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NEW AND RENEWABLE ENERGY IN THE APEC REGION

PROSPECTS FOR ELECTRICITY GENERATION

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FOREWORD

I am pleased to present the final report of the study, New and Renewable Energy in the APEC Region: "Prospects for Electricity Generation". The study is one of four research projects commenced in mid-2003, and is the second in the series of studies undertaken by APERC in the similar field since 1999.

The objective of the study is to investigate the penetration of New and Renewable Energy (NRE) technologies in the APEC Region with the aim of providing some insights for other economies that have plans to promote the further use of NRE in their respective economies particularly for electricity generation.

The principal findings of the study are highlighted in the executive summary of this report.

This report is published by APERC as an independent study and does not necessarily reflect the views or policies of the APEC Energy Working Group or of individual APEC member economies.

Masaharu Fujitomi
President
Asia Pacific Energy Research Centre

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APEC	Asia-Pacific Economic Co-operation
APERC	Asia Pacific Energy Research Centre
ASEAN	Association of Southeast Asian Nations
AWEA	American Wind Energy Association
AusWEA	Australian Wind Energy Association
CCGT	Combined Cycle Gas Turbine
CO_2	Carbon dioxide
CWEA	Canadian Wind Energy Association
DG	Distributed Generation
EDMC	Energy Data and Modelling Centre (Japan)
EIA	Energy Information Administration (USA)
EWEA	European Wind Energy Association
GDP	Gross Domestic Product
GHG	Greenhouse gas
GW	Gigawatt (10^9 Watts)
GWh	Gigawatt hour (one million kilowatt hours)
IEA	International Energy Agency
IPPs	Independent Power Producers
JPEA	Japan Photovoltaic Energy Association
kW	Kilowatt (= 1,000 watts)
kWh	Kilowatt hour (= 1,000 watts hour)
ktoe	Kilo tonnes of oil equivalent
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
METI	Ministry of Economy, Trade and Industry
MRET	Minimum Renewable Energy Target
Mtoe	Million tonnes of oil equivalent
MW	Megawatts (= 1,000 kilowatts)
MWh	Megawatt hour (one thousand kilowatt hours)
NEDO	New Energy & Industrial Technology Development Organization
NREL	National Renewable Energy Laboratory US DOE
NO_X	Nitrogen oxides
OECD	Organisation for Economic Cooperation and Development
ONL	Oakridge National Laboratory (US DOE)
PVTEC	Photovoltaic Power Generation Technology Association
PV	Photovoltaic
RE	Renewable energy
RPS	Renewable Portfolio Standard
Si	Silicon
SO_X	Sulphur oxide
TPES	Total Primary Energy Supply
TWh	Terawatt hour (one billion kilowatt hours)
US or USA	United States (of America)
US DOE	United States Department of Energy
Wp	Peak Watt(s)

EXECUTIVE SUMMARY

The positive attributes of generating electricity from new and renewable energy (NRE) sources are widely accepted worldwide, although some of these technologies may not be currently competitive commercially with conventional fuels. Nevertheless, they could address four key issues related to electricity generation, namely, environmental concern, energy security, rural electrification and applications in niche markets where conventional electricity supply is not feasible.

BENEFITS OF NRE FOR THE APEC REGION

There are four major areas where electricity generation could benefit from new and renewable energy:

- provide environmental benefits by avoiding greenhouse gases and other pollutants like sulphur dioxide, nitrogen oxide and particulate matters;
- provide indigenous, safe and reliable energy supply;
- offer a cost-effective alternative to supply electricity to rural households; and
- serve as an alternative electricity supply option for niche markets where conventional electricity supply technology is not cost-competitive or practical.

Electricity generation from NRE can avoid environmental degradation associated with conventional fossil-fuelled technologies that emit greenhouse gases (GHGs) as well as other atmospheric emissions like sulphur dioxide, nitrogen oxide and particulate matters. Coal is currently the main fuel for electricity generation in the APEC region and will probably remain so until at least 2020. Although it is currently the most abundantly available and the cheapest fuel, it also produces the highest atmospheric emissions. APEC economies with high dependence on coal for electricity generation could therefore, reduce atmospheric emissions by introducing NRE technologies. China is already taking positive measures by introducing NRE technologies like wind, photovoltaics (PV), biomass and hydro in large scales. The United States could take similar measures, for example, by harnessing the vast wind resources in North Dakota and Texas to reduce GHG emissions from its coal plants.

The APEC region has an overall energy import dependency of about 10 percent and this is expected to increase to 19 percent in 2020[1]. APEC Asia's dependency is even much higher, at 60 percent and 80 percent for the same period (1999-2020). Many of these economies are also the fastest growing in the region and the most vulnerable to oil price volatility and supply disruption. Chinese Taipei, Hong Kong, China, Korea and Japan are economies that could strengthen their security of supply by increasing NRE utilisation in power generation. Although these economies also have a significant share of the region's nuclear capacity, eroding public acceptance and heightened terrorist threats could render nuclear as a non-option.

NRE has been widely utilised by developing economies for providing electricity to rural households. Most often, this is also the most cost-effective option for providing electricity in areas too remote for electricity grid extension. Without NRE, rural communities in most of these economies may never get the needed electricity supply for decades to come. China's rural electrification programme, utilising PV and wind technology, serves as a shining example for other developing economies.

[1] APERC (2002)

Aside from direct power applications, NRE technologies also serve as the most cost-effective and practical solution in a wide range of niche market applications such as in telecommunication repeater stations, navigation buoys, lighthouses, vaccine refrigeration, etc. NRE is the most practical choice for these growing markets.

NRE RESOURCES AND APPLICATIONS

There is a current lack of comprehensive renewable energy resource data for wind and photovoltaics in the APEC region. In many economies where reasonably detailed data on renewable energy is available, the resources far exceed current energy demand. In some economies certain NRE technologies were not even considered as a viable option until preliminary resource assessment has indicated otherwise. The Philippines, for example, which previously has not considered wind as an economically viable option (due to absence of resource data) is now developing three utility-scale wind farms of 40 MW each[2].

Many developing economies in the region still do not have renewable energy resource data and exclude NRE technologies such as wind and photovoltaics from their generation planning. In terms of NRE applications, developed economies are well ahead of developing economies in the region in all respects. Most of the current installed NRE capacities are in developed economies where the size of such facilities is relatively larger or utility-scale. These economies also have well-established institutional and regulatory framework. In contrast, developing economies utilise NRE technologies almost exclusively for rural electrifications and other niche market applications.

BARRIERS AND POLICY OPTIONS

The main hurdles that impede greater deployment of NRE technologies are high costs, inadequate regulatory and institutional framework and various market barriers. These hurdles could be cleared in part by employing the following policy options:

- **Demand-pull strategies** such as Renewable Portfolio Standards (RPS) have been successfully utilised to stimulate demand for electricity from NRE sources in several states in United States. The most compelling evidence for the successes of feed-in-tariff is Germany, where wind capacity grew from virtually zero in 1990s to 14,000 MW in 2003[3];
- **Financial incentives** in the form of subsidies and rebates, tax credits and grants have provided a significant boost to the deployment of NRE technologies in developing economies. The Production Tax Credit (PTC) policy of the United States clearly illustrates the significant role for these incentives where investment in new wind capacity stopped altogether when the policy expired in 2001. Rebates offered by the Japanese government under its sunshine policy have turned Japan into a world leader in terms of installed PV capacity as well as PV module/cell manufacturer;
- **Market facilitation and investment** policy in the form of public benefit fund, carbon tax and government procurement have been very successful in stimulating demand for NRE in several states in the United States as well as other economies;
- **Rural electrification** policy such as energy service concession, micro credit and rural business development reveals positive gains in the development of new NRE capacity. One of the most successful cases for rural energy service concession is the World Bank/PERMER project in Argentina[4];

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[2] Renewable Energy Policy Framework, Department of Energy, Philippines, 2003

[3] Martinot (2004)

[4] Reiche, Covarrubias and Martinot (2000)

- **Distributed generation policies** such as real-time pricing and net-metering have successfully stimulated growth in NRE technologies. Japan and the United States present evidence of substantial gains resulting from these policies.

SCENARIO ANALYSIS

APEC economies would gain substantial environmental and economic benefits if the share of NRE in electricity generation were increased. Increasing the share of NRE in the generation fuel mix to 42 percent by 2050 would result in a total fuel cost savings of US$4.4 to US$5.8 trillion. Total carbon dioxide emissions of between 206 billion and 254 billion tons could also be avoided depending on the timeframe adopted. This should be examined more carefully, however, by comparing the costs of deploying NRE technologies in large-scale taking into consideration their technical limitations. The comparative cost analysis is not included in this study.

INTRODUCTION

WHY IS NRE IMPORTANT TO THE ELECTRICITY SECTOR?

The positive attributes of generating electricity from new and renewable energy (NRE) sources are widely accepted, although some of these technologies may not be currently competitive commercially with conventional fuels. NRE technologies can help solve energy issues related to electricity generation, namely, **environmental concern**, **energy security**, **rural electrification** and applications in **niche markets** where conventional electricity supply is not feasible.

Almost all economies are facing the challenge of sustaining their economic growth and at the same time ensuring a clean environment. The extent of environmental degradation and its impacts on people depends on various factors, such as geographical location, share of generating plants with high atmospheric emissions, level of industrialisation and the technologies employed. Fossil fuel combustion for electricity generation is one of the major causes of anthropogenic greenhouse gas (GHG) emissions, but one that can be averted and mitigated with NRE technologies. Developed economies with commitments to reduce their GHG emissions could especially benefit by harnessing more renewable energy to meet their electricity demand.

Although developing economies generally do not have any commitments to reduce their GHG emissions, they could take advantage of the clean development mechanism under the Kyoto Protocol (KP) as well as bilateral and multilateral assistance from developed economies to harness NRE resources to meet their energy demand. This would ensure a more sustainable development while at the same time curtail environmental degradation related to electricity infrastructure development.

Developing economies with underdeveloped energy infrastructures also stand to benefit the most by taking the right step from the beginning with NRE technologies. Introduction of NRE technologies as a retrofit to existing fossil-fuelled plants poses various challenges and usually incur very high costs unlike new generating facilities utilising NRE.

NRE resources are also available across the APEC region in various percentages of total primary energy supply (TPES). Utilisation of depletable fossil fuel is not a sustainable option in the long term. Furthermore, fossil fuels are subject to price-volatility and the fuel supply chain is vulnerable to disruptions. Most of the APEC economies are energy importers with an overall energy import dependency for the region that is expected to reach 19 percent by 2020 from 10 percent in 1999. APEC Asia's oil dependency is expected to increase from 60 percent in 1999 to 80 percent by 2020 and this region is also expected to have one of the highest growth rates in the APEC region.[5] It is especially critical for the developing economies in APEC that are currently dependent on oil import, to diversify their energy supply by harnessing NRE in order to sustain their economic growth. NRE technologies have been utilised in niche markets where conventional electricity supply is not cost-competitive or practical. Photovoltaic (PV) technology that was initially utilised by NASA in outer space exploration has been expanded to a variety of applications ranging from powering small calculators to remote telecommunications repeater stations, navigational buoys, street lights, power supply to off-shore oil rigs and other applications.

Some of the more common NRE applications in most developing economies are task-oriented such as providing electricity for water pumps, refrigeration for remote health facilities (vaccine storage) as well as other agriculture-related applications. The ongoing research and development (R&D) of solar PV technology, has resulted in newer materials such as the thin-film type that can be folded and stowed. It is currently being tested for a number of applications ranging from

[5] APERC (2002)

rooftop power generation to powering military equipments in battlefields. Other technologies like wind are also utilised in niche markets, especially in remote areas, for charging batteries, as power supply for water pumps, as well as other agriculture-related applications.

Utilisation of NRE technologies in developing economies are mostly concentrated in rural electrification as well as other task-oriented applications. Photovoltaic and wind turbines serve as the most appropriate and cost-effective option for electrifying rural households in developing economies. Adequately planned and implemented electricity systems utilising PV and wind energy require little maintenance. These systems that are provided to communities in remote places where grid extension is economically infeasible could make a world of difference in improving the quality of life of the people living in these areas.

Despite the compelling evidence in support of NRE technologies, NRE's utilisation for electricity generation remains marginal due in part to technical limitations. Due to the intermittent nature of electricity from wind and PV, these technologies could not substitute conventional power plants unless they are connected to diesel generators (as hybrid systems) or other energy storage technologies. Aside from these limitations, the costs of generating electricity from some NRE technologies are higher than conventional plants. Existing regulatory barriers (such as restrictions on siting, access to grid and construction), in most economies are also not supportive of NRE technologies while various market barriers (for example lack of access to credit); make these technologies unattractive to investors.

However, the implementation of favourable energy policies could help expand NRE technologies to their technical limits. If NRE technologies like wind and PV are to be fully deployed to their current on-grid limit of 20 percent[6], APEC economies stand to make substantial gains in terms of savings from displaced fossil fuels. In addition to monetary gains, economies could also reduce significant amounts of GHGs and other pollutants like nitrogen oxide and sulphur dioxide. By implementing these policies now, APEC economies could accelerate the learning rate of these technologies and bring down further their costs relative to competing fossil fuels.

SCOPE OF STUDY

The utilisation of NRE technologies is more promising for electricity generation currently. This study is therefore, focused on the role of NRE technologies in electricity generation in the APEC region and will:

- examine the current status of NRE technology utilisation in the APEC region;
- examine the existing barriers that impede greater utilisation of NRE technologies in the region;
- analyse possible paths to increase NRE utilisation and the benefits to be gained under different scenarios; and
- propose possible policy options that can be adopted to accelerate the deployment of NRE technologies.

[6] Grid-connected wind in Denmark is up to 20 percent currently and is expected to increase to 50 percent by the year 2030.

NRE RESOURCES AND THEIR CURRENT UTILISATION IN SOME APEC ECONOMIES

INTRODUCTION

Renewable energy has long been an important source of fuel for electricity generation in the APEC region and the rest of the world. Canada, New Zealand, Peru and Vietnam all had more than 50 percent of their electricity generated from hydro in 1999[7]. Hydropower and biomass have been the two most commonly used renewable energy resources in the region.

Wind and Photovoltaics (PV) recorded double-digit annual growths of 17 and 29 percent, for the 1993 to 2003 period, however, it must be noted that these high growths were recorded from a very low base of 1,700 MW for wind and 93.4 MW for PV in 1993.[8] The share of both wind and PV in electricity generation is still marginal for the APEC region. Other sources of NRE like mini hydro, geothermal and biomass recorded a more moderate growth since these are relatively mature technologies.

Developed economies in the APEC region with better financial and technical resources have been better able to harness NRE resources for power generation. Large, utility-scale renewable electricity facilities such as wind and photovoltaics are only available in developed economies currently. Developing economies on the other hand, still rely on financial and technical support from more developed economies to exploit their NRE resources.

Technological advances and policy support in the last decade have also helped in making photovoltaics (PV) and wind energy emerge as the fastest growing NRE technologies in the world. Ongoing research, development and demonstration (RD&D) as well as favourable policy support have boosted the development of wind and photovoltaics in the APEC region by reducing the electricity generation costs. Generation costs for these technologies are expected to decline further with market expansion and further technological improvements. Table 1 shows the cost trend for wind, PV, geothermal, hydro and biomass.

Table 1 NRE Technology Investment and Generation Cost Trend

	$/kW		Cents/kWh (low)		Cents/kWh (high)	
NRE Technology	2002	2010	2002	2010	2002	2010
Wind	850-1700	700-1300	3-5	2-4	10-12	6-9
PV	4500-7000	3000-4500	18-20	10-15	25-80	18-40
Small hydro	1000-5000	950-4500	2-3	2	9-15	8-13
Geothermal	1200-5000	1000-3500	2-5	2-3	6-12	5-10
Biomass	500-4000	400-3000	2-3	2	10-15	8-12

Source : IEA (2003) citing NET Ltd. Switzerland

[7] APERC (2001)

[8] For comparison, the total electricity generated in APEC in 1993 was 7,457 TWh (approximately 851 GW)

The remaining issue however, is, how to accelerate the deployment of NRE in the developing economies of APEC bearing in mind that these economies will be experiencing the highest growth rate in the next 40 years. Without any commitments to reduce GHG emissions currently, developing economies in the region, would account for 14.1 billion tons of CO2 emissions or 68 percent of total emissions in 2050[9]. Although many projects have been implemented in developing economies under the CDM mechanism, the most effective way to accelerate the deployment of renewable energy technology is by technology transfer and technical and financial support from developed economies. The development of a domestic PV industry in China is a good example of how such a cooperation and technology transfer could work.

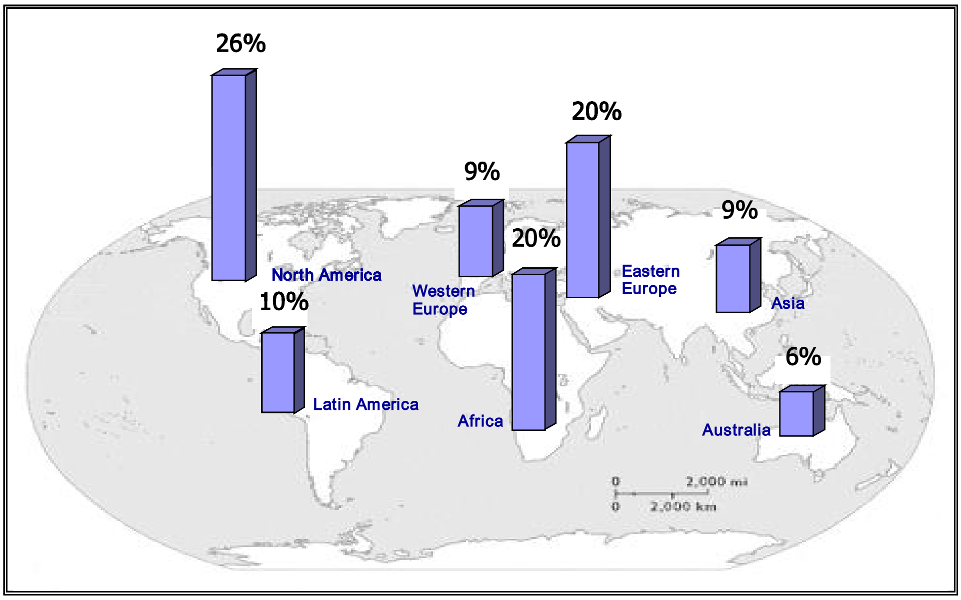
One of the main issues related to technology transfer that makes developed economies wary of recipient economy is the intellectual property rights issue. Developing economies could address this by enacting and enforcing appropriate laws concerning intellectual property rights.

Despite the expanding market liberalisation and globalisation, many developing economies still impose high tariffs on imported renewable energy equipments. This issue often stems from old tariff classification systems that has not been updated or a lack of understanding due to poor access to information. Both donor economy and recipients of NRE technology transfer could work together to address this issue.

WIND RESOURCES AND ITS UTILISATION

Wind technology is currently the fastest growing energy technology in the world. Its global annual growth rate in 2003 exceeded 30 percent, more than in the APEC region at 17 percent per annum for that year. However, it must be acknowledged that these high growths were accomplished from only a small base. The global total installed capacity for wind was 40.3 GW at the end of 2003. The corresponding figure for the APEC region was 8.1 GW. The global distribution of wind energy resources is shown in Figure 1 below.

Figure 1 Global Distribution of Wind Energy Resources (Total: 53,000TWh/year)

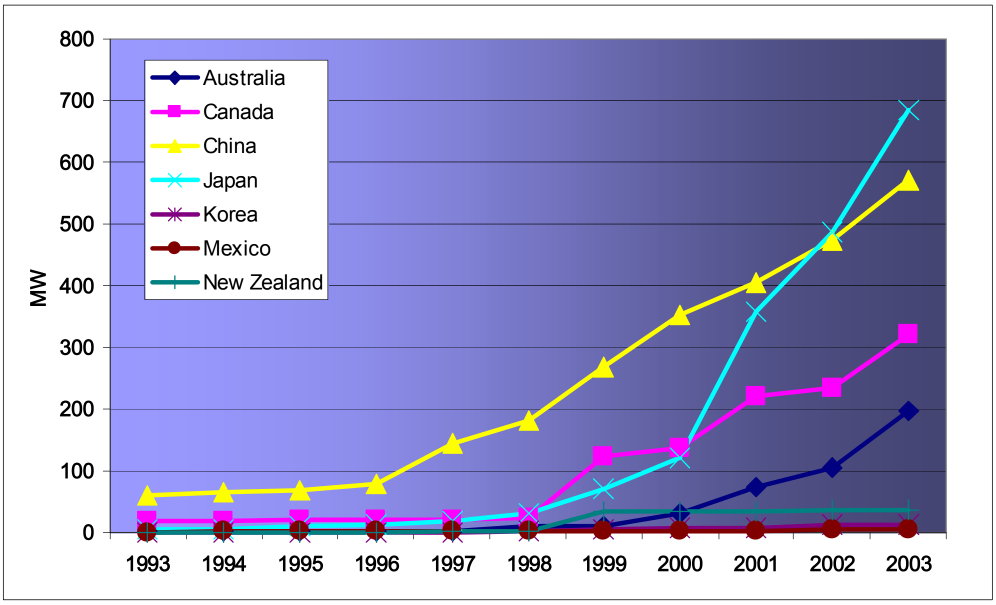


Source: EWEA (2004) citing Michael Grubb and Neils Meyer (1994)

[9] Based on Reference Case of Scenario Analysis of this study

There are no detailed assessments of wind energy potential that is currently available for the APEC region as a whole. However, the global wind resources are estimated to be around 53,000 TWh annually[10]. In comparison, electricity demand for the APEC region is expected to double from 9,214 TWh in 2000 to 18,558 TWh by 2025 and could reach 35, 670 TWh by the year 2050.[11] Figure 1 shows that North America, Asia and Australia represent 41 percent or 21,600 TWh of the total wind energy resources, which exceeds the total APEC electricity demand in 2025 and more than half the total electricity demand in 2050.

Figure 2 Installed Wind Capacities in the APEC Region (Excluding the US), 1993-2003



Source: Adapted from AWEA, EWEA, CanWEA and WWEA, 2004

Figure 2 above illustrates the growth of wind technology in selected APEC economies from 1993 to 2003. While most of the growth in wind installations worldwide is taking place in the European Union (EU) region, led by Germany, Spain and Denmark, the United States is the leading economy for the APEC region. In 2003, USA accounted for 78 percent (6,300 MW) of the region's total installed wind capacity. Japan has the second highest capacity with a total of 684 MW, followed by China (571 MW), Canada (316 MW), Australia (104 MW), New Zealand (37MW), Korea (13.8 MW) and Mexico (5 MW).

AUSTRALIA

Australia is well endowed with conventional energy resources like coal, oil and gas as well as renewable resources like wind, hydro, geothermal, solar and biomass. The economy's wind energy resource is estimated at 3,180 TWh/year (six percent of the global wind energy resource) or fourteen times its total electricity generation in 2002.[12] Excellent to good wind resources are found in south western and southern part of the economy with the highest concentration of wind resources, with speed ranging from 6 m/s to more than 8 m/s, located in Tasmania (as illustrated in Figure 3). Installed wind capacity also grew at an impressive average annual rate of 44 percent from

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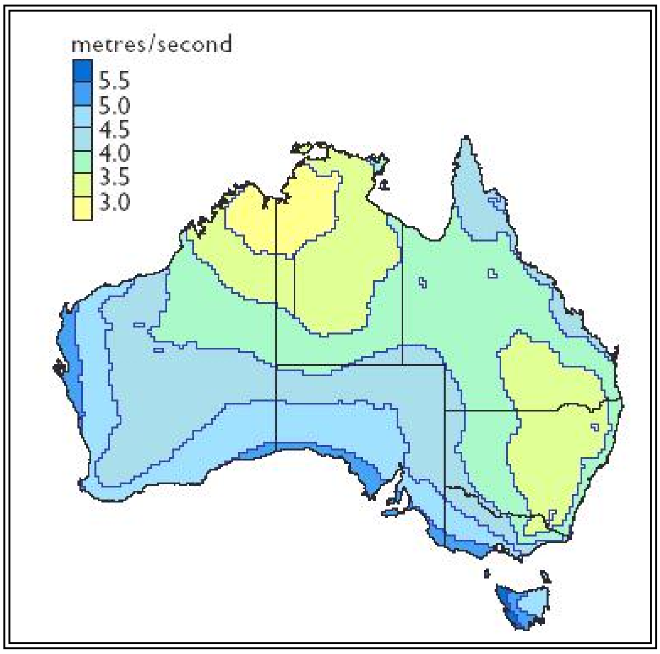
[10] Wind Force 12, A Blueprint to Achieve 12% of the World's Electricity From Wind Power by 2020, May 2004

[11] Projections based on APERC's Energy Demand and Supply Outlook (2002), with the assumption of an average annual growth of 2.7 percent from 2000 to 2050

[12] EDMC (2004)

1993 to 2003. However, the highest average annual growth of more than a hundred percent was recorded from 1999 to 2002.

Figure 3 Wind Resource Map of Australia



Source: ABARE (2004)

The massive growth in new capacity during this period was boosted by the federal government's policy to increase the share of renewable energy to two percent by 2020. The Australian wind energy industry seized this opportunity by setting a target to install 100 MW of new generation capacity by 2002 and have already exceeded the target. The total installed capacity in 2003 stood at 196 MW with an additional 2,700 MW at various stages of planning, tendering and construction.[13]

Stringent environmental regulations concerning bird and bat mortality, as well as other environmental issues such as noise pollution and visual impact may prove to be major impediments for the development of wind energy in Australia. However, the government's other enabling policies such as the Mandatory Renewable Energy Target (MRET) and the continued effort from the industry players to educate both the public and regulators are expected to help boost the development of wind energy in the longer term.

CANADA

Canada's installed wind energy capacity grew at an average annual growth rate of 36 percent from 1993 to 2003. Seven of its 13 provinces have some level of wind generation capacity as of 2002 ranging from pilot projects to private sector ventures.[14] The economy also has vast wind energy resources. The province of Quebec, in its southern half alone, is estimated to have wind energy potential of about 101,000 MW within 25 km of existing transmission line[15]. Figure 4 shows distribution of wind resource in Canada.

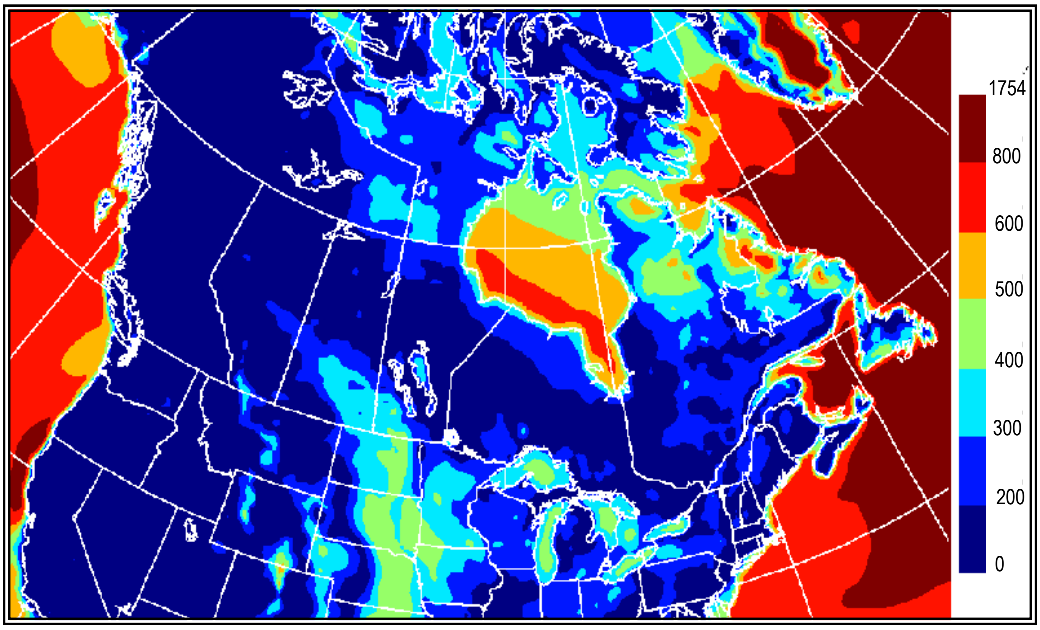
[13] Lloyd-Besson, I (2003)

[14] The Conference Board of Canada (2003)

[15] CanWEA

Wind is expected to have a "bright future" in Canada in view of its vast resources. Although wind energy and other renewable energy sources will have to compete with gas, which is available in relative abundance in Canada, wind could still prove to be cost-competitive at its current learning rate. As in other economies in the region, the development of wind energy resources faces several barriers such as high transaction costs, "not in my backyard" (NIMBY) syndrome and siting issues.

Figure 4 Wind Atlas of Canada



Source: Canadian Meteorological Centre

However, the introduction of favourable government policies such as the Wind Power Production Incentive (WPPI) is also expected to drive the expansion in wind capacity in Canada. The introduction of WPPI in 2002 (which is similar to the PTC in United States) has resulted in many provincial governments taking measures to expand wind energy production.

CHILE

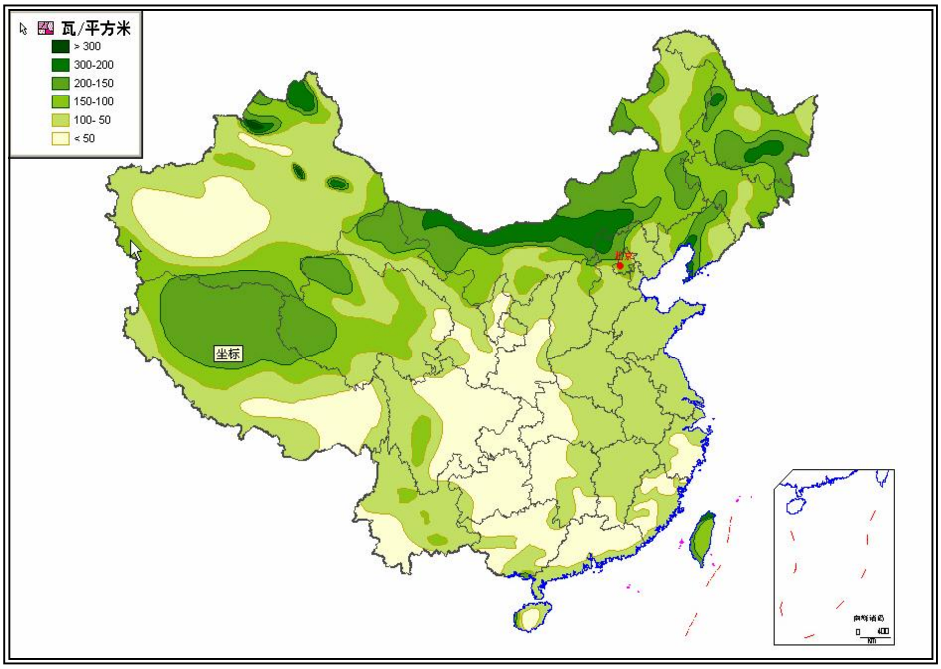
The northern and southern parts of Chile have good potential for wind energy development. According to a recent study, almost 3,500 families could be supplied with energy from hybrid wind-diesel plants in the 32 islands of the Chiloe archipelago. An initial demonstration project has already entered service on the island of Tac. The project has electrified 71 houses, a health care centre and a school, using two small wind generators rated at 7.5 KW each, with battery storage and a 12 KW diesel generator via a 13 km long island transmission system. A private company under a 10-year contract carries out the operation and maintenance of the system. Similar projects have also been implemented in Puaucho, Isla Nahuehuapi and Villa Las Araucarias in Region IX.

Total wind power installed capacity in 2003 was 2 MW. An additional 37.5 MW is likely to come on stream in the near future from Codelco (a copper company) to support its operations. From the total wind power installed capacity, the role of wind power in contributing to the Chilean energy mix is still marginal. There are no target policies in place to promote wind energy utilisation currently. The liberal Chile energy policy and electricity market emphasises the primacy of competition, which tends to minimize intervention from the government, though the government has stated its desire to see wind power development in the economy.

CHINA

China's estimated total wind resource is 1,000 GW. Currently, it has an installed wind capacity of 571 MW. Its vast wind resources could generate the current total installed electricity capacity three times over. Annual installed wind capacity grew at an annual rate of about 28 percent from 1996 to 2003, ahead of other developing economies in the region. The government of China is planning to install a total of 20 GW from wind energy by the year 2020 and expand it to 100 GW by 2030.[16] Figure 5 shows the areas with excellent to moderate wind energy resources. China has also developed wind turbine generators with capacities ranging from 55kW to 200kW as early as 1986. These were accomplished through international cooperation and several demonstration wind farm projects in areas like Shandong, Fujian, Xinjiang, Inner Mongolia, Guangdong, Zhejiang and Liaoning, with a total installed capacity of up to 14 MW.

Figure 5 Wind Resource Map of China (Watts/m^2)



Source: Office of National Coordination Committee on Climate Change, China

The development of local manufacturing capacity is vital for harnessing China's vast wind resources in a cost-effective manner. There are currently six domestic manufacturers that produce 660 kW and 750 kW turbines.[17] The research and development effort to develop wind turbines with a capacity of 1 MW is under way.

As one of the fastest growing economies in the region, China is taking urgent measures to meet its electricity demand and incorporate environmental considerations at the same time. These measures include renewable energy policy revisions to boost the development of wind energy in China. Some of the major revisions that have been incorporated include longer power purchase agreement periods (previously re-negotiated on an annual basis) and the introduction of wind farm concessions (up to 20 years) to encourage large-scale wind farm developments with capacities ranging from 100 MW to 200 MW. Two such 100 MW concessions were awarded in 2003 with an additional 20 new sites to be identified by 2006. The introduction and adoption of a bidding process also ensures a more competitive tariff.

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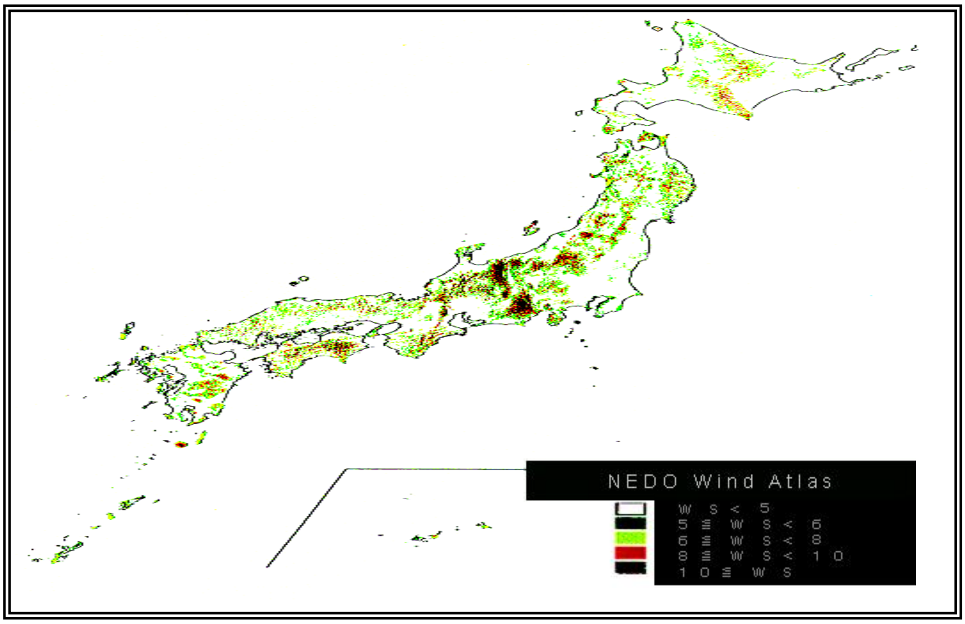
16 Ku (2004a)

17 Ibid

JAPAN

Japan's wind energy resource is estimated at 24.25 GW[18]. Figure 6 shows the distribution of Japan's wind resource. The economy also recorded the second highest average annual growth rate of 54 percent from 1993 to 2003 with 272 MW of new capacity being installed in 2003. Japan is the second most important wind energy market in the APEC region after the United States. The economy had total installed wind capacity of 684 MW at the end of 2003. The Japanese government supports renewable energy market development with various policies, incentives and a sizable annual funding, making it one of the best models for developing renewable energy in the region. Japan introduced its Renewable Portfolio Standard (RPS) policy in April 2003, however the target of increasing the share of renewable energy to only 1.35 percent by 2010 is considered very low.

Figure 6 Wind Resource Map of Japan



Source: Ushiyama (2004)

In addition to government support, the private sector also contributes to the development of renewable energy industry in Japan by voluntary green energy purchase and the installation of renewable energy generation facilities such as wind turbines.

Most of the suitable sites with good wind regimes in Japan are located in mountainous terrains, hindering faster growth in wind energy. Nevertheless, Japan still has good wind regimes in the islands of Okinawa, Miyako-jima and other offshore areas. The total installed capacity for wind is expected to reach 3,000 MW by 2010.[19]

KOREA

At the end of 2003, Korea's total installed wind capacity reached 22.1 MW, with an average annual growth rate of 51 percent from 1993 to 2003. The government's effort to promote NRE began in 1987 with the promulgation of NRE Promotion Act of 1987. Subsequent amendments to the legislation resulted in more comprehensive measures to be undertaken by the Korean

[18] Global Energy Network Institute

[19] NEDO (2004)

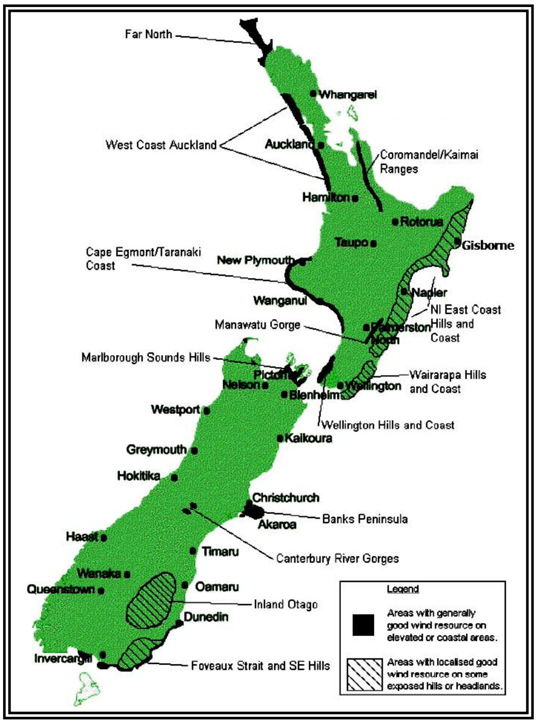
government to develop and deploy NRE. In 2003, the government announced a 3 percent NRE target by 2006, to be increased further to 5 percent by 2011 under the "10 Year National Basic Plan For NRE Technology Development and Dissemination."[20] The share of wind energy for the corresponding period is 2.2 percent and 9.7 percent respectively. The government is also planning to spend a total of 9.1 trillion Won by the year 2011 for the promotion of NRE in Korea. These allocations include 4.4 trillion Won in subsidies, 3 trillion Won in loans and 1.5 trillion Won for R&D.[21]

NEW ZEALAND

New Zealand's wind energy resource is estimated to be 100 TWh/year with most areas having an average wind speed of 9 m/s[22]. The economy also recorded the highest average annual growth rate at 65 percent from 1993 to 2003. Although the current installed capacity is only 37 MW, the economy is well suited for wind energy development due to its location in the prevailing northwesterly winds and long coastline. Figure 7 shows the map of New Zealand with favourable wind conditions.

A total of thirteen sites, mostly along coastal areas with high wind speed and consistency have been identified as suitable for wind farms. Advances made in wind turbine technology makes it possible to install "off-the-shelf" machines in New Zealand. Unlike Europe, there is no land scarcity issue in New Zealand and the high average wind speed does not require large rotors. The most cost-effective sizes for land-based wind turbine here are between 600kW and 1 MW.

Figure 7 Wind Resource Map of New Zealand



Source: Energy Efficiency and Conservation Authority (2001), Review of New Zealand's Wind Energy Potential to 2015

[20] KEMCO (2004)

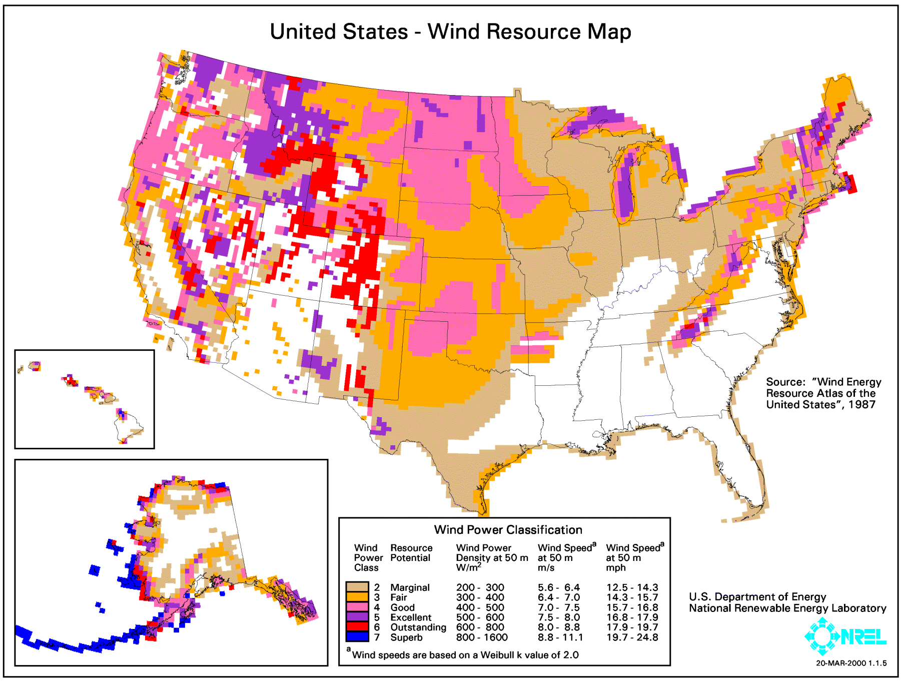
[21] Ibid

[22] Review of New Zealand's Wind Energy Potential to 2015, EECA, 2001

UNITED STATES

The United States has the largest wind resources (as shown in Figure 8) in the world. With an annual average growth of 15 percent from 1993 to 2003, the economy is emerging as a significant market for wind energy. A total of 1,687 MW of new wind capacity was added in 2003 with utility-scale turbines operating in 30 states. Much of its success in developing the wind market is due to the Federal Production Tax Credit (PTC) that was introduced in 1992 and the Renewable Portfolio Standards (RPS) policies that are being adopted by an increasing number of states. Continued high growth in 2004, however, was stymied due to the PTC's expiration in 2003. Most analysts believe 2005 will see a return to high growth in US wind capacity because the PTC expiration date has now been extended to the end of 2005.

Figure 8 Wind Resource Map of the United States



Source: NREL

Fifteen states had adopted the RPS policy ranging from 2.2 percent to 30 percent by early 2004. In addition to PTC and RPS, there are eight other state-level financial incentives that were adopted to support the development of renewable energy in the US. These incentives and other policy measures will be discussed in greater detail in the succeeding chapter on Challenges and Policy Measures.

Despite the great success in developing the wind market in the US, wind energy still accounts for less than one percent of total electricity generated in the US in 2003. The US DoE projects (in its 2004 Annual Energy Outlook) that generation from wind will increase to about 5.7 percent of total generation or 331 TWh by 2025[23].

OTHER ECONOMIES

With the exception of China, the deployment of wind technology in developing economies of the APEC region is still very limited. The Philippines, is developing a wind farm with a total

[23] In the DoE goals case.

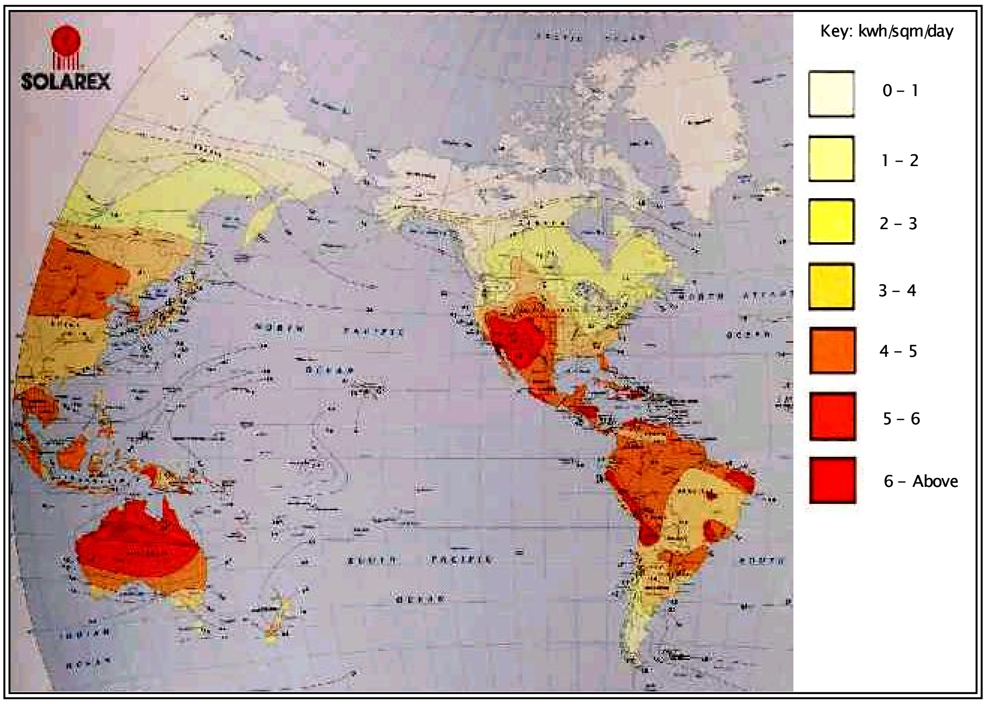
installed capacity of 120 MW in Burgos, Illocos Norte[24]. Many developing economies are still meeting their electricity demand by utilising conventional fossil fuel. The use of wind energy in developing economies is mostly confined to niche market applications or task-oriented such as water pumping for agricultural activities and battery charging stations for rural electrification purposes.

PHOTOVOLTAICS AND ITS UTILISATION

Photovoltaics is the second fastest growing renewable technology in terms of capacity expansion, recording an annual growth rate of 28 percent in the APEC region from 1992 to 2003. This growth rate only represents PV development in the six OECD economies of APEC, namely, Australia, Canada, Japan, Korea, Mexico and United States.

The average annual global solar irradiation is estimated to be 19 trillion tonnes of oil equivalent or 221 million TWh.[25] Assuming an energy conversion efficiency level of 18 percent[26], this resource is still equivalent to 39.8 million TWh. Even at such conservative estimate, it still represents more than a thousand times the electricity demand for APEC region in 2050. Despite being one of the most abundantly available resources worldwide, the utilisation of photovoltaics (PV) technology for electricity generation remains marginal at less than 5 percent in the APEC region. Figure 9 below shows solar irradiation level for APEC region.

Figure 9 APEC Region's Solar Resources



Source: Advanced Energy Group, Http://www.solar4power.com/map1-global-solar-power.html

Figure 10 illustrates the growth in PV capacity for selected APEC economies from 1992 to 2003. Developed economies, are able to harness PV technology in large-scale applications as well

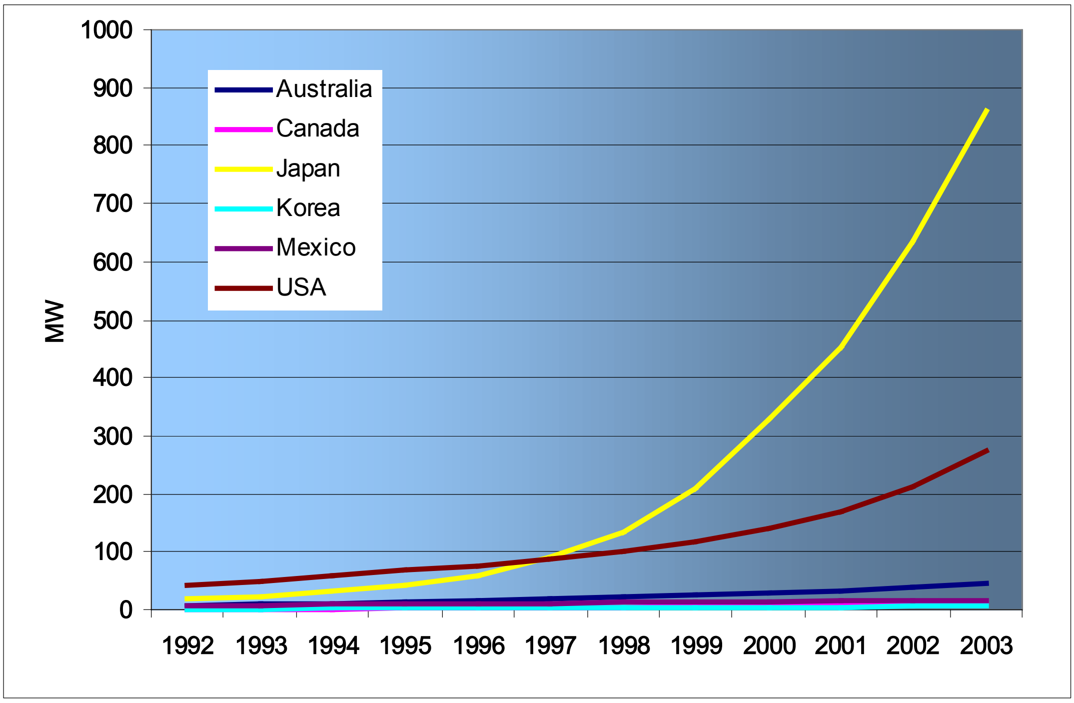
[24]Department of Energy, Philippines, 2003

[25] WEC

[26] The current average energy conversion efficiency for solar cells is about 18.3 percent

as carry out research, development, and demonstration activities. Japan is the world leader in PV utilisation with an installed capacity of 860MWp in 2003. The United States, which has the second largest installed capacity in the region, has 275MWp, followed by Australia (45MWp), Mexico (17MWp), Canada (12MWp) and Korea (6MWp). In developing economies PV technology is utilised in rural electrification programmes mainly, as well as other task-oriented applications.

Figure 10 Installed Photovoltaics Capacities in the APEC Region, 1992-2003



Source: IEA-PVPS (2004)

AUSTRALIA

Australia had a total installed photovoltaics capacity of 45.6 MW at the end of 2003. With an average annual growth rate of 17 percent from 1992 to 2003, most of the growth was concentrated in the off-grid non-domestic application. From the total installed capacity in 2003, 57 percent were in off-grid industrial while off-grid residential accounted for 30 percent of the total. Figure 11 shows Australia's solar energy resources.

The Government's PV Rooftop Programme is supporting the growth of PV application for distributed grid-connected generation. PV cell production capacity in Australia increased to 33.5 MW in 2003 with a planned expansion up to 40 MW by 2004/5.[27] As a result of domestic manufacturing capacity, government policy support and competition, Australia has one of the lowest PV system price in the world. About 64 percent of locally manufactured cells and 49 percent of modules were exported in 2003. Various Government's initiatives to develop renewable energy in general as well as PV technology in particular (as described in Box 1) had contributed to the development of PV industry in Australia.[28]

[27] IEA-PVPS (2004a)

[28] Ibid

Box 1 Australian Government Programmes to Promote NRE

Mandatory Renewable Energy Target (MRET) – this target seeks to increase the contribution of renewable energy sources in Australia's electricity mix by 9 500 GWh per year by 2010. Since 1 April 2001 electricity retailers and large energy users (known as liable parties) must purchase increasing amounts of electricity from renewable sources. A trade in Renewable Energy Certificates (RECs) and financial penalties for non-compliance are features of this scheme. A major review of the scheme – Renewable Opportunities: A Review of the Operation of the Renewable Energy (Electricity) Act 2000 – was published in September 2003.

Supporting the Use of Renewable Energy for Remote Power Generation (RRPGP) – this programme commenced in 2000 and is expected to make over 200 million Australian dollars available over the life of the programme for the conversion of remote area power supplies (including public generators and mini-grids) from diesel to renewable energy sources, and for new renewable installations that would otherwise have been fueled by diesel. The RRPGP may provide up to 50 % of the capital value of the replacement or new renewable generation for off-grid users of diesel-based power generation. The programme is administered by state governments and a number of states also provide additional financial support for off-grid renewables.

Supporting the Use of Solar Photovoltaic Electricity on Residential and Community Buildings, the PV Rebate Programme (PVRP) – this programme commenced at the beginning of 2000 with 31 million Australian dollars available over four years. The programme has now been extended until 2005 with a further 5,8 million Australian dollars available. Funding is provided by the Australian Government, with administration by the State Governments, and provides rebates to householders or community building owners who install grid-connected or stand-alone photovoltaic power systems. Under the PVRP extension, householders are eligible for a rebate of 4 AUD/W (previously 5 AUD/W), capped at 4 000 AUD per residential system (previously 7 500 AUD). Rebates are also paid for extensions to an existing system. Community buildings attract the same rebate except it is capped at 8 000 AUD (previously 10 000 AUD). The Australian Government has also made available one million Australian dollars to fund projects by residential housing developers, through a competitive bidding process.

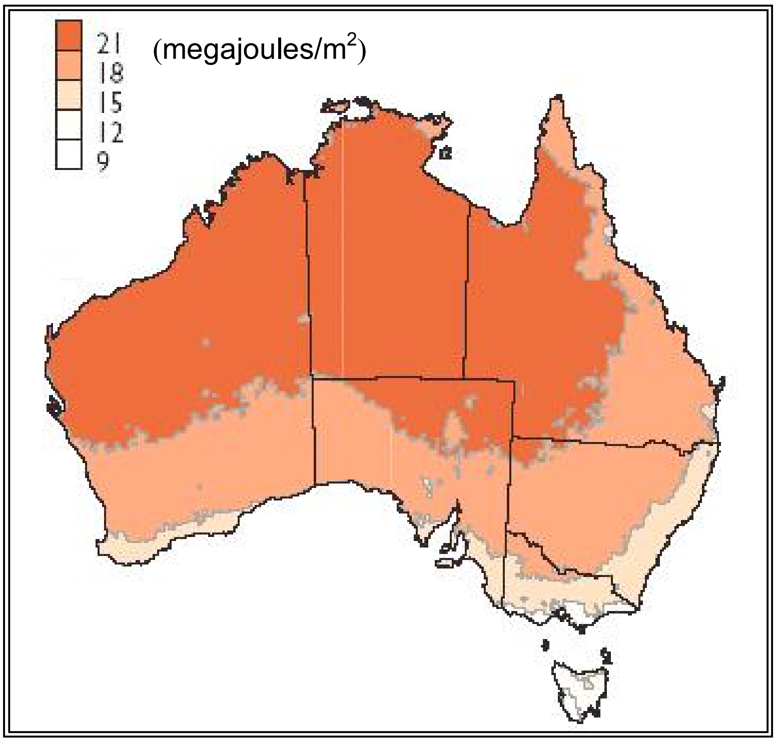
Renewable Energy Equity Fund (REEF) – venture capital can be made available by the fund manager to small innovative renewable energy companies that can demonstrate that they have an innovative development that is being commercialized. Although the Government is not directly involved in making investment decisions, along with the fund manager and private investors they can share in any profits from REEF.

Source: IEA-PVPS (2004)

In addition to the four programmes for promoting renewable energy in Australia, the government has also allocated AU$5.57 million for R&D and another AU$5.79 million for demonstration and field tests in 2003. The largest share of incentive totalling AU$19.5 million was provided for market incentives in the same year. The total government support for PV increased by nearly AU$10 million from 2002 to 2003. Government expenditure on R&D and market development is more than matched by Australian industry expenditure. The government has proposed a new Renewable Energy Development initiative, which will provide targeted funding for commercial development and will move the emphasis of government support back towards R&D.[29]

[29] IEA-PVPS (2004a)

Figure 11 Solar Resource Map of Australia



Source: ABARE (2004)

CANADA

Canada's PV deployment is concentrated in the off-grid non-domestic sector. In 2003, more than 50 percent of its installed capacity was in off-grid non-domestic sector with no subsidy. Most of these applications are for water pumping, road signals, navigational buoys, remote telecommunication repeaters, industrial sensing, monitoring, and controlling. Deployment of PV technology in the distributed generation sector is hampered by an existing barrier - access to transmission and distribution systems.

The single module manufacturer in Canada has a production capacity of 2 MW[30]. It has exported 176 kW or 13 percent of the market volume in 2002. The manufacturings of stand-alone PV systems for use in bus-stop signalling and airport runway illumination are emerging. In addition to a CAD 6.35 million allocated by the government to promote PV technologies, several other programmes are also developed to support the industry and create awareness. Three such programmes are:

- **On-site Generation at Government Facilities** – In 2002 the government planned to support the installation of about 15 PV systems over the coming year at government facilities. Preference will be given to high visibility projects that demonstrate the application of building-integrated PV products;

- **Climate Change Technology and Innovation Program** – As part of this measure, the National Science and Engineering Research Council will manage a research fund for novel next-generation energy technologies related to greenhouse gas mitigation. This program targets early-stage and exploratory research in Canadian Universities and will enhance the knowledge base for longer-term solutions to climate change; and

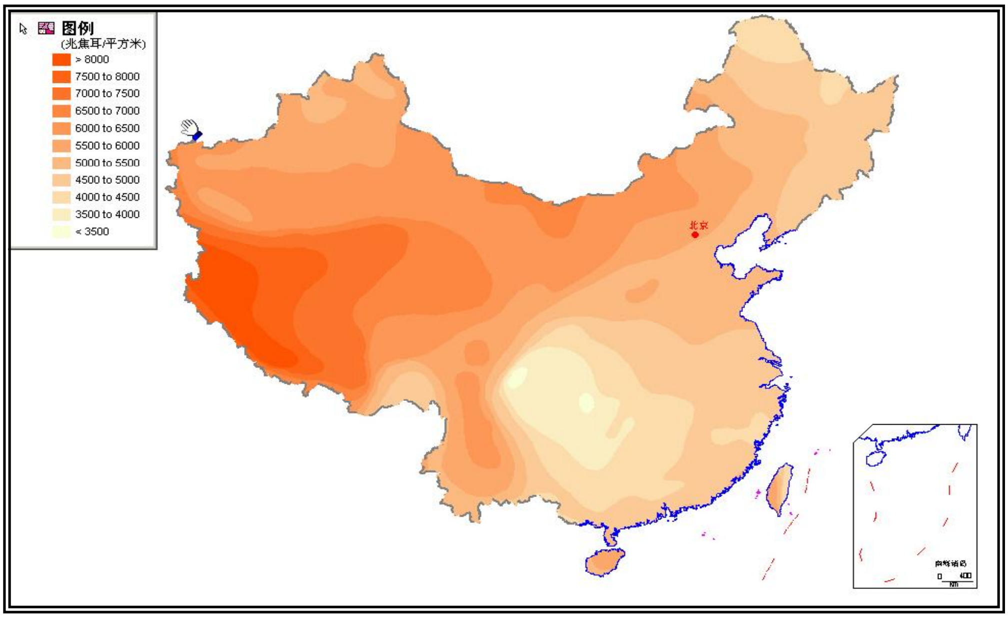
[30] IEA-PVPS (2004b)

- **Federation of Canadian Municipality (FCM) Green Fund** – The National government provides funding to the FCM to initiate green energy projects. By partnering with a local community champion, PV companies have an opportunity to propose PV deployment projects.[31]

CHINA

China has vast solar energy resources. The total solar radiation hitting China's land area is estimated at 1.38 million TW/h annually or equivalent to 170 billion tons of standard coal equivalent (tce).[32] Figure 12 shows the distribution of the total solar radiation hitting China's land surface. The concentration of solar radiation is greater in Tibet, Qinghai, Xinjiang, the southern part of Inner Mongolia, Shanxi, northern Shaanxi, Hebei, Shandong, Liaoning, western Jilin, the middle and southwest parts of Yunnan, the southeastern part of Guangdong, the southeastern parts of Fujian, the eastern and western parts of Hainan. The Qinghai-Tibetan Plateau receives the highest level of solar radiation in all of China.

Figure 12: China's Solar Energy Resources (million joules/meter^2 per year)



Source: Office of National Coordination Committee on Climate Change, China

Note: 1 MJ/m^2 = 2.78 x 10^{-1} kW. H/ m^2

China is taking advantage of this huge resource by embarking on ambitious programmes to harness solar energy to meet its growing electricity demand, especially for providing power to rural areas. The current installed capacity in photovoltaics is over 50MW. Rural electrification accounts for 50 percent of this capacity. China launched its solar home system (SHS) for providing electricity to rural communities in 1995 under a World Bank/GEF assisted programme with an initial capacity of 10MWp. The five-year project included a direct subsidy given to SHS dealers at USD1.5/Wp and other capacity building activities including training, pilot projects, formulation of regulations and standards for renewable technologies.[33]

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[31] IEA-PVPS (2004b)

[32] Office of National Coordination Committee on Climate Change, China

[33] Li, Z (2003)

The government undertook an ambitious plan to supply 220 MW of electricity to one million people in 1,061 townships under one of the world's largest rural electrification programme in 2004. 20 MW of this power will be supplied with photovoltaics system. The central government allocated USD240 million for the purchase of hardware for the systems.[34] The systems are expected to last for 15 years. Local PV cell production capacity is nearly 100MW currently although the production cost is still relatively high at USD3/Wp.

The construction sector with an annual growth of 10 percent is a promising market for building-integrated PV (BIPV) system. The government of China has launched an R&D programme targeting this sector with the implementation of two BIPV demonstration projects in Beijing and Shenzen with capacities of 20kW and 50kW respectively. A private company is also exploring the potentials for implementing a 2MW BIPV system in Lhasa, Tibet. China's long-term plan for renewable energy utilisation includes the installation of 1 GW in PV capacity by 2020.[35]

JAPAN

Japan's solar insolation ranges between 2-4 kWh/m²/day. Despite the relatively low insolation rate, Japan is well ahead of all other economies in the APEC region in developing and harnessing photovoltaic technology for electricity generation. In addition to having the highest installed capacity for photovoltaics in 2003, Japan also recorded the highest average annual growth of 37 percent from 1992 to 2003.

The success of the economy in developing photovoltaics technology stems from its multi-tiered approach of enabling policy, technology and market development. Japan accounted for approximately 45 percent of solar cells sold worldwide in 2002, a remarkable accomplishment achieved through the overwhelming support of its Sunshine Policy and other incentives from government. The first Sunshine Policy was introduced in 1974 as a response to world oil crisis. With its success, the Sunshine Policy was introduced again in 1993 with the basic aim of introducing "new energy" in the national energy supply.

The government's allocation for subsidising rooftop photovoltaics reached a total of 136 billion Yen[36] from 1994 until 2003. The allocation provided a subsidy ranging from 50 percent to 30 percent of the total installation cost per PV system. In addition to the national government's subsidy, various local governments provided their own subsidy scheme for rooftop PV systems. This effort by government had brought down the unit price of a 3kWp system from 6 million Yen in 1994 to between 1.5 and 1.8 million Yen, or 70 to 75 percent reduction, by 2003.

In order to bring down further the cost of PV cells, the government has provided R&D grants to the private sector. The two grant schemes that were introduced through New Energy and Industrial Technology Development Organisation (NEDO) are in the form of seed identification and the Advanced PV Generation (APVG). NEDO provides for 50 percent of the funds under the seed identification scheme for the development of PV production technologies, industrialisation and commercialisation of PV. The APVG scheme provides full funding for R&D activities by selected research institutes and companies as well as the development of pilot plants for new PV technologies. The Government has also set short- to mid-term targets as well as long-term targets for its R&D programme. Cost reduction, mass production, reliability and infrastructure are the main targets in the short- to mid-term. The long-term targets, on the other hand, deal with prospective research, including the conversion of R&D results on innovative PV technologies into production processes.

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[34] Ku, J (2004a)

[35] Ibid

[36] PV Status Report, 2003

The market situation in Japan is also conducive for the mass deployment of PV technologies by teaming with the construction sector. With the rising level of environmental awareness in Japan, many house buyers are now concerned with the amount of carbon dioxide released from the operations and maintenance of their homes. Many PV manufacturers either buy housing development companies, or form strategic alliances, which allow them to incorporate PV systems in the new houses being built. As the world's leading manufacturer of PV cells, there are no issue of supply shortage for PV cells. They are able to meet the demand of house buyers who are environmentally conscious while at the same time bring down the cost of PV system substantially. As a result of all these programmes and activities, 90 percent of all installed PV systems in 2003 were for grid-connected distributed generation in Japan.

MALAYSIA

Malaysia is moving forward to promote solar energy so that a small group of home owners will get the rare opportunity to have PV systems installed in their homes at reduced costs. Under the Suria 1000 component of the five-year Malaysian Building Integrated Photovoltaic (BIPV) project which will kick off next year, homeowners could bid to have PV systems installed in their homes. The bidding will start at a quarter of the current cost of a 4kWp PV system typically needed for a house. Such an installation now costs about RM100,000 or US$40,000.

Under the existing policy, electricity supply options for rural population is determined by the Ministry of Rural Development, together with the power utilities. The same mechanism for the rural electrification would also be applicable to solar home system-based electrification projects. The Local Village Security and Development Committee (VSDC) could initiate, organise, implement and even administer solar home system (SHS) projects at the grass-root level. The utility companies could help in the introduction of SHS technology to the VSDC, for areas that are not appropriate for conventional electrification (either grid extension, mini/micro-hydro or diesel generators).

The whole of Peninsular Malaysia has been electrified through the grid. As a result, the application of photovoltaics (PV) power supply will be restricted to some special applications, such as remote telecommunications (relays), lighthouses or sea buoys. The application of solar PV technology is currently focused in east Malaysia namely, the states of Sabah and Sarawak.

About 2,000 SHS had been installed in Malaysia by the year 2000. The first PV installations were some maritime beacon power supplies in 1976. Altogether, over 2.1 MWp of PV systems have been installed (for buoys, beacons, lighthouses, remote villages, repeater stations etc.) with the largest proportion, (i.e. around 320 kWp) for rural telecommunications.

In 1996 NEDO of Japan funded the implementation of a pilot 100kWp centralised PV facility in Sabah. The project was aimed at studying the efficiency of PV cells under tropical conditions. It was the largest centralised PV generation facility in Southeast Asia at the time. The project was a great success technically and the villagers of Marak Parak enjoyed electricity supply to their homes and community centres. However, the power utility that took over the operations and maintenance of the facility was incurring losses since the villagers were only charged the average tariff. Existing law regarding power supply prohibits power utilities from practising price discrimination. The consumers in the same village are now enjoying grid-connected power while the PV facility is used to supply power to a rest house.

Of the 5,000 SHS installed through the financing scheme of the Ministry of Rural Development (MORD), majority of the systems are in the 300 Wp range. The "Smaller" SHSs are around 160 Wp. Church and community hall power supplies are around 700 Wp each, classrooms range from 320 -500 Wp, clinics/police station were equipped with around 500 Wp, vaccine freezers 320 - 415 Wp and compound lighting systems were around 80 Wp per system. In 1997 the MORD undertook to install the world's largest photovoltaics rural infrastructure project, which entailed the installation of total capacity of 2.2 MWp. The programme was intended to provide electricity to about 1,600 facilities ranging from rural households to rural community halls, churches, rural police stations, rural schools, vaccine freezers and is expected to be completed in 2004.

MEXICO

In 2003, Mexico had 17.1 MWp installed PV capacity recording an average annual growth of 10 percent from 1992 to 2003. About 80 percent of the installed capacity is for off-grid residential application in rural households.[37] Almost all the remaining capacity is utilised in off-grid non-domestic application such as unmanned oil rigs, telecommunications repeater stations in remote sites, water pumps for irrigation small agricultural land, livestock watering and fence energizing.

The PV technology deployment largely depends on the government's support for renewable energy, which was stressed in the National Energy Programme 2001-2006. This programme emphasises the utilisation of renewable energy for rural electrification as well as private sector participation. Current R&D programme on PV is focused on the performance of PV systems operation.

THE PHILIPPINES

Being geographically located just above the equator, the Philippines has a vast potential for various solar energy applications. The economy's average daily insolation level is around 5 kilowatt hour per square meter per day (kWh/m²/d). Estimated also from the Philippine Atmospheric, Geophysical, Astronomical Services Administration (PAG-ASA) weather data, the economy's average solar radiation based on sunshine duration is 161.7 W/m² with a range of 128-203 W/m².

About 3,957 systems of various PV applications are located in the economy with an equivalent capacity of 567 kWp. These installations are largely attributed to the initial efforts of the Philippine-German Solar Energy Program (PGSEP) in the 1980's. The program's objective was to demonstrate the technical viability of using PV for electrification. The project demonstrated and tested various PV applications ranging from telecommunication, battery charging stations, PV-powered video cinemas, refrigerators, incubators, streetlights and others.

To date, mostly mono- and poly-crystalline modules have been utilised. Amorphous silicon panels have generally been used in very small applications. The archipelagic nature of the economy with many remote islands and islets as well as the dispersed small communities, many in mountainous areas make the PV technology a very promising option for electrification for these rural areas.

A number of local firms in the economy are now involved in system integration, design, installation and distribution of PV modules and products. Most of the products especially PV panels are imported from the US, Australia, Germany and Japan. There is also some local capability in the manufacturing of balance-of-systems and solar batteries.

Currently, about 3,455 SHSs are estimated to have been installed in various locations in the economy. With the real costs of PV project development above the affordability level of most of the rural population (a complete SHS costs between US$600-800), international cooperation is necessary in the realisation of such projects. Systems have been installed through private companies, local cooperatives (multi-purpose, agricultural, credit, etc.) as well as Rural Electric Cooperatives. The technical potential for SHS is difficult to establish and will strongly vary with the system price offered. At present, about five (5) million rural households have no access to electric power and could, in principle, be electrified through SHS. However, given the on-going

[37] IEA-PVPS (2004c)

conventional electrification by grid-extension and other competing alternative options, combined with limited affordability and accessibility of remote rural households has resulted to date a commercial potential of only about 500,000 SHS.

PV seems especially attractive for back-to-back relay stations for telecom companies in the economy since most of them operate in their own backyards. From the engineering's perspective, such relays are often situated at optimal locations with grid power not readily available (e.g., mountain tops). Two companies (RCPI and PT&T) have pilot tested over a period of almost 10 years to supply power to their telecom system. The system generated around 2 kWp with 3 kilovolt amperes (kVA) of backup diesel capacity for emergency purposes. The performance of the PV systems had been better than expected. Two additional stations of 4.5 and 5.7 kWp have been added over the years. The potential market for PV for the telecommunication industry would amount to more than 100 PV systems with a capacity of at least 3 kWp. About 119 systems with a total capacity of 94 kWp have been installed.

PV FOR WATER PUMPING AND OTHER APPLICATIONS

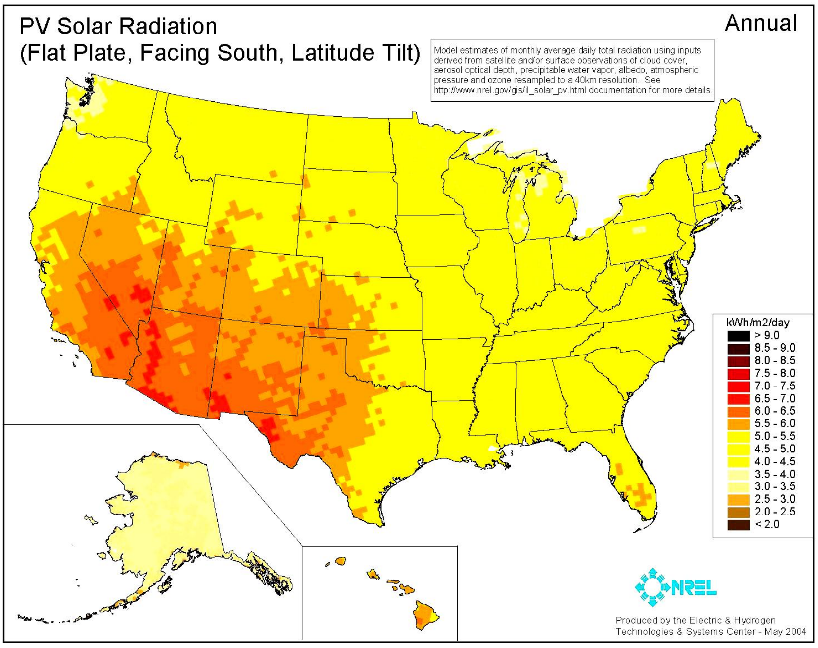
Although PV for irrigation is still considered too costly, its use to pump drinking water appears to be promising. 126 of such systems had been installed nationwide with a total capacity of 174.8 kWp. Other applications include communal battery-charging stations (257), vaccine refrigerators, incubators (for hatching chicken and duck eggs), streetlights, lighthouses and the newly commissioned 28 kWp centralised plant providing electricity to 200 households in Pangan-an Island. In 2002, some 280 households were provided with electricity with the installation of 140 solar home systems and seven photovoltaic battery-charging stations in 14 remote villages of Palawan island.

UNITED STATES

The United States has the second highest PV capacity in the APEC region with 275.2 MW as of 2003. The average annual solar insolation in the United States ranges from 3.5kWh/m^2/day to 7kWh/m^2/day as shown in Figure 13. The average annual installed capacity for PV in the United States grew at a rate of 17 percent from 1992 to 2003. Total PV cells and modules shipment in 2002 were 121 MW, of which, only 44MWp were installed in the United States.[38]

[38] IEA-PVPS (2004d)

Figure 13 US Annual Solar Insolation



Source: NREL

Despite the relatively higher average insolation and a sizable market, institutional barriers impede the deployment of photovoltaics on a wider scale in the United States. There is currently no federal RPS mandate and the different states adopt their own RPS standards. As of February 2003, 13 states have established RPS mandate. Among these states, California currently has the highest RPS target with 20 per cent of electricity to be generated from renewable sources by 2017.

Table 2 Types of Financial Incentives in the United States

Regulations	No. of States
Tax Credits & Deductions	29
Subsidies and Rebates	12
Grants	19
Production Incentives	8
Low-interest Loans	20
Sales Tax Exemptions	18
Property Tax Incentives	25
Industry Recruitment Incentives	11

Source: Ku (2004b)

The "Million Solar Roof" initiative that was launched in 1997 aimed to install a million solar systems by the year 2010. The initiative has proven very successful since it had already resulted in the installation of about 350,000 systems by 2002. However, the programme has not received any budget allocation apart from support measures from the Department of Energy for the removal of market barriers and development of local promotion programmes. Support for renewable energy at state, local authority and utility levels are more encouraging than federal support. In 2001, federal support for renewable energy sources only amounted to US$66 million out of a total renewable energy fund of US$470 million.

The most successful federal and state level programmes that have been adopted to accelerate the deployment of PV and other renewable energy are legislative mandates such as RPS and financial incentives. Since there are no uniform federal incentives for PV market development, apart from several tax breaks, many states have adopted their own programmes. Table 2 shows the different types of financial incentives adopted at state-level. Tax credits and deductions, property tax incentives and low-interest loans are three of the top incentives adopted by most states.

Other policy and regulatory measures that were adopted include Public Benefit Funds, Net Metering and Interconnection, Green Power Option Requirements, Green Power Purchasing Policies, Fuel Source and Emissions Disclosure, Solar and Wind Access Laws, Construction and Design Policies, Contractor Licensing and Equipment Certification.

GEOTHERMAL

The global potential of geothermal for electricity generation ranges between 1,000 to 40,000 TWh/y.[39] Its direct uses however, is estimated between 30,000 to 50,000,000 GWth.[40] With over 8,000 MW of installed capacity worldwide, geothermal electric power is a well-proven technology that has been especially successful in most economies and islands that have a high reliance on imported fossil fuels. Geothermal utilisation in the APEC region represented 84 percent of total global share as shown in Figure 15.

The use of geothermal resources dates as far back as 10,000 years, with the settlement of Paleo-Indians in hot spring areas. Since then, geothermal energy had been used for healing and physical therapy, including cooking, space heating and other uses. Technological advancement has made it possible and economic to find geothermal reservoirs, pipe the steam or hot water out to the surface, use the heat directly (for space heating or other industrial purposes) or finally to convert it into electricity. Scientists have estimated that by tapping just 1 percent of the upper most 10 kilometres of the earth's crust would produce about 500 times that of the total energy generated by the earth's oil and gas resources.[41]

There are two basic categories of geothermal resources: hydrothermal and hot dry rock. A hydrothermal resource is the most common, and is usually tapped for commercial electricity production. Resources such as these would normally be at relatively shallow depths (from a few hundred to 3,000 meters below the surface). They contain hot water, steam or sometimes a combination of the two. Hot dry rock (HDR) resources, on the other hand, are deep masses of rock that have little or no steam/water at all. They exist at above average temperature gradient of greater than 50ºC/km. There are strong similarities and differences between HDR and hydrothermal, but they commonly share the same technology components like power plant and drilling methods. The most distinct differences, however, would be their commercial availability and the magnitude of the resource. These differences have initiated the need to improve R&D programs that would try to lower the cost in hydrothermal exploitation on the one hand, and improve geothermal technology, on the other, to make HDR exploitation economically feasible in the future. For power generation, two separate power generation technologies are currently in use: flash and binary. Flash technologies use hot water, from high temperature resources (177°C to about 370°C, or 350°F to more than 700°F), or steam to produce electricity through a turbine. Low temperature resources, on the other hand (177°C or 350°F) are harvested through binary power plant technology. Here, geothermal fluid is tapped to heat a working fluid that will vaporize

[39] IGA

[40] Ibid

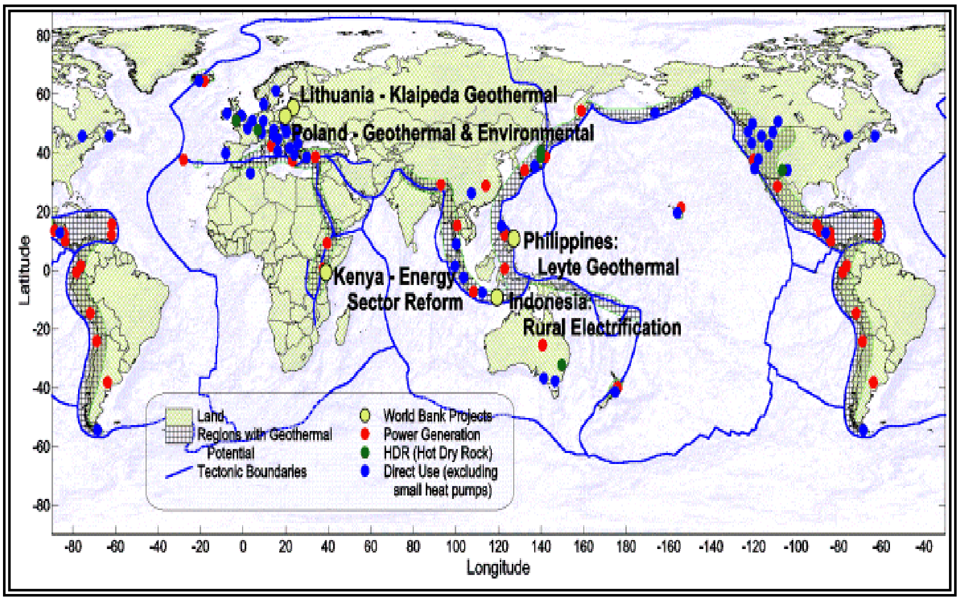
[41] Ibid

at low temperatures, transferred to a turbine, re-condensed and repeatedly re-heated into a closed-loop cycle. A fast becoming popular application of geothermal heat is its direct-heat applications, usually in households.

KEY GEOTHERMAL AREAS

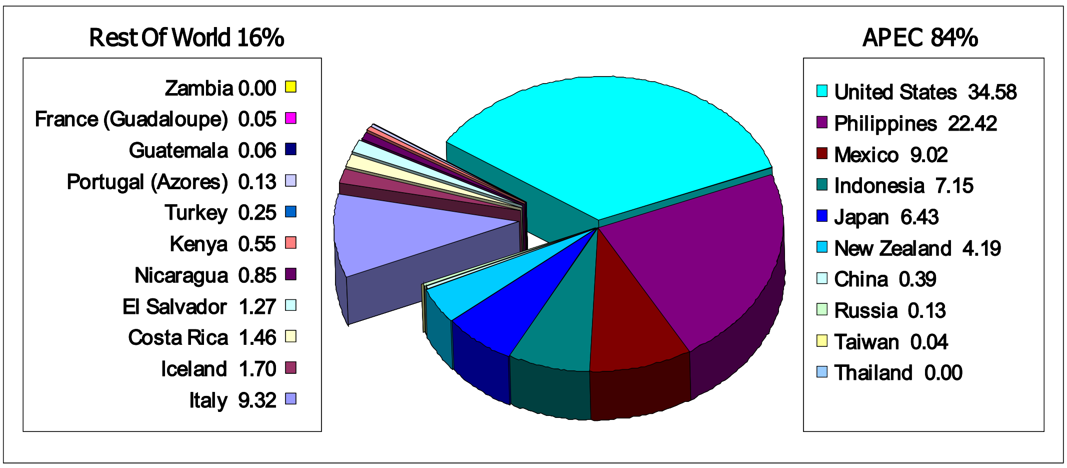
Geothermal systems are generally found along the edges of the Pacific Ocean, the so-called "Ring of Fire". The region abounds in active volcanoes, which stretches from the Aleutian islands of Alaska east to the Philippines and Indonesia and south to the Andes Mountains in South America. Most geothermal projects are being developed at or near these areas (Figure 14).

Figure 14 World Geothermal Areas



Source: World Bank

Figure 15 Percentage Distribution of Geothermal Capacity in the World, 1999



Source: IGA

TECHNOLOGY STATUS

The first conversion of high-grade hydrothermal or geothermal energy to electricity was in 1904, at the Larderello dry steam field in Italy. A 250 kWe geothermal plant began its operation in

1913. Geothermal energy's first commercial development however started at the Geysers in California, USA, with a 10-11 MW power plant owned by Pacific Gas and Electric. Box 2 describes the important milestones in the development of geothermal energy in the United States:

Box 2 Geothermal Milestones

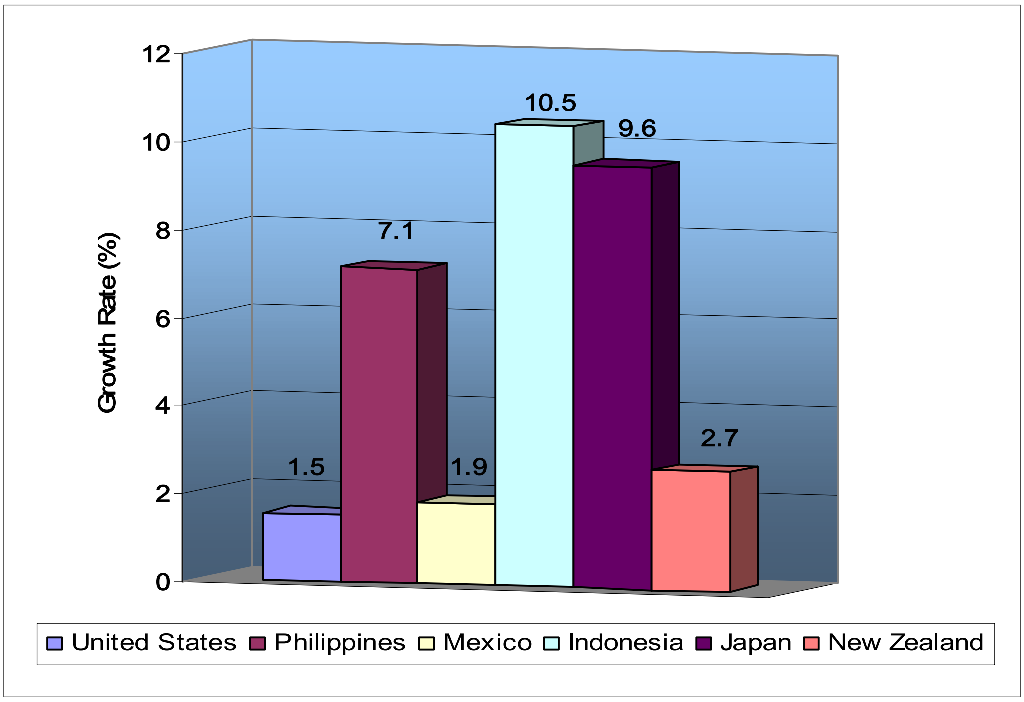
Year	Event/Description
1960	The first commercial-scale development of geothermal was opened and operated by Pacific Gas & Electric at the Geysers in California, with a capacity of 10-11 MW
1970	The Geothermal Resources Council is formed to encourage the development of geothermal resource worldwide. A Geothermal Steam Act is enacted to provide the Secretary of the Interior authority to lease public lands and other federal lands for geothermal exploration and development. Reinjection of geothermal spent fluids back into the production zone began as a means to dispose of wastewater and maintain reservoir life.
1972	The Geothermal Energy Association is formed comprising of US companies involved in the development of geothermal resources for power generation worldwide. Deep well drilling technology was improved that led to deeper reservoir drilling and access to more resources.
1974	The US government enacts the Geothermal Energy Research, Development and Demonstration (RD&D) Act, and instituted the Geothermal Loan Guaranty Program. The Program provided investment security to public and private sectors using and developing technologies to exploit geothermal resources.
1975	The Energy Research and Development Administration (ERDA) is formed aimed at focusing the federal government's energy research activities. The Division of Geothermal Energy takes over the RD&D, program which started in 1974.
1977	The US Department of Energy (DOE) is formed. With financial assistance from the DOE, the hot dry rock geothermal power was demonstrated. The first hot dry rock was developed at the Fenton Hill, New Mexico.
1978	The Public Utility Regulatory Policies Act (PURPA) is enacted. PURPA mandated the purchase of electricity from qualifying facilities (QF) that meet certain technical standards on energy source and efficiency. QFs are small power producers using renewable energy sources and cogeneration. PURPA also exempted QFs from both State and Federal regulation under the Federal Power Act and the Public Utility Holding Company Act.
1980	The first commercial-scale binary plant in the US, installed in Southern California's Imperial Valley, began operation. California's Standard Offer Contract system for PURPA QFs provided renewable energy systems a relatively firm and stable market output, which allowed the financing of capital-intensive technologies such as geothermal energy facilities.
1981	With support from the DOE, ORMAT successfully demonstrated the binary technology in the Imperial Valley, California. The project established the technical feasibility of larger-scale commercial binary power plants. ORMAT repaid the loan within a year.
1982	California Satton Sea geothermal field started its economic electric generation using crystallizer clarifier technology. The technology has resulted from a government effort to manage the high salinity brines at the site. Geothermal electric generating capacity, which was primarily utility owned, reached a new high level of 1,000 MW.
1989	The world's first hybrid (organic Rankine/gas engine) geopressure geothermal power plant begins operation at Pleasant View, Louisiana, using both the heat and the methane of a geopressured resource.

1990	DOE funding for geothermal energy dropped throughout the 1980s, reaching its lowest point in fiscal year 1990.
1991	The world's first magma exploratory well was drilled in the Sierra Nevada Mountains to a depth of 7,588 feet. It did not encounter magma at that depth inside the caldera.
1994	DOE creates two industry/government collaborative efforts to promote the use of geothermal energy to reduce greenhouse gas emissions. One effort is directed towards the accelerated development of geothermal resources for electric power generation, and the other is aimed at accelerating the use of geothermal heat pumps.
1995	A DOE low-temperature resource assessment of 10 western states identified nearly 9,000 thermal wells and springs and 271 communities co-located with a geothermal resource greater than 50°C. Worldwide geothermal capacity reaches 6,000 MW in 20 economies.
2000	DOE initiates is GeoPowering the West Program to encourage the development of geothermal resources in the western United States. An initial group of 21 partnerships with industry was funded to develop new technologies.

Source: Geothermal Energy for Electric Power, A REPP Issue Brief (2003)

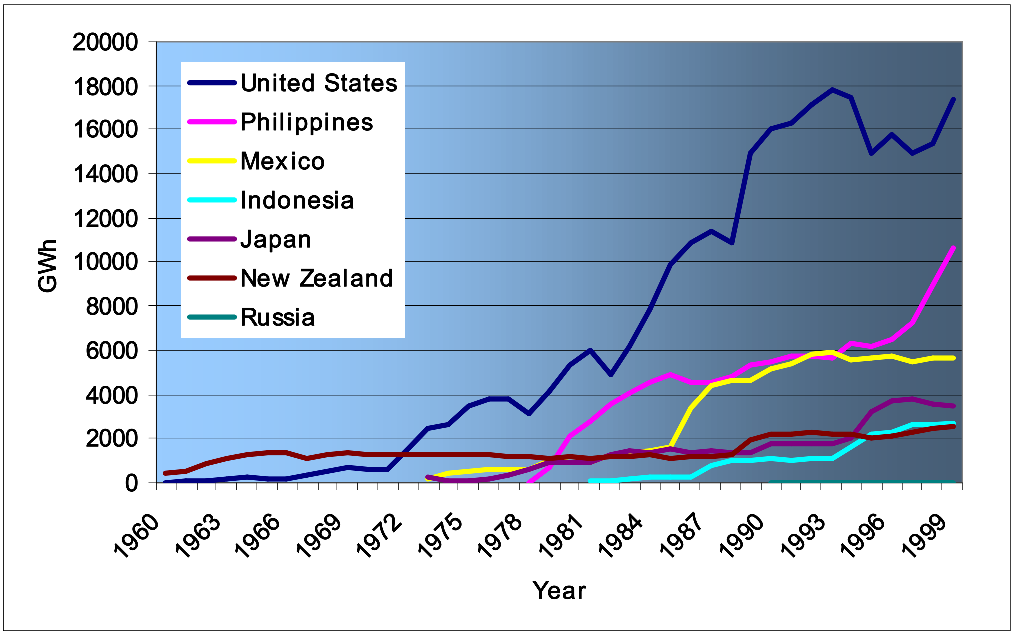
Geothermal power generation for selected APEC economies is shown in Figure 16. Steam field development and technology advancement has continuously improved the US geothermal capacity. From 35 GWh of power generation capacity in 1960, it has grown to 17,381 GWh (Figure 17), or an annual growth rate of 17 percent over the last 39 years. New Zealand which started its geothermal field development almost at the same time with the US, lagged behind at 4.8 percent. The Philippines, which closely follows the US in terms of geothermal generation increased its capacity by almost 50 percent over the last 21 years. However, as shown in Figure 16, over the last decade (1989-1999), Indonesia had experienced the greatest improvement in geothermal field development, improving its capacity by as much as 10.5 percent annually. For the same period Japan trailed at 9.6 percent followed by the Philippines at 7.1 percent, whereas the US, surprisingly trailed behind at 1.5 percent.

Figure 16 Annual Growth Rate of Geothermal Energy Generation, 1989-1999



Source: IEA (2003a)

Figure 17 Geothermal Power Generation in selected APEC economies



Source: IEA (2003b)

INDONESIA

The nearly 200 volcanoes and 100 geothermal fields make Indonesia a promising area for future geothermal power generation. Geothermal development started in Indonesia as early as the 1920s with its first shallow steam wells drilled at the Kamojang Province. The field which produced 250 kWe in 1979 has been producing 140 MWe from dry steam since 1985. Indonesia has aggressively pursued the expansion of its steam field capacity generation by as much as 10.5 percent annually, outpacing the US and Philippines, over the last decade.

JAPAN

Japan is the best-known example of a volcanic economy on the Pacific "ring of fire". It has been volcanically active over the last 20 million years. Because of its cold winters, the economy has been the world's largest user of direct geothermal heat. It first started its geothermal electricity production in 1966 with a dry steam plant in Matsukawa. Japanese geothermal development is often bordered by national parks and spas, therefore areas available for drilling tend to be small as the fields themselves (about 40 MWe). The longer range goal therefore is to build additional plants in small capacities for small communities.

MEXICO

Mexico is the third largest producer of geothermal steam for power generation, next to the Philippines. Its geothermal system occurs at Cerro Prieto along an offshore segment of the East Pacific Rise which bounds the North American and Pacific plates. This field now produces 720 MWe from its reservoirs up to 4,000 meters deep. Its first geothermal generation started in 1973 at 161 GWh and has grown to 5,623 GWh in the last 26 years (at an annual growth rate of 14.6 percent).

Despite the late start in Mexico's geothermal field development, it surpassed the US annual growth rate by 0.4 percent to 1.9 percent from 1989 to 1999. The annual growth however trailed that of other APEC economies.

NEW ZEALAND

New Zealand, just like the US, had an early start in developing its own geothermal resource. By 1960, its Wairakei field was generating 69 MW of electricity. It was the first large hot-water field ever developed. Several fields were then developed bringing its total geothermal generation capacity to about 2,502 GWh in 1999.

THE PHILIPPINES

The Philippines has a sizeable geothermal resource. Geothermal fields in the Philippines are large (average 220 MWe) and development is active. Most of the geothermal resources being developed are in Luzon (the main island and population centre) and the island of Leyte. Geothermal power generation started only in 1978. The Philippines is currently the world's second largest geothermal steam producer, next to the US.

HYDRO

The global theoretical potential for hydropower is estimated at 8,292 TWh/year[42] as shown in Figure 18. Electricity generation from hydro in the APEC region accounted for 14 percent (from a total generation of 7.38 TWh) in 1999 and is expected to maintain the share to 2020[43]. Although hydropower has long been an important source for generating electricity globally, large-scale hydro has become less appealing in recent times. Impacts from the construction of large-scale hydro schemes are manifold, ranging from displacement of local communities, extinction of fish and other aquatic species, as well as greenhouse gas emissions (from methane and carbon dioxide).

International waterway is perhaps the most important issue related to the construction of large-scale hydropower schemes. This is especially critical in the absence of adequate international laws governing this issue that could result in potential international conflict. For these reasons, small hydropower has become the preferred choice for generating electricity worldwide although some economies still build large-scale schemes, like the 18.2 GW Three Gorges Dam project in China.

There is no international consensus on the definition of small hydropower currently. The upper limit varies between capacities of 2.5 and 50 MW, but a value up to 10MW is becoming generally accepted. Small hydro can be further classified by the following definitions:

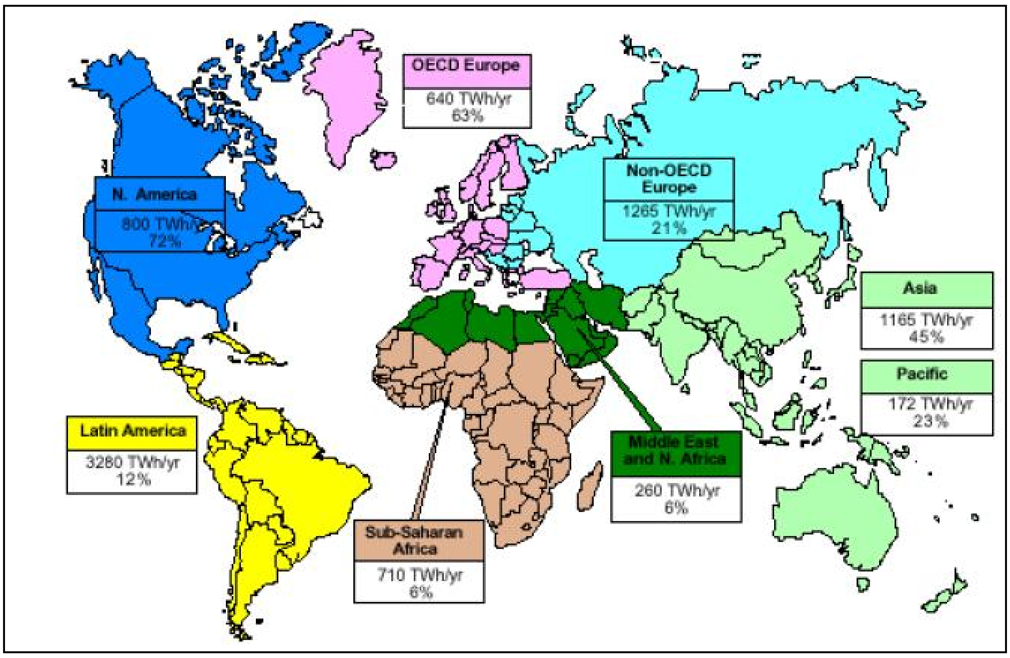
- Mini hydro power stations – capacity ranging from 5 KW to 10,000 KW;
- Micro-hydro power stations – maximum capacity of 5 KW or less; and
- Pico-hydro units – typically between 200-500W

The potentials of small hydropower in APEC region is difficult to estimate since most economies do not make a distinction between large-scale schemes and small hydropower in the energy balance report.

[42] Lako, P, et.al. (2003)

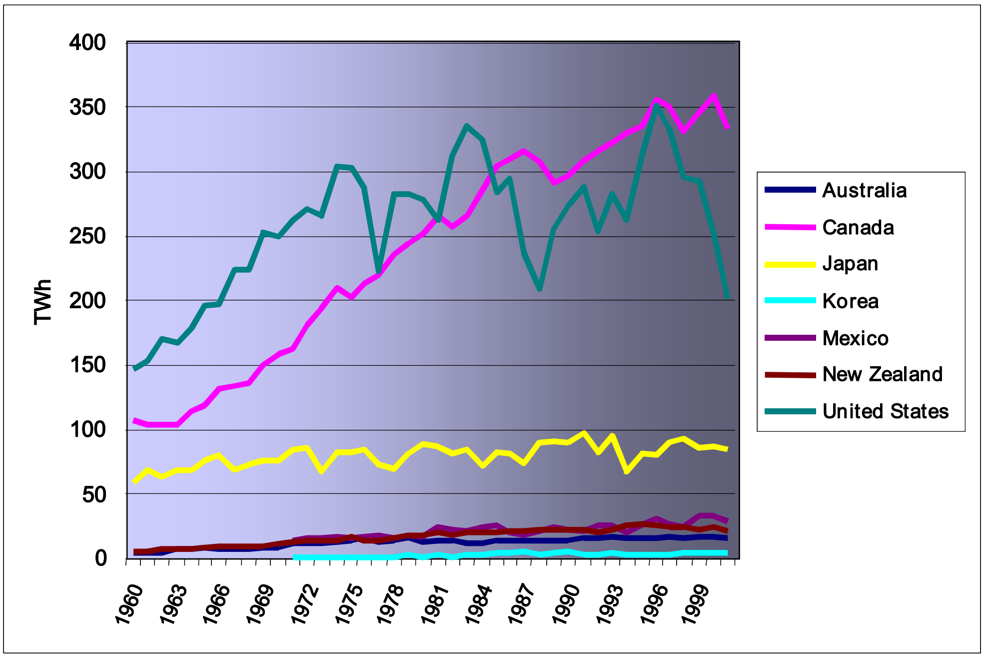
[43] APERC (2002)

Figure 18 Net Exploitable Hydropower Potential (TWh/year) Worldwide



Source: Department of Economic and Social Affairs of the United Nations Secretariat, based on Energy Statistics Yearbook, 1996; and Renewable Energy Resources: Opportunities and Constraints, 1990-2020, as cited in Lako,P, et. al., 2003
Note : Percentages refer to extent of exploitation

Figure 19 Electricity Generation from Hydropower in Selected APEC Economies



Source : IEA (2003c)

Figure 19, illustrates the electricity generated from hydropower in selected APEC economies. The average annual growth rates from 1971 to 2001 for these economies range between 1.2 and 3.9 percent except for Japan and the United States which recorded declines. As these economies have almost exhausted the hydro resources that could be developed economically, small hydro power could be a promising alternative. Developing economies on the other hand, have greater hydro potentials that can be exploited for generating electricity. Small hydropower with its lower environmental and social impacts could be beneficial for these economies.

AUSTRALIA

Australia has about 200MW of installed small hydro capacity generating 710 GWh of electricity annually. A number of small micro-hydro units are utilised for domestic remote area power supplies, tourist facilities and cathodic protection for pipelines. New small hydro potentials in New South Wales (NSW) have been identified by the Sustainable Energy Development Authority (SEDA) at more than 36 sites, each with a potential output in excess of 1,000 MWh/year. Although Australia has vast water resources that could be developed as small hydropower, most of the good sites have already been exploited. Development of new small hydropower could only be attractive with further technological improvement that could bring down the cost substantially.

CANADA

Canada's exploitable hydro resource is estimated at 160 GW with an economical potential of 523 TWh per annum.[44] As of 2001, Canada's small hydro capacity was 2,000 MW which contributed about three percent of its total hydro capacity. The economy is estimated to have a further small hydro potential of 11,000 MW. However, only 15 percent of this capacity is economically feasible to develop under the present regulations and socio-economic conditions. Further capital cost reduction of about ten to 15 percent through technological advances could provide an additional 2,000 MW in small hydro capacity.

The development of small hydro industry in Canada is supported by favourable policies. The research and development effort is focussed on developing appropriate small hydropower technology for exploiting hydro resources economically. This effort brings together expertise from the public and private sector as well as the academe. The primary effort is now concentrated on developing tools and techniques to reduce equipment and construction costs.

CHINA

China has the richest water resource in the world, which accounts for 17.6 percent of the world total.[45] The total theoretical reserve of water resources in China is estimated at 688 GW with an estimated electricity output of 5,920 TWh per annum.[46] China had a total installed capacity of 92.2 GW by the end of 2003. This water resource could be exploited to provide an estimated 139 GW of electricity with medium to small hydropower technology. Since most of the water resources are located in the mountainous western region, small hydropower provides a viable option for rural electrification programmes.

There are 40,000 small hydropower units with installed capacity below 50MW that provide 29 percent of total hydroelectricity currently. In recent years, the Chinese government has been pursuing a vigorous rural electrification programme harnessing new and renewable energy. Under this programme, hydropower is expected to account for 50GW of total new generation by the year

[44] Lako,P et.al. (2003)

[45] International Hydropower Atlas (IHA)

[46] Youmei (2004)

2020.[47] About 300 million people in approximately 800 counties benefit from these small hydropower schemes.

In order to encourage the development of small hydropower-based rural electrification, the central and local governments have made a series of policies and have adopted several measures to promote rural electrification. Essential support provided under these policy measures include special government-provided commercial loans and small discount on loans for rural electrification programme as well as tax exemptions for new hydropower plants developed at the site of old hydroplants. The government has also established rural electrification standards, which takes into consideration the endowment of energy resources in each county and determines the technical standards such as quality of supply and minimum supply per household.

INDONESIA

Hydroelectric is one of the most developed forms of renewable energy in Indonesia over the last three decades with utilisation increasing from 3.8 TWh in 1980 to 10.4 TWh in 1999[48]. The hydro potential for the economy is estimated at 75.7 GW with a current installed capacity of 4.2 GW. Mini hydro systems are defined as systems of 500 kW up to 5 MW that are planned for grid connection. Micro hydro systems with capacities below 500 kW are typically utilised for rural electrification programme and powering small industries. The mini/microhydro potential for Indonesia is estimated at 460 MW with a current installed capacity of 64MW.

Under the East Indonesia Renewable Energy Development (EIRED) Programme, PLN (state-owned power utility company) has identified small hydro power plants at 15 sites in Sulawesi, Papua Barat (former Irian Jaya), and Flores. The total capacity of these planned schemes is approximately 25 MW. A Memorandum of Understanding (MOU) for the development of 11 minihydro with a total capacity of 25.6 MW was signed between PLN and the government of France. These minihydro schemes will replace the existing diesel generation units in South Sulawesi.

JAPAN

Hydropower accounted for 84.2 TWh or around ten percent of total electricity generation in 2001. Japan's hydro resources have been extensively developed with up to 95 percent of exploitable hydro resources being developed by 1986. Further hydropower development does not hold much potential with the exception of pumped storage.

MALAYSIA

Malaysia's hydropower capacity is estimated at 25 GW with a total electricity output of 107 TWH/year.[49] There are currently 50 mini hydro plants with installed capacities ranging from 200 kW to 2.2 MW with a total installed capacity of 38.85 MW in operation. A small hydropower resource assessment is not currently available for this economy.

Most of the mini hydro systems that are in operation in the economy are public-funded under Malaysia's rural electrification programme. These are mini hydro schemes which are based on run-of-river systems ranging from 500 kW to 1000 kW capacity. Currently thirty-nine units with a total generating capacity of 16.185 MW have been commissioned in Peninsular Malaysia. Seven units with a total capacity of 2.35 MW have been commissioned in Sarawak. In Sabah, five units with a total capacity of 5 MW have been commissioned. In peninsular Malaysia, these units are owned by the power utility company, Tenaga Nasional Berhad (TNB). The situation in the states of Sabah and

[47] Ku,J (2004)

[48] ACE (2000)

[49] National Energy Balance, Malaysia 2003

Sarawak (northern Borneo island) offers better opportunities for the application of renewable energy since electrification level is relatively low.

MEXICO

Mexico's theoretical hydro potential is estimated at 155TWh/year with a net exploitable potential of 64 TWh/year.[50] The current installed capacity in the economy is 9.6 GW producing an estimated 33 TWh per annum that accounts for 19 percent of total electricity generation.

With about 50 percent of exploitable hydro potential already being developed, small hydropower scheme could be a promising alternative for Mexico. Small hydropower potential in Mexico is estimated at 11.38TWH/year.[51] This potential includes 119 existing hydropower plants with an average capacity of one megawatt that are currently not operational (3.3 percent of the potential).

A study carried out by the National Energy Saving Commission (CONAE) at the Veracruz Puebla area in 1995, identified small hydro potential of 3.5 TWH/year. In addition to that, there are 25 principal rivers and 130 tributaries that have yet to be assessed. Mexico has more than 100 years of experience in mini-hydro power, most of them in rural electrification and for the textile industry. Therefore, Mexico has qualified professionals in operation and maintenance of mini-hydro system. There are more than 80 mini hydro plants that are in operation in Mexico now, most of which are managed by independent power producers.

PAPUA NEW GUINEA

Hydropower accounted for 40 percent of Papua New Guinea's electricity generation in 1999. The gross theoretical hydropower potential of PNG is 175,000 GWh/year (20,000 MW). Out of this, the technically feasible potential is 122,640 GWh/year (14,000 MW) with an economically feasible potential of 36,800 GWh/year or 4,200 MW.[52] As of 1994 only one percent of the technically feasible potential has been developed, and 4.3 percent of the economic potential.

There are 10 small, mini and macro hydro plants (of less than 2 MW) in operation, with a total capacity of 19.8 MW. With about 90 percent of its population unelectrified, development of small hydropower could be a promising option to be considered.

PHILIPPINES

Philippines' hydropower potential is estimated at 14,367 MW at 293 sites throughout the economy. Small and mini-hydro projects have the potential to provide energy in isolated villages and hilly areas where the extension of grid systems is uneconomical. The government encourages the development of mini-hydropower plants in the economy through its "O Ilaw" rural electrification programme (which stipulates 100 percent electrification by 2006) and the Republic Act 7156, an act granting incentives to mini-hydroelectric power developers. The total identified mini-hydropower resource potential is about 1,132.5 MW.

The demand for power is projected to require an addition of 76.79 MW of capacity by year 2008 from mini-hydro sources as embodied in the Philippine Energy Plan (1999-2008). This shall be supported by more public-private sector partnerships to identify more potential mini-hydro sites and the subsequent implementation and installation of more mini-hydro projects.

[50] Lako,P et.al. (2003)

[51] VINSA (2003)

[52] IHA

A continuing review of existing administrative and legislative policies will be effected to attract more investment in small-scale hydropower. Adoption of a power tariff structure, less stringent environmental considerations for mini-hydro projects, relaxation of financial qualifications, and identification of more financing sources will also be studied and if found beneficial will be considered.

The DOE has also started the compilation of more reliable and updated information on the economy's mini-hydro potentials, hydrologic and other technical data to be made available to prospective developers. It has also initiated the holding of business meetings (e.g. Romblon and Catanduanes) to gather the different players to look for ways and means to develop viable potentials in these areas.

Lastly with the formation of the Philippine Association of Small Scale Hydropower, Inc. (PASSHYDRO), the Department of Energy (DOE) has found an active partner to enhance and promote further acceleration of the country's mini-hydropower development programme.

UNITED STATES

The United States has a sizable hydro resource with an estimated theoretical potential of 512 GW, equivalent to 4,485 TWh/year[53]. The current installed capacity is 79.5 GW producing an average 316 TWh of electricity per annum. This accounts for 85 percent of the economically feasible potential.

Although hydroelectricity has one of the lowest operations and maintenance cost per kWh, there are limited sites for new development. The share of hydro in electricity generation is expected to decline from 7 percent in 1999 to 6 percent in 2020, with a projected average annual growth of 0.4 percent.[54] The impact of hydro schemes on fish mortality and downstream water quality has drawn public criticism and resulted in more stringent regulations. The US Department of Energy (DOE) has initiated the development of advanced hydropower turbine systems to improve the overall performance and acceptability of the hydro schemes since 1993.[55]

The US DOE's current goal is to develop the next generation hydropower system to harness undeveloped hydropower resources without the use of dams. This new technology is expected to extract energy from free flowing water sources ranging from municipal water systems and effluent streams to natural streams, tidal waters, ocean currents and canals. The system, classified as low power hydropower, generally has an installed capacity of less than one megawatt of electricity. An assessment of water energy resources by DOE indicates a potential of approximately 170 GW of annual average power located across the 50 states.[56] This huge resource is excluding areas that have been excluded from hydropower development by federal statutes and policies. From this total, about 50 GW could be utilised, as low hydropower while the remaining 120 GW of high power resources could also be utilised using low power technologies.

VIET NAM

There are currently 370 small hydro plants in Viet Nam with capacities ranging from 5 kW to 7,500 kW. In Table 3, a summary of the potential and current utilisation of hydro resources in Viet Nam is presented. These account for a total installed capacity in small hydropower of 73 MW. The majority of the plants fall within the size range of 10 kW up to 50 kW and plant factors for these schemes are typically in the range of 15 to 25 percent. Most of the systems were developed with

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[53] Lako,P et.al. (2003)

[54] APERC (2002)

[55] EERE (2004)

[56] Ibid

public funding or international aids. Upon completion of the installation, ownership is generally transferred to a local entity, which then becomes responsible for the operation and maintenance of the system. Different management models were used and are still in use namely: management by the power sector; by local authority; by industrial enterprise and by community or cooperative.

Table 3 Potential and Current Utilisation of Hydro Resources in Viet Nam

Resource	Potential, MW	Current Usage, MW
Hydro power	800 - 1400	115
- pico-hydro	90 - 150	30 – 75
- isolated mini-grids	300 - 600	20
- grid connected mini hydro	400 - 600	60
Total	1,000 - 1,900	120

Small hydropower systems provide about 65-120 kWh annually for residential uses, agricultural production, and small industrial requirements in mountainous, midland and high land areas. There are around 120,000 pico-hydro power units with a total capacity of 20,000 kW. These systems' sizes range from 200 W to 500W with low investment cost (around US$ 45 per unit). They are classified as "hydro home systems" to generate electricity for lighting in about 130,000 households in mountainous areas because of relatively low cost, durability and ease of installation in small streams with a head of 1-1.5 m.

BIOMASS

Biomass in general refers to all plant and animal matters that include all water- and land-based organisms, vegetation, and trees, or virgin biomass, and all dead and waste biomass such as, bio-solids (sewage) and animal wastes (manures) and residues, forestry and agricultural residues, and certain types of industrial wastes. Biomass is defined as renewable in the sense that only a short period of time is needed to replace what is used as an energy resource.[57] Experts disagree on the status of municipal solid wastes (MSW) and landfill gas, although most economies include these two resources in their definition of biomass.[58] For the purpose of this study, both MSW and landfill gas are treated as biomass.

Despite being available in relative abundance, biomass is also one of the most poorly documented resources. The lack of data and/or its absence altogether impede sound decision-making process when it comes to biomass energy. The global technical potential for biomass was estimated to be more than 4.8 billion toe/year (200 EJ/y) in 2000. The global utilisation in 2000 was 1.2 billion toe/year (50 EJ)/year. [59] Biomass represented 14 percent of total global energy consumption in 2001.[60] Most of this consumption took place in developing economies, where biomass is utilised primarily for cooking and heating. Table 4 shows that the share of biomass in total energy consumption for developing economies is significantly higher, at 26 percent compared to only 3 percent for industrialised economies in 2000.

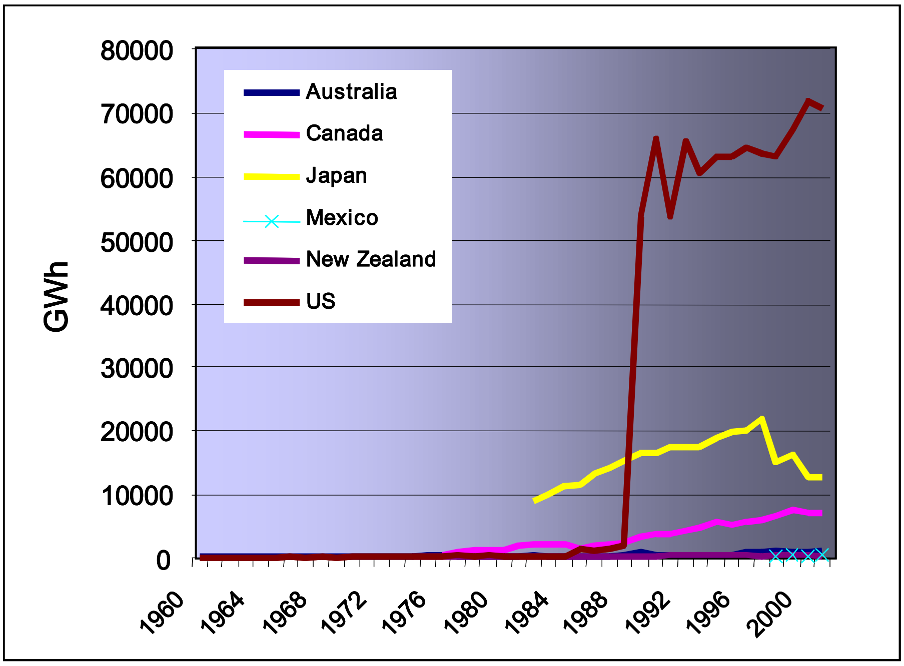
[57] Klass L. Donald (2004)

[58] The disagreement on MSW stems from the fact that it comprises many different organic and non-organic materials; difficulties and high costs associated with sorting such material, which make it an unlikely candidate for renewable energy except for disposal purposes; re-used MSW is mostly for recycling, such as paper; and MSW disposal would be done in landfills or incineration plants

[59] Goldemberg.J (2000)

[60] IEA (2003b)

Figure 20 Historical Consumption of Biomass in Power Generation in APEC region



Source: IEA (2003d)

Note: The big rise in biomass electricity generation for United States in 1989 is due to the inclusion of non-utility generation that were previously not accounted for.

On the other hand, modern biomass utilisation like electricity generation is almost absent in developing economies in APEC (and the rest of the world). Figure 20 shows the biomass utilisation for electricity generation trend for selected APEC economies. The United States has the highest amount of electricity generation from biomass resources, followed by Japan and Canada. Biomass utilisation in developing economies is expected to decline in coming decades as they become more affluent and trade off traditional biomass for other modern fuels.

Table 4 Global Biomass Consumption in 2000

Economy/Region	2000			
	Biomass (Mtoe)	Conventional Energy (Mtoe)	Total (Mtoe)	Biomass share (%)
China	214.48	943.40	1,157.90	18.50
Asia	343.20	467.74	810.94	42.30
Latin America	69.34	284.96	354.30	19.57
Africa	221.10	157.37	378.47	58.40
Total non-OECD	859.65	2,417.86	3,277.51	26.23
OECD	126.17	3,551.32	3,677.49	3.40
World	985.20	5,969.18	6,955.00	14.20

Source: IEA (1998) and (2003)

AUSTRALIA

Australia's main biomass electricity is produced from landfill gas, harvested in many landfill sites. About 100 MW of electricity is produced this way in about 30 generating plants. The largest plant is located in Perth, Western Australia and is capable of producing 13 MW.

Bagasse is used to generate electricity by burning waste sugar cane after it has been crushed. These generating plants are located at sugar mills in Australia's sugar growing areas. Surplus electricity is sold to the local electricity suppliers. There are 26 participating mills and in peak season they generate 60 - 70 MW of electricity. Gas from sewage is being used to generate electricity in Adelaide (3.0 MW), Brisbane (3.2MW) and Melbourne (1.3MW).

CHINA

China has a significantly large biomass resource estimated at 600 million ton per year. It is expected to increase to about 800-1,000 million tons per year.[61] The biomass resource consists of 150 million TEC/year of agricultural straw, 80 GM^3 (60 MTEC) biogas from livestock farm and industrial wastewater, 200 million TEC/year of fuel wood, forest, timber residue, 15 M TEC/year landfill gas and other energy crops such as rapeseed and sweet potato.[62] The economy also has technical know-how in developing biomass technology.

The total installed capacity from biomass is currently 1,900 MW. It consists of 1,700 MW in co-generation from bagasse, 150 MW from landfill gas and 50 MW from rice husk. The economy is targeting to generate 20 GW of electricity from biomass by 2020. China is also well ahead of other developing economies in terms of R&D initiatives and manufacturing capacity.

China has developed two types of biomass gasifier equipments that are capable of converting biomass such as wood chip, rice husk, nut shell and straw to combustible gas through thermo-chemical process. The small-size biomass gasification set is suitable for use in hilly and rural areas to meet the requirements for illumination, living and power. The equipment was incorporated with a modified gasoline generator, the Peako Mark-I, and began operation in 2002 in Guangzhou province. In addition, China has also developed the technology for producing ethanol from biomass. The current production capacity is estimated at 400,000 ton and is expected to reach a million ton in the near future.[63]

INDONESIA

Biomass is the traditional and oldest energy source in Indonesia, accounting for around 35 percent of total energy consumption. The total biomass potential in Indonesia is estimated at 49.8 GW with a current installed capacity of 178 MW.[64] It is estimated that Indonesia produces 146.7 million tons of biomass per year, equivalent to about 470 GJ/y. The main sources of biomass energy in Indonesia are rice residues which give the largest technical energy potential of 150 GJ/year, rubber wood with 120 GJ/year, sugar residues with 78 GJ/year, palm oil residues, 67 GJ/year, and the rest with smaller than 20 GJ/year are from plywood and veneer residues, logging residues, sawn timber residues, coconut residues, and agricultural wastes. These sources of biomass can help in supplying both heat and electricity for rural households and industries.

Biomass in the form of bagasse and oil palm waste are currently utilised for electricity co-generation in Indonesia. Gasification technology for rural electrification programme is still at

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[61] Song (2004)

[62] Ibid

[63] Ibid

[64] Kamarudin

demonstration stage, however. Future development of biomass generation includes a 30MW plant in east Kalimantan. Another 10.3 MW is being developed by the private sector in Northern Sumatera.[65]

Although there are over 400 sawmills that are in operation in the economy producing wood residues ranging from 10,000 and 50,000 m^3/year very little of this had been utilised for generating electricity. Most of the sawmills utilise diesel generators to meet their power demand while some large sawmills utilise wood waste to produce electricity. However, all ply-mills use wood waste to generate process steam for dryers and hot presses. An estimated 40 ply-mills have capacities of less than 50,000 m^3/year and 70 plants produce between 50,000 and 200,000 m^3/year. A 5.5MW waste-wood power plant T Siak Raya Timber in Pekanbaru, Sumatra had been developed with partial technical and financial support of the ASEAN-EC COGEN programme.[66] Feasibility studies and demonstration projects show favourable results with respect to the return on investment for self-generation. Pre-crisis assessments also showed that power sales to the grid could be feasible, based on the Small Power Purchase Tariffs set by the power utility, PLN. Ensuring the regular fuelwood supply for this purpose is the most critical factor for this operation.

At present, there are 56 sugar mills in operation in Indonesia. Bagasse produced from one tonne of sugar cane could be converted into an estimated 100 kWh of electricity. There is a huge potential to produce excess electricity from bagasse in commercial-scale. Three co-generation plants utilising bagasse with a combined total capacity of 25 MW have been planned in Java (18MW), Sumatra (6MW) and Sulawesi (1MW). In addition, another 12 bagasse projects are planned with a total combined capacity of 104 MW. These plants are to be located in Sumatra (38 MW), Sulawesi (13MW), Kalimantan (4 MW) and Java (29 MW). Some 100 MW of (mostly biomass and bagasse co-generation) projects have been identified for power generation and supply to the grid, under the PSKSK (SPPA) arrangements with the utility purchasing the excess power at fixed rates.[67]

The economy has an active policy to relocate sugar cane fields from East Java to Kalimantan, Sumatra and Sulawesi. The sugar mills should follow. The relocation of the sugar mills to the newly developed sugar cane plantations outside Java may provide a good opportunity to install new power generation equipment.

In Indonesia, the national energy policy aims to reduce dependence on oil and gas and to diversify the energy mix to include other energy resources such as renewable energy. The Ministry of Mines and Energy published the tariff for purchase of electricity under the Small-Scale Renewable Energy Power programme which aims to ensure the availability of electricity and to provide business opportunities for small-scale power investors (DJLPE, 2003).

JAPAN

Japan's electricity generation capacity from biomass accounted for only 69MW in 2000, from a total generation of 368 GW or 0.02 percent. This is expected to increase to 330 MW by the year 2020.[68] The utilisation of biomass in Japan has gained renewed interest with the adoption of "Biomass Nippon Strategy" in 2002. Formulation of the Strategy involved several ministries, including, Ministry of Agriculture, Forestry and Fisheries, the Ministry of the Environment and the Ministry of Economy, Trade and Industry.

The Strategy outlines the directions to be taken in order to achieve the increased utilisation of biomass as well as the necessary technology and infrastructure required to accomplish the goals. In

[65] Nuzahar (2003)

[66] ACE (2000)

[67] Ibid

[68] Ito (2003)

the short term, Japan is expected to increase the utilisation of waste by-products from livestock, food, construction derived wood residues, black liquor and sewage. In addition, the economy will also begin utilising biomass resources that were previously not used such as agricultural wastes and forestry residues. Finally Japan aims to cultivate energy crops by 2020.

In case 1, a gas turbine of 250 kW runs 10 hours a day. All the electricity and heat production is utilised in four public facilities. In cases 2 and 3, a gas turbine of 500 kW (case 2) and a steam turbine of 1,000 kW (case 3) continuously run. Their heat production is supplied to the public facilities, but all the electricity produced is sold. Therefore, the public facilities bought electricity from grid.

There are two kinds of the feedstock, sawmill waste (most of that is bark) and the forestry waste, are utilized. Available amounts of sawmill and forestry wastes are 12,056 Gcal/y and 44,872 Gcal/y, respectively. Since the cost of sawmill waste is much cheaper than that of forestry waste, all cases precede use of sawmill waste. The equipment cost includes the co-generation installation, the absorption type refrigerator to cool in summer season and the thermal supply pipe arrangement. Since the distinct heat system is not popularised in Japan, the cost unit of the thermal supply pipe is very high and its cost accounts for more than 50% of the equipment cost.

MALAYSIA

Based on a 1999 study, it is estimated that Malaysia's biomass resource could generate 665 MW of electricity. This estimate is based only on agricultural wastes, such as rice husks, wood wastes, oil palm wastes, bagasse, and palm oil mill effluent (POME). The estimate is potentially higher if other sources of biomass, such as poultry farm wastes, landfill gas, pulp and paper industry wastes, municipal solid wastes and sewage sludge is included in the estimate. There are no plans to cultivate energy crops currently.

The total installed capacity from biomass is estimated at 203 MW in 2004, mostly from oil palm residue.[69] Crop residue utilisation for power generation is to a large extent dominated by the use of waste material in the palm-oil sector. Empty Fruit Bunches (EFB), shells, fibre, and even the palm oil mill wastewater (effluent or POME) can be used for the generation of steam and electrical power. Residues in the rice milling industry are not yet used on a large scale, and the very few sugar mills operating, with low rated capacities, offer little scope for further development of power generation. The single generator utilising rice husk for power generation currently connected to the grid has a capacity of 10MW. Rice mill could take advantage of the "Small Renewable Energy Programme" (SREP) that was launched by the government in 2001 to promote electricity generation from renewable energy.

New and more profitable markets for EFB are emerging. These residues can also be utilised as basic material for MDF boards, for mattress filling and for insulation. Such competing alternatives may eventually result in waste shortages at palm-oil mills. Such shortages, combined with stricter enforcement of environmental standards, will lead to a call for more efficient (high pressure systems of more than 80 bar), environmentally friendly co-generation equipment. An example of a successful project for a palm oil mill (supported by the COGEN programme) is in Pontian, Johore, where a boiler producing 25 tons of steam per hour (23 bar, saturated) is connected to a 1.2 MW back pressure turbine (4.1 bar) for power generation. Retro fitting existing palm oil mills with (partly) new co-generation equipment is expected to become a viable commercial opportunity.

Rice husk generated at the rice mills while milling paddy can be considered as fuel for heat and power generation, provided it comes in regular and sufficient quantities. So far, experiences in the utilisation of rice residues for process heat and power generation are limited. One of the problems is the fact that paddy needs to be dried as soon as it enters the rice mill, which is only in the harvest

[69] For comparison, the total installed capacity in Malaysia at the end of 2003 was 18,030 MW

season. Actual rice milling can, in principle, be done all year round. This means that the required heat/power ratio for co-generation will vary with seasons. In addition, rice husk is probably the most difficult of all biomass fuels to burn, with relative low calorific value, high volatile matter content and rather high ash content. The high silica content of the ashes causes substantial wear and tear in furnace de-ashing systems. This is compounded by the high volatile matter content causing clinkering of the ashes. On the other hand, these high silica ashes are of commercial value to metal industries and glass.

Renewed interest for rice husk based co-generation will start with the implementation of successful projects. It appears that some companies may now have overcome all major difficulties. An example is the recently installed system in Pendang, Kedah Darul Aman. A steam boiler, 6.5 tonnes per hour, 30 bar, saturated, is connected to a 450 kWh back pressure turbine and a heat exchanger (1,200,000 kcal/hr). The co-generation system is used both for the mill's power supply as well as the heating requirements. Expected pay-back is less than 3 years.

For the palm-oil sector, boilers with a rated capacity of 25–30 t/h are standard. For power generation, turbines are usually no larger than 1–1.5 MWe and practically always in a back-pressure set-up, as the first priority is for heat generation for sterilisation purposes. For rice mills, the boiler size is 5–15 tonnes/hour coupled to a turbine rated between 0.5 and 1 MWe.

For the palm-oil mills, all suppliers are basically offering the same standardised technology; water tube boilers with a fixed grade and spreader stoker. In most mills, co-generation is in the form of a back-pressure turbine, with the primary function of producing of steam for the sterilisers. Investment costs per installed kW may vary between US$ 800 and US$ 1,200 for back-pressure systems. For rice mills, development costs may range between US$ 1,500 and US$ 2,000 per kW installed or for smaller rice mills systems, around 500 kW and for large systems (about 2 MW) US$ 1,400 - 1,600 per kW.

WOOD FUEL

Data on the actual use of wood fuel for power generation is limited. Table 3 lists down cogeneration projects in the wood processing industry. Previously, it was assumed that the bulk of sawmill residues was left unused, either burnt or dumped and that plymills utilise anywhere from 30 percent to 50 percent of their residues for steam production. However, with the gradually stricter enforcement of environmental laws which forbid the open burning of wood residues, this situation will drastically change.

Table 5 Existing EC-ASEAN Cogen Projects for Wood Processing Industries in Malaysia, 1997

Industry	Location	Technical Description	States of Project Development, April'97
Sawmill with kiln drying	Sarikei, Sarawak	Boiler: 30 TPH, 21 bar Turbine: 1.65 MW fully condensing Process Steam: 10TPH, 7 bar	Fully Operational
Sawmill, moulding and kiln drying	Bentong, Pahang	Boiler: 16TPH, 22 bar Turbine 1: 0.9 MW condensing Turbine 2: 0.6 MW back pressure Process Steam: 4TPH, 6 bar	Currently operated at 0.9 MW capacity, operators are under-going training

Source: ACE (2000)

COGEN estimated that the net log production was 21 million tonnes in 1996. Assuming a residual rate of 50 percent this would translate to 9.5 million tonnes of wood waste material. Based on 2 kg per kWh of generated electricity, this would amount to 5.2 GWh/year, sufficient for a few hundred small-scale power plants. However, because of the present alternative uses for wood residues, this technical potential will be hard to realise.

A rough estimate of 7 million m^3 of rubber wood should be available every year, but with the increased interest in rubber wood for furniture and fibre board making, the actual volume of rubber wood for heat and power generation quickly decreases, with only cuttings, trimmings, shavings and sawdust available for future use in power generation. Waste material of other plantations (cocoa and coconut) is commonly used to meet fuel requirements and also construction needs. In general, any company with abundant wood waste resources, auto generation can be realised at costs competitive to the tariffs charged by utilities to the industrial sector. Rough guidelines indicate that for ply-mills with a turn-over of 40,000 m^3/y, and for sawmills with a turn-over of 20,000 m^3/y, cogeneration should be considered an attractive option.

Boiler capacities for the wood processing and manufacturing industries range from 5 to 45 tonnes of steam per hour. Generation capacities vary between 0.5 and 10 MWe. Its cost is US$1000-US$1,200/KW.

PHILIPPINES

In 1999, the Philippines' estimated biomass potential was around 247.9 MMBFOE, and projected to increase to 301.5 MMBFOE in 2008. Biomass fuels include wood and wood wastes, bagasse, coconut and rice residues, animal wastes and municipal solid wastes.

Bagasse is considered a new source of off-grid power for household electrification in remote countryside areas. It is estimated to account for half of NRE's contribution to the commercial/industrial sectors. Because of its growing popularity, its contribution is further projected to increase to about 21.6 MMBFOE by 2008.

Wood-wastes and coconut residues will also be used significantly as fuel for in-plant power generation and for process heating by wood processing plants and coconut mills, respectively. Commercial establishments such as restaurants and bakeries will also continue to use fuel-wood and charcoal as fuels for cooking.

In 2001, a 40-MW power plant using rice-husk as fuel was eyed for construction in Bulacan and connected to the grid. In 2008, more bagasse-fired power plants will be installed and about 50 MW of the new plants made available to the grid. A number of ready technologies such as agro-dryers, communal rice husk power plants, and other decentralised energy systems have passed the feasibility study stage and are now ready for implementation. This could be done through several schemes such as joint-ventures, contracted projects and energy service arrangements. The Belgian representatives, for example, has offered to provide technical and financial assistance in the commercialisation of communal rice husk power plants (1 - 3 MW capacities) as a result of PNOC-ERDC's market and feasibility studies in eighteen selected sites.

The Philippines has substantial biomass resources as shown in Table 6. Biomass accounts for a significant proportion of renewable energy generation (99 percent of new and renewable energy demand excluding geothermal and hydro power for 1996), mainly from wood fuel and charcoal. Large amounts of agricultural residues and municipal solid waste are also produced, offering promising resources for heat and power generation.

Table 6 Supply of New and Renewable Energy Sources (in Peta Joules)

Biomass	1996	2000	2005	2010	2015	2020	2025
Rice Residues	44.29	51.12	56.43	62.28	68.81	75.95	83.88
Coconut Residues	112.73	122.06	134.75	148.78	164.27	181.35	200.20
Bagasse	67.04	78.45	95.47	116.14	141.28	171.90	209.11
Fuelwood	489.77	537.72	608.54	693.63	796.05	919.21	1067.51
Animal Wastes	72.35	75.34	79.12	83.20	87.41	91.87	96.56
Municipal Wastes	23.73	641.30	736.40	833.14	934.77	1040.48	1149.12
TOTAL	809.90	1505.98	1710.69	1937.19	2192.60	2480.76	2806.38

Source: Non-Conventional Energy Division, the Philippines Department of Energy. 1996 figures are approximations of actual use.

Table 7 below shows the demand for biomass for 1996. The use of biomass is expected to triple in the period up to 2025, with a shift away from biomass use for cooking, process heat and mechanical drive, towards a greater use for power generation.

Table 7 Demand for New and Renewable Energy Sources (in Peta Joules)

Biomass	1996	2000	2005	2010	2015	2020	2025
Rice Residues	23.55	28.55	32.09	36.11	40.63	45.63	51.30
Coconut Residues	71.25	82.23	92.23	103.46	116.02	130.05	145.79
Bagasse	58.93	70.76	86.74	106.32	130.36	159.76	195.81
Fuelwood	258.28	272.61	300.98	333.55	371.13	414.62	465.31
Animal Wastes	0.06	2.99	6.10	9.52	13.24	17.32	21.78
Municipal Wastes	0.00	0.00	0.00	18.12	27.02	31.48	44.41
TOTAL	412.06	457.14	518.14	607.08	698.39	798.86	924.40

Source: Non-Conventional Energy Division, The Philippines Department of Energy

The Paper Industries Corporation of the Philippines does operate a total tree utilisation policy, under which forest and saw mill wastes are burnt with black liquor for cogeneration of process heat and electricity.

There are also plans to construct power plants that will utilise excess rice husk, such as the large-scale power generation project scheduled for construction in Bulacan province. The 40 MW plant developed by a US company intends to use ricehull from various sources, 80 km around the plant. There are however doubts about the feasibility of such a large scale collection operation. The Decentralised Energy System Project of the Philippine National Oil Company Energy Research Development Centre has completed the detailed feasibility studies for the installation of two communal rice husk-fuelled plants in Cabatuan and Aurora, Isabela, each with a capacity of 2 MW, using rice husk from local mills.

The EC-ASEAN Cogen Programme identified attractive business opportunities for cogeneration using rice hull for high capacity rice mills, but also considered rice husk-fired power generation to be a viable option for small-scale rice mills. Even small-scale rice mills seem to offer promising market opportunities, although the technological problems encountered seemed more difficult to overcome. Small-scale cogeneration from biomass (400 kW to 1 MW) is a challenging problem itself, reinforced by the high ash and silica content (up to 20 percent) of rice husk. Automatic deashing, constant and uninterrupted combustion and low flue gas speeds are required.

THAILAND

Thailand is one of the world's biggest exporters of rice, with a 3 percent annual increase in paddy production over the past ten years. A few of the largest mills burn husk for mechanical power, electricity, or steam for drying paddy or parboiling rice. But often the mills use old technology which may not be clean or efficient. Other millers are forced to dump or burn the husk out in the open - with serious environmental consequences. Open burning husk freely emits unfiltered smoke and ash. Dumped, decomposing husk releases the greenhouse gas methane. Less than 1 percent of Thailand's installed grid capacity of 22,000 megawatts relies on renewable energy sources (other than large-scale hydro).

Biomass is the major indigenous resources of energy, accounting for 18.8 percent of total energy supply or 34 percent of the indigenous supply. Wood, in forms of firewood and charcoal, is the main biomass source which is approximately accounted for 75 percent of the total biomass used while a considerable portion of biomass sources originate from the large agricultural wastes, with approximately 18 Mt of agricultural waste. Bagasse and paddy husk are the predominant energy sources used for production activities.

Regarding electricity production, the utilisation of biomass has been sought through the Energy Conservation Act and the 'Announcement for the Purchase of Power from Small Power Producers', made by EGAT in March 1992. Under this new framework, 22 applications proposed to sell biomass-generated power to the grid, with a total capacity of 229 MW.

Agricultural residues may offer the biggest prospects for energy production in the future, but fuelwood is still the main energy source in rural regions. More than 60 percent of the population are still relying on wood and charcoal for cooking. Utilisation of fuelwood has been one of the major causes of deforestation in the country.

Bagasse is used as fuel in sugar mills for generating steam in the boilers to drive the primary machinery, as well as for boiling and concentrating sugar cane. The sugar industry is one of the largest energy consuming industries of the country. In 1995, over 50 sugar mills with capacity of about 0.4 Mt of cane per day, obtained power from 17.6 Mt of bagasse, which accounted for 4.3 percent of the total energy supply. The installed generating capacities of electrical and mechanical power in the Thai sugar mills are estimated at 580 MW and 270 MW respectively.

More efficient cogeneration systems in the sugar mills will lead to the saving of bagasse, which can be sold as a raw material for paper or fibre board production. These energy conservation measures could lead to savings of 2.7 Mt of bagasse, and generation of additional power of about 80 MWe. Furthermore, if cane leaves and tops are also used as fuel, the total potential for additional generating capacity could reach 240 MWe. At an assumed cane residue price of 8 US$/t, the electricity production from cane residue is estimated between 3.2-5.2 US cents/kWh for a power plant of 2.5-3.5 MW.

Paddy husk is produced in rice mills, from the milling of paddy to produce rice. It is used as an energy source mainly through direct combustion in large mills (it can also be utilised as a filler in the brick industry, or in producing charcoal from wood logs, as a fuel for domestic purposes in villages and occasionally as bedding material for animals). In 1995, 1.82 Mt of the 4.8 Mt of paddy husk were used as fuel in rice mills, representing 0.85 percent of total primary energy supply of the country, whereas more than 3 Mt, with a technical potential of 299 MW were not utilised and mainly destroyed. The heating value of rice husk varies from 14.6 to 16.3 MJ/kg. The existing technology concerns mills of more than 20 ton/day capacity, which traditionally use direct combustion by employing fixed bed, flat-grate or inclined-step grate furnaces. They are generally inefficient, cause pollution and are low-pressure systems, and thus not suited for power production. These systems provide little or no control over the quality of ash produced.

The par-boiled mills used paddy husk to generate power and heat for the par-boiling process. Steam is supplied directly from the boiler instead of exhaust steam from the engine. Typical efficiencies of the boiler and steam engines are 40 percent and 15 percent respectively, thus the overall efficiency of the system is very poor, about 6 percent. The average par-boiled mill has a milling capacity of 165 t/day of paddy and a power generating capacity of 207 kW. If improved co-generation systems were to be implemented, the total potential for electricity generation in these 52 mills could yield 31.2 MWe from which 20.5 MWe could be sold to the grid.

The white rice mills use paddy husk to generate about 35.8 MW of power for milling. The average white rice mill has a milling capacity of 196 t/day of paddy and a power generating capacity of 174 kW. The existing 260 mills, with the use of steam cogeneration systems with back pressure turbines, would have the potential to generate 150 MWe from the paddy husk, of which 60 MWe would be available for export. The identification of a promising market for this type of mill was verified by the 1994 EC-ASEAN COGEN Programme assessment, particularly if the sale of rice husk ash is foreseen.

There is no pricing policy for biomass energy currently. Prices of wood and charcoal are left to market forces. In view of the supply constraints, charcoal production has increased its profitability. The market prices of biomass indicate a strong competition in the biomass supply, as listed in Table 8 below. Nevertheless, in general terms these high prices have acted as a disincentive for the utilisation of biomass in electricity production, particularly in the case of small rice mills, where owners were more interested in selling the husks or ash than reducing their energy costs.

For rice mills, development costs may range between US$ 1,500 and US$ 2,000 per kW for smaller systems up to 500 kW. For large systems of up to 2 MW, the cost ranges from US$ 1,400 to 1,600 per kW.

At present, there are 49 small power producers in Thailand using biomass fuel including, paddy husk, bagasse, wood, and bark. The total capacity is 506.6 MW (Table 8). There are 20 sugar factories using bagasse as fuel for power generation with capacities ranging from 12 MW to 52 MW. The first sugar factory to use bagasse for generating electricity was Mitr Phol Sugar Co. Ltd. Dan Chang, in Suphan Buri. The power plant has an installed capacity of 24 MW and began operation in 1994. Five rice mills used paddy husk and wood chips for power generation. The total capacity of the power plants in rice mills is 79.2MW. There are currently 23-power plants using paddy husk, wood chips and bagasse as fuels for electricity generation with installed capacities ranging from 3.0MW to 87.2MW. There is only one paper plant using bark and wood chips to generate electricity with an installed capacity of 74MW. The plant was in operation in June 2000.

Table 8. List of Small Power Producers in Thailand as of August 2003.

No	Power plant type	Fuel used	Quantity	Capacity, MW
1	Rice mill	Paddy husk and wood chips	5	79.2
2	Sugar factory	Bagasse	20	432.6
3	Paper plant	Bark, wood chips	1	74.0
4	Power plant	Paddy husk, wood chips	13	347.6
5	Power plant	Bagasse	10	176.9
	Total		49	506.6

Source : EPPO, 2004

UNITED STATES

Electricity generation from biomass accounted for 9,733 MW or 1.1 percent of the total electricity generation of 903 GW in 2002[70]. Although electricity from biomass only contributed 59 TWh or 17 percent of total generation from NRE sources in 2002, it still represents the highest amount in the APEC region. The main source of biomass utilised for power generation is wood and wood waste, accounting for 56 percent in 2002 while municipal solid waste (MSW) and landfill gas combined, accounted for 32 percent for the same year. The share of electricity generated from biomass in the United States has also remained constant at around 60 TWh/year from 1998 to 2003[71]. The total electricity generated from biomass resources in the APEC region in 1999 was 95.6 TWh. The United States accounted for 66.4 percent of this total.[72]

Federal tax incentives like Production Tax Credit and Renewable Energy Production Incentives (REPI) were introduced to promote commercial renewable energy generation. However, most states still offer various other incentives for electricity generation from biomass and other renewable energy sources. Current R&D on biomass is focussed on developing bio-fuel since biomass electricity generation is a relatively mature technology.

VIET NAM

Although biomass accounted for 66.5 percent of Viet Nam's total primary energy supply (TPES) in 1998, it was not utilised for power generation[73]. Almost all of biomass utilisation in Viet Nam is in the residential sector for cooking. The utilisation of biomass in this manner poses a serious deforestation problem for the economy. Forested areas were lost at a rate of 6.23 percent annually from 1985 to 1989. The total forested area in 1989 was 9.8 million hectares.

There are 51 sugar mills with a total capacity of 92,000 tons of cane per day and 127 rice mills in operation with capacity of 10 tons per shift in Viet Nam currently[74]. Baggasse from these sugar mills can be used for power generation. But more than 50 percent of the baggase is dumped as wastes. Viet Nam's power utility, EVN, allows small Independent Power Producer utilising baggasse, however, there are no such plants in operation currently. This is largely due to its high price. In 2000, a 50 KW co-generation system with technical support from Australia and Malaysia was installed in a rice mill. Results of the plant's operation are not known currently.

The total electricity generation potential from agricultural wastes such as rice and sugar cane was estimated at 3 TWh/year and 1 TWh/year respectively in 1997.[75] The potential electricity generation capacity for the same year for both rice and sugar wastes were estimated at 353 MW.[76] The development of electricity generating plants utilising biomass is currently unattractive due to the absence of institutional support and regulatory framework.

Since its introduction in 1960, there are around 3000 biogas plants with digester volumes ranging from one to 15 m^3 installed in Viet Nam.[77] The biogas is utilised mainly for cooking, lighting and small-scale engines for rural electrification. Lack of trained individuals to maintain

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[70] EIA (2003)

[71] Ibid

[72] IEA (2000) and APERC (2002)

[73] APERC (1998). TPES for Viet Nam in 1998 was 33.7 Mtoe. Biomass accounted for 22.4 Mtoe.

[74] ACE (2000)

[75] ACE (2000a) based on 1997 estimate.

[76] Ibid

[77] Ibid

these plants have also resulted in many of them being abandoned. Despite the availability of technology and know-how, biogas utilisation for electricity generation remains unattractive due to institutional and financial barriers.

CHALLENGES AND POLICY MEASURES TO BOOST NRE UTILISATION IN THE APEC REGION

INTRODUCTION

Despite the abundance of NRE sources around the world and its merit as an alternative energy resource, NRE technologies (i.e. solar, wind, hydro, and biomass) remain among the least utilised in most APEC economies. The appeal of these technologies, especially in power generation, has been moderated by its intermittent nature, high capital cost and high production costs. Therefore, in order to harness these resources for the generation of electricity, it would require, among others; additional inputs in the form of financing and technology; legal and regulatory support (although not unique to NRE) compared to conventional power generation systems utilising natural gas, coal or oil; and other associated costs. The impetus to harness NRE for power generation therefore still rests on regulators or governments in many economies due to the various barriers/conditions that inhibit investor interests in this area.

DRIVERS FOR NRE IN THE APEC REGION

Economies in APEC (and the rest of the world) are in disparate stages of economic growth, each with diverse aspiration for energy independence and the realisation of its energy sector goals: accessibility, availability and acceptability. Economies are also faced with disparity of capital investment requirements to develop energy infrastructure. Although investment in generating capacity in most developed APEC economies is expected to decline in the next 20 years, stricter environmental regulations could still increase investment requirements to finance environmental mitigation technologies. Developed economies thus consider NRE as a stopgap measure to achieve this purpose. Developing economies, on the other hand, with their high economic growth targets, high-energy demand and high investment requirements would then consider diversifying their indigenous energy resources with NRE as its next (best) energy supply option.

Because of the diverse nature of energy policies in each of the economies in APEC, the following is an attempt to characterise NRE deployment approaches in the region by economic grouping. The groupings are based on the criteria used by the World Bank and APERC (in its recently published Energy Investment Outlook).

HIGH INCOME ECONOMIES

Economies with low energy investment burdens and economic growth targets (e.g. Australia, Canada, Hong Kong China, Japan, New Zealand, Singapore, Chinese Taipei, and United States) have utilised (or started to utilise) NRE technologies primarily to reduce GHG emissions. For some developed economies, energy security is considered a secondary NRE goal. Japan targets a ten-fold increase in NRE capacity by 2010. Hong Kong China likewise targets an increasing share of NRE in its energy demand, rising from 1 to 2 percent in 2012, and 3 percent by 2022. Chinese Taipei expects to have 12 percent of generation capacity coming from NRE in 2030 with plans to build solar cities, wind farms and geothermal park over the next 10 years. Finally, New Zealand plans to increase its renewable energy by up to 42 percent in 2012.

MIDDLE INCOME ECONOMIES

Most economies with moderate energy investment burdens (e.g. Chile, Korea, Malaysia, and Mexico) consider NRE as a key option in providing expanded electricity access in isolated areas. By reducing dependence on expensive imported energy through a broadened energy supply resource base (by using indigenous, inexhaustible and environmentally benign NRE), governments in these economies foresee savings on foreign exchange intended for the importation of oil or coal. Korea targets at least an 8.3 percent NRE share in their power generation mix by 2015. Malaysia, likewise is undertaking one of the largest rural infrastructure project, a 2.2 MWp supplied by PV. It plans to increase its NRE share in its power generation mix to 5 percent by 2005.

LOW INCOME ECONOMIES

Developing economies with high energy investment needs (e.g. Papua New Guinea, Peru, Philippines, Thailand, and Viet Nam) are still burdened by weak regulatory institutions, capital market systems and energy infrastructure. As a proxy to expensive grid extensions (for rural electrification), NRE technologies are utilised instead. NRE technologies are able to provide the economic and social development (in the countryside) brought about by more access to electricity, health benefits from access to clean energy for cooking, income generation for the local community, capacity building, livelihood project development and local employment. The Philippines, by 2013, plans to increase its NRE based capacity to 9,147 MW; more than 100 percent higher than its current level of 4,449 MW. Thailand, on the other hand, has very limited fossil fuel resources and therefore is inadequate to satisfy its energy demand. The development of its NRE therefore would help reduce not only its energy supply burden but also the import of fossil fuels. Thailand plans to increase the share of NRE in the commercial primary energy from 0.5 percent in 2002 to 8 percent by 2011. Viet Nam, with about 50 percent of its population still un-electrified, have initiated a solar power cooperation program which aims to provide electricity to the southern provinces of Gia Lai, Quang Nam, and Binh Phuoc.

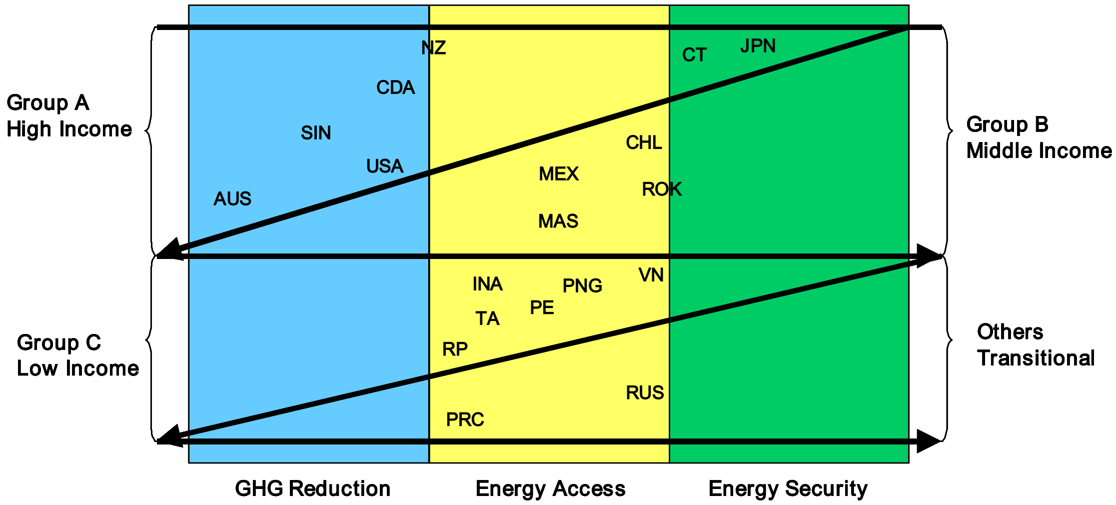
Although Indonesia (a major oil and gas producer) has less difficulty meeting its energy needs, it uses NRE mainly to provide power to rural villages and small islands. Providing access to affordable and reliable electricity in rural (isolated) areas is still the primary concern of its government. The Indonesian government has geared up for more NRE utilisation of at least 78,500 million BOE by 2010.

OTHER ECONOMIES

Other economies (e.g. China and Russia) have experienced some difficulty in getting energy projects off the ground, more so with NRE. The government of China had increased its attention to NRE, basically to reduce its reliance on coal (and its associated adverse environmental impacts), and provide energy to its 80 to 100 million poor people living mainly in remote areas. In its 10th Five-year plan for NRE Development (2000-2005), China expects to utilise 13 million TCE (9.1 MTOE) and provide power to some 5-6 million people and jobs to 200,000 more. Russia for over two decades had conducted research and development on the different forms of NRE. It has developed its technological infrastructure, scientific and technical knowledge, engineering and technical skills, including its factories and equipment. Despite all these however, the translation of these assets into commercial renewable technologies and markets remains a problem. Russia is expected to increase its NRE capacity from 1 MTCE in 2000 to 12-20 MTCE in 2020.

The following figure illustrates NRE utilisation tendencies in the APEC region. The size of area occupied by each of the economies indicates the degree at which these economies pursue the use of NRE: whether by GHG reduction, greater energy access or energy security. Although it can be observed that most economies approached energy access as a priority driver for NRE, it is important to note that such economies also (in one way or another) have began utilising NRE both to reduce GHG and securing its energy supply.

Figure 21 NRE Drivers in APEC by economic grouping



GHG MITIGATION AND SUSTAINABLE DEVELOPMENT

Most, if not all, of the developed APEC member economies consider NRE to reduce emissions associated with electricity generation. By displacing other generating plants (coal and oil), emissions of greenhouse and acidic gases from fossil fuel stations and the potential radiation associated with nuclear fuels are minimised.

One way of reducing carbon dioxide emissions from electricity production is to switch fuels used in the power generation mix. Past studies revealed that significant reductions in CO_2 emissions had been achieved by switching from either coal to natural gas, or from fossil fuels to NRE. Fuel switching is applied either by modifying existing power plants to use a different fuel, by replacing old plants with another plant using different fuels, or by changing the intensity with which different types of plants generate electricity.

Estimated GHG Emission Reductions from NRE in the Power Sector

Substantial increases in NRE share in electricity generation would result in significant environmental benefits particularly for GHG emission reduction. An increased share of NRE in the power generation fuel mix of 42 percent by 2050 (as described in detail in the Scenario Analysis of this study) would result in a total fuel cost savings of US$4.4 to US$5.8 trillion. This then could easily translate to a total of 206 billion to 254 billion ton of carbon dioxide emission avoided.

ENERGY SECURITY

Based on current estimates, domestic energy supply will not be sufficient to meet the rising demand for energy as a result of improved economic activities. Increased growth would certainly take its toll on the demand for more energy amid depleting energy reserves. Even current energy exporters (e.g. Malaysia and Indonesia) will soon join the list of world energy importers. Securing supply via alternate resources is carefully sought. Since NRE resources are abundant worldwide, each economy will have at least one or two of the NRE technologies that can be used as an alternative energy resource or a switching fuel for coal and oil. It could undoubtedly make a huge contribution to diversify and secure indigenous energy supplies and promote stable energy costs.

The small-scale and modular nature of NRE could also lessen the need for investment in a costly grid extension. In addition, further reductions in the cost of NRE would make its decentralised deployment a cheaper and economically attractive alternative for rural electrification in developing economies.

Table 9 below outlines the import dependencies and the projected NRE (hydro and non-hydro) inputs in energy supply and power generation for the period 1999-2020. A cursory look at the table reveals that low to moderate income and energy import dependent economies (i.e. Chile, Korea, Philippines, Thailand, and Peru) are most likely candidates for higher NRE inputs to energy supply and increased shares in power generation from NRE. Net energy exporters (i.e. Malaysia, Mexico, Indonesia, Papua New Guinea, Viet Nam, and Russia), on the other hand, are least likely to show improvements in their NRE deployment strategies to diversify its energy supply sources but might consider NRE for countryside energy distribution (or rural electrification).

Table 9 Projected NRE Energy Supply in APEC

	Projected NRE* Input in Energy Supply (Mtoe) 1999-2020		Import Dependency % (2001)	Projected NRE Input in power generation (%) 1999-2020	
	Hydro	Other NRE		Hydro	Other NRE
Group A High Income Economies					
Australia	1.4-1.7	5.4-9.1	0	3.0-2.5	2.6-4.4
Brunei Darussalam	-	0.1-0.1	0	-	-
Canada	29.3-36.2	10.9-16.8	0	36.2-33.6	2.3-2.1
Hong Kong China	-	0.1-0.1	100	-	0.00-0.2
Japan	7.4-9.2	9.5-17.5	79.9	3.5-3.3	3.2-4.9
New Zealand	2.0-2.3	3.8-6.2	16.7	29.5-23.0	39.2-44.4
Singapore	-	0.2-0.2	100	-	2.1-1.3
Chinese Taipei	0.7-0.9	0.0-0.1	87.3	2.0-1.1	0.0-0.1
United States	24.8-27.0	97.9-163.0	23.6	2.6-2.1	6.8-8.3
Group B Middle Income Economies					
Chile	1.2-2.6	4.0-5.0	55.7	18.2-12.7	5.2-1.6
Korea	0.4-0.8	2.3-2.4	82.3	0.6-0.5	2.9-1.3
Malaysia	0.6-1.8	2.5-3.1	-42.0	5.2-4.5	0.0-1.2
Mexico	2.8-5.3	12.9-18.5	-52.6	6.1-4.8	14.2-8.2
Group C Low Income Economies					
Indonesia	0.8-1.6	49.0-54.5	-78.8	4.1-2.3	15.9-7.6
Papua New Guinea	0.1-0.2	-	-381.2	18.8-22.8	-
Peru	1.3-2.2	4.4-4.9	25.0	51.4-40.0	2.4-1.2
Philippines	0.7-1.3	18.4-26.6	59.7	4.3-3.4	58.5-42.7
Thailand	0.3-0.8	13.6-18.3	56.9	1.5-1.6	0.6-3.1
Viet Nam	1.2-3.5	22.3-24.7	-68.9	32.1-15.5	-
Others Transition Economies					
China	17.5-71.1	212.9-213.7	3.4	6.0-10.1	0.4-0.8
Russia	13.8-16.2	7.4-9.8	-60.5	5.6-3.9	0.5-0.4

Source: *APEC Energy Supply Demand Outlook 2002

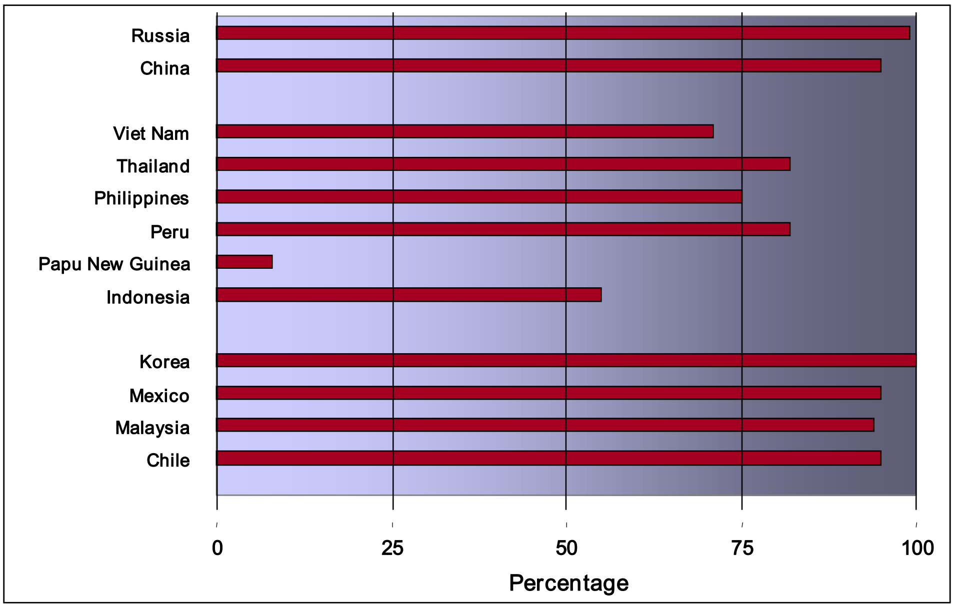
ENERGY ACCESS AND RURAL ELECTRIFICATION

For over 10 years, NRE has been utilised by most developing economies as an alternative electricity resource in uneconomically viable isolated (off-grid) areas. The most common type of non-hydro NRE technology used for rural electrification application is the Solar PV system. These systems usually have very low operating and maintenance costs as compared with other fossil fuels, but with high initial capital costs.

There are about 200 million people in the APEC region that are still without access to electricity (Figure 22). One of the underlying reasons probably is income threshold (that which is even below the least cost of electricity). This might either be the result of electricity tariffs that are too high a percentage of disposable income, or perhaps the economy's wealth is simply not enough to provide for the basic services needed at a price poorer consumers could afford to pay. Despite the growth in urban cities and industrial economic zones in most developing economies (low to middle income), access of rural communities to grid-based electricity service is still very low. Extending transmission and distribution networks in these areas may take time and huge amounts of investments. Therefore the need for immediate and alternative means, such as NRE, could fill in the distribution gap.

Most governments in APEC (particularly developing economies) give rural electrification of high priority: to meet its economic, social, political and regional development goals. The rapid growth in population (particularly in rural areas) has increased the need for more access to grid-based electricity. It is often more expensive in rural areas than in urban areas because of its lower load densities, low capacity utilisation rates, and high electricity line losses. Extending the lines to these isolated areas therefore would only increase the costs of the overall generated electricity. While some of the rural electricity consumers will be served by grid connections in the coming decades, still a large number will remain off-grid (as population in these areas continue to grow). The high cost of grid-based extension will linger on as a limiting factor, especially for governments. Governments, more often are at odds in assuming a high electricity cost, if it decides to have a grid-based extension, or finding an alternative resource to meet its rural electrification needs at the least cost.

Figure 22 Electrification level (%) in selected APEC economies



Source: APEC Energy Overview 2002

CHALLENGES TO NRE UTILISATION

For many years, NRE had been observed to be socially and environmentally attractive, but with very limited niche market because of high costs and technological barriers. But in the last decade, new technology and growing energy demand has dramatically lowered its costs. Some NRE technologies today are almost competitive with conventional sources of energy. Once environmental costs are included, NRE could be cheaper than non-renewable fuels. However, many governments have not found a better way of incorporating these 'hidden costs'.

But why is NRE not widely utilised despite its being economically competitive, abundant and environmentally desirable? NRE like any other technology faces the same situation that confronts new technologies; market inertia, investor uncertainty, regulatory obstacles and limited access to initial capital investment. NRE has had difficult time breaking into markets which have long been dominated by traditional fossil fuels. While advances in technology somehow have lowered the costs, many NRE technologies are still too expensive because of low manufacturing volumes and poor economies of scale. Likewise, traditional fuels have benefited from a wide range of long-standing government subsidies. Government regulations have also been designed for centralised, fossil-based energy production. Not to mention the investors' and consumers' attitudes to change (to new untested fuel sources), thereby the need for public education and awareness programmes.

Given the huge economic, health and environmental benefits of NRE, governments should be able to level the playing field, address these NRE barriers, and provide the same support and leadership it had traditionally provided for conventional energy fuels.

The key challenge therefore is to identify, understand and overcome these problems that continue to hold back the speedy growth of NRE. The succeeding discussions will attempt to discuss the three most important barriers to NRE deployment: High Capital Cost and Pricing, Government Policies and Regulation, and Poor Market Performance, and subsequently the policy measures that are available in addressing such barriers.

A. HIGH CAPITAL COST AND PRICING

The initial capital cost for NRE technologies has often been regarded as higher than competing conventional fuels (e.g. natural gas and coal), which would naturally result in a much higher cost per-unit of electricity. These perceived "high-cost" NRE electricity options would therefore be less appealing than other power generation systems using conventional fuels. However, if comparisons could be made (e.g. based on a life-cycle analysis for NRE technologies), taking into consideration the initial capital cost, projected operation and maintenance costs, fuel and decommissioning costs, and facility lifespan, the cost of NRE is less than expected. But life-cycle cost analysis requires too detailed information, such as, future fuel costs and future discount rates, before one could arrive at an accurate cost comparison. Since investments for NRE-based power plants are front-loaded, financial institutions often impose a premium on borrowings in view of the perceived higher risk. In some developing economies, where NRE technologies are relatively less popular, high import duties and taxes are imposed on plant equipment and components. This further reduces the competitive advantage of NRE technologies against the other better-known conventional technologies, which might even enjoy a tax relief.

Incentives (in the form of subsidies) issued by governments to conventional fuels further aggravate this situation by "artificially reducing" their prices. Attempts at reducing or removing fossil fuel subsidies have thus far been largely unsuccessful because of possible political ramifications. As a result, policy makers have resorted to the more common practice of adopting policy measures that would add incentives for NRE in the form of tax credits and favourable power purchase options/prices, including the reduction of transaction costs.

Table 10 Cost of Annual Energy Subsidies (1995-1998), US$ Billion

	OECD Countries	Non-OECD Countries	Total
Coal	30	23	53
Oil	19	33	52
Gas	8	38	46
All Fossil Fuels	57	94	151
Electricity	a.	48	48
Nuclear	16	Nil	16
Renewable and End-Use	9	Nil	9
Non-payments of Bail-out[b]	0	20	20
Total	82	162	244
% Global Energy Subsidies	34	66	100
Per Capita Subsidies ($/cap)	88	35	44
Per Capita GDP ($/cap, 2000)	23,132	3,903	7,316

Notes: a. Subsidies for electricity in OECD countries have been attributed to fossil fuels according to shares. b. Subsidies from non-payments and bail-out operations have not been attributed to energy sources.
Source: de Moor, 2001, and WRI, CAIT (for GDP numbers).

SUBSIDIES FOR COMPETING FUELS

While there are no definite figures on the actual amount of subsidy granted to fossil fuels by governments annually, there is a general consensus that these subsidies are dispensed through various channels. For example, there is an estimated US$5 billion spent annually, in various forms of subsidy, to the oil industry alone in the United States. Large public subsidies, both implicit and explicit, are channelled in varying amounts to all forms of energy, which can distort investment cost decisions. The World Bank and International Energy Agency have issued global annual subsidies for fossil fuels in the range of US$100-200 billion, although figures are difficult to estimate, it is important to note that the world spends annually around US$1 trillion, to purchase fossil fuels alone. Public subsidies may be in the form of: direct budgetary transfers, tax incentives, R&D spending, liability insurance, leases, land rights-of-way, waste disposal, or guarantees to mitigate project financing or fuel price risks. Maintaining fossil fuel subsidies can significantly bring down final energy prices, which would put NRE at a great disadvantage. Table 10 illustrates cost of annual energy subsidies from 1995 to 1998 for comparison.

DIFFICULTY OF FUEL PRICE RISK ASSESSMENT

The risks associated with changes in fossil-fuel prices may not be quantitatively considered in decisions for new power generation projects because these risks are intrinsically difficult to assess. In the past, future fuel price risk has not been considered an important factor because future fossil fuel prices were assumed to be stable or moderately increasing. Thus, risks of severe fluctuations are often ignored. But with greater geopolitical uncertainties and changes in the energy market, new awareness had evolved on future fuel price risks.

NRE technologies do not have fuel costs (with the exception of biomass) and are therefore without fuel price risk. However, this benefit or "risk-reduction premium," is often not included in economic comparisons and analytical tools because it is simply too difficult to quantify. For some regulated utilities, for example, fuel costs are tucked-in the regulated power rates, passing the burden of fuel price risks to consumers. Therefore, future utility investment decisions are made without consideration to fuel price risk.

UNFAVOURABLE POWER PRICING RULES

Grid connected NRE technologies may not get full credit for its power supply. Since NRE is an intermittent resource (whose output level depends largely on its resource – sun and wind) and cannot be controlled, utilities could not depend on the power at any given time and may therefore only be willing to pay a much lower price. The utility then might consider paying a zero price for the capacity value of the generation (only the energy value of the resource) or pay a fixed price paid at peak times (whenever power is more valuable), which might be slightly lower than the competing fuels at peak prices.

TRANSACTION COSTS

Because of the smaller nature of NRE technologies as against conventional energy projects, NRE projects may need more information not readily available. Some information might even require more time and attention because of unfamiliarity with technologies or performance uncertainties. Such requirements, including resource assessment, siting, permitting, planning and development of project proposals for financing and negotiations, might pull together added costs on a per kilowatt per capacity basis than for a standard conventional power plant. Higher transaction costs are not necessarily an economic distortion in the same way as some other barriers, but it simply makes renewables more expensive.

ENVIRONMENTAL EXTERNALITIES

Most NRE have some environmental burdens other than life cycle emissions. A study prepared by IEA on the environmental implications of renewables has indicated that many of the potential environmental impacts are site-specific and usually small and reversible.[78] Similarly with conventional fossil fuels, the environmental impacts may likewise result in real costs to society; in terms of human health (i.e., loss of work days, health care costs), infrastructure decay (i.e., from acid rain), declines in forests and fisheries, and perhaps ultimately, the costs associated with climate change. Costs of environmental externalities however are difficult to evaluate and depend largely on assumptions that can be a subject of a wide debate. Although environmental externalities and associated costs are often considered in comparing renewable and conventional energy, investors rarely include such environmental costs in their decisions.

B. GOVERNMENT ENERGY POLICIES AND REGULATIONS

Markets require good information to operate effectively and governments play an important role in analysing market trends. Government agencies should ensure that market players are receiving adequate information on emerging issues.

INADEQUATE LEGAL FRAMEWORK (FOR INDEPENDENT POWER PRODUCERS)

Many power utilities in most economies still control a monopoly of electricity production and distribution. In such instances where legal and regulatory framework is absent, independent power producers may not be able to invest in NRE facilities and sell power to the utility or to third parties. Utilities could negotiate power purchase agreements directly on an individual ad-hoc basis, making it difficult for project developers to plan and finance projects.

In Russia, utility electric-power monopolies and the absence of regulatory frameworks for independent power producers make third-party renewable energy development difficult or impossible. A 1996 Russian law on energy efficiency has allowed for the first time, independent power production in Russia. However it encountered application and implementation problems. Non-utility producers of electricity may sell electricity to regional utilities, and regional utilities must buy this power from the producer at a contracted price that is subject to approval by the regional

[78] IEA (1998)

energy commission. But regional energy commissions have yet to address how such agreements and contracts should be regulated, when no contractual models have yet been developed. The lack of viable regulatory framework for independent power producers is made more complex by the lack of viable contract institutions, upon which a power-purchase agreement would be based, and without which third party developers face enormous risks.[79]

RESTRICTIONS ON SITING AND CONSTRUCTION

Building restrictions on height, design, noise, or safety (particularly in urban areas) may apply an unnecessary pressure on wind turbines, solar water heaters, PV installations and biomass combustion facilities. Some urban planners' or building inspectors' lack of familiarity with NRE technologies and the absence of established rules, might create siting or permitting problems. Likewise, competition with agriculture, tourism, recreation or other development interests could also occur.

In New Zealand, for example, resource management issues including public perceptions about the visual impact and noise output of wind turbines have the potential to delay implementation. There is also a concern that local authority planners, not familiar with the technology, may require extensive planning procedures or recommend onerous conditions for preliminary survey work involving such structures as anemometer towers.[80]

TRANSMISSION ACCESS AND UTILITY INTERCONNECTION REQUIREMENTS

Utilities may charge high transmission access rates in exchange for favourable NRE dispatch. Transmission access is necessary since most NRE sources are sited far from population centres. Likewise, transmission and distribution access is necessary for direct third-party sales (i.e. NRE producer and final consumer). Finally, new NRE transmission access routes to remote NRE sites may be held back by transmission-access rulings or in some cases, right-of-way disputes.

Utilities may also have inconsistent, or unclear interconnection requirements when individual and/or commercial systems are connected to utility grids. The mere lack of standard rules could increase transaction costs. Although safety and quality of power are valid utility concerns, utilities tend to set interconnection requirements beyond what is necessary or practical for small power producers. In the mean time, the costs of hiring legal and technical experts to understand and comply with such interconnection requirements might prove significant. Therefore, policies that would create sound, consistent and transparent interconnection rules can reduce interconnection problems and lower transaction costs.

C. POOR MARKET PERFORMANCE

ACCESS TO CREDIT

Lack or inadequate access to credit usually weighs down on the development of an NRE project. In rural areas, "micro-credit" lending facilities for small-scale (household type) NRE systems usually do not exist. If ever there is one available, the loan terms may be too short relative to life of the investment. In some countries, power project developers have difficulty obtaining bank financing because of uncertainty as to whether utilities will continue to honour long-term power purchase agreements to buy the power. In the Philippines, for example, financing companies require financial guarantees from government to ensure payments should defaults on loans occur.

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79 Martinot (1999)

80 EECA, NZ (1996)

MARKET INTERMEDIATION

Market intermediation provides the knowledge, information, skills, services, financing, and analysis necessary to overcome barriers, where either or both parties to a potential transaction may be unwilling or unable to provide. Intermediation to overcome barriers is often discussed in the context of international technology development. In general terms, the greater the barriers that separate the parties who could create relationships of mutual benefit, the greater is the need for intermediation. Interventions include stipulation of information to consumers and manufacturers about taxes and subsidies, credit services, direct support of the distribution system, and direct participation in equipment manufacture. Russia, for example, had proposed sector-specific market intermediation as an important policy goal for greater international technology transfer, development and cooperation. Governments, therefore, play an intermediary role in providing interventions necessary for developing NRE production and marketing systems in developing economies for mature energy technologies. Some commonly used government interventions include: a) assurance of demand, b) availability of credit, c) marketing and access to technology, and d) licensing and distribution. The UNDP has had various cooperation agreements and support programmes with various governments in the APEC region (e.g. Philippines and Viet Nam), that seek to remove barriers to NRE development through capacity building and market intermediation.

TECHNOLOGY PERFORMANCE UNCERTAINTY AND RISK

Proven, mature technologies may still be viewed as risky when there is little experience with them in a new application or region. The low familiarity with NRE and the lack of concrete/actual working (or operating) installations could invite scepticism and negative perception on NRE's effectiveness and future performance. Such perceptions might increase the required rate of returns, lesser capital availability, or more stringent requirements to justify selection and use of technology. "Lack of utility acceptance" is a phrase used to describe the historical biases and prejudices on the part of traditional electric power utilities. Utilities may be hesitant to develop, acquire, and maintain unfamiliar technologies, or give them proper attention in planning frameworks. Finally, prejudice may exist because of poor past performance against current performance norms.

TECHNICAL OR COMMERCIAL SKILLS AND INFORMATION

Access to low-cost information helps markets progress quickly. Sufficient technical, financial, and business development skills may not always be available to project developers. Lack of information about NRE and necessary technical skills to understand them might increase the perceived notion on NRE's merits and in the end block potential NRE projects.

POLICY OPTIONS AND MEASURES TO ADDRESS BARRIERS

High capital cost, lack of institutional support, poor market performance, and intermittency have all played a big part in bringing down NRE's competitive advantage over the more popular conventional fossil fuels. NRE technologies would need more than what current government policy interventions have offered and assert for more aggressive policies that would affirm their role in arresting the impact of energy on environment, provide an accessible, reliable and affordable supply of energy and wider people's access to electricity.

Just as economies in APEC are invariably unique in terms of growth (i.e. energy development, energy investment burdens, and energy policy goals), approaches to NRE deployment have likewise differed quite considerably over the last 10 or 20 years. There are two distinct policy intervention options most developed economies have used in the last ten years; one is to address cost reduction, and the other to assure greater NRE demand. The potential to reduce costs depends largely on the maturity of the technology and market size. Mature technologies have demonstrated the highest prospect for cost reduction because of its steep "learning curve" in terms of a decreasing price resulting from increasing manufacturing volume. Some studies reveal that if markets will continue to grow at its current rate, solar technology costs (for example) would continue to decrease by as much as 30-50 percent by 2020. Hydro, as another example, would have a lower learning curve cost reductions for every doubling in capacity, perhaps at about 5-10 percent.

Some of the current energy policies are still considered un-sustainable and have not demonstrated maximum public benefit. But the diffusion of NRE could help bring down costs that could create more and new market opportunities. The following policy options have been proven successful in some economies in promoting demand for NRE.

A. DEMAND-PULL STRATEGIES

Demand-pull strategies are policies that tend to reduce cost and pricing-related barriers by creating a favourable pricing scheme for NRE against other energy sources used for power generation. The amount of investment resulting from such a scheme is not often specified, but the prices are known before hand. Another demand-pull strategy, quantity-forcing policy, on the other hand does the opposite. It mandates a certain amount (usually in percentage) or an absolute quantity of generation from NRE, this time at an unspecified price.

These policies oftentimes occur almost simultaneously with other policies (e.g. investment cost reduction policies). One of the most successful price-setting policies currently in use in Europe is the "Electricity Feed-in Laws". Examples of quantity-forcing policies, on the other hand, include, 1) Competitive-biding of NRE obligations, 2) Renewable Portfolio Standards (RPS), and 3) Renewable Energy (Green) Certificates.

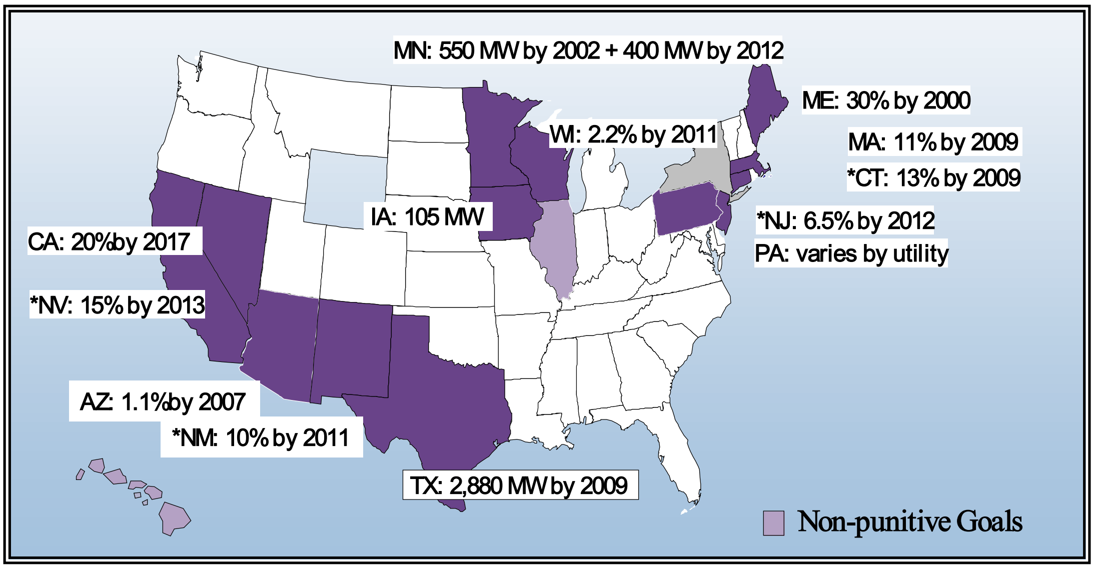
RENEWABLE PORTFOLIO STANDARDS (RPS)

RPS is a quantity-based policy. It sets a target quantity for NRE to be included in the generation mix within a specific date. This means that a minimum percentage of generation sold or capacity installed should be supplied by renewable energy. Utilities are required to ensure that the target is met, either through their own generation, power purchases from other producers, or direct sales from third parties to the utility's customers. RPS obligations are typically placed on the final retailers of power, who must purchase either a portion of renewable power or the equivalent amount of green certificates (please refer to next section). Two types of standards have emerged: a capacity-based standards which set a fixed amount of capacity by a given date, and another, generation-based standards that mandates a given percentage of electricity generation from a renewable energy source.

In the United States, many RPS policies have been established along with utility restructuring legislation. These are generation-based standards that are implemented by phases to allow utilities to reach step increases over a period of time. At least 13 US states have enacted an RPS, ranging from about 1 to 30 percent of its electricity generation. In addition, Minnesota and Illinois have set goals, but have not enacted an RPS.

However, the amount of new and additional generation that is expected from these standards varies widely depending on existing renewable energy capacity. The state of Maine, for example, will not be in any way affected by the standards since, historically, it was already generating over 40 percent of its power from renewable resources. In California, on the other hand, its requirement to increase renewable sales from 10.5 percent in 2001 to 20 percent by 2017 will likely result in a significant amount of new in-state renewable energy generation. Texas has implemented an RPS in 2000 and is requiring 2000 MW of new renewable capacity by 2008. It has been substantially ahead of schedule, with half of the targeted capacity in place by 2002. In Ontario, Canada, a new RPS has called for 300 MW of new wind capacity by 2005 and 2,000 MW by 2010.

Figure 23 States in the US which adopted RPS in 2004



Source: Ku (2003b)

Netherlands has been a leader among RPS initiatives in Europe. Dutch utilities have voluntarily adopted an RPS, based on targets of 5 percent of electricity generation by 2010, increasing to 17 percent by 2020. Some of the countries with regulatory requirements for utilities or electricity retailers to purchase a percentage of renewable power include Australia, Brazil, Belgium, Denmark, France, Japan, Spain, Sweden, and the United Kingdom. The UK's 'Renewables Obligation' on suppliers is expected to rise from 3 percent in 2003 to 10 percent in 2010. In Denmark, legislation obliges end users to purchase 20 percent of their electricity from renewable sources by 2003.

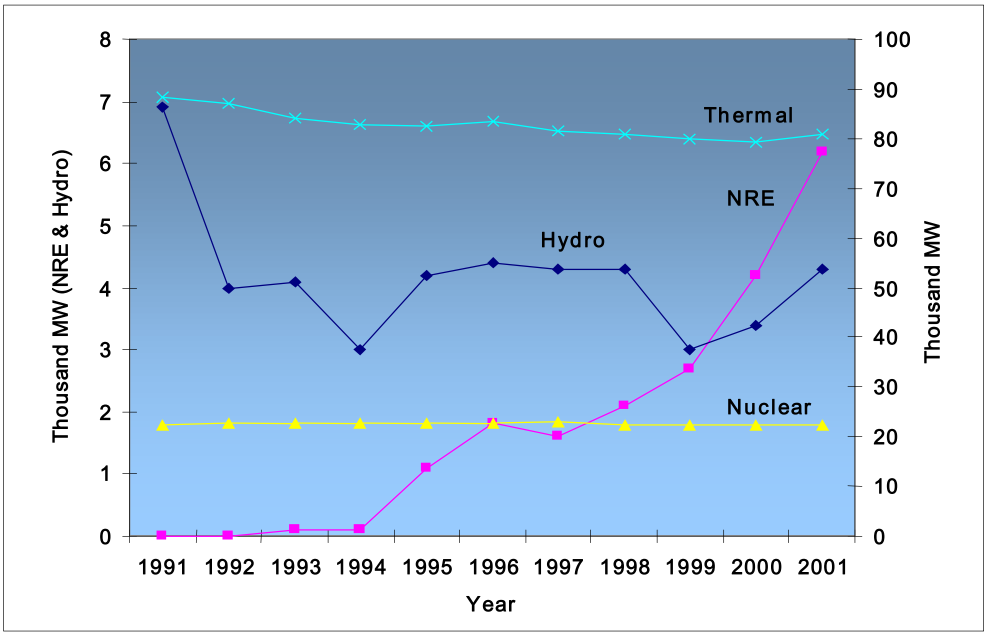
In Brazil, there is a policy, enacted during the electricity crisis of 2001, that requires national utilities to purchase over 3,000 MW of renewable energy capacity by 2016. Purchase prices are then set by government: at about 80 percent of the national average electricity retail price. Therefore, in contrast with most national policies elsewhere, Brazil's policy is effectively both "price-setting" and "quantity-forcing."

In Japan, RPS was introduced in May 2002 and became effective in April 2003. Government has set the target every four years increasing modestly at 1.35 percent until 2010, against that of Denmark (29 percent), Germany (10.3 percent), the UK (10.4 percent) or France (8.9 percent) in the same period.

ELECTRICITY FEED-IN LAWS

A feed-in law is a price-based policy which allows the interconnection of a renewable resource to the grid at a specified price, paid for every kilowatt-hour (kwh) generated. It also specifies the price to be paid for NRE whereby the amount is determined by the type of NRE available in the region and its relative cost to the feed-in price. Normally NRE developers are guaranteed a power sales price (the feed-in tariff), together with an obligation to purchase (a guaranteed market) by electric utilities under standardised interconnection requirements. The level and term of the price may vary, but would normally be attractive enough to ensure NRE's development.

Figure 24 Germany's NRE installed generation capacity, 1991-2001



Source: DOE/EIA

The electricity feed-in laws in Germany, and some other European economies in the 1990s, have set a fixed price for utility purchases for NRE. As early as 1991, Germany's renewable energy producers could sell their power to utilities at a rate almost equal (90 percent) that of the retail market price. The utilities were then compelled to purchase the power. Germany's feed-in law therefore has resulted in the rapid expansion of NRE capacity. Wind power purchase prices have become highly favourable, to about DM 0.17/kWh (US 10 cents/kWh) (Martinot 2002), and was applied over the entire life of the plant. The total wind power installed capacity has grown from almost zero in the early 1990s to over 14,000 MW by 2003, making Germany a world leader in wind installation. However as retail electricity prices went down because of competition, brought about by electricity deregulation, the feed-in pricing law was subsequently modified. Under the new law, German Renewable Energy Law of 2000, pricing was later based on fixed norms, unique to each type of technology (and based on estimated production cost changes over time).

Other economies in Europe with renewable electricity feed-in laws include Denmark, France, Greece, Italy, Portugal, Spain and Sweden. A combination of feed-in tariffs, production subsidies of DK 0.10/kWh, and a strong domestic market helped the Danish wind industry maintain a 50 percent market share of global wind turbine production for a number of years.

Although the birth of today's modern renewable energy industry can be traced in some form to the feed-in law developed in California, Maine, New York, and some other states in the US in the mid 80's, fixed priced feed-in laws have not been commonly or politically viable to renewable energy development in the US. US policy makers have increasingly supported the mechanisms that could stimulate competition and reduce costs (specifically the implementation of the Public Utilities Regulatory Policy Act or PURPA).

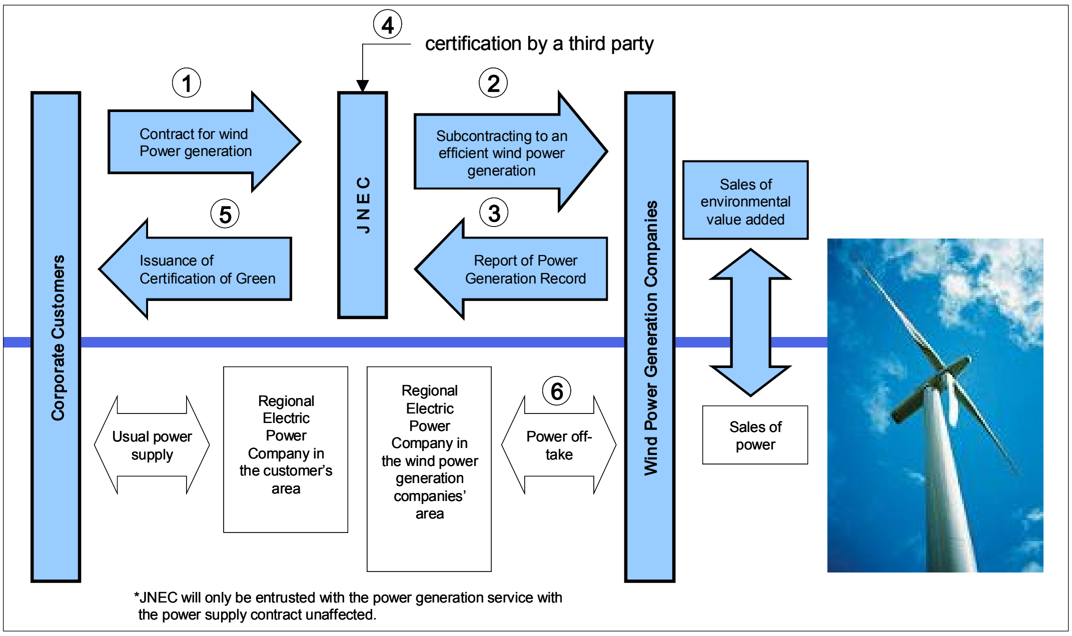
RENEWABLE ENERGY (GREEN) CERTIFICATES

A Green Energy Certificate (or "Renewable Energy Certificates") represents the delivery of one megawatt-hour of renewable power to the total energy infrastructure.[81] Certificates represent the environmental benefits created when electricity is generated from renewable resources instead of fossil fuels, like coal or natural gas, which release GHG. Purchase of a Certificate is as good as supporting clean energy development. Therefore, as purchases of Green Certificates increase, so does the demand for new and more clean renewable energy technologies.

Renewable energy certificates have emerged as a means for utilities and customers to trade renewable energy production and/or consumption credits in order to meet their RPS obligations and similar policies. Standardised certificates provide evidence of renewable energy production, and are coupled with institutions and rules for trading that separate renewable attributes from the associated physical energy. This has brought up a "paper" market for renewable energy, created independently from actual electricity sales and flows. Green certificate markets are emerging in several economies. It has allowed producers or purchasers of renewable energy who earn green certificates to sell the certificates to those who are in need to meet obligations but have not generated or purchased the renewable power themselves. Those that are without obligations, but wish to voluntarily support green power (for philosophical or public-relations reasons) may also purchase the certificates.

There are now public and private institutions that are emerging that keep track of renewable energy generation, assign certificates to generators, and register the trading and sales of certificates. The Japan National Energy Company Limited, a joint venture of TEPCO and 10 other companies will develop wind and other NRE resources and sell certificates representing the environmental attributes of the power output to business customers.

Figure 25 Green Power Business Outline



Source: JNEC

[81] 3 Phases Energy Services

Figure 25 shows the green power business outline in Japan. The process flow is described as follows:

1. Corporate customers entrust power generation to JNEC.

2. Upon consulting with the customers, JNEC then decides whether to carry out wind power generation by itself or to subcontract it to the most efficient wind power generation company.

3. The subcontracted wind power generation company generates power based on the contract and then reports of the amount generated to JNEC.

4. A neutral third party certifies the actual record of natural energy power generation.

5. JNEC issues a "Certification of Green Power" according to the amount granted

Finally, the generated power is purchased by a regional electric power company in the power generation facility area at a reasonable price.

With the Certification of Green Power, JNEC believes that customers could therefore show proof of use of green electricity. Certification could also serve to meet targets, i.e. fossil fuel savings, CO_2 emission reductions, to obtain ISO and improve corporate identity or production image. JNEC also believes that through Certification, they are able to separate 'sales of environmental value added' from that of 'sales of electric power', whereby wind power generation service could be provided regardless of the area an electric company covers.

The certificates will be sold at a premium of 4 yen/kWh (~3.4¢/kWh US). In its first year, the company plans to make available about 20 GWh of green certificates and hopes to contract with some 20 companies. Green certificate trading is gaining ground in the UK, Belgium, Denmark, Australia, and the United States. Europe has embarked on a "test phase" with an EU-wide renewable energy certificate trading system between 2001 and 2002. More than 40 companies in 7 economies have opened trading accounts, and still over 100 companies have shown interests in late 2002. There were over 1,000 GWh of certificates issued through 2002. Figure 26 shows an example of a JNEC Green Certificate.

Figure 26 The Certificate of Green Power in Japan

Source: Yoshihara (2004)

COMPETITIVE BIDDING FOR NRE OBLIGATIONS

Competitive bidding or tendering is usually government initiated competitive process of meeting its target with long-term power purchase agreements to its NRE generators. Competitive bidding is similar to feed-in laws and RPS, the only difference is that price and eligible projects are selected through competitive bidding. While feed-in laws sets the price and guarantee to purchase the NRE output from any eligible facility at that price, competitive bidding selects the projects at the best price offer. The lowest priced bid are then selected with a guarantee to purchase all the projects output. The guarantee to purchase helps reduce investor risk and helps secure the necessary project financing.

The United Kingdom had tried competitive bidding for its renewable energy resource obligations during the 1990s, under its "Non-Fossil-Fuel Obligation" (NFFO) policy. Under this policy, power producers compete and bid for the supply of a fixed quantity of renewable power. The lowest bidder wins the contract. There were four bidding rounds in succession and bidders each tried to bring down their price offers relative to the last round. In the case of wind power contract, for example, contract prices have declined from 10p/kWh in 1990 under NFFO-1, to 4.5 p/kWh in 1997 under NFFO-4. One of the lessons learned from this UK experience was that competitively determined subsidies could well lead to rapidly declining prices for renewable energy. But there are also criticisms that the process has encouraged competing projects to bid below cost just to get contracts, which resulted in having successful bidders not capable of meeting the term requirements of the bid. This criticism may actually be true in actual practice as in the case of contracts awarded to low-bidders, which have not translated into projects on the ground. The UK has abandoned the NFFO approach after the fourth bidding round in 1997. Other economies with similar competitive-bidding mechanisms include Ireland (under the "AER" program), France (under the "EOLE" program), and Australia (under the "RECP" program).

B. PUBLIC INVESTMENTS AND MARKET FACILITATION POLICIES

PUBLIC BENEFIT FUNDS

Public funds for renewable energy development (in the case of the United States) are raised through a System Benefits Charge (SBC), which is usually applied on electric power consumption, on a per-kWh basis. These funds are essentially taxes on electricity consumption, with the resulting revenue used to support various energy related goals such as efficiency, R&D and renewable energy. Many analysts believe that this is one of the more effective policies (for promoting NRE development) that has actually resulted from the electricity restructuring in the US. There are about 15 states in the US that have established public benefit funds. It is estimated that until 2011, there will still be about US$3.5 billion in system benefit charges that will be collected in 15 states in the US alone. In Europe, the same levies exist. But as a general rule, funds are used for a variety of purposes, such as to pay for the difference between the cost of renewables against that of traditional generating facilities, reductions in the cost of loans for renewable energy facilities, provision for energy efficiency services, funding public education on energy-related issues, low-income energy assistance, and support of R&D.

INFRASTRUCTURE POLICIES

Market facilitation supports market institutions, participants, and rules to encourage renewable energy technology deployment (Martinot 2003). Policies for design standards, equipment standards, siting and permitting, contractor education and licensing invariably help build or maintain NRE market infrastructure. There are also policies that help persuade NRE technology manufacturers to site locally, facilitate direct sales of NRE systems to customers at concessionary rates which allows the market to flourish. Some of the notable infrastructure policies include: a) construction and design policies, b) site prospecting, review and permitting, c) equipment standards and contractor certification, and d) direct equipment sales. Industrial recruitment policies likewise use financial incentives (i.e. tax credits and grants) and some government commitments to attract

NRE equipment manufacturers to locate in a specific area. Such incentives are designed to create local jobs, improve the economics of local NRE iniatives and bolster the local economy.

Direct equipment sales have allowed consumers to buy (or lease) NRE systems directly from its electricity providers at discounted rates. Examples of these are in Arizona which allows a buy-down of about US$2 per peak-watt for PV and the California Sacramento Municipal Utility District (SMUD) offer of a 50 percent buy-down and a 10-year financed loan and net-metering.

SMUD and other financing programs have provided commercial and industrial customers incomparable value by establishing one-stop financing assistance. The programmes have helped reduce project costs through incentives, low-interest financing, and little or no up-front costs.[82]

GOVERNMENT PROCUREMENT

Government procurement policies are intended to promote a continued and disciplined commercial development of NRE technologies. Purchase agreements by governments could reduce negative perceptions and risks and may accelerate the development through long-term contracts and guaranteed purchases. Purchases of government in the early stages of NRE technology market development could help overcome fears and uncertainties that prevent commercialisation. Government purchases help develop the necessary start-up infrastructure and supply the catalyst for technologies to grow through some regulatory changes and technical support.

CUSTOMER EDUCATION AND MANDATED GENERATION DISCLOSURE INFORMATION

In the U.S., restructuring and deregulation policies have mandated that information should be provided to customers to help them understand the complexities of the electricity supply and help them choose their electricity providers. It has been required in most states, to raise the level of awareness of customers on renewable energy and the environmental impacts of energy generation. Websites and printed materials have extensively been used to achieve this purpose.

SOLAR AND WIND ACCESS LAWS

Access laws are intended for property owners that allow them continued access to a renewable energy resource. Easements on the other hand, are voluntary contracts (and may be transferred with the property title) that grant privileges to individuals for continued access to a renewable energy resource (without obstructions). Covenants laws prohibit the restriction of the installation or use of renewable energy equipment. Access laws, and policy mechanisms (in the form of ordinances, street orientation guidelines, zoning and building restrictions, and renewable permits) has been viewed as useful tools for NRE's continued deployment.

C. INVESTMENT COST REDUCTION POLICIES

There are various policy interventions that reduce the costs of investments through incentives. These incentives may either be in the form of direct subsidies and rebates, tax relief, loans and financial assistance, or through direct reduction of capital and installation costs through savings from bulk procurement.

UP-FRONT REDUCTION OF CAPITAL COSTS

Direct subsidies and or rebates reduce the initial capital outlay of consumers. Subsidies are used to 'buy-down' the initial capital costs of the system making it cheaper for consumers.

In the case of the US, at least 19 states have offered rebate programs either at the state, local, and/or utility levels to promote the installation of NRE equipment. Majority of these programmes are

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[82] California Air Resources Board

available in state agencies and utilities owned by municipalities and support solar water heating and/or photovoltaic systems. The programs were made available for homes and businesses including specific industries and public institutions.

Efforts have been made to increase the use of renewables through coordinated, multi-year, multi-policy initiatives. Japan, Germany, and the United States, for example, have all in some way subsidised capital costs of solar PV as part of their "market transformation" programmes.

- Japan's Sunshine Program has provided capital subsidies and net metering for rooftop PV systems. From 1994 to 2003[83], the government has invested almost 136 billion yen, which resulted in more than a hundred thousand installations and over 220 MW of PV capacities. Subsidies started at 900,000 yen/peak-kW (US$5/peak-watt) in 1994, and were gradually reduced to 120,000 yen/peak-kW (US$1/peak-watt) in 2001 as the PV prices fell.

- The United States launched a similar initiative in 1997 to install solar PV systems and solar thermal systems on top of one million buildings until 2010. The program included a long-term low-interest customer financing, guaranteed procurement for federal buildings, commercialisation programmes, and productions incentives. Some of its individual states have also instituted capital subsidy programmes for PV where the California Energy Commission have offered rebates of up to $4.50/peak-watt or 50 percent off the system purchase price. New York and New Jersey have offered up to $5/peak-watt subsidies, while New York offered rebates by as much as 70 percent of the cost of eligible equipment in 2002.

- Germany, on the other hand, began its "1,000 solar roofs" program in 1991. The program offered subsidies for individual household purchases of solar PV of up to 60 percent of capital system costs. The program was expanded in 1999 to 100,000 roofs over five years, providing 10-year low-interest loans to households and businesses. As a result of favourable feed-in tariffs and low-interest loans, the program was expected to provide 300 peak-MW of PV capacity.

- Among developing countries, Thailand has provided subsidies for small renewable energy power producers in 2000. It solicited bids for about 300 MW of small renewable power, and has offered production subsidies above that of the standard power purchase rates for the first five year operation of each power facility.

TAX RELIEF[84]

Tax relief policies have been widely used in developed economies such as the US, Europe and Japan, and have been especially popular in the US. In the US, it has been used at least in 11 federal and state tax policies that address energy production, property investment, accelerated depreciation, and renewable fuels. Some of these tax policies are: a) investment tax credits, b) accelerated depreciation, c) property tax incentives, d) sales tax incentives, and others.

In the US, investment tax incentives have been offered to business and residential customers. Customers receive at least 10 percent tax credit for the purchase of solar or geothermal renewable, although for some states, investment tax credits may reach up to as high as 35 percent

Accelerated depreciation, on the other hand, allows would be renewable energy investors to receive the benefits sooner that expected (based on standard depreciation rules). In the US, business developers can recover investments in solar, wind and geothermal property by

[83] PV Status Report (2003)

[84] Cutler J. Cleveland (2004)

depreciating them over a period of 5 years, instead of 15 or 20 years (typical depreciation periods of conventional power investments).

Property tax incentives are implemented either by partially or fully excluding renewable energy property from property tax assessment, setting a cap on the value of renewable energy property similar to an equivalent conventional energy system, or as a tax credit awarded just to offset property taxes.

At least 16 US states have policies that provide retail sales tax exemptions for renewable energy systems. These states have offered a 100 percent exemption for capital expenses, and have provided specific exemptions for renewable fuels.

PRODUCTION TAX CREDITS

Production tax credits are annual tax credits, based on the amount of electricity generated by an investor or owner of qualifying property. The tax credits somehow have encouraged improvements in performance. In the US, the Renewable Electricity Production Credit (PTC) has provided tax credit (on a per-kWh basis) for electricity generated from wind, biomass, or poultry waste resources. It was estimated that Federal tax credits of about 1.5 cents/kWh (adjusted annually for inflation) are earmarked for the first ten years of operation, for all qualifying plants that have entered the service from 1992 through mid-1999, and later extended to 2001. Congress has extended the PTC, which expired on 31 December 2003 to end of 2005.

Another similar credit in the US is the Renewable Energy Production Incentive (REPI). State and local government entities (including municipal utilities) and not-for-profit electric cooperatives are eligible for the incentive. Unlike the PTC, REPI can be used for most types of renewable generation including solar, wind, geothermal, and biomass. REPI has the same value as the PTC – currently placed at 1.8 cents per kWh. Like the PTC, REPI provides 10 years of financial support. Although REPI expired Sept. 30, 2003, an extension of REPI was in the 2003 Energy Bill that failed to pass the Congress. It is likely that future energy legislation will revive REPI. Historically it has fully funded requests from solar, wind, geothermal, and closed-loop biomass facilities; while other technologies such as landfill methane have received partial funding due to appropriation shortfalls. See the DOE-prepared REPI summary for contacts and further information.

GRANTS AND LOANS

Many economies have offered grants for renewable energy purchases or R&D activities. In the US, many state governments and utilities have provided grants for renewable energy ranging in size from hundreds to millions of dollars.

Loan programs on the other hand, offer financing for the purchase of renewable energy equipment. Loans can be at market-rate, low-interest (below market rate), or forgivable. In many states in the US, loans are available to virtually all sectors—residential, commercial, industrial, transportation, public, and non-profit. Loan payment schedules may vary, with terms ranging from up to 10 years with interest rates (for renewable energy investments) often 1 percent or more higher than those for conventional power projects because of the higher perceived risks involved. Funding may also come from various sources, including municipal bonds, system benefit funds, revolving funds, and utility penalty or overcharge funds. Financing may also be for a fraction to 100 percent of a project. Some loan programs may also have minimum or maximum limits, while others are open-ended. Terms may range from 3 years to the actual life of a project, while still others are contractor-driven, and may include service contracts in the loan amount.

Grants and loans are sometimes combined. In the case of Iowa, for example, it provides a 20 percent forgivable loan combined with an 80 percent loan at prime rate for renewable fuels projects. In China, multilateral loans (for renewable energy) were believed financed by lenders, usually in conjunction with commercial lending.

KEY CONSIDERATIONS IN SELECTING OR EVALUATING THE EFFECTIVENESS OF SELECTED NRE POLICIES[85]

Policy instruments and mechanisms could effectively speed up the development of the renewable energy sector if they are designed and implemented properly. Some of the key considerations that APEC member economies might consider using in order to evaluate the success and effectiveness of some NRE policies have been identified and described in a report prepared by the Centre for Resource Solutions for China (Wiser Consulting, June 2002). Some of the key considerations, which some APEC member economies might find useful, are described here.

COST MINIMISATION

Cost and price minimisation is the ability of the renewable energy policy to minimise the costs of generation while it enhances competition in the renewable energy sector. It was observed that reductions in the cost of energy from renewable have resulted from; a) efficiencies in manufacturing activities, b) industry infrastructure development, c) project development experience that builds human capacity to design and operate renewable facilities more efficiently, and d) the opportunity for multiple project development that allowed the incorporation of the cost reduction features.

Feed-in law, as analysed, may stimulate the development of a local renewable industry as it generates a large number of projects, which would also result to an effective cost reduction for local development. However, unless it is carefully constructed, it will not reduce market prices because the specific feed-in tariff is often fixed. Fixed feed-in tariffs do not generally ensure least cost development.

RPS on the other hand, might create wholesale price competition among renewable energy suppliers, as long as there are several suppliers bidding on any particular contract. While this policy does not inherently reduce costs of production, it could create the volume that would allow renewable energy generators to bring down costs because of 'economies of scale'. It is important to note that experience gained by local renewable energy developers could also help bring down costs.

ACHIEVEMENT OF TARGETS

Policies are evaluated by its ability to meet the firm development targets for renewables. RPS, for example, seems to create a specific supply target and with appropriate penalty provisions for non-compliance, could be very effective. In bidding or tendering policies, on the other hand, there seem to be no guarantees whether the contracts awarded will be met.

RESOURCE DIVERSITY

Another important policy objective is to encourage an assortment of renewable energy supply sources. Particularly at the beginning of renewable energy resource development, it is frequently valuable to see what types of renewable energy technologies will be developed, and at what cost, by the market rather than to speculate what policy experts think will be developed within a particular price range.

[85] Center for Resource Solutions (CRS), 2002

MARKET FOR POWER

A market for the renewable energy will exist if government will effectively enforce its renewable energy mandate, e.g. higher energy price than energy costs, guaranteed power purchase agreement with minimal transaction costs, or availability of a fair and reasonable interconnection. Whether it will be sustainable, however, is the biggest challenge. Physical sustainability usually hinges on the 'perceived' costs and benefits of the policy, the underlying economic health of the electricity sector, stability of government policies, public support for renewables, and the relative political influence of developers of competing technologies. If the financial community thinks that political support is not sustainable, and policies are likely to change (or are not enforced), they may well be reluctant to finance new renewable energy projects.

POLITICAL VIABILITY AND STABILITY

There are several factors that influence political viability (the ability of the policy in achieving the necessary political support). These are cost to implement the policy, success in other markets and the perceived compatibility with current political philosophy.

The stability of a policy environment likewise is essential for the development of a secure renewable energy industry, and its access to reasonable financing. Some policies may provide high-level short-term regulatory security over a reasonable period. But modifications applied essentially to reduce cost might compromise investor's interests if applied retroactively.

LOCAL INDUSTRY DEVELOPMENT

Policies should be able to increase local renewable infrastructure and create a local renewable energy manufacturing industry that will have economic development and employment. For example, with the continuous incentive to reduce costs, established equipment suppliers and developers would likely compete to dominate the market. Therefore it is important to already have local suppliers established so they can compete.

COMPATIBILITY WITH ELECTRICITY INDUSTRY AND REGULATORY STRUCTURE

Some NRE policies may require strong and efficient administration mechanisms to be effective. In Europe, for example, economies have considered abandoning or phasing out certain systems in favor of RPS. Without such advanced administration mechanisms, RPS might not function effectively. Some policies usually are effective in a newly restructured wholesale market.

COMPETITIVE PARITY

Competitiveness of NRE policies in electricity markets might increase the desire not to unfairly shift public policy on certain market participants. In a fully implemented RPS, for example, all utilities and retail suppliers are required to meet the same renewable energy purchase agreements. A similar situation is prevented with tradable renewable energy certificates, where the incremental cost of the policy could be spread fairly across jurisdictions.

INTEGRATION

Another important objective of renewable energy policy is to ensure that renewable generation is integrated fully into the overall electricity industry, systematically reducing or eliminating institutional barriers to its development.

Under any of the renewable energy policies, if there is no incentive for the utility to reduce the institutional barriers to the development of renewable energy, barriers will remain.

SIMPLICITY

The design, administration, and enforcement of tariffs should be simple. From a contractual and transaction cost perspective, interconnection requirements, contract terms, and conditions are supposed to simplify negotiations and speed up the development and contracting process for renewable energy generators.

PROSPECTS OF NRE TECHNOLOGIES FOR THE POWER SECTOR IN THE APEC REGION

INTRODUCTION

The purpose of these scenario analyses is to assess the impact of policy measures on renewable electricity supply and demand over the next 50 years. APEC economies would gain substantial environmental and economic benefits if the share of NRE in electricity generation were increased. As to how much and how soon these gains will be realised are determined by how vigorously and how early these economies implement the necessary policy measures to promote the development and implementation of NRE technologies.

The scenarios presented here are based on a set of optimistic but reasonable assumptions. The applicability of the derived results and their impact could vary significantly from economy to economy. Four key potential results derived from the analyses are:

1. Total fossil fuel savings;
2. Total cost savings from displaced fossil fuels;
3. Total avoided CO_2 emissions; and
4. Total cost savings from avoided CO_2 emissions

This chapter will illustrate the possible paths to accomplish partial **energy independence**, **avoid carbon dioxide emissions** by almost half and make a sizable **savings in total fuel cost** by 2050. The study is based on three different scenarios. The first scenario assumes no active policy interventions are taken to promote NRE and market forces are allowed to determine the choice of fuel for power generation. This is the Reference Scenario and it forms the baseline of the analyses. The next two scenarios assume active policy interventions to promote NRE in the APEC economies and the aim is to assess the effect of timing for implementation of these policies, i.e., the impact in the results, vis a vis GHG emissions and fuel consumptions. Thus, Scenario 1 or Accelerated NRE Deployment assumes a vigorous policy intervention and capital investments taking place before 2010. Scenario 2 or Delayed NRE Deployment Scenario assumes policy interventions and capital investments post 2010. The analysis will show the impact of a ten-year delay on annual CO_2 emissions and annual fuel consumption savings for the APEC region.

This study does not include estimates of investment costs in NRE technologies or the cost of displacing existing fossil fuel plants. Therefore, no cost-benefit analyses are presented for the scenarios in relation to technology investments. The study also has excluded the benefits of electricity grid interconnections in estimating fuel cost savings and avoided CO_2 emissions.

As international agreements on economical and environmental issues usually set goals for a given deadline, the analysis presented in this chapter may help to assess the savings that a timely policy adoption on NRE may have, along with an estimate of cost for a more drastic course of action is required when the same goal has to be achieved in less time.

ANALYTICAL FRAMEWORK AND ASSUMPTIONS

Three different cases are presented for the scenario analyses based on a reference case, accelerated implementation of NRE's mass deployment policy and delayed implementation of NRE's mass deployment policy measures. In all three cases, an annual average electricity demand growth of 2.8 percent is assumed for the period from 2000 to 2050 across the region. Annual average GDP growth for the same time horizon is assumed to be 3.7 percent.

In this section a forecast of the consumption of electricity in the next 50 years is presented. Of all the factors influencing electricity trends, and in general energy trends, three of the most vital are the GDP, price of oil, and status of the economy. The GDP is a measure of the demand for goods and services that require energy. Different forms of energy have different costs, but most variable is petroleum. The price of petroleum depends on political and market decisions that occur outside most APEC economies – external issues. Inevitably, APEC energy policy makers are likely to confront the following in the future:

- How to reduce CO_2 emissions and slow down global climate change
- How to reduce the high dependence on imported energy sources and
- How to assure that a reasonable diversity of supply options is available at the lowest and affordable costs.

The aim of this chapter is to present some exercises that will help the process of decision making that will shape the energy and environmental landscape of APEC economies.

REFERENCE SCENARIO

The Reference Scenario assumes that present trends are continued and no major policy initiatives to promote NRE on massive scales are undertaken. Thus energy technologies are chosen only based on operating and capital cost. As a result, fossil fuel utilisation is expected to grow because it is the most economical energy source available under the current price trend in the region. The key assumptions of the Reference Scenario are as follows:

- From 2000 to 2020 the reference scenario is the same as the reference scenario of the APEC Energy Demand and Supply Outlook[86].
- From 2021 to 2050 the annual average growth of coal is maintained at the same rate as the preceding period, at –1.0 percent;
- Similarly, for hydropower an average growth rate of 2.5 percent yearly is used for 2021-2050.
- Natural gas share is increased steadily from 27.5 percent share in 2020 to a 33 percent share in 2050, as moderate new developments for this technology are expected in this period. A yearly growth rate of 3.7 percent is assumed for this technology.
- For the period 2021-2050 oil based electricity production is phased out gradually with no new oil-based generation after 2025;
- After 2020 a scenario with low development for nuclear power is assumed. As a consequence, nuclear power is expected to peak in the period 2010-2020, and after that

[86] APERC (2002)

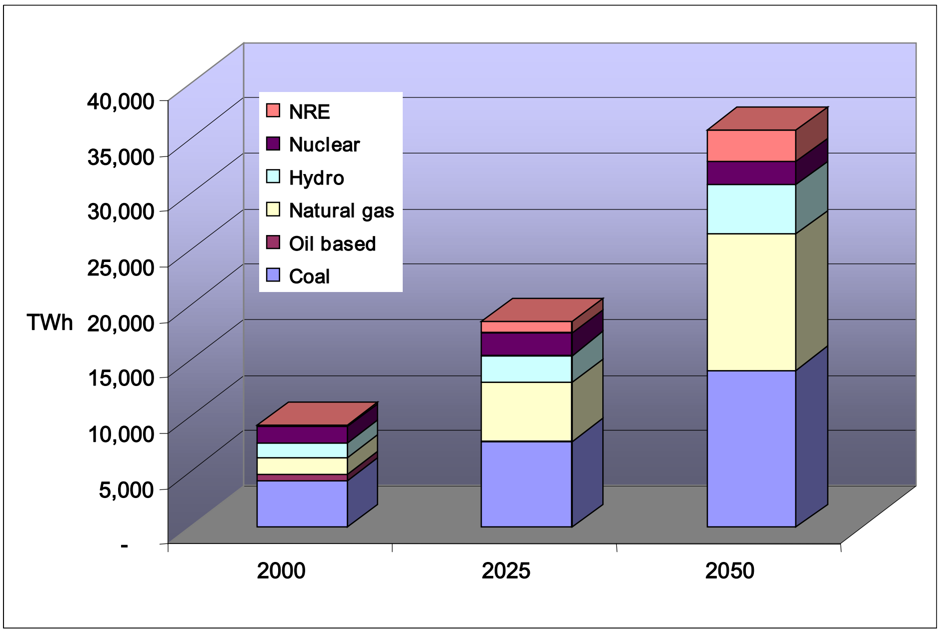
the rate of decommissioning is assumed to be equal to the rate of construction of new facilities. Therefore, after 2020 nuclear power generation is expected to remain constant until 2050 albeit with a declining share from overall electricity generation;

- Petroleum price is expected to remain high over the time horizon;

Under the reference scenario, NRE has only a two percent share in year 2000, while coal is the major source of power generation with a 44 percent share. The second major energy source is Natural gas at 17 percent, followed by Nuclear at 16 percent and hydro at 14 percent. Oil has a 7 percent share.

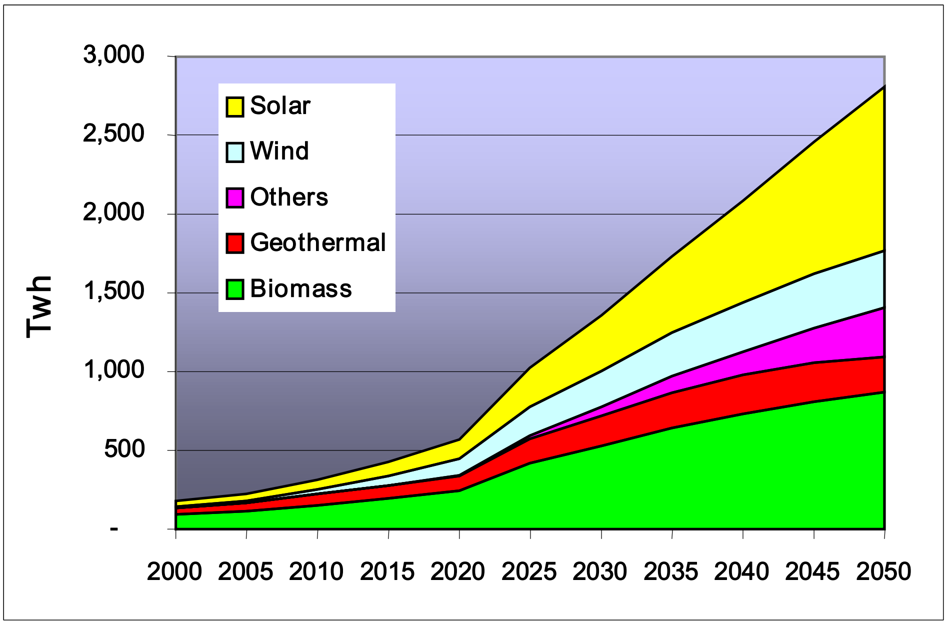
Reference scenario evolution is shown in Figure 27. The share of NRE doubles to four percent in 2025 and coal remains the major fuel source with 42 percent. The share of natural gas more than doubles to 31 percent from 14 percent while nuclear's share declines by half to eight percent. Hydro remains almost unchanged with 13 percent while oil's share declines to 2 percent.

Figure 27 Fuel mix in Reference Case.



The next Figure shows that biomass will be the prevailing NRE energy resource for electricity until 2050, as the technology has matured and is fully commercialised. It will be followed by solar and in the third place by wind power. It is expected that by 2020 wind power will reach the maximum share of NRE, and afterwards no significant growth for this technology is foreseen due to lack of space and wind resources. After 2030 solar technology will be the up and coming NRE source that will contribute significantly to supply the growing demand. PV is likely to contribute significantly to electricity generation after 2050.

Figure 28 NRE Mix in Reference Scenario



Overall, the reference scenario indicates that coal will maintain its share around 40 percent, while oil will decline to a minimum, which accounts mainly for indigenous consumption in economies that are producers of this fuel. Similarly, hydropower is kept constant around 13 percent throughout the time horizon. Natural gas is expected to reach nearly one third of the electricity production in APEC economies around 2020, which will be maintained until 2050.

The Reference scenario is built on the basis that traditional fuels will be available and no constraints on emissions are in place. Furthermore, this approach is feasible if the following conditions are met:

- Domestic oil and gas reserves prove adequate to support the projected production at reasonable prices,
- Future fossil fuel prices are kept within current levels,
- Rural electricity consumption may be supplied with current status of technologies.

As all these conditions are unlikely to occur simultaneously, a deviation from the Reference scenario is needed to foresee possible alternative ways for the evolution of the energy demand and supply in the APEC region.

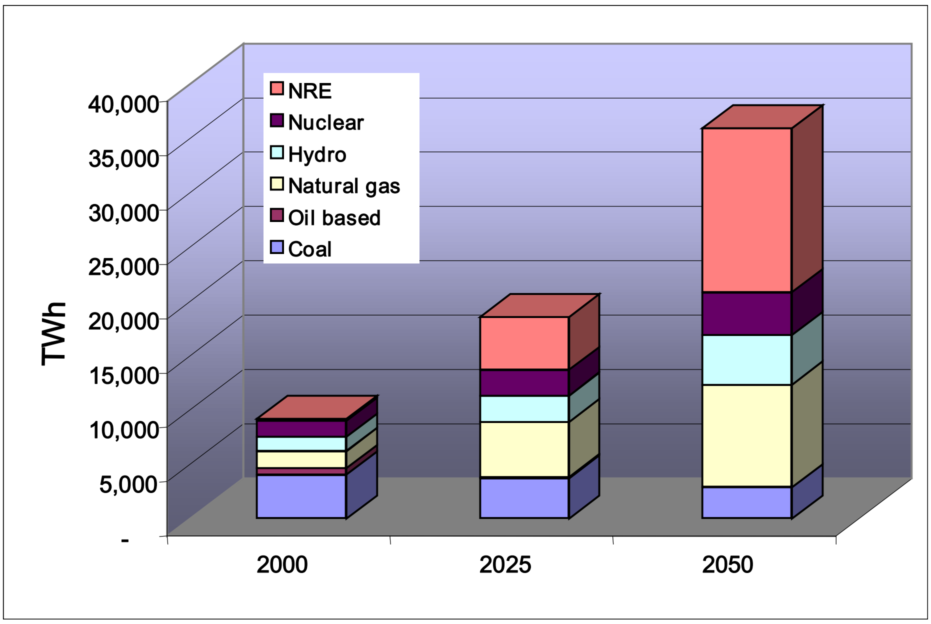
SCENARIO 1- ACCELERATED DEPLOYMENT

An alternative scenario with a higher share of NRE is studied. In this scenario an active role for policies promoting NRE is assumed. Particularly, this scenario considers policy efforts to constraint emissions and shift conventional fuels to NRE starting from now, which will have visible consequences around 2010, for this reason this scenario is named Accelerated NRE Deployment Scenario. The following assumptions are made:

- Increasing international agreements on reduction of emissions and consequently, increasing pressure over the rest of the economies to reduce emissions. Thus, fossil-fuel-based electricity production will peak in the 2010-2020 decade and will continuously decrease afterwards.
- A sustained improvement in NRE technologies will enable lower production costs, which will be fully competitive after 2010. This assumption is supported by current calls for greater emphasis to be placed on renewable energies by major renewable equipment producing economies and nations like USA and Japan in APEC and many European Union nations.
- RPS Mandated Policies are taking major stronghold in many APEC economies. This is also a consequence of international awareness and implementation of emission reduction policies.
- A moderate annual growth rate of 2 percent for nuclear power plants is assumed. Main economies involved in this growth are China, Japan, Korea, and Russia.
- Coal electricity power generation is decreased steadily at 2 percent per annum from 2010 to 2050. Similarly, oil electricity production is decreased steadily at 2 percent per annum.
- Generation growth rate by Natural Gas source is the same as the Reference scenario.

Electricity demand growth still remains at 2.8 percent annually in this scenario. Thus, the emphasis here is on NRE along with a mild increase in nuclear power generation. The resulting share for technologies in 2025 and 2050 are shown in the following figure.

Figure 29 Fuel mix in Accelerated Scenario



NRE will reach 26 percent in 2025, whereas coal will be reduced to 20 percent. Natural gas, hydropower and nuclear technologies are similar to the reference scenario (see Figure). Thus, the main energy displaced by NRE is coal.

As shown in Figure 29, NRE reaches 42 percent of the electricity production by 2050, whereas coal is reduced to 8 percent. Natural gas along with hydropower is similar to the reference case. Nuclear power increases from 2 percent in the reference scenario to 11 percent in this alternative case. Finally, oil based technologies are reduced to less than 1 percent in 2050, similar to the situation in the reference case (2 percent).

Under this scenario, Figure 2 shows that NRE will be the dominant source for electricity in 2050, with a share of 42 percent. The second most important resource will be natural gas with a 26 percent of share by 2050. On the other hand, coal resources are reduced constantly throughout the period, and they reach 8 percent by the year 2050. The rest of the technologies do not experience important changes.

Growth rates for NRE technologies are shown in Table 11.

Table 11 Growth rates for NRE Technologies in Accelerated Scenario

Electricity	% Growth rates 2000-2020	% Growth rates 2021-2050	% Average Growth rate 2000- 2050
Biomass	15.5	3.9	8.6
Geothermal	14.5	2.7	7.4
Others	20.6	14.4	16.9
Wind	27.1	3.9	13.2
Solar PV	17.3	6.9	11.1

The fastest growing technology in the period 2000-2020 for this scenario is wind (27.1 percent), which is expected to reach full deployment by 2020. In subsequent years, wind power is expected to maintain the production with a growth rate of 3.9 percent for the period 2021-2050. The fastest growing technology after 2020 is Others, as is it expected that new advances in promising technologies; such as Ocean Thermal Energy Conversion (OTEC), tidal and wave electricity generation; will experience a fast development.

Throughout the period, PV technology maintains an average growth rate of 11.1 percent, which will enable it as the most important technology by the end of 2050, with a share of 37 percent.

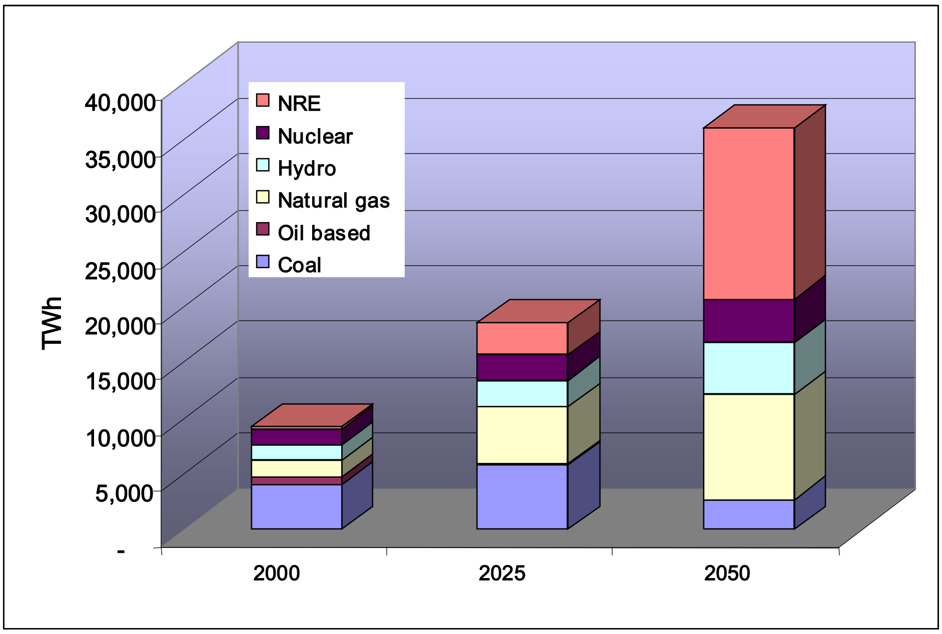
SCENARIO 2 – DELAYED DEPLOYMENT

The objective of this scenario is to estimate the effect of a delay in NRE policies on fuel consumption and CO_2 emissions in the APEC region. Accordingly, Scenario 2 assumes that until 2020 no major policy changes are introduced, therefore the Reference Scenario dominates the trend. However, as fossil fuels are expected to peak around 2020, NRE technologies have to be strongly promoted to satisfy the demand. The following assumptions are made in this scenario:

- Increasing international agreements on reduction of emissions and consequently, and increasing pressure over the economies to reduce emissions. Thus, fossil fuel-based electricity will peak around 2020 and will continuously decline afterwards.
- A sustained improvement in NRE technologies will enable lower production costs, which will make NRE electricity generation fully competitive after 2020. This assumption is supported by current calls for greater emphasis to be placed on renewables by major renewable equipment producing economies and nations such as USA and Japan in APEC and many European Union nations.
- RPS Mandated Policies start taking major stronghold in many APEC economies after 2020. This is also a consequence of international awareness and implementation of emission reduction policies.
- A moderate annual growth rate of 2 percent for nuclear power plants is assumed. Main economies involved in this growth are China, Japan, Korea, and Russia.
- In order to achieve the same final state as the Accelerated Scenario, coal electricity power generation is decreased steadily at 3 percent per annum from 2020 to 2050. Similarly, oil electricity production is decrease steadily at 3 percent per annum. Higher rates as compared to those of the Accelerated NRE Scenario are imposed here in order to achieve a similar final state in 2050.
- Generation growth rate by Natural Gas source is the same as the Reference scenario.

Electricity demand still remains at 2.8 percent annually in this scenario. The following figure shows the evolution of shares of energy sources in APEC economies.

Figure 30 Fuel Mix in Delayed Scenario



In the projection for year 2025, shows that NRE will reach 16 percent share, which corresponds to a total increase of 14 percent as compared to year 2000. Coal is still the major source of power generation fuel with 29 percent, but it is followed closely by Natural gas at 28 percent (up 11 percent from 2000). On the other hand, nuclear energy is reduced by 4 percent as compared to year 2000. Hydropower is kept almost with the same share at 13 percent. Energy from oil is reduced farther to a 2 percent share (down 5 percent).

For the year 2050, Figure 30 shows that NRE will reach 42 percent, which compromises a strong increase of its 14 percent share from year 2025. Natural gas and hydropower remain the same as 2025, i.e., 28 percent and 13 percent respectively. Nuclear is reduced approximately at 10 percent, i.e., a reduction of 2 percent with respect to 2025. Coal is reduced to 8 percent, whereas Oil is nearly 0 percent.

The following issues may be drawn from these projections:

- NRE will be the main technology of choice for electric power generation because of its long-term availability and ability to fulfil international environmental restrictions.
- Nuclear power maintains the same share, nearly 10 percent of the total production.
- Coal and Oil are reduced vigorously due to environmental constraints and the limited time allocated for the changes (delayed in 10 years with respect to Scenario 1).

Growth rate for each technology is presented in Table 1. Growth rates indicates that Wind will be the main source until 2020 at 15.5 percent, whilst Others (9.6 percent) and solar PV (6.6 percent) bring the rear. Biomass (4.9 percent) will be constant throughout the time horizon, similar to Geothermal (1.4 percent). For geothermal, the main reason for being stagnant and low growth rate is limitations on resource availability.

Table 12 NRE growth rates in Delayed Scenario, 2000-2050.

Electricity	% Growth rates 2000-2020	% Growth rates 2021-2050	Average % Growth rate 2000- 2050
Biomass	4.9	10.8	8.5
Geothermal	3.9	9.6	7.3
Others	9.6	22.4	17.3
Wind	15.5	12.7	12.7
Solar PV	6.6	14.0	11.0

Table 12 indicates that in the period 2021-2050 a strong promotion of NRE is needed to meet the required final state in 2050 (same as the one obtained from the Accelerated NRE Scenario. In fact, the average growth of Wind, PV and Others have to be greater than 10 percent yearly throughout 2021 to 2050, which is a major challenge from the technical and political point of view. Biomass will be the mainstay source as the technology has matured and commercialised. Before 2025 PV is not likely to contribute significantly to electricity generation.

SCENARIO RESULTS - IMPACT ON FUEL CONSUMPTION, GHG EMISSIONS AND POLICY IMPLICATIONS

In this section a comparison among the Reference Scenario, the Accelerated and Delayed NRE scenarios is presented. The main purpose of this study is to account for differences in fuel consumption, GHG emissions and subsequent policy implications.

FUEL DISPLACEMENT

Estimations of fuel displacement obtained from scenarios 1 and 2 with respect to the reference scenario, for the whole period 2000-2050, are shown in Table 13.

Table 13 Summary 2000 to 2050-Fuel Displacement with respect to Reference Scenario

Fuel	Scenarios	
	Accelerated Scenario	Delayed Scenario
Coal [million ton]	85,213	67,591
Oil [million bbls]	3,600	0
Natural Gas [BCM]	10,180	10,180

Total coal displacement of Accelerated Scenario with respect to the reference case are nearly 85 trillion tons. On the other hand, Delayed scenario produces an approximate displacement of 67 trillion ton. Thus, an approximate 18 trillion tons of coal consumption are at stake if Accelerated NRE Scenario is followed instead of the Delayed NRE Scenario. It is important to keep in mind that coal is the most important source of CO_2 emissions for APEC region.

In Table 13 natural gas displacement is the same for both Accelerated and Delayed scenarios. Total savings amount 10 TCM (trillion CM) for the whole APEC region.

With respect to oil, Accelerated scenario produces a displacement of 3.6 billion bbls as compared to the reference case. On the other hand, no savings are achieved in Delayed Scenario as patterns of yearly reductions are the same as those of the reference scenario.

By using average values for fuel production, preliminary estimates indicate that displaced fuels amount nearly US$5.8 trillion if Accelerated scenario is adopted. On the other hand, if the Delayed Scenario is adopted an estimated US$4.4 trillion in fuels is displaced as compared to the reference scenario.

CO_2 EMISSIONS

Table 14 shows the summary for the period 2000-2050 for the CO_2 emissions, as well as estimated cost for GHG for each scenario.

Table 14 Summary of CO_2 Emissions, 2000 to 2050

Total Values for period 2000-2050	Scenarios		
	Reference	Accelerated Scenario (1)	Delayed Scenario (2)
CO_2 Emissions [million tons]	628,674	374,306	423,050
Estimated Cost [trillion US$]	12.38	4.90	4.03
Estimated Savings with respect to reference scenario [trillion US$]	-	7.48	8.35

Table 14 shows that both NRE Scenarios achieve a substantial decrease in CO_2 emissions as compared with the reference case. In fact, by 2050 Accelerated and Delayed NRE scenarios produced less than half of CO_2 emissions of the Reference case.

In order to have preliminary comparisons of emission savings between the two NRE cases, a cost assessment by using a value of US$20 per ton of CO_2 is presented in Table 14. By taking into account the whole time horizon, a potential saving nearly US$5 trillion may be achieved if the Accelerated scenario is chosen instead of the baseline case. On the other hand, the Delayed scenario could render US$4 trillion savings as compared to the reference case.

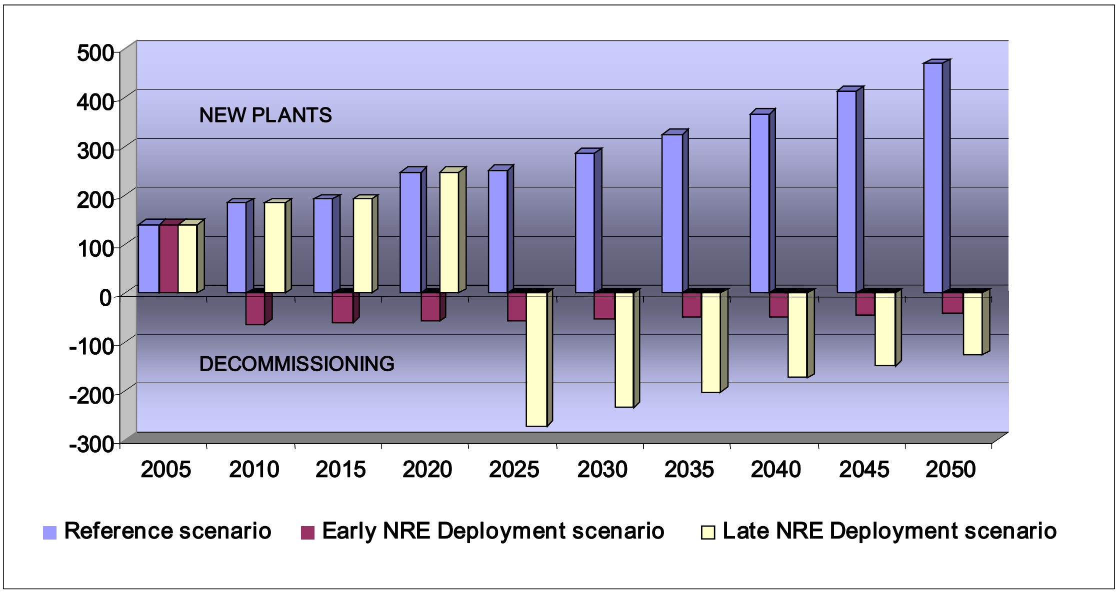
This exercise provides a preliminary estimation of the cost on CO_2 emissions that a 10-years delay in adoption of NRE friendly policies may have on APEC economies.

POLICY IMPLICATIONS

Besides the economical cost and savings of alternative scenarios, an important variable is the policy implications in terms of rate of change that must be undertaken to achieve the desired goals.

To portrait the implications on policy for the election of one or another scenario, in Figure 31 the evolution of new and decommissioned coal plants for each scenario is presented. In the reference case, new plants of coal technology are built steadily throughout the period 2000-2050, as no constraints on air emissions are considered. Figure 31 shows also that until 2020 the Delayed scenario follows the same pattern as the Reference scenario, and after 2020 a decommissioning period for coal plants starts.

Figure 31 Coal Plants Decommissioning Rate



From Figure 31 we see that for the Delayed scenario it is necessary to decommission nearly 270 coal plants in the period 2020-2025 in APEC economies (approximately 54 plants per year). Also, for the period 2025-2030 another 230 plants are required to be taken out of service. The trends continue in the same fashion until 2045-2050 where 127 coal plants will have to be decommissioned.

On the other hand, for the Accelerated scenario decommissioning process starts early in 2010, where nearly 60 plants are required to be taken out of service. The trends are maintained around 50 plants every 5 years, which gives an annual average of 10 plants being decommissioned for the APEC region.

Clearly, from a political point of view to decommission 50 plants per year, as in the Delayed NRE Scenario, is much more difficult to achieve than 10 plants per year as in the Accelerated NRE Scenario. In addition, the economical burden of the decommissioning process is heavier when the time frame is shorter, as in the Delayed scenario. Therefore, the Accelerated scenario is much more feasible from the economical and political point of view than the Delayed scenario.

CONCLUSION

Current reserves and the rate at which fossil fuels are utilised today are simply not a sustainable and a long-term option to meet the increasing energy demand in the APEC region. NRE as an alternate choice, although not a solution to all our energy needs, could certainly address the four key energy issues – energy security, environmental concerns, rural electrification and niche market needs related to the electricity sector.

The technical limitations of photovoltaics and wind energy have downplayed their share in the total electricity generation mix to a mere 20 percent. However, the ongoing progress in storage technology development and the declining costs could offer a permanent solution to this problem. Wind and PV technologies are now considered the most promising new energy technologies that could be harnessed in utility-scales and regarded as having greater potential to displace conventional fossil fuels. Other NRE technologies like biomass, mini hydro and geothermal are relatively more mature and have been able to compete with conventional technologies in terms of costs.

The three major barriers - high costs of energy from NRE, inadequate regulatory and institutional framework and market barriers could be addressed either with demand-pull strategies, financial incentives, market facilitation and investment, rural electrification policy and or distributed generation policy. These policies, in combinations, have resulted in massive deployment of NRE technologies in many economies in APEC region as well as outside the region.

Although developed economies are currently well ahead of the developing economies in terms of NRE utilisation, the latter stands to gain the most in many respects. Developing economies in the APEC region are projected to have the highest growth rate for the next 45 years. Energy infrastructure in most of these economies is also still underdeveloped. These conditions allow these economies to include NRE technologies in their development plans since it is more cost-competitive to develop NRE infrastructure from the beginning rather than install them as retrofits. NRE technologies are also cheaper on a life-cycle cost basis since the fuel for some of these technologies like PV, wind, geothermal and mini-hydro is free through the life of the facilities.

The immediate and critical measures for APEC economies to consider in order to accelerate the mass deployment of NRE technologies would be to re-examine their existing energy policies, undertake concrete measures to remove barriers and to assess and establish their renewable resources. The APEC region not only represent almost 50 percent of world population, it also have some of the fastest growing economies as well as economies that contribute the most GHG emissions in the world. By increasing the share of NRE through mass deployment, the region could displace significant amount of fossil fuels annually, **save some US$4.4 to US$5.8 trillion** in fuel costs as well as **avoid 206 to 254 billion tons in carbon dioxide** emissions by 2050.

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