity of the Asian nations is expected to grow to 5.3 GW.[37]

4.2.3 Renewable Technologies

Because the renewable energy industry is less mature and renewable energy technologies are less widely used than their conventional energy counterparts, the costs and status of renewable energy technologies can fluctuate (and improve) as the technologies are deployed on a larger scale. Conventional technologies, such as coal-fired steam turbines, are very mature and equipment costs tend to be stable, although fuel supply expense and availability (especially of imported fuel) can vary widely. In contrast, renewable energy technologies such as photovoltaics (PV), have much to gain from economies of scale of production and experiential learning-by-doing.[38,39] That is, costs will fall as 1) PV is produced on a larger scale and 2) the PV industry learns from experience and becomes more efficient in production. These factors have conspired to reduce the cost of PV ten-fold in the last two decades. Similar cost reductions have been demonstrated in wind turbine and solar thermal technologies.

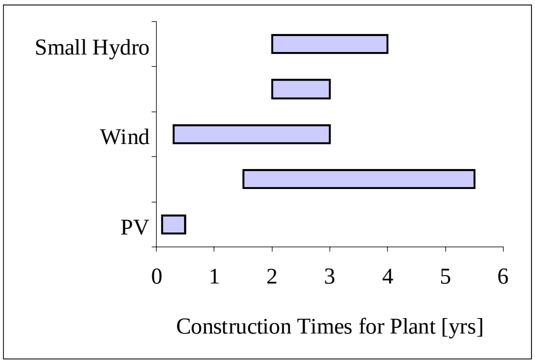
Renewable energy technologies often boast the following advantages over conventional technologies:

- Zero or minimal net greenhouse gas emissions, pollution and health risks;
- Modular components leading to flexibility in meeting diverse demands, on or off-grid;
- Rapid construction times (see Figure 4.3); use of indigenous resources;
- Zero fossil fuel price risk; and
- Cost-effectiveness on large or small scales of implementation (see Figure 4.4).

In this section, we review the various technologies, their status and projected cost for the year 2000.

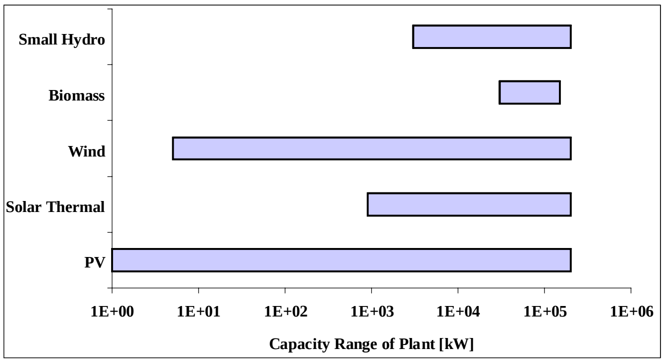
[36] Johansson , et al. (1993), p. 632.
[37] Mosby, et al. (1997)
[38] Duke and Kammen (1997)
[39] Neij (1997)

Figure 4.3: Construction Lead Times for Various Renewable Energy Technologies



Source: U.S. Export Council for Renewable Energy (1998)

Figure 4.4: Size Range for Renewable Energy Technologies



Source: U.S. Export Council for Renewable Energy (1998)

The costs of renewably-generated electricity are dependent upon many factors including: the renewable energy resource, the project site, the project size, the specific technology used, transmission and distribution considerations and transaction and financing costs.[40]

4.2.3.1 Photovoltaics

Solar photovoltaics (PV) are the fastest growing energy source. The market has exploded in recent years due to the applicability of this technology for small-scale remote areas which need power for telecommunications and rural electrification, and national PV rooftop programs that provide distributed generation. As production has increased, costs have fallen dramatically, from about $10-20/W$_P$ in the early 1980's to $4-5/W$_P$ today.[41] However, despite this reduction, the high cost of this technology is one of the most significant barriers to the widespread use of PV systems.

Like most renewable energy sources, solar is intermittent, and so PV provides an intermittent power source. However, peak demand periods, when power is most valuable, often correlate with the sunny periods when PV is producing power. Therefore, PV power is often worth more than conventional baseload generation. In order for PV to provide firm (dispatchable) power, it must be combined with storage or another generation source.

Research and development programs have been conducted by national and private sector laboratories around the world to improve PV efficiency and decrease production cost. There are two main types of PV materials:

- **Single- or poly-crystalline silicon**. This is the most commonly used PV cell material. Silicon is melted and slowly cooled around a seed crystal until a long ingot forms. This ingot is then sliced into wafers. This highly mature technology for producing silicon wafers comes from the computer industry, where high purity silicon wafers are needed for electronic devices. Until the construction of dedicated silicon wafer production, the PV industry depended upon the scrap material from the computer industry. While efficiencies of 10-12% can be reached, the production of crystalline silicon is energy intensive and thus relatively expensive.

[40] Office of Technology Assessment (1995)
[41] Ahmed (1994)

- **Thin films**. Thin films have the potential to be a low-cost alternative to crystalline silicon. Amorphous silicon thin films are commonly used in consumer PV products like watches and calculators. Although efficiencies of amorphous silicon thin films are lower (8-10%) than their crystalline counterparts, the lower production cost is believed to lead to lower costs of electricity. There are also other thin film materials, such as copper-indium-diselenide and cadmium telluride, which have higher conversion efficiencies than silicon.

Costs

Many studies have been conducted on the future costs of PV. It is generally accepted that the costs of PV have fallen as production has increased, in accordance with a learning curve showing experiential learning. In the year 2000, commercial PV capital costs are predicted to reach US$ 3-4/W_P, with electricity costs of 12-14 US cents per kWh.[42] At this level, PV costs will remain well above that experienced for utility-scale baseload power. However, the solar resource is relatively coincident with the peak loads in regions with high air-conditioning loads and daytime commercial uses. While PV costs are higher than baseload power, they are competitive with peak power costs.

4.2.3.2 Solar Thermal Electric

Solar thermal electric technologies are among those renewable energy technologies that are near competitive with conventional power production. Power is produced in a similar way to conventional steam turbine power generation except that the sun is used to heat the steam instead of coal, oil, or nuclear sources. Solar thermal electric can provide firm, dispatchable power in large multi-megawatt capacities, allowing it to replace conventional fossil-fuel baseload generation.

The parabolic trough technology is commercial and has matured through successive installations in nine sites in the U.S., totaling 354 MW. Already, 12 countries, including Brazil, Egypt, and India, have planned solar thermal electric projects totaling 400-600 MW of solar power in the near term.[43]

There are three main technologies for generating power using the heat of the sun:

- **Central receivers**. These power towers use highly reflective heliostats to concentrate the sunlight onto a fluid in a receiver in a tower. The heat (up to 565 °C) is used to generate electricity in a conventional steam turbine. This technology allows for some thermal storage. In U.S. research programs, Solar One and Solar Two demonstrate this technology in the deserts of Southern California. The molten salt technology is near-commercial.
- **Parabolic Troughs**. Reflectors shaped as long parabolic troughs concentrate sunlight onto a tube receiver. The heat (up to 400 °C) is used to generate electricity in a steam turbine. This technology was commercialized and deployed in the 1980's.
- **Solar dish generators**. Reflectors shaped as round parabolic dishes focus sunlight onto a central receiver. This technology is highly efficient and can create extremely high temperatures (up to 800 °C). Engines mounted on the dish generate power. These systems can be of much smaller capacities (5-50 kW) than the central receivers and parabolic troughs that use conventional steam turbines. This technology is currently in a demonstration phase.

[42] OTA (1995)
[43] From Solar Thermal Power Division of the Solar Energy Industries Association.

Solar thermal electric is ***not*** included in the proposed energy mix for the Renewable IPP mainly because of the meteorological conditions of Southeast Asia. Solar thermal electric technology requires direct sunlight, but most locations in the region have long periods of overcast skies during the year. For instance, good solar thermal power-plants sites typically have at least 2,500 kWh per m^2 of sunlight available annually, which corresponds to an average daily sunlight value of 6.8 kWh per m^2. [44] However, the Meteorological Department of Thailand estimates that the annual average mean daily solar radiation for the country is 4.5 – 4.7 kWh per m^2. [45] Furthermore, none of the other Southeast Asia countries has included solar thermal electric in their future power development plans.

Costs

The parabolic trough technology is mature. Luz International, the company which commercialized the technology, brought costs down from 24 US cents per kWh with their first plant in 1984 to 8 US cents per kWh with their last plants in 1989.[46] They went bankrupt before they were able to reach their projected future costs of 5 US cents per kWh. Central receiver technology is expected to be in the 6-10 US cents per kWh range (with capital costs in the US$ 2-3/W_P range) in the year 2000. [47]

4.2.3.3 Wind Energy

Wind is one of the world's fastest growing energy sources, with annual growth of 24-35% during 1995-98. Installed capacity at the end of 1997 reached over 8,710 MW. This growth has been fueled by very favorable national energy policies for wind energy development, with Germany recently becoming the world leader in wind power development and surpassing the U.S. In Denmark, wind power provides for 7% of the country's electricity demand. Further strong growth in Europe is likely, following a pledge by the European Union to increase wind capacity on the continent to 10,000 MW by the year 2010. And as utility restructuring plans in the U.S. begin to gel, wind development has begun to grow again, with almost 800 MW of new capacity scheduled to become operational by the end of 1999.

The fastest-growing market for wind in the mid-1990's was India. This was a result of the government's commitment to renewable energy through its establishment of a Ministry of Non-Conventional Energy Sources and enactment of favorable renewable energy policies. Wind activity in some other developing countries, such as China, is growing slowly; meanwhile some of these governments are investigating renewable energy policies that may accelerate growth in their countries.

The widespread use of wind power is due to the fact that wind power is now often cost competitive with conventional coal power, although still more expensive than natural gas. However, wind can be intermittent, so wind turbines are not always the best option for base load power but can be combined with other energy options. Current trends in utility-scale wind turbines is towards larger machines, with 750-1500 kW turbines now being installed in the US and Europe. Wind turbines continue to be installed singly or in small groups, especially in

[44] Johansson et al. (1993), p. 214.
[45] Woravech (1997), p. 2.
[46] Wiser (1997)
[47] OTA (1995)

Denmark, but large wind farms (> 50 MW) are becoming a more common way to deploy this technology.

There are a number of wind turbine technologies commercially available. The industry's tried-and-true stall-regulated, constant-speed turbines are being challenged by newer designs. Among technology choices are:

- *horizontal axis*, which is the typical configuration with the axis of rotation parallel to the ground, or *vertical axis*, in which the axis of rotation is perpendicular to the ground.
- *downwind*, in which the wind naturally blows the rotor downwind of the tower, or *upwind*, in which an active yaw system is necessary to keep the rotor facing the wind.
- *stall-regulated*, in which the blades are kept at a fixed angle and are less efficient in very high winds, or *active pitch*, in which the angle of the blades can be changed to optimally extract energy from the wind or to reduce output in very high winds.
- *constant-speed*, in which the turbine's speed is relatively constant over fluctuations in wind, or *variable speed*, in which the turbine's speed varies with fluctuations in wind.
- *direct drive*, in which the rotor is directly connected to the generator or *transmission*, in which the rotor and the generator have different speeds.

As yet, there is no clear technological winner in this race. Much of the grid-connected capacity consists of upwind, stall-regulated, constant-speed turbines with transmissions. Although this technology is not new, it has been reliable and proven for many years. More advanced technology makes use of active-pitch blades and direct drive, variable-speed generators, which may have increased efficiencies.

Costs

Capital costs for wind turbines are typically around US\$ 0.8-1/W_P, including installation. Operations and maintenance costs are in the range of 0.5-1 US cents per kWh. For good wind resources in the U.S., this has led to several installations producing energy for as low as 4.5 US cents per kWh.[48] The average wind energy production cost in northern Europe is approximately 10 US cents per kWh. Financing methods play a large role in the cost, because the financial community still perceives this sector as risky. When wind plants receive the same financing terms as conventional gas power plants, costs of energy will drop nearly 30% from today's costs because it is perceived to be less risky by lenders and sponsors.[49]

4.2.3.4 Biomass Energy

Biomass is widely used for power generation or cogeneration. About 8,000 MW of biomass power capacity is installed in the U.S.. Biomass power is similar to conventional power generation in that biomass is stored energy which can be utilized when it is needed, thus providing baseload or load-following capabilities. It is also similar to conventional resources in that biomass fuel supplies must be secured and costs and availability of power are dependent upon supplies.

Many countries in Southeast Asia depend heavily upon agricultural production and utilization. The result is a tremendous amount of biomass resources from residues which are often left unused in the fields or burned for disposal purposes. Industries which have a particularly high

[48] This cost does not include any subsidies.
[49] Wiser and Kahn (1996)

potential for biomass power generation or cogeneration are the sugar, palm oil, rice and secondary wood processing and other agro-based industries. In addition, the potential for growing biomass supplies through dendrothermal plantations exists in this region and can help to provide a stable, dedicated source of biomass. In Southeast Asia, there are already many direct combustion biomass cogeneration plants. Many of the plants run on residues from the sugar or rice industries.

There are three main processes through which biomass can be converted to electricity:

- **Gasification**. Biomass can be gasified, producing a high energy content biogas which can then be burned in a conventional gas turbine through a simple or combined cycle process. Future prospects for this biogas may be the use of fuel cells which can convert the gas into electricity at very high efficiencies.
- **Pyrolysis**. Biomass can be heated in an oxygen-free atmosphere and converted into oils in a pyrolysis process. These oils can then be used in place of conventional petroleum fuels to produce power.
- **Direct combustion**. Finally, biomass can be directly burned to run a steam turbine.

Most existing power plants and cogeneration plants use the direct combustion technology with conventional steam turbines. Because steam turbines tend to be less efficient at small scales, and because the nature of the biomass feedstock and feedstock transportation limitations require small-scale plant sizes, biomass plants tend to have low efficiencies.

Other biomass technologies exist in a demonstration and pre-commercial phase. For example, in Brazil, the World Bank and Global Environmental Facility are funding the installation of a biomass gasifier/gas turbine which will run on dedicated plantation wood. These new integrated gasification/gas turbine technologies can nearly double the efficiency of conventional steam turbine technologies.

Costs

Biomass power is cost-competitive in many areas where low- or zero-cost feedstocks are available. They are projected to become cost-competitive with dedicated plantation energy crops in the near future. In the year 2000, biomass power costs are expected to reach 5.0-7.5 US cents per kWh. [50]

4.2.3.5 Small Hydroelectric Energy

Hydropower is the most commonly used renewable energy source for electricity generation, providing about 20% of the world's electricity supplies. Of this, small hydropower, which ranges from 1 to 30 MW, provided about 24,000 MW in 1989.[51] It is very common in China, for example, where 69,000 small, mini and micro hydro turbines, providing 19,200 MW, are installed. Needless to say, hydropower is extremely mature technology and cost reductions are likely to minor compared to the other technologies described in this section.

Small hydro plants are usually "run of the river", that is, they do not use dams to store water so that seasonal fluctuations in water flow affect power output and can dramatically affect the capacity factor of the plant.

[50] OTA (1995)
[51] Johansson et al. (1993)

There are two basic types of hydro turbines – reaction and impulse wheels. Reaction wheels use both pressure and kinetic energy to turn the turbine. Water enters the reaction wheel, completely fills the wheel and the pressure causes the wheel to turn. Impulse wheels use only kinetic energy to turn the turbine.

There are various kinds of hydro turbines that have been designed for different head (height of water drop) and flow conditions:

- **Low-head**. Propeller turbines can be used in low-head conditions (0.5-4 meters).
- **Medium-head**. Cross-flow and Francis turbines can be used in medium-head situations (4-10 meters).
- **High-head**. Pelton turbines (impulse wheels) can be used in high-head conditions (greater than 10 meters).

Costs

Hydropower is a mature technology and cost reductions are not expected. Small hydropower facilities cost range from US$ 1-3/W_P, with some recent small hydro installations in South and Southeast Asia costing about US$ 1.3-1.5/W_P. However, only about 0.5 US cents per kWh is needed for operations and maintenance so that costs of energy generation for larger plants are typically in the range of 4.5-7.5 US cents per kWh.[52] Hydro turbines can have prolonged lifetimes, e.g. 45 years.

4.2.3.6 Summary of Renewable Energy Costs

Figure 4.5: Range of Expected Costs for Renewable Energy Generation in the Year 2000

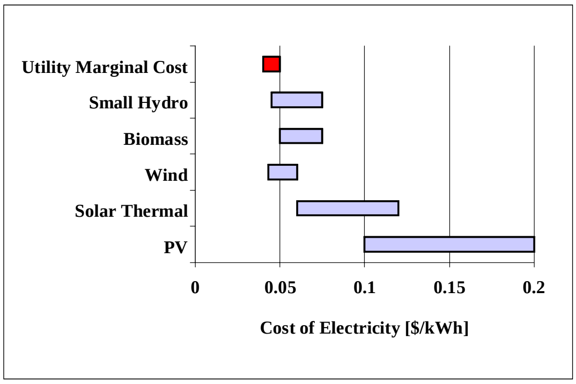


Figure 4.5 summarizes the per-kWh cost of renewable energy technologies that are presented in the previous sections. It can be observed that, by the year 2000, some renewable energy technologies such as wind and small hydro are expected to cost about the same as the utility's marginal cost of electricity in Southeast Asia. Other technologies such as photovoltaics and solar thermal will still be higher than the marginal cost.

[52] OTA (1995).

4.2.4 Potential for Energy Efficiency in Practice

A number of studies have examined the technical, economic, and achievable potential for energy efficiency or demand-side management (DSM). It is generally agreed that utility DSM programs have the potential to reduce electricity sales and peak demand by at least 20% at a cost less than the utility's long-run marginal cost.[53] A review of U.S. utility DSM plans in the early 1990s showed that utilities projected savings in the range of 5-20% for energy and peak demand for the period 1991-2000.[54]

Studies and experience in Asia have shown the technical and achievable potential to be quite large. In Thailand, studies of DSM potential have estimated 10-year potential savings of 2,000 to 3,000 MW, or roughly 30% of the projected power demand during the period 1991-2001.[55] In reality, the Thai DSM program has achieved 450 MW in just five-years of program implementation.[56]

In estimating the costs of end-use efficiency measures for this study, we reviewed data collected in the Asian context rather than relying on estimates or studies conducted for the U.S. or Europe, which would have limited applicability to Asia. Table 4.2 presents a summary of costs of different measures in comparison to the typical utility marginal or avoided cost for supply.

Table 4.2: Range of Efficiency Costs Compared to Utility Supply Costs[a]

Measure	Cost per kWh (US cents/kWh)	Cost per kW (US$/kW)
Lighting efficiency	0.8-2.2	230-1,350
Refrigerator efficiency	0.4-1.6	210-830
Air-conditioner efficiency	0.3-3.6	130-800
Motor efficiency	1.0-1.1	90-630
Utility marginal or avoided cost [b]	4.0-5.0	1,000-1,500

[a] Proxy efficiency costs for Asia are based on data for Thailand [from IIEC (1991) and (1993)], Indonesia [Hagler, Bailly (1991)], and India [Nadel et al. (1991)].
[b] Utility supply numbers are based on IIEC (1993) for Thailand and Hagler, Bailly (1991) for Indonesia.

4.2.4.1 Lighting

Efficient lighting is one of the most cost-effective energy-efficiency measures. This is because lamps are simple and less expensive to replace than other end-use equipment such as electric motors or appliances. The types of lighting efficiency measures that could be considered include the following:

- replace incandescent lamps with compact fluorescent lamps
- replace T-12 (fat-tube) fluorescent lamps with T-8 (thin-tube) fluorescent lamps
- replace standard magnetic ballasts (5W losses) with low-loss (5W) magnetic ballasts

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[53] Nadel (1992), p. 532.
[54] Ibid., p. 514.
[55] Cherniack and du Pont (1991), p. 21.
[56] Suwich Charpaisarnworn, Thai DSM Office, personal communication, September 1998.

- replace magnetic ballasts with electronic ballasts
- replace low-efficiency streetlighting (fluorescent and mercury) streetlighting with high-efficiency (high-pressure sodium) streetlighting.

The costs of efficient lighting technologies in Asia ranges from 0.8-2.2 cents/kWh, compared to utility marginal costs in the range of 4-5 cents/kWh. The costs of avoided peak for lighting measures ranges from US$230-1,350/peak kW, compared to utility avoided costs in the range of US$1,000-1,500/peak kW.

4.2.4.2 Refrigerators

Refrigerators are a rapidly growing end use in Asia, as Asian consumers in both urban and rural areas see their purchasing power increase. In Thailand, for example, the percentage of homes with a refrigerator will increase from 65% to 92% over the next decade.[57]

Improvements in refrigerator efficiency are highly cost-effective and can be made by improving the compressor efficiency, increasing the thickness of the wall insulation, by improving the gaskets and door seals, or a number of other options. In the U.S. for example, cost-effective improvements in refrigerator technology, mandated by national minimum efficiency standards, have led to a 60% decrease in average energy use since 1972. In Thailand, significant improvements (on the order of 15%) have been made in refrigerators since 1995 as a result of the national voluntary labeling program.[58]

The costs of refrigerator efficiency improvements in Asia ranges from 0.4-1.6 cents/kWh, compared to utility marginal costs in the range of 4-5 cents/kWh. The costs of avoided peak for refrigerator measures ranges from US$210-830/peak kW, compared to utility avoided costs in the range of US$1,000-1,500/peak kW.

4.2.4.3 Residential Air Conditioners

The use of air conditioners is also growing quite rapidly in Asian households, and although fewer households use air conditioners, the air conditioner is an extremely energy-intensive appliance. In Thailand, for example, the percentage of homes with a refrigerator will increase from 14% to 26% over the next decade, and 40% of new electric demand will be for air conditioners.[59] Growth in the use of this appliance will be similarly rapid in many Asian countries.

The main efficiency improvements in residential air conditioners are achieved by improving compressor efficiency. Additional cost-effective improvements can be made by increasing the heat transfer surface area, improving fin and tube design, and improving the fan and motor efficiency.

[57] Thai Load Forecast Subcommittee (1993).
[58] DSM Office, Electricity Generating Authority of Thailand. Internal data.
[59] Thai Load Forecast Subcommittee (1993).

The costs of air conditioner efficiency improvements in Asia ranges from 0.3-3.6 cents/kWh, compared to utility marginal costs in the range of 4-5 cents/kWh. The costs of avoided peak for air conditioner measures ranges from US$130-800/peak kW, compared to utility avoided costs in the range of US$1,000-1,500/peak kW.

There may also be opportunities for renewable energy-based air-conditioning in the future. Technologies using solar energy to operate air-conditioning systems are currently under development.

4.2.4.4 Electric Motors

Roughly 70-80 percent of industrial electricity is consumed in motors, and large motors (>20HP) typically account for most motor energy use. Fortunately, there are a number of significant efficiency improvements that can be made to both the motor itself as well as to the system or process that the motor drives.

Studies in Thailand, Indonesia, and India have shown that the costs of motor efficiency improvements is on the order of 1.0 cents/kWh, compared to utility marginal costs in the range of 4-5 cents/kWh. The costs of avoided peak for motor measures ranges from US$90-630/peak kW, compared to utility avoided costs in the range of US$1,000-1,500/peak kW.

4.2.4.5 Summary of Energy Efficiency Costs

The following graphs summarize the costs of different energy efficiency measures in comparison to the typical marginal cost of electricity supply for the Southeast Asia region.

Figure 4.6: Energy Efficiency Cost per kWh

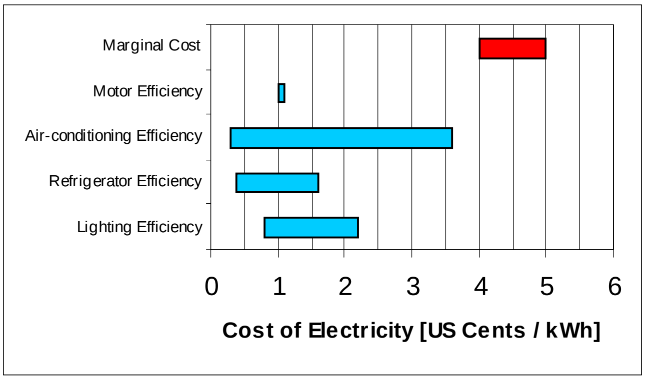
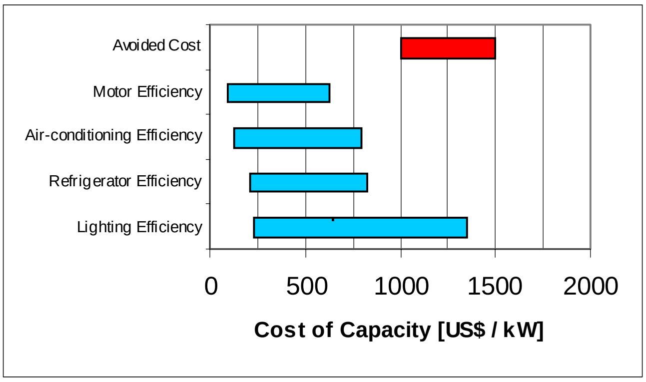


Figure 4.7: Energy Efficiency Cost per kW



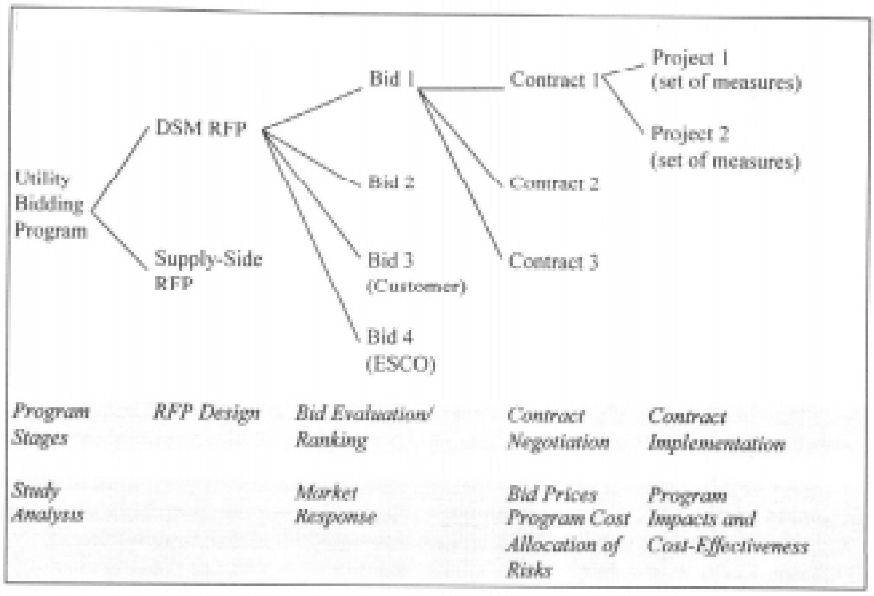
The most important point to note in terms of costs is that the per-kWh cost of all the energy efficiency measures presented here are ***less*** than the marginal cost of electricity of most countries in the Southeast Asia region. In fact, energy efficiency measures are the least-cost option when compared to other electricity generation technologies.

4.2.4.6 Demand-Side Management (DSM) Bidding

The first major DSM competitive bidding program in the U.S. was offered by Central Maine Power in 1987. Since then more than 30 utilities in 14 states have solicited bids from energy service companies (ESCOs) and customers, with over 1,500 MW of demand reductions in response to these solicitations. Most of the projects have been proposed by ESCOs, versus individual customers, as the customers are concerned with the high transaction and bid preparation costs, and the perception of higher risks relative to other utility DSM programs. As DSM developers have become more familiar and comfortable with the DSM bidding concept, the number of bids on any given solicitation has increased substantially. For example, more recent solicitations have resulted in utilities receiving 30-45 bids proposing 100-150 MW of demand reduction, compared to 10-15 bids in early solicitations.

The major stages of a bidding program [Request for Proposals (RFP) design, bid evaluation/ranking, contract negotiation, contract implementation and monitoring] are shown below in Figure 4.8. The programs usually consist of long-term contracts with several DSM developers based on submitted bids. A third party developer (i.e., ESCO) will usually develop projects at one or more customer sites in order to achieve their contracted savings or peak demand reduction.

Figure 4.8: DSM Bidding[60]



Almost all DSM bidding programs have cost less than the utility's supply-side alternatives. DSM bidding programs differ from conventional utility DSM programs in several ways. In a bidding program, the supply and cost of DSM resources depends on the price competitiveness of projects offered by individual customers and third party bidders, while the size of conventional utility DSM programs is usually determined administratively as part of a utility planning process which looks at the size and costs of DSM resources. In a bidding program,

[60] The figure is a scanned image taken from IIEC's final report to the United States Agency for International Development (US AID) for the project: *Integrated Resource Bidding in Southeast Asia*.

the bidders usually assume much of the performance risks and marketing costs; in a conventional program these risks and costs are borne by the utility.

Almost all DSM bidding programs have cost less than the utility's supply-side alternatives [at the time of the Request for Proposals (RFP); as noted below, utility avoided costs often dropped during the contract period due to changes in the electric industry in recent years. This issue has affected the cost-effectiveness of contracts on supply-side bids as well, sometimes on a much larger scale]. The bidding programs also have led to the development of detailed and very accurate monitoring and verification protocols that provide for much greater certainty in the savings that result from the programs.

A major ancillary benefit of demand-side bidding is its economic development effect of jump starting a private ESCO industry in the region where the bidding program takes place. These ESCOs often provide many other energy efficiency services, and develop additional energy savings projects, well beyond the projects that are funded through the DSM bid. This said, though, these ancillary benefits do bear some cost that show up in the price of DSM bids.

Measurement and Verification (M&V) is a very important issue in DSM bidding and all forms of performance contracting. In DSM bidding programs and all contracts between customers and ESCOs, M&V is an important part of contracts and usually necessary to justify compensation for projects. In 1994, the U.S. Department of Energy recognized the need for a consistent protocol to be able to develop new methods for financing energy efficiency improvements, and began the development of the National Energy M&V Protocol (NEMVP, which was subsequently been renamed the North American Energy M&V Protocol, and is now being called the International Performance M&V Protocol, or IPMVP).

The IPMVP is a document which discusses procedures that, when implemented, allow building owners, ESCOs, and financiers of buildings energy efficiency projects (such as the sponsors of bidding programs) to quantify energy conservation measure performance and energy savings. Its purpose is to provide those involved in such projects with a basis for negotiating the contractual terms, which ensure that a project achieves or exceeds its goals of saving energy and money. The IPMVP is available on the Internet at <www.ipmvp.org>.

DSM bidding has been demonstrated to be cost-effective ways to deliver electric capacity, and provide a more level playing field on which to compare demand and supply side options. In countries that are restructuring their power sectors and need to consider adding new capacity, DSM bidding can be a very effective way to introduce demand-side technologies while keeping the cost of energy supply to a minimum. An important finding from the North American experience is that DSM bidding and the competitive conservation contracts can be most helpful in stimulating private energy efficiency markets, including the development of a local ESCO industry, in areas where there is not already an active market. This is the case in much of the world.

Many reports have been written about the immense potential for energy efficiency to provide significant energy capacity in areas where energy needs are growing and capacity shortages are faced. DSM bidding provides a real market based, competitive situation where the validity of these studies can be tested. Particularly during the present time of economic uncertainty in much of the world (East Asia in particular), demand-side resources that can be acquired through DSM bidding programs can be solicited and contracted for in smaller increments than most supply alternatives. Additionally, the construction lead-time for most demand-side technologies is generally shorter than the planning and construction time necessary for generation options.

In many developing countries there is a strong desire and need to maximize the use of local materials and labor to cut down on imports, and again, demand-side technologies provide significantly more local input to the economy relative to generation technologies that are mostly imported from the developed countries. Most DSM projects, be they re-lighting buildings or installing new controls technology in industrial processes, are heavily labor intensive in their installation, and can be done with local labor.

4.3 Financing Considerations for a Renewable IPP

Renewable IPPs in Southeast Asia will face similar financing issues as those faced by conventional IPPs (discussed in Section 3) since they also must rely on private investment institutions and financiers to provide capital for the project's implementation. There are a wide variety of factors that impact project finance costs. These include size; location; fuel supply; country risk profile; sponsor company profile; the strength and nature of the power purchase agreement (PPA); the ability of the energy buyer to accept and pay for the energy over the long term (20 years); the distance and cost of transmission and distribution; the availability of debt and equity financing for the project; and the strength of the construction contractor building the plant. Clearly, the number of project-specific variables that potentially impact the financing of a Renewable IPP again make it difficult to generalize about project costs. However, we can address some of the major issues that influence the costs and economic viability of conventional and Renewable IPPs.

To qualify for private sector investment and financing, without subsidized funding, a Renewable IPP needs to be able to compete with the financial criteria for traditional power plants that produce a market rate of return of between 15% and 20%. Some specialized funds are designed to finance green power resources and recognize (and fund) the environmental benefits of renewable energy and energy efficiency. In addition, more funds are being developed in the short term to support Global Climate Change objectives, and some private sector companies are beginning to invest in this market (see Table 4.3 for a sample listing of possible energy funding sources for Asia).

Project sponsors and financiers of Renewable IPPs must consider the following unique challenges and incentives for funding these projects:

1. Environmental (green) attractiveness – Some financiers have specific mandates to invest in environmentally-friendly technologies. To comply with their investment requirements, they may be willing to invest in Renewable IPP project development or to offer concessionary terms. They may also finance a project over a longer term, for example, to obtain the long-term cost advantages and environmental benefits. In addition, environmentally aware lenders may better understand the cash flows of an energy efficiency project and how energy service companies (ESCOs) represent a growing market segment. Table 4.3 on financing sources provides more details.

2. Environmental financial benefits (carbon offsets) – Renewable IPPs generate an additional source of revenue not offered by coal-fired IPPs: carbon offset credits that will eventually be able to be traded in the global carbon market. Private sector investors and funds are already beginning to explore these as an investment option that increases the potential value of energy efficiency and renewable energy projects. However, until the United Nations Framework Convention on Climate Change establishes maximum carbon emissions, the carbon market and the value of these credits remain highly speculative.

3. Size and transaction costs – One of the greatest financing barriers that Renewable IPPs face is the relatively small size of an individual energy generation or efficiency project. Engineering, project development, operations and other costs are still incurred for individual bundled transactions; costs that can be offset by the environmental benefits of a Renewable IPP. Often a financier must invest equivalent resources in evaluating the viability and structuring the financing for a small IPP (or a group of smaller projects) as for one larger project. Therefore, most financiers prefer to do their due diligence work on larger projects, where the transaction costs relative to the project size and thus to the potential returns are lower. This issue can be partially addressed by energy service companies and other methods of grouping smaller projects within a larger transaction, particularly since a smaller project may be more appropriate for a given economic endeavor, region (an off-grid area for example) or resource.

4. Financing of Renewable IPP is independent of world fossil fuel prices.

Potential financing sources for energy in Asia are shown in Table 4.3 on the next page.

Table 4.3: POTENTIAL FINANCING SOURCES FOR ENERGY PROJECTS IN ASIA

Multilateral Development Banks	Asian Development Bank	Large (min. US$ 10 million) development loans & investments to private and public sector projects.
	The World Bank	1. Large (min. US$ 10 million) development loans to public sector entities. 2. Special programs for environmental projects, often using GEF grant funds.
	International Finance Corporation (IFC)	1. Large (min. US$ 10 million) loans and investments to the private sector. 2. Specialized funds and programs for environmental projects. 3. Channels GEF grants for climate change mitigation projects.
	Global Environmental Facility (GEF)	Grants for global environmental projects including climate change mitigation. Funds channeled through the World Bank/IFC, UNDP, and UNEP. Includes Project Development and Mid-Sized Grant Facilities.
Export Promotion Agencies	Export Import Bank of the USA	Loans to support U.S. exports: loans and credit guarantees to U.S. exporters and foreign importers of U.S. products; low minimum-credit amounts for environmental projects.
	Overseas Private Investment Corporation (OPIC)	Provides political risk insurance and credit guarantees for U.S. companies investing internationally.
Environmental Investment Funds	Environmental Enterprises Assistance Fund	Loans and equity investments in small to mid-sized environmental companies and projects in developing countries, usually under US$ 1 million.
	Renewable Energy and Energy Efficiency Fund (REEF)	Specialized fund for debt and equity for renewable energy and energy efficiency small to mid-sized companies in developing countries; funding provided by IFC/World Bank, GEF and private banks, expected to close in 1999.
	E & Co.	Lends to and invests in small to mid-sized environmental companies in developing countries, including early-stage project development funding.
Environmental Mitigation Funds	Global Climate Change Mitigation Funds and Programs	Grants or other funding for greenhouse gas reduction projects; usually for project development or under Activities Implemented Jointly (AIJ) Programs.
Private Sector Investment Funds	Asia Infrastructure Fund, Emerging Markets Partnership	Equity investors in large infrastructure and energy projects that generate a minimum market return on equity.
	GE Capital Global Power Fund	Equity investments in large energy projects with a market rate of return.
	Energy Asset Management (Pacific Enterprises, Dresser Industries and Bechtel)	Equity investments in large energy projects that generate a market rate of return.
Private Companies	Shell Oil	Possible equity investments and project development funds for projects that could generate carbon offset credits.
	British Petroleum	Equity investments and project development to generate carbon offset credits.

5 Comparison of a Conventional IPP and a Renewable IPP

This section presents some important issues that differentiate Renewable IPPs from conventional power plants. These issues are: environment impacts, costs, and employment effects. In the evaluation of these issues, we first analyze a hypothetical 150 MW power plant that uses entirely coal as the energy source. An energy mix of one-hundred percent imported coal is used because it has been shown that there is a trend towards the usage of more coal in future power plants of Southeast Asia (see Section 2.3). We then conduct a similar analysis for a hypothetical 150 MW Renewable IPP using an energy mix that comprises both renewable energy resources and energy efficiency. The energy mix is the same as that proposed in Section 4.2.

5.1 Environment Impacts

Many Southeast Asian countries are experiencing an increase in environmental degradation as a result of the growth of electricity production. The most visible environmental problem resulting from the combustion of fossil fuels is atmospheric pollution due to the emission of sulfur dioxide (SO_2), nitrogen oxides (NO_X), and particulates. Atmospheric emissions from fossil fuel-fired power plants in the major electricity consuming Southeast Asian countries are shown in Table 5.1.

Table 5.1: Current Trends of Atmospheric Emissions of Fossil Fuel-Fired Power Plants

	SO_2 [million tons]			NO_X [million tons]			Particulates [million tons]			CO_2 [million tons]		
	1993	2005	2010	1993	2005	2010	1993	2005	2010	1993	2005	2010
Indonesia	0.29	0.83	1.37	0.13	0.60	1.09	0.05	0.17	0.22	9.80	37.40	66.10
Philippines	0.15	0.18	0.28	0.04	0.17	0.30	0.02	0.05	0.06	3.90	10.00	17.40
Thailand	0.53	0.81	1.14	0.13	0.54	0.93	0.18	0.24	0.25	11.20	35.10	56.60

Source: International Energy Agency (1997)

Sulfur dioxide causes problems of local and regional significance because it reacts with water in the air, which results in acid precipitation. Increased levels of acidification within watercourses destroy aquatic life and cause damage to vegetation. Where SO_2 emissions are allowed to reach higher than acceptable ambient air quality standards, human health will also suffer. The Mae Moh lignite-fired power plants in northern Thailand represent a good example of the effects of SO_2 on the surrounding human population. Sulfur dioxide in combination with other emitted particles from the power plants has a synergistic effect in creating conditions that increase the occurrence of asthma and bronchitis. This has resulted in impaired lung functions on the order of 70-80 percent normal capacity in the student population living in the vicinity. Furthermore, acid rain (pH 4) has been measured in the Mae Moh area adjacent to the power stations. Aquatic life is badly affected at pH levels of 4.5 or lower. [61]

The current techniques being used to reduce SO_2 emissions in thermal power plants are: (1) flue gas scrubbers and (2) flue gas desulfurization (FGD). However, these technologies cannot

[61] Asian Development Bank (1995), p. 171.

eliminate SO_2 emissions completely. For instance, wet FGD has a removal efficiency of 80 – 90 percent, while dry FGD has a removal efficiency of 70 – 90 percent.[62]

Nitrogen oxides (NO_X) and particulates such as dust, fly ash and smoke are also emitted in the combustion of fossil fuels. Similar to SO_2, NO_X can also cause acid rain through the formation of nitric acid. It also creates photochemical smog and causes ozone depletion. Particulate emissions can cause respiratory tract problems in human populations. For example, aggravation of the alveoli of the lungs can result, leading to broncho-pulmonary conditions such as asthma and bronchitis. Lung function will also be reduced. Improving the combustion efficiency and using low-NO_X burners (LNB) in thermal power plants can reduce NO_X. LNBs have removal efficiencies within the 30-55% range. Electrostatic precipitators (ESPs) can be used to capture fly ash and other particulates. The particulate removal efficiency of ESP is close to 100%.[63]

Another important atmospheric emission of fossil fuel combustion is carbon dioxide (CO_2). CO_2 is naturally present in the atmosphere at very low levels and is one of the gases responsible for maintaining the natural greenhouse warming effect that makes this planet habitable. However, in the last 150 years, atmospheric CO_2 concentrations have increased by 25 percent from 275 ppm to 348 ppm due to the burning of fossil fuels and deforestation. The continuing release of CO_2 into the atmosphere could result in a 1.5 °C to 4.5 °C global increase in temperature that will result in increased coastal flooding altered precipitation patterns.[64] It is postulated that global warming will have the greatest impact on countries in tropical regions, including Southeast Asian countries. There is currently no technology to reduce CO_2 resulting from combustion in thermal power plants.

5.1.1 Environmental Impacts of a Coal-Fired IPP

With the exception of Vietnam (which produces anthracite coal), most of the indigenous coal resource in Southeast Asian countries is lignite and sub-bituminous coal. Indonesia is the main producer of coal in the region, and approximately 97 % of its production is lignite and sub-bituminous coal.[65] However, by the year 2010, the region's dependence on imported coal will account for over one-third of the total global trade in coal.[66]

Coal-fired power plants generate larger quantities of atmospheric pollution than other fossil fuels. For instance, coal has a higher carbon content than fuel oil or natural gas, and its combustion thus results in more CO_2 released into the atmosphere. The information in the following table compares the emissions of various fossil fuel-fired power

Table 5.2: Emissions of Power Plants According to Fuel Type

	Emissions [gram per kWh produced]			
Fuel	**CO_2**	**SO_2**	**NO_X**	**Particulates**
Coal, lignite	1,200	6.23	9.55	0.874
Coal, anthracite	1,130	3.76	3.79	0.329
Fuel oil, heavy	770	4.90	1.66	0.247
Natural gas	440	0.02	0.78	-

Source: Asian Development Bank (1995) and World Bank (1993)

[62] International Energy Agency (1997), p. 108.
[63] Ibid.
[64] Asian Development Bank (1995), p. 169.
[65] United States Energy Information Administration (1998).
[66] International Energy Agency (1997), p. 40.

plants.

Other direct environmental impacts due to using coal as fuel are also important. For instance, coal-fired power plants generate large quantities of fly and bottom ash. Some of the fly ash can be captured before it escapes into the atmosphere via the flue gas by using scrubber technologies. Bottom ash has to be disposed of in landfill sites. The conventional method is slurry pumping and settling into ponds. The pond water has a high pH (normally pH 10), which results from the lack of buffering components within the ash.[67] Any runoff from the pond to surrounding areas will result in significant adverse environment impacts.

Table 5.3: Key Environmental Impacts of Coal-Fired Electricity Generation

Key Environmental Impact	Source of Impact
Air pollution	Emissions of SO_2, NO_X and particulates
Water pollution	Effluent from coal-fired plants, acid drainage from coal mines and ash disposal sites
Solid waste	Coal bottom and fly ash, gypsum from FGD
Acid precipitation	Emissions of SO_2 and NO_X
Land use and siting	Deforestation and degradation from coal mining
Global climate change	CO_2 emissions

Source: International Energy Agency (1997), with some modifications.

Another problem arises from the cooling requirements of the thermal cycle used to generate electricity. Conventional steam turbine power stations generate large quantities of waste heat; up to 50 % of the total thermal value of the fuel is discharged as waste heat either to the surface water or the atmosphere. Where surface water is used as the cooling medium, there is potential for thermal pollution of lakes and streams due to the high temperature of the cooling water discharged from the power station. This thermal pollution can result in disturbances to the local aquatic ecosystem.

With the exception of atmospheric impacts, it is difficult to numerically quantify the other environmental impacts of using coal in electricity production. In terms of the hypothetical 150 MW IPP using imported low-sulfur coal, atmospheric emissions can be estimated by using data from Table 5.2.[68] The analysis was conducted with the assumption that the power plant is fitted with FGD, LNB, and ESP technologies to reduce pollutant emissions. The details of this calculation can be found in the Appendix. The results are shown in Table 5.4. It is important to note that the amount of emissions calculated does not reflect the entire life cycle of the coal plant. In reality, there would be additional emission contributions from the transport of coal to the plant, construction of the plant, etc.

[67] Asian Development Bank (1995), p. 173.
[68] Although lignite is the predominant type of coal contained in indigenous coal reserves of the region, there is not enough to meet future demands. Southeast Asia countries such as the Philippines and Thailand will likely rely on imported coal to meet future energy demands. Imported coal to the region is typically low-sulfur. [World Bank (1993) and SRC International (1995)]

Table 5.4: Atmospheric Emissions of a 150 MW, Coal-Fired IPP

Generation Capacity [MW]	Load Factor[a]	Electricity Generation[b] [GWh/yr]	Atmospheric Emissions[c]			
			CO_2 [million metric tons per year]	SO_2 [thousand metric tons per year]	NO_X [thousand metric tons per year]	Particulates [thousand metric tons per year]
150	80%	1051.2	1.188	0.593	1.793	0.00346

[a] The load factor indicates the percentage of the maximum capacity at which the power plant operates on average during the year. The value of 80 % is assumed here because it is a typical value for baseload coal plants.

[b] The annual electricity generation is obtained by multiplying the generation capacity (MW), the plant factor (%), and a conversion factor of 8.76 X 10^6 (kWh/MW-yr).

[c] The emissions are calculated by multiplying the annual electricity generation by data from Table 4.2 for anthracite coal, and then taking into account emission reduction technologies. It is expected that imported coal to the region will be of the low sulfur (0.5%) anthracite type. [World Bank (1993) and SRC International (1995)]

5.1.2 Environment Impacts of a Renewable IPP

The energy mix of the proposed Renewable IPP consists entirely of renewable energy and energy efficiency. There are no significant environment impacts in terms of atmospheric pollution from solar, wind and small hydro technologies. The only technology in the mix that generates electricity through a combustion process is the biomass technology. Similar to fossil fuel combustion, burning biomass also emits CO_2. However, if the biomass fuel is obtained from crop residues, then there are no net carbon emissions, since trees and plants act as carbon sinks when they grow back.

According to a study by the National Renewable Energy Laboratory in the U.S., the atmospheric emissions of a hypothetical biomass integrated combined-cycle power plant in the Midwestern U.S. was found to be much less than that of fossil fuels.[69] This study assessed the environmental consequences of the system, taking into account the entire life cycle, including biomass fuel production and transportation, electricity generation, and any upstream processes required to operate the system. The relevant emissions from this system for the purposes of comparison with the coal-fired IPP are shown in Table 5.5. It is important to note that the resulting emissions are not entirely due to the direct biomass combustion process, but the biomass fuel feedstock production and transportation. For instance, diesel fuel is burned in the operation of the tractors that collect biomass, and also in the trucks that carry the biomass feedstock to the plant site. In any case, the system studied was found to have a 95% carbon closure, with 100% representing total recycle, i.e., no net addition of CO_2 into the atmosphere.

Table 5.5: Emissions of Biomass Combined Cycle Power Plant

	Emissions [gram per kWh produced]			
Fuel	**CO_2 (net)**	**SO_2**	**NO_X**	**Particulates**
Biomass	45.9	0.302	0.686	0.0416

Source: Spath and Mann

Biomass combined-cycle technology produces electricity at the highest efficiency compared to other biomass-fired technologies. Assuming that the hypothetical Renewable IPP uses biomass combined-cycle electricity generation technology, the annual atmospheric emissions can be estimated. Table 5.6 shows the results of this calculation, with all of the emissions being contributed by the biomass portion of the mix. Further details can be found in the Appendix. However, it is important to note that in reality, the emissions will also vary according to the exact type of biomass feedstock fuel.

[69] Spath and Mann

Table 5.6: Atmospheric Emissions of 37.5 MW Biomass Combined Cycle Power Plant[70]

Generation Capacity [MW]	Load Factor	Electricity Generation [GWh/yr]	Atmospheric Emissions			
			CO_2 [million metric tons per year]	SO_2 [thousand metric tons per year]	NO_X [thousand metric tons per year]	Particulates [thousand metric tons per year]
37.5	80%	262.8	0.012	0.079	0.180	0.011

The Renewable IPP energy mix allows Southeast Asian countries to avoid the emissions that would otherwise be emitted by a 150 MW coal-fired power plant. The amount of emissions avoided would be equal to that calculated for the coal-fired IPP in Section 5.1.1, minus that calculated for the Renewable IPP in Table 5.6. Table 5.7 below compares the emissions of a coal-fired and a Renewable IPP.

Table 5.7: Comparison of Atmospheric Emissions

	Atmospheric Emissions			
	CO_2 [million metric tons per year]	SO_2 [thousand metric tons per year]	NO_X [thousand metric tons per year]	Particulates [thousand metric tons per year]
Coal-fired IPP	1.188	0.593	1.793	0.00346
Renewable IPP	0.012	0.079	0.180	0.01100

It is important to note that, for the Renewable IPP, the contribution of emissions originates only from the biomass energy resource. Other resources in the mix do not contribute any emissions. Still, with the exception of particulates, the emissions of the Renewable IPP are much lower than the coal-fired IPP. Particulate emissions are lower for the coal-fired IPP because we assume that the plant is fitted with high efficiency (99%) electrostatic precipitators. The carbon emission of the Renewable IPP is lower than that of the coal-fired IPP by a factor of 99. Furthermore, there are no direct carbon emissions from the Renewable IPP, since carbon is absorbed when trees, plants and other biomass material grow back. The carbon contribution is the result of machinery operation to harvest, collect, and transport the biomass feedstock to the power plant site.

5.2 Overview of Costs

One of the most important indicators determining the energy mix for an IPP is the economic cost of the project. This cost is a function of many factors, including power plant capital costs, fuel costs, operation and maintenance, interest, and externalities. All of these factors combine to determine the average price of electricity produced by an IPP. To this end, the electricity cost over the power purchase contract period is considered. This section compares the costs associated with the hypothetical 150 MW coal and Renewable IPPs.

[70] Calculation methodology is similar to that of Table 5.4.

5.2.1 Costs of a 150 MW Coal-Fired IPP

In the Philippines, the electricity price for power purchased by the National Power Corporation (NPC) varies depending on technology, capacity and location. According to a study by SRC International, it ranges from 4.7 to 8.0 US cents per kWh.[71] Typical examples of the electricity prices are:

- Navotas gas turbine power plant: 6.9 US cents per kWh
- Pagbilao coal-fired power plant: 6.6 US cents per kWh
- Sual coal-fired power plant: 5.3 US cents per kWh
- Iligan city diesel power plant: 4.8 US cents per kWh

These figures compare reasonably with the prices of electricity from IPP projects in other Asian countries. In Pakistan, for example, the price contracted in power purchase agreements ranges from 5.6 to 7.0 US cents per kWh. In China, the Shajiao coal-fired power plant shows an electricity price of around 5.0 US cents per kWh. It is also important to note that the power purchase prices indicated have included financing costs in the case of debt financing. This comparison of prices, however, gives only a very rough indication, as the country-specific circumstances which affect the price that an investor is willing to accept may vary from country to country. Examples of such circumstances are risk allocation, possible price adjustments, and repatriation of foreign exchange.

In the case of a 150 MW coal-fired IPP in Southeast Asia, an estimate of the price of electricity can be obtained using information from studies by the World Bank and SRC International.[72] Table 5.8 shows the factors that are used, along with the results of this analysis.

Since this 150 MW power plant will use imported coal as the energy source, the fuel cost accounts for a large portion of the total operation and maintenance costs. The cost of coal is also expected to escalate, and for the purposes of this analysis, the escalation is based on the values used in the World Bank and SRC International studies. The results indicate that, for a hypothetical coal-fired IPP situated in a Southeast Asian country such as Philippines or Thailand, the price of electricity production is about 4.8 US cents per kWh. If this price were used in the power purchase agreement, then the IPP would break even. In reality, there might be interest expense and transaction costs due to debt financing, and investors will want to earn an equity return on their investment. In an actual power purchase agreement, the price of electricity would be expected to be higher.

The methodology for this analysis was based on the cash-flow analysis used in the Thailand Fuel Options Study.[73] Data for the analysis was derived from several sources, as detailed in the Appendix.

[71] SRC International (1995)
[72] World Bank (1993) and SRC International (1995)
[73] The methodology can be found in World Bank (1993).

Table 5.8: Cost Characteristics for Coal-Fired Power Plant with Emissions Control

	Philippines	Thailand
Fuel Type	Imported Coal	Imported Coal
Plant Size	150 MW	150 MW
Load Factor	80 %	80 %
Plant Efficiency	36 %	36 %
Lifetime	25 years	25 years
Construction Time	3 years	3 years
Capital Costs [US$/kW]	1,440	1,190
Operation and Maintenance Costs [US$/kW-yr]	46.1	47.6
Price of Fuel at first year of operation [US$/tonne]	35.9	54.8
Annual Fuel Price Escalation	2.0 %	0.5 %
Calorific Value of Fuel [MJ/kg]	26.6	26.4
Total Electricity Costs [US cents / kWh]	**4.75**	**4.90**

5.2.2 Costs of a 150 MW Renewable IPP

The price of renewable energy technologies and energy-efficiency measures has been discussed in previous sections. A summary of the range of their electricity prices has been presented in Figures 4.5 and 4.6. The cost characteristics of the renewable technologies are shown in Table 5.9. Using the information contained in these figures and table, the electricity price for a 150 MW Renewable IPP operating on the fuel mix proposed in Section 4.2 can be estimated. The median value of the range of price is selected as the cost of each technology/measure. Table 5.10 shows the results of this analysis.

Table 5.9: Cost Characteristics for Renewable Energy Technologies

	PV	Solar Thermal	Wind	Biomass	Small Hydro
Fuel Type	-	-	-	wood and residues	-
Load Factor	-	-	-	80%	-
Plant Efficiency	-	-	-	28%	-
Lifetime	30 years	30 years	30 years	30 years	45 years
Construction Time	1 year	1 year	1 year	2 years	1 year
Capital Costs [US$/kW]	2,738	3,153	1,072	2,397	1,400
Operation and Maintenance Costs [US$/kW-yr]	8.8	34.1	25.2	114.9	0.5 US cents/kWh
Calorific Value of Fuel [MJ/kg]	-	-	-	varies	-
Total Electricity Costs [US cents / kWh]	**12.0 – 14.0**	**6.0 - 10.0**	**4.5 – 5.5**	**5.0 – 7.5**	**4.5 – 7.5**

Note: Most of the data for this table is from EPRI (1993).

In the analysis of the Renewable IPP costs, it is important to note that such a facility will required multiple projects and technologies to be bundled together into a larger facility. Therefore it is necessary to compensate for the additional costs associated with this “bundling” of resources, such as engineering, project development and management, transaction costs, financing costs, etc., as detailed in the footnotes of Table 5.10. An adjustment factor of an additional 30% is used to estimate the cost of the hypothetical Renewable IPP. This adjustment is not necessary for the case of the single facility coal-fired IPP because there are no multiple transaction costs associated with one large project.

This analysis indicates that a Renewable IPP can provide 150 MW of electricity services at a price that is comparable to a coal-fired IPP plant of the same size. In this case, a 150 MW

Renewable IPP produces electricity at a price of about 5.0 US cents per kWh, as compared to approximately 4.8 US cents per kWh of the hypothetical coal-fired IPP. This is made possible by selecting a sample energy mix for the Renewable IPP that balances between the higher cost of renewable energy technologies and the lower cost of energy efficiency measures (relative to the cost of a coal-fired IPP). Note that in a given country situation and under a market-driven Renewable IPP bidding approach, the renewable energy/energy efficiency power allocation would be made by maximizing the use of the lowest-cost power source first before utilizing more expensive sources. Under this approach a Renewable IPP could potentially be even lower cost than in this example or compared to a fossil fuel power generation option.

Table 5.10: Renewable IPP Cost Analysis

Total Generation Capacity = 150 MW

Green Energy Resource	Capacity[a]	Estimated Electricity Cost[b]	% Allocated in Mix	Theoretical Weighted Cost	Adjusted Theoretical Weighted Cost[c]
	MW	US cents / kWh		US cents / kWh	US cents / kWh
Renewables					
Photovoltaics	3.75	15.00	2.5%	0.38	0.49
Wind	18.75	5.00	12.5%	0.63	0.82
Biomass	37.50	6.25	25.0%	1.56	2.03
Small Hydro	15.00	6.00	10.0%	0.60	0.78
Energy Efficiency					
Motor Efficiency	29.25	1.05	19.5%	0.20	0.26
Lighting Efficiency	10.50	1.50	7.0%	0.11	0.14
Air-conditioning Efficiency	18.00	2.00	12.0%	0.24	0.31
Refrigerator Efficiency	17.25	1.00	11.5%	0.12	0.16
Total Electricity Price of Renewable IPP[d]			**100.0%**	**3.8 US cents / kWh**	**5.0 US cents / kWh**

[a] Resource allocations were drawn from the Philippines National Energy Plan previously discussed. The allocation is reflective only of the resources/generation potential and relative cost advantages for the Philippines. In reality, a Renewable IPP would likely have a different mix of renewables and energy efficiency and this would be driven by the relative prices of renewable energy and energy efficiency resources developed in the local market by the private sector. Further, any given country would benefit most from first maximizing the use of its least expensive resource, e.g. energy efficiency.

[b] The estimated renewable energy generation costs are based on U.S. data and projections. For energy efficiency, all of the costs are based on data from Asian countries. See Section 4.2 for more details of the costs of renewable and energy efficiency technologies. These costs are meant to provide a general estimate of per-kWh costs for a hypothetical renewable and energy efficiency power generation project.

[c] The per-kWh costs for the Renewable IPP are adjusted upward by an additional 30% to account for the following: per-site engineering, project design, project development, project management, power transmission, logistics, structuring and financing costs.

[d] Note that these values are for a hypothetical mix of renewable energy and energy-efficiency resources for international energy generation. Actual project costs could vary widely depending on the project size, location, structure, fuel supply (if applicable), initial and long term cost of capital, and other factors.

5.2.3 Externality Costs of a Coal-Fired and a Renewable IPP

Electricity generation using coal involves a process in which the actual total cost of the IPP may not be appropriately reflected in the market prices charged for the electricity produced. True resource costs should include both the private costs incurred to generate electricity and the external costs to the country and society of environmental deterioration. As previously examined in Section 5.1.1, electricity generation using coal has multiple environmental impacts, the most notable impact being atmospheric pollution. The environmental damage caused by these impacts is labeled environmental “externalities”. In most cases, the costs of externalities are not added to the price charged to consumers, i.e. the retail price charged is lower than it would be if the costs of externalities were properly included in the project.

Although the complete environmental impacts of a coal power plant depend on the plant site, some generic cost values can be placed on the impacts of atmospheric emissions. Some notable studies have led to government legislation to incorporate the costs of these emissions in electricity generation planning in the United States. The following table shows the externality cost values of different pollutants that have been adopted by some states.

Table 5.11: Externality Values for Different Pollutants
[US$ per metric ton]

State	CO_2	SO_2	NO_X	Particulates
California	10	4,945	10,053	5,079
Massachusetts	26	1,874	7,937	4,850
Minnesota	11	165	937	1,404
Nevada	26	1,892	8,245	5,068
New York	1	1,584	2,090	367
Oregon	28	0	3,858	3,307
Average	**17**	**2,092***	**5,520**	**3,346**

* Value does not include Oregon.
Source: U.S. Department of Energy (1995), with conversion to metric values.

Overall, a number of studies have attempted to evaluate externality cost values for other regions of the world. The methodology used for calculating these externality costs varies from one study to another. Some studies use a "top-down" approach to evaluate externalities on a national or regional level, while others employ a "bottom-up" approach that takes into account all impacts from extraction of materials for manufacturing to disposal. Some studies rely on previous estimates, which are not site-specific; other studies rely on abatement costs, which are the marginal costs of abating emissions. Still other studies use the damage function approach, where the impact from each burden related to the technology is identified, and the damage caused by the burden is quantified and monetized.

An important parameter in estimating externalities is the fact that some earlier studies only include regional and local impacts and do not account for the global impacts related to greenhouse gases. Some recent studies and results that do account for the impacts of greenhouse gases such as CO_2 are summarized in Table 5.12.

Table 5.12: Results of Some Studies on Externality Costs
[in US cents / kWh]

Region/Country	European Union	Switzerland	Germany
Estimate for Natural Gas	1.1	9.1 – 13.6	1.0 – 5.7
Estimate for Coal	4.6	-	1.0 – 5.7

Source: Adapted from Lotte (1998) and Asian Institute of Technology (1998b)

So far there has been no in-depth study of externality cost values for the Southeast Asia region. However, it would still be useful to approximate these costs using the values derived for the United States. For the purposes of this report, the average externality costs in Table 5.8 can be applied to evaluate the externality costs of the hypothetical 150 MW coal-fired IPP. Details of this evaluation can be found in the Appendix. ***Including externality costs, the total cost of electricity from the coal-fired IPP would increase by about 3.0 US cents per kWh.*** Going back to Table 5.5, the Philippines coal-fired IPP would have an electricity cost of 7.7 US cents per kWh, while Thailand's coal plant would have 7.9 US cents per kWh.

Similar to the coal-fired IPP, externality costs of atmospheric emissions can also be analyzed for the Renewable IPP. However from a life cycle point of view, solar, wind and hydro technologies only contribute emissions during the production and construction of the individual facilities. There are no emissions during the operation of the facilities, and the net emissions during the entire life cycle are usually negligible. In fact, a study by the Asian Institute of Technology concluded that solar energy has negligible environmental externality costs in a Southeast Asia country such as Thailand.[74] Similarly, the New York State Energy Plan also assigns an externality cost of zero for photovoltaics, wind and small hydro technologies.[75]

The emissions due to the biomass portion of the Renewable IPP mix has been estimated in Section 5.1.2. A few studies have been performed to analyze the externality costs resulting from biomass-fired electricity generation, as shown in the following table.

Table 5.13: Biomass Externality Costs [US cents per kWh]

Asian Institute of Technology	New York State Energy Plan
0.73	Gasification: 1.45 Direct Combustion: 1.32

Source: Asian Institute of Technology (1998b) and New York State (1994)

The biomass externality cost calculated by the Asian Institute of Technology (AIT) may be more applicable to the Southeast Asia region, since the analysis was conducted specifically for a project for the Thai government. In the case of the hypothetical Renewable IPP, biomass accounts for 37.5% of the 150 MW energy mix. Therefore, assuming the externality cost of biomass as calculated by AIT, biomass would contribute 0.18 US cents per kWh to the electricity price of the Renewable IPP. ***Therefore including externalities, the electricity price of the hypothetical Renewable IPP would total approximately 5.2 US cents per kWh.***

Table 5.14 shows the comparison of a coal-fired and a Renewable IPP. Although the cost of the Renewable IPP is a little more than that of the coal-fired IPP, the addition of externality costs causes the Renewable IPP to be the least-cost option. Externalities add about 3.0 US cents per kWh to the cost of the coal-fired IPP, while only about 0.2 US cents per kWh to the cost of the Renewable IPP.

Table 5.14: Comparison of Costs of a Coal-fired and a Renewable IPP

	Cost Excluding Externalities	Cost Including Externalities
Coal-fired IPP	4.8 US cents per kWh	7.8 US cents per kWh
Renewable IPP	5.0 US cents per kWh	5.2 US cents per kWh

5.3 Employment Issues

Another socioeconomic impact of electricity generation is employment. In the development of any electricity generation and service infrastructure, human resources are required to implement many activities such as manufacturing, installation, construction, operation, maintenance, etc. In general, renewable energy and energy efficiency tend to create more jobs than conventional fossil fuel-fired power plants. For example, wind energy creates more jobs watt-for-watt, dollar-for-dollar than any other utility scale energy source in the United States.[76] Energy efficiency activities have a larger employment impact as compared to fossil fuel-fired

[74] Asian Institute of Technology (1998b)
[75] New York State (1994)
[76] American Wind Energy Association (1995), p. 10.

power plants. This is because the latter is mainly capital intensive, but a relatively smaller number of staff are required during the actual operation of the power plant while efficiency conserves not only energy but economic resources as well.

Energy efficiency can contribute to Southeast Asia's economic development and job creation in a number of ways. First, implementing energy efficiency activities creates job in a variety of trades, such as engineers, architects, contractors, plumbers, and the many jobs related to the production of energy efficiency products. Second, energy efficiency reduces the cost of electricity, and thereby creates additional jobs through "indirect" effects. Some of these indirect benefits may include the increased productivity of an industry and a country's energy use and their ability to compete in international markets. Residential customers will have lower electricity bills, which provides them with more disposable income to spend on goods and services, thus expanding local markets. When these indirect effects are taken into account, implementing energy efficiency activities tend to generate roughly 1.5 to 4 times more jobs than supply-side resources.[77] In addition, energy efficiency activities generally create jobs that utilize labor with skills that are available in the local economy of the region, whereas a power plant construction often requires highly specialized labor that has to be imported.

Renewable energy also creates employment through indirect effects. In a 1993 study for the California Energy Commission, the American Wind Energy Association (AWEA) took a comprehensive employment survey of California wind plant operators and their service providers. AWEA found an average of 460 jobs per TWh of wind energy generation power year. The results compare favorably with those for Denmark, where it has been estimated at an average of 440 jobs per TWh per year. Nearly all jobs in California are related to operating, maintaining, and servicing the existing fleet of wind turbines. California's wind industry also indirectly creates more than 4000 jobs.[78] A study by Greenpeace[79] also concluded that indirect effects accounted for 37 and 41 percent of the Germany's wind and photovoltaic energy sectors respectively.

A recent study of energy conservation and renewable resource development in Washington State, in the Pacific Northwest US, concluded that these industries had become a US $1billion industry rivaling that of Washington State's most famous export, apples. Together these industries have employed nearly 4,000 people.[80] The renewable and efficiency industries in the Pacific Northwest US, comprising the Washington, Oregon, Idaho and Montana states, are a direct outgrowth of the renewable and energy efficiency resource acquisition initiatives which have operated there since 1981.

So far there has been no study of the employment impacts of electricity generation and energy efficiency specific to the Southeast Asia region. Table 5.15 shows some employment impacts that have been estimated in other regions of the world.

[77] Biewald et al. (1995)
[78] Gipe (1995), p. 438.
[79] Greenpeace (1997), p. 23.
[80] ECONorthwest (1998)

Table 5.15: Employment Impacts

Resource	Information Source			
	Bonneville Power Administration[a]	New York State[b]	AWEA[c]	World Watch Institute[d]
	[jobs per mil. US$ invest.]	[jobs per mil. US$ invest.]	[jobs per mil. US$ invest.]	[jobs per TWh]
Central thermal electricity[e]	33[f]	13.1	13	116
Photovoltaics	N/A	7.4	N/A	N/A
Solar thermal electricity	N/A	N/A	N/A	248
Wind-generated electricity	N/A	10.0	14	542
Biomass-derived electricity	N/A	17.0-22.6	N/A	N/A
Hydro-derived electricity	N/A	4.0	8	N/A
Motors efficiency	53 (Motors, Lighting, A/C and Refrigerator efficiency combined)	21.5	N/A	N/A
Lighting efficiency		21.9	N/A	N/A
A/C efficiency		22.2	N/A	N/A
Refrigerator efficiency		13.6	N/A	N/A

[a] Source: 1984 Employment Effects of Electric Energy Conservation, Table 1-1, p. 4.

[b] Source: 1994 New York State Energy Plan, Volume III: Supply Assessments, Table 57, p. 612.

[c] Source: American Wind Energy Association (AWEA) (1995)

[d] Source: Scheer (1993), p. 110.

[e] Bonneville study compared employment impacts between nuclear and conservation. Other study's comparison was a coal plant.

[f] This analysis also examined the net differential between power production positive impacts and rate-paying negative job impacts and concludes conservation is the better investment with a net of 2 jobs per million kWh supplied while the conventional resource had a net loss of 31 jobs.

N/A means that the data is not available.

5.4 The Need for Supporting Policies

While the concept of a Renewable IPP holds great promise, it is important to realistically assess the policy scenario presented by power sector privatization and restructuring. In order for Renewable IPPs to be implemented in Southeast Asia, a regulatory and policy framework must exist to provide an environment that supports investment in and development of Renewable IPP projects.

A number of international studies have assessed the impacts of power sector privatization and restructuring on energy efficiency and renewable energy programs. These studies have reached a similar stark conclusion: that unless efficiency and renewables are explicitly concluded in the development of the reform legislation, funding for, and investment in, efficiency and renewable energy resources falls off drastically. This is because the fundamental goals of utility privatization and restructuring to improve the short-term efficiency of utility operation (without accounting for the longer term or overall costs) do not address the primary market and policy barriers to the widespread implementation of renewable energy and energy efficiency. For this reason, there is the need for a range of regulatory and market-based policies that can be used to effectively promote renewable energy. Such policies could include adequate power purchase agreements, investment and production incentives, externality adders, environmental taxation, green marketing, and other policy mechanisms.

The Appendix contains a list of supporting policies which have proven invaluable to significant expansion of renewable and efficiency energy resources.

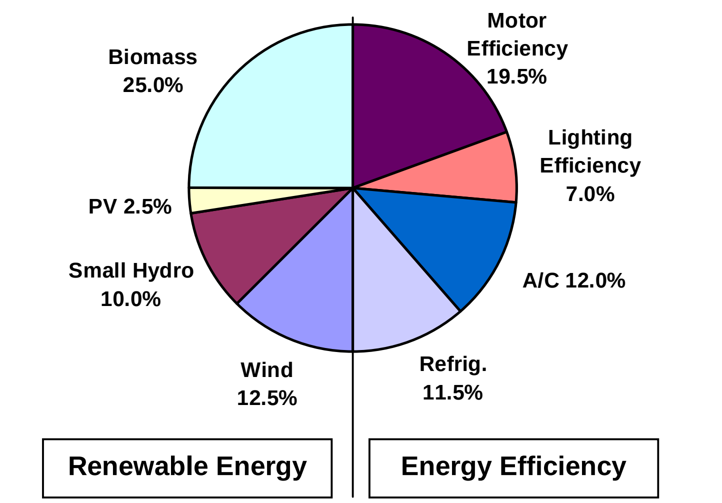
6 Conclusions

The Renewable IPP concept could be implemented either through market-driven bidding processes as those used in North America, or through policy support mechanisms similar to the "feed-in" laws found in several European countries.

North American utilities have been using a request for proposals (RFP) process to solicit competitive bids from independent power producers to provide demand-side (i.e. energy-efficiency or load management) and renewable resources. These bidding programs have led to the development of more than 1,500 MW of efficiency alone in the U.S.[81] In some cases, the utility establishes separate bidding processes for supply and efficiency resources. In other cases, the offer integrates for both supply and efficiency resources. The State of California recently procured more than 500 MW of new renewable power in a competitive auction in which they provided incentives of just 1.1 to 1.3 cents per kWh.[82]

The idea proposed in this report is to apply the IPP concept to the provision of efficiency and renewable resources in Southeast Asia by inviting bids from a full spectrum of efficiency and renewable energy service providers. This will allow the private sector to provide the least-cost solution to meet the energy needs of the market.

Figure 6.1: Energy Mix of Renewable IPP



In this report, we analyzed a hypothetical 150 MW Renewable IPP in the Southeast Asia region that would use a mix of renewable energy and energy-efficiency resources. For this case, we assumed a mix of resources that mimics the projected mix of renewable and energy-efficiency resources called for in the Philippine National Energy Plan. In actual practice, the mix of resources provided by Renewable IPPs will depend upon the market conditions and the cost and availability of efficiency and renewable resources in the particular country.

We compared the 150 MW Renewable IPP to a hypothetical coal-fired IPP of the same total generation capacity. We made the comparison in terms of environmental impacts, costs including externalities, and employment impacts.

6.1 Emissions Comparison

81 Hinge (1998)
82 Tutt (1998)

Atmospheric emissions are a quantifiable environmental impact. The estimated emissions from both hypothetical IPPs are shown below.

	Atmospheric Emissions			
	CO_2 [million metric tons per year]	**SO_2 [thousand metric tons per year]**	**NO_X [thousand metric tons per year]**	**Particulates [thousand metric tons per year]**
Coal-fired IPP	1.188	0.593	1.793	0.00346
Renewable IPP	0.012	0.079	0.180	0.01100

It is important to note that for the Renewable IPP, the contribution of emissions originates only from the biomass energy resource. Other resources in the mix do not emit significant amounts of any pollutant. Still, with the exception of particulates, the emissions of the Renewable IPP are much lower than the coal-fired IPP. Particulate emissions are lower for the coal-fired IPP because we assume that the plant is fitted with high-efficiency (99%) electrostatic precipitators. The carbon emissions of the Renewable IPP are lower than those of the coal-fired IPP by a factor of 99. Furthermore, there are no direct carbon emissions from the Renewable IPP, since carbon is absorbed when trees, plants and other biomass material grow back. The carbon contribution results from the use of machinery to harvest, collect, and transport the biomass feedstock to the power plant site.

6.2 Cost Comparison

It is important to note that wherever possible in our calculations, we have used the actual costs of implementing renewable and efficiency resources in the Southeast Asia. In cases where regional data were not available, we have used data from North America as a proxy. For the coal-fired IPP, we used actual data from Thailand and the Philippines. We found that the cost of the hypothetical Renewable IPP compares favorably to the coal-fired IPP. The following table shows the estimated electricity costs of both IPPs.

	Cost Excluding Externalities	**Cost Including Externalities**
Coal-fired IPP	4.8 US cents per kWh	7.8 US cents per kWh
Renewable IPP	5.0 US cents per kWh	5.2 US cents per kWh

Although the cost of the Renewable IPP is slightly higher than the coal-fired IPP, the addition of externality costs causes the Renewable IPP to be the least-cost option. Externalities add about 3.0 US cents per kWh to the cost of the coal-fired IPP, while only about 0.2 US cents per kWh to the cost of the Renewable IPP. The externality costs were evaluated by first estimating the types and amount of atmospheric emissions of the hypothetical IPPs. Then the average externality value (US$ per tonne of emissions) of several states in the U.S. is used to convert the amount of emissions to monetary values. The evaluation of externality costs assumes that the only externalities are due to the atmospheric emissions of the hypothetical IPPs.

It is apparent that the electricity price of the hypothetical Renewable IPP is dependent upon its energy mix. The analysis conducted in this study assumes a 50 % renewable energy – 50 % energy efficiency mix. This energy mix is based on the National Energy Plan of an actual Southeast Asian country: the Philippines. The low cost of energy efficiency measures has functioned to offset the higher cost of renewable energy, and has allowed the hypothetical

Renewable IPP to be price competitive with a coal-fired IPP of the same capacity. If the proportion of renewable energy were to increase, then the price of the Renewable IPP can be expected to increase, and the Renewable IPP as a whole will not be as competitive.

For example, a 150 MW Renewable IPP based on 100 % renewable energy resources only and keeping the same proportion of technologies (PV, wind, etc.) is expected to have an electricity price of 8.2 US cents per kWh. A scenario of 70 % renewable energy – 30 % energy efficiency is estimated to yield an electricity price of 6.3 US cents per kWh. Externality costs due to the biomass portion of the mix will be a slight addition to these numbers. In other words, it will be difficult to develop an IPP based mainly on renewable energy in Southeast Asia because the price of electricity generated will exceed even the fully externalized electricity price of a coal plant of the same capacity.

6.3 Employment Comparison

Another socioeconomic impact of electricity generation is employment. In the development of any electricity generation and service infrastructure, human resources are required to implement many activities such as manufacturing, installation, construction, operation, maintenance, etc. In general, renewable energy and energy efficiency tend to create more jobs than conventional fossil fuel-fired power plants.

Energy efficiency can contribute to Southeast Asia's economic development and job creation in a number of ways. First, implementing energy efficiency activities creates job in a variety of trades, such as engineers, architects, contractors, plumbers, and the many jobs related to the production of energy efficiency products. Second, energy efficiency reduces the cost of electricity, and thereby creates additional jobs through "indirect" effects. When these indirect effects are taken into account, implementing energy efficiency activities tend to generate roughly 1.5 to 4 times more jobs than supply-side resources.

Renewable energy also creates employment. In a 1993 study for the California Energy Commission, the American Wind Energy Association (AWEA) found an average of 460 jobs per TWh of wind energy generation power year. Similarly Denmark has estimated an average of 440 jobs per TWh per year. A study by Greenpeace also concluded that indirect effects accounted for 37 and 41 percent of the Germany's wind and photovoltaic energy sectors respectively.

Multiple studies have estimated a positive economic and employment impact from energy efficiency over conventional power plants. In all cases energy efficiency generates nearly 50 percent higher employment impact, while renewable generate at least equivalent employment and is likely to generate higher employment levels. The most recent study demonstrates the validity of these impact estimates. The Washington State study demonstrates that energy efficiency and renewable resource priorities in the utility sector deliver economic vitality. This study's carefully economic analysis documents a billion-dollar industry with nearly 4,000 jobs.

6.4 Next Steps and Opportunities

This report has presented a market-based policy framework for promoting renewable energy and energy efficiency as a primary solution for Southeast Asia's energy future. It carefully demonstrates that Renewable Independent Power Producers (IPP) can provide a significant power resource at a competitive cost, while dealing with the increasingly important issues of economic development and environmental degradation in Southeast Asia.

Next Steps

In the Southeast Asian context, the expanded view of bundling renewable energy and energy efficiency resource delivery by way of a Renewable IPP still needs some technical and policy assistance. On the policy end, several countries around the world have demonstrated the beneficial impact of key policy innovations. Yet further consideration of theses policies is not yet widespread in the Southeast Asian countries. Specific support for policy initiatives could diffuse these successes quickly were the support to come from policy peers in economic or political groupings such as APEC, ASEAN, etc., or from multilateral banks.

A key function of the Renewable IPP that is not yet proven is the ability of the IPP operator to dispatch the combination of renewable and efficiency resources. While actual dispatch would significantly enhance the value of the resource to the purchasing utility, for a variety of reasons physical dispatch may not be required, deemed dispatch might suffice. Deemed dispatch is simply giving the combination of renewable resources full credit for utility dispatchability based on prior calculations of resource availability profiles. This assertion should be examined in detail through probability analysis of existing utility systems with measurable efficiency and renewable energy components.

The components of physical dispatch for utility systems are well known. However the scalability of these systems to match the likely size of GIPP systems needs to be explored in greater detail. This may result in a need to develop smaller appropriately scaled dispatch and control systems.

Opportunities

This study has identified a number of challenges that must be overcome before the various forms of renewable energy and energy efficiency resource supply are fully accepted as viable and widely implemented. These challenges present opportunities for various key organizations and institutions to take on parts of the overall objective and move it forward through the various political, policy, technical, business and other arenas.

Educate the Renewable Energy and the Energy Conservation communities about the mutual benefit that can be achieved through the synergy of their interests. The science of demand-side management, measurement, and evaluation of energy savings is not understood by the renewable energy community. Nor are the issues of renewable energy intermittence, utility dispatch needs and other renewable resource based issues understood by the conservation and efficiency communities. This lack of mutual understanding has made it difficult for these two key solution oriented climate change constituencies to work together.

Engage multi-lateral institutions to identify issues and obstacles to the concept. There is a need to identify circumstances and information needed to prove or disprove the viability of a Renewable IPP.

Small Power Producer Dispatch Tools. There is a need to assess the current status and applicability of utility dispatch data, and control systems including hardware and software available in Europe and North America. This analysis could form the basis for a future research, development, and demonstration project that would resolve remaining technical barriers to a viable Renewable IPP.

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Appendix

List of Variables and Assumptions

		Units:	Comments:
Size of Coal-Fired IPP =	150	MW	*; size of hypothetical IPP and Renewable IPP*
Load Factor [%] =	80%		*; assumed, it is a typical load factor for a base-load coal plant*
Plant Efficiency [%] =	36%		*; value used in World Bank (1993)*
Discount Rate [%] =	10%		*; value used in World Bank (1993)*
Calorific Value of Thai imported coal =	26.4	MJ/kg	*; derived from World Bank (1993)*
Calorific Value of Phil. imported coal =	26.6	MJ/kg	*; value used in SRC International (1995)*
Annual Thai coal price escalation =	0.5%		*; derived from World Bank (1993)*
Annual Phil. coal price escalation =	2.0%		*; derived from SRC International (1995)*
Capital costs of Thai coal IPP=	1190	US$/kW	*; value used in World Bank (1993)*
Capital costs of Philippines coal IPP =	1440	US$/kW	*; value used in SRC International (1995)*
O&M costs of Thail coal IPP =	4.0%	% of capital	*; value used in World Bank (1993)*
O&M costs of Philippines coal IPP=	3.2%	% of capital	*; value used in SRC International (1995)*
Life cycle of coal power plant =	25	years	*; value used in World Bank (1993)*
Construction time =	3	years	*; value used in World Bank (1993)*
Efficiency of FGD [%] =	85%		*; derived from ADB (1995)*
Efficiency of LNB [%] =	55%		*; derived from International Energy Agency (1997)*
Efficiency of ESP [%] =	99%		*; derived from International Energy Agency (1997)*
Size of Renewable IPP =	150	MW	*; size of hypothetical Renewable IPP*
Size of biomass plant =	37.5	MW	*; allocated in proposed Renewable IPP mix*
Plant factor of biomass plant =	80%		*; assumed to be equal to that of the coal-fired plant*
Externality cost of biomass =	0.0073	US$/kWh	*; Source: AIT (1998b)*

Low Sulfur Coal Power Plant with FGD
Based on: Thailand Fuel Option Study

Assumptions:

Size[MW] =	150	Capital Costs [US$/kW] =	1190	
Load Factor [%] =	80%	O&M [% of capital] =	4%	
Plant Efficiency [%] =	36.0%	Life [yrs] =	25	
Discount Rate [%] =	10%	Construction Time [yrs] =	3	
Annual Coal Price Escalation =	0.5%	Calorific Value of Coal =	26.4	[MJ/kg]

YEAR	Capital Cost [$ mil]	Elec. Gen. [GWh/yr]	Vol. of Coal [mil. tonnes]	Imported Coal CIF [$/tonne]	Fuel Cost [$ mil.]	O&M Cost [$ mil.]	Total O&M [$ mil.]	Total Cost [$ mil.]
1998	59.5	0	0	0	0	0	0	59.50
1999	59.5	0	0	0	0	0	0	59.50
2000	59.5	0	0	0	0	0	0	59.50
2001	0	1051.2	0.398	54.81	21.82	7.14	28.96	28.96
2002	0	1051.2	0.398	55.09	21.94	7.14	29.08	29.08
2003	0	1051.2	0.398	55.36	22.04	7.14	29.18	29.18
2004	0	1051.2	0.398	55.64	22.15	7.14	29.29	29.29
2005	0	1051.2	0.398	55.75	22.20	7.14	29.34	29.34
2006	0	1051.2	0.398	56.03	22.31	7.14	29.45	29.45
2007	0	1051.2	0.398	56.31	22.42	7.14	29.56	29.56
2008	0	1051.2	0.398	56.59	22.53	7.14	29.67	29.67
2009	0	1051.2	0.398	56.87	22.64	7.14	29.78	29.78
2010	0	1051.2	0.398	57.16	22.76	7.14	29.90	29.90
2011	0	1051.2	0.398	57.45	22.88	7.14	30.02	30.02
2012	0	1051.2	0.398	57.73	22.99	7.14	30.13	30.13
2013	0	1051.2	0.398	58.02	23.10	7.14	30.24	30.24
2014	0	1051.2	0.398	58.31	23.22	7.14	30.36	30.36
2015	0	1051.2	0.398	58.60	23.33	7.14	30.47	30.47
2016	0	1051.2	0.398	58.90	23.45	7.14	30.59	30.59
2017	0	1051.2	0.398	59.19	23.57	7.14	30.71	30.71
2018	0	1051.2	0.398	59.49	23.69	7.14	30.83	30.83
2019	0	1051.2	0.398	59.78	23.80	7.14	30.94	30.94
2020	0	1051.2	0.398	60.08	23.92	7.14	31.06	31.06
2021	0	1051.2	0.398	60.38	24.04	7.14	31.18	31.18
2022	0	1051.2	0.398	60.69	24.17	7.14	31.31	31.31
2023	0	1051.2	0.398	60.99	24.29	7.14	31.43	31.43
2024	0	1051.2	0.398	61.30	24.41	7.14	31.55	31.55
2025	0	1051.2	0.398	61.60	24.53	7.14	31.67	31.67
NPV	147.97	7168.88			154.26	48.69	202.95	350.92
							US$ / kWh	0.0490

Low Sulfur Coal Power Plant with FGD
Based on: Philippines Long Term Power Planning Study

Assumptions:

Size[MW] =	150	Capital Costs [US$/kW] =	1440	
Load Factor [%] =	80%	O&M [% of capital] =	3.2%	
Plant Efficiency [%] =	36.0%	Life [yrs] =	25	
Discount Rate [%] =	10%	Construction Time [yrs] =	3	
Annual Coal Price Escalalation =	2.0%	Calorific Value of Coal =	26.6	[MJ / kg]

YEAR	Capital Cost [$ mil]	Elec. Gen. [GWh/yr]	Vol. of Coal [mil. tonnes]	Cal. Value [GJ]	Imp. Coal [$/GJ]	Fuel Cost [$ mil.]	O&M Cost [$ mil.]	Total O&M [$ mil.]	Total Cost [$ mil.]
1998	72	0	0	0	0	0	0	0	72.00
1999	72	0	0	0	0	0	0	0	72.00
2000	72	0	0	0	0	0	0	0	72.00
2001	0	1051.2	0.395	10512000	1.35	14.19	6.91	21.10	21.10
2002	0	1051.2	0.395	10512000	1.38	14.51	6.91	21.42	21.42
2003	0	1051.2	0.395	10512000	1.41	14.82	6.91	21.73	21.73
2004	0	1051.2	0.395	10512000	1.44	15.14	6.91	22.05	22.05
2005	0	1051.2	0.395	10512000	1.48	15.56	6.91	22.47	22.47
2006	0	1051.2	0.395	10512000	1.51	15.87	6.91	22.79	22.79
2007	0	1051.2	0.395	10512000	1.54	16.19	6.91	23.10	23.10
2008	0	1051.2	0.395	10512000	1.57	16.50	6.91	23.42	23.42
2009	0	1051.2	0.395	10512000	1.61	16.92	6.91	23.84	23.84
2010	0	1051.2	0.395	10512000	1.64	17.24	6.91	24.15	24.15
2011	0	1051.2	0.395	10512000	1.67	17.58	6.91	24.50	24.50
2012	0	1051.2	0.395	10512000	1.71	17.94	6.91	24.85	24.85
2013	0	1051.2	0.395	10512000	1.74	18.29	6.91	25.21	25.21
2014	0	1051.2	0.395	10512000	1.78	18.66	6.91	25.57	25.57
2015	0	1051.2	0.395	10512000	1.81	19.03	6.91	25.95	25.95
2016	0	1051.2	0.395	10512000	1.85	19.41	6.91	26.33	26.33
2017	0	1051.2	0.395	10512000	1.88	19.80	6.91	26.71	26.71
2018	0	1051.2	0.395	10512000	1.92	20.20	6.91	27.11	27.11
2019	0	1051.2	0.395	10512000	1.96	20.60	6.91	27.52	27.52
2020	0	1051.2	0.395	10512000	2.00	21.02	6.91	27.93	27.93
2021	0	1051.2	0.395	10512000	2.04	21.44	6.91	28.35	28.35
2022	0	1051.2	0.395	10512000	2.08	21.86	6.91	28.78	28.78
2023	0	1051.2	0.395	10512000	2.12	22.30	6.91	29.21	29.21
2024	0	1051.2	0.395	10512000	2.16	22.75	6.91	29.66	29.66
2025	0	1051.2	0.395	10512000	2.21	23.20	6.91	30.11	30.11
NPV	179.05	7168.88				114.39	47.14	161.53	340.58
								US$ / kWh	0.0475

Externality Costs of Coal-Fired IPP

Externality Values (US$/metric ton)*

State	CO2	SO2	NOX	Particulates
California	10	4,945	10,053	5,079
Massachusetts	26	1,874	7,937	4,850
Minnesota	11	165	937	1,404
Nevada	26	1,892	8,245	5,068
New York	1	1,584	2,090	367
Oregon	28	0	3,858	3,307
Average	**17**	**2,092**	**5,520**	**3,346**

Emission of Coal-Fired Power Plant [grams per kWh electricity] **

CO2	SO2	NOX	Particulates
1,130	3.760	3.790	0.329

Pollutants Emitted Annually by 150 MW Coal-Fired IPP

Capacity [MW]	Load Factor [%]	Electricity [GWh/yr]	CO2 [mil metric tons]	SO2 [1000 metric tons]	NOX [1000 metric tons]	Particulates [1000 metric tons]
150	80%	1051.2	1.188	3.953	3.984	0.346

Pollutants Reduced by FGD and Other Emission Reduction Technologies

CO2 [mil metric tons]	SO2 [1000 metric tons]	NOX [1000 metric tons]	Particulates [1000 metric tons]
1.188	0.593	1.793	0.00346

Externality Costs of Pollutants

CO2	SO2	NOX	Particulates	Sum
Mil. US$	Mil. US$	Mil. US$	Mil. US$	**Mil. US$**
20.19	1.24	9.90	0.01	**31.34**

Footnotes:

* Source: United States Department of Energy (1995)

** Source: ADB (1995)

Low Sulfur Coal Power Plant with FGD
Based on: Thailand Fuel Option Study
INCLUDING EXTERNALITY COSTS

Assumptions:

Size[MW] =	150	Capital Costs [US$/kW] =	1190	
Loadt Factor [%] =	80%	O&M [% of capital] =	4%	
Plant Efficiency [%] =	36.0%	Life [yrs] =	25	
Discount Rate [%] =	10%	Construction Time [yrs] =	3	
Annual Coal Price Escalation =	0.5%	Calorific Value of Coal =	26.4	[MJ/kg]

YEAR	Capital Cost [$ mil]	Elec. Gen. [GWh/yr]	Vol. of Coal [mil. tonnes]	Imported Coal CIF [$/tonne]	Fuel Cost [$ mil.]	O&M Cost [$ mil.]	Total O&M [$ mil.]	Externality Costs [$ mil.]	Total Cost [$ mil.]
1998	59.5	0	0	0	0	0	0	0	59.50
1999	59.5	0	0	0	0	0	0	0	59.50
2000	59.5	0	0	0	0	0	0	0	59.50
2001	0	1051.2	0.398	54.81	21.82	7.14	28.96	31.34	60.31
2002	0	1051.2	0.398	55.09	21.94	7.14	29.08	31.34	60.42
2003	0	1051.2	0.398	55.36	22.04	7.14	29.18	31.34	60.53
2004	0	1051.2	0.398	55.64	22.15	7.14	29.29	31.34	60.64
2005	0	1051.2	0.398	55.75	22.20	7.14	29.34	31.34	60.68
2006	0	1051.2	0.398	56.03	22.31	7.14	29.45	31.34	60.79
2007	0	1051.2	0.398	56.31	22.42	7.14	29.56	31.34	60.90
2008	0	1051.2	0.398	56.59	22.53	7.14	29.67	31.34	61.01
2009	0	1051.2	0.398	56.87	22.64	7.14	29.78	31.34	61.13
2010	0	1051.2	0.398	57.16	22.76	7.14	29.90	31.34	61.24
2011	0	1051.2	0.398	57.45	22.88	7.14	30.02	31.34	61.36
2012	0	1051.2	0.398	57.73	22.99	7.14	30.13	31.34	61.47
2013	0	1051.2	0.398	58.02	23.10	7.14	30.24	31.34	61.58
2014	0	1051.2	0.398	58.31	23.22	7.14	30.36	31.34	61.70
2015	0	1051.2	0.398	58.60	23.33	7.14	30.47	31.34	61.82
2016	0	1051.2	0.398	58.90	23.45	7.14	30.59	31.34	61.93
2017	0	1051.2	0.398	59.19	23.57	7.14	30.71	31.34	62.05
2018	0	1051.2	0.398	59.49	23.69	7.14	30.83	31.34	62.17
2019	0	1051.2	0.398	59.78	23.80	7.14	30.94	31.34	62.29
2020	0	1051.2	0.398	60.08	23.92	7.14	31.06	31.34	62.40
2021	0	1051.2	0.398	60.38	24.04	7.14	31.18	31.34	62.52
2022	0	1051.2	0.398	60.69	24.17	7.14	31.31	31.34	62.65
2023	0	1051.2	0.398	60.99	24.29	7.14	31.43	31.34	62.77
2024	0	1051.2	0.398	61.30	24.41	7.14	31.55	31.34	62.89
2025	0	1051.2	0.398	61.60	24.53	7.14	31.67	31.34	63.01
NPV	147.97	7168.88			154.26	48.69	202.95	213.74	564.66
							US$ / kWh		0.0788

Low Sulfur Coal Power Plant with FGD
Based on: Philippines Long Term Power Planning Study
INCLUDING EXTERNAILITY COSTS

Assumptions:

Size[MW] =	150	Capital Costs [US$/kW] =	1440	
Load Factor [%] =	80%	O&M [% of capital] =	3.2%	
Plant Efficiency [%] =	36.0%	Life [yrs] =	25	
Discount Rate [%] =	10%	Construction Time [yrs] =	3	
Annual Coal Price Escalation =	2.0%	Calorific Value of Coal =	26.6	[MJ / kg]

YEAR	Capital Cost [$ mil]	Elec. Gen. [GWh/yr]	Vol. of Coal [mil. tonnes]	Cal. Value [GJ]	Imp. Coal [$/GJ]	Fuel Cost [$ mil.]	O&M Cost [$ mil.]	Total O&M [$ mil.]	Externality Costs [$ mil.]	Total Cost [$ mil.]
1998	72	0	0	0	0	0	0	0	0	72.00
1999	72	0	0	0	0	0	0	0	0	72.00
2000	72	0	0	0	0	0	0	0	0	72.00
2001	0	1051.2	0.395	10512000	1.35	14.19	6.91	21.10	31.34	52.44
2002	0	1051.2	0.395	10512000	1.38	14.51	6.91	21.42	31.34	52.76
2003	0	1051.2	0.395	10512000	1.41	14.82	6.91	21.73	31.34	53.08
2004	0	1051.2	0.395	10512000	1.44	15.14	6.91	22.05	31.34	53.39
2005	0	1051.2	0.395	10512000	1.48	15.56	6.91	22.47	31.34	53.81
2006	0	1051.2	0.395	10512000	1.51	15.87	6.91	22.79	31.34	54.13
2007	0	1051.2	0.395	10512000	1.54	16.19	6.91	23.10	31.34	54.44
2008	0	1051.2	0.395	10512000	1.57	16.50	6.91	23.42	31.34	54.76
2009	0	1051.2	0.395	10512000	1.61	16.92	6.91	23.84	31.34	55.18
2010	0	1051.2	0.395	10512000	1.64	17.24	6.91	24.15	31.34	55.49
2011	0	1051.2	0.395	10512000	1.67	17.58	6.91	24.50	31.34	55.84
2012	0	1051.2	0.395	10512000	1.71	17.94	6.91	24.85	31.34	56.19
2013	0	1051.2	0.395	10512000	1.74	18.29	6.91	25.21	31.34	56.55
2014	0	1051.2	0.395	10512000	1.78	18.66	6.91	25.57	31.34	56.91
2015	0	1051.2	0.395	10512000	1.81	19.03	6.91	25.95	31.34	57.29
2016	0	1051.2	0.395	10512000	1.85	19.41	6.91	26.33	31.34	57.67
2017	0	1051.2	0.395	10512000	1.88	19.80	6.91	26.71	31.34	58.06
2018	0	1051.2	0.395	10512000	1.92	20.20	6.91	27.11	31.34	58.45
2019	0	1051.2	0.395	10512000	1.96	20.60	6.91	27.52	31.34	58.86
2020	0	1051.2	0.395	10512000	2.00	21.02	6.91	27.93	31.34	59.27
2021	0	1051.2	0.395	10512000	2.04	21.44	6.91	28.35	31.34	59.69
2022	0	1051.2	0.395	10512000	2.08	21.86	6.91	28.78	31.34	60.12
2023	0	1051.2	0.395	10512000	2.12	22.30	6.91	29.21	31.34	60.56
2024	0	1051.2	0.395	10512000	2.16	22.75	6.91	29.66	31.34	61.00
2025	0	1051.2	0.395	10512000	2.21	23.20	6.91	30.11	31.34	61.46
NPV	179.05	7168.88				114.39	47.14	161.53	213.74	554.33
								US$ / kWh		0.0773

Renewable IPP Cost Analysis

Total Generation Capacity = 150 MW

Green Energy Resource	Estimated Electricity Cost*	Allocated % in Mix**	Theoretical Weighted Cost	Adjusted Weighted Cost***
	US Cents per kWh		US Cents per kWh	US Cents per kWh
Renewables				
Photovoltaics	15.00	2.5%	0.38	0.49
Solar Thermal Electric	8.00	0.0%	0.00	0.00
Wind	5.00	12.5%	0.63	0.81
Biomass	6.25	25.0%	1.56	2.03
Small Hydro	6.00	10.0%	0.60	0.78
Energy Efficiency				
Motor Efficiency	1.05	19.5%	0.20	0.27
Lighting Efficiency	1.50	7.0%	0.11	0.14
Air-conditioning Efficiency	2.00	12.0%	0.24	0.31
Refrigerator Efficiency	1.00	11.5%	0.12	0.15
Total Cost of GIPP******			**3.83**	**4.98**
			US Cents / kWh	**US Cents / kWh**

FOOTNOTES

* The estimated renewable energy generation costs are based on U.S. data and projections. All costs for energy efficiency measures are based on Asian sources. These costs are meant to provide a general estimate of a possible per kWh cost for a hypothetical renewable or energy efficiency power generation project. Please see the text for more explanation.

** Resource allocations were drawn from the Philippines National Energy Plan previously discussed. The allocation is reflective only of the Philippines' resources/generation potential or relative cost advantages. Thus an actual Renewable IPP would likely have a different mix of renewables and energy efficiency. Further, a given country would benefit most from first maximizing the use of its least expensive resourcs, e.g. energy efficiency.

*** The per kWh costs are adjusted by an additional 30% for the bundled, individual project: per-site engineering, project design, project development, project management, power transmission, logistics, structuring and financing costs for the multiple, smaller projects that constitute the total 150 MW to be generated.

**** Note that these figures are for a hypothetical use of renewable energy and energy efficiency resources for energy generation internationally. Actual project costs could vary widely depending on the project size, location, structure, fuel supply (if applicable) initial and long term cost of capital, and other factors.

Externality Costs of Renewable IPP

Emission of Biomass Power Plant [grams per kWh electricity] **

CO_2	SO_2	NOX	Particulates
45.9	0.302	0.686	0.0416

Pollutants Emitted Annually by Biomass Plant

Capacity [MW]	Load Factor [%]	Electricity [GWh/yr]	CO_2 [mil metric tons]	SO_2 [1000 metric tons]	NOX [1000 metric tons]	Particulates [1000 metric tons]
37.5	80%	262.8	0.012	0.079	0.180	0.011

Externality Cost of Biomass* =** 0.0073 US$/kWh

Percent of Biomass in GIPP mix = 25%

Externality Cost of GIPP = 0.00183 US$/kWh

Footnotes:

* Source: United States Department of Energy (1995)

** Source: Spath and Mann

*** Source: Asian Institure of Technology (1998)

Policy Mechanisms for Promoting Renewable Energy

There are a range of regulatory and market-based policies that can be used to effectively promote renewable energy. These have been tried in a number of industrialized and developing countries over the past twenty years. The section below is drawn from a recent report to the Thai government. It briefly summarizes the types of tools at the disposal of policymakers.[83] A number of these may still be necessary as supporting policies to a Renewable IPP regime.

Power Purchase Agreements
Reliable power purchase contracts are perhaps the single most critical requirement of a successful renewable energy project. The vast majority of renewable energy projects have been implemented by independent developers who are not affiliated with utilities.

Investment Incentives
Investment incentives are often used to reduce project developers' capital costs and thus induce developers to invest in renewable energy. Incentives are typically paid either by the government through the general tax base or by utility customers through a surcharge on their utility bills. They can take a variety of forms, including subsidies, tax credits, and preferential finance.

Production Incentives
Unlike investment incentives, which are paid based on initial capital costs, production incentives are paid per kWh of electricity generated. Production incentives can be superior to investment incentives by eliminating the temptation to inflate initial project costs and by encouraging developers to build reliable facilities which maximize energy production.

Externality Adders
Some regulators have attempted to address this issue of environmental externalities by increasing the hypothetical cost of conventional power plants through an environmental externality charge or "adder" in the planning stage. Typically, externality adders are included only in the planning stage for resource selection but are not actually charged on operations, thus not affecting power plant dispatch once projects are built.

Environmental Taxation
Like the externality adder, environmental taxation adds to the cost of fossil fuel based energy by imposing a per-kWh tax on the basis of pollutant emissions. Environmental taxation can thus provide a competitive advantage to renewable technologies with low emissions. Unlike the externality adder, however, environmental taxes involve actual payment of money and are not merely a hypothetical charge for planning purposes only.

Research, Development, and Demonstration Grants
Many governments provide research, development, and demonstration (RD&D) grants for renewable energy technologies as well as for resource assessment, environmental considerations, and other related areas. According to the International Energy Agency, OECD spending on renewable energy research and development (R&D) was on the order of US$ 880 million in 1995, the largest percentage of which came from the USA, followed by Japan, Germany, and Spain (IEA, 1997).

[83] Redlinger (1998)

Government-Assisted Business Development

Governments can also indirectly stimulate the implementation of renewable energy by providing various types of business development assistance. Possible types of assistance include encouraging the formation of risk-sharing consortia, providing technology export promotion, setting technical and safety standards and providing certification, and others. One mechanism successfully employed in Sweden is known as "technology procurement," in which the government organizes a consortium of buyers (e.g., of wind turbines), specifies technical specifications, and solicits bids from manufacturers.

Green Marketing

Green marketing is a relatively new concept in which electricity customers are given the option to voluntarily pay a higher price for electricity generated from renewable sources. This concept stems from the fact that many surveys conducted in many developed countries indicate that members of the public would be willing to pay a price premium for clean energy; and green marketing thus allows people to "vote with their wallet" for renewables. There is little evidence to date, however, that green marketing programs have had a significant impact on the penetration of renewable energy and energy-efficiency technologies.

Other Policy Mechanisms

Other mechanisms exist for promoting the implementation of renewable energy. One such mechanism that allows flexible access to the electricity grid is *wheeling*, in which the utility's transmission grid can be used to transmit, or "wheel", the power from the generation site to the consumer's site. Another is *electricity banking*, which is a contractual system in which renewable generators can essentially "store" their electricity in the utility grid, to be used later.