Philippines

Renewable Energy Report

APCTT-UNESCAP

**Asian and Pacific Centre for Transfer of Technology
Of the United Nations – Economic and Social
Commission for Asia and the Pacific (ESCAP)**

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1.1 Country Overview

Figure 1. Map of the Philippines

Geography – The Philippines, officially Republic of the Philippines (Republika ng Pilipinas), is an archipelago of about 7,107 islands and islets lying about 500 miles (800 km) off the southeastern coast of Asia, covering a land area of about 115,800 square miles (300,000 square km). The country spans about 1,150 miles (1,850 km) from north to south at its longest extent and about 700 miles (1,125 km) from west to east at its widest extent. It is surrounded by the Pacific Ocean, bounded by the Philippine Sea to the east, the Celebes Sea to the south, the Sulu Sea to the southwest, and the South China Sea to the west. The three principal islands of the Philippines are Luzon in the north, Mindanao in the south, and Visayas at the center.

The Philippines have a maritime tropical climate with temperature variations being almost entirely a result of elevation. Manila, its capital, has an average annual temperature of 81°F (27°C). The archipelago is well watered, with the western Philippines having a distinct dry season. Typhoons frequently strike the more northerly eastern coast. More than one-third of the country is forested, having a large variety of hardwoods such as lauan (Philippine mahogany) as well as softwoods, including pine.

The Philippines is rich in mineral resources. Deposits of gold, silver, iron ore, copper, lead, chromite, nickel, manganese, and limestone occur in commercial quantities. Limited petroleum reserves are located in the island of Palawan, the isolated island southwest of Luzon.

Demography – The people of the Philippines (who are called Filipinos) are predominantly of a Malay stock frequently admixed with Chinese and sometimes with American or Spanish ethnic groups. More than four-fifths of the population is Roman Catholic, and a sizeable minority is Muslim; some of the population belongs to Philippine Independent Church (Aglipayan) and others are mainline Protestant.

The estimated population in the Philippines is 97.98 million, with a population growth rate of 1.96% (CIA, 2009). Life expectancy at birth averages at a value of 71.09 years for the total population. Population density is relatively high, with nearly two-fifths younger than 15 years of age. Heavy migration from rural to urban areas has caused overcrowding, particularly in metropolitan Manila.

Economy – The economy of the Philippines is based largely on agriculture, light industries, and services, with a GDP composition by sector of 14.7% agriculture, 31.6% industry and 53.7% services (CIA, 2009). The Philippine economy grew at its fastest pace in three decades in 2007 with real GDP growth exceeding 7%, but growth slowed to 4.6% in 2008 as a result of the world financial crisis. High government spending, a relatively small trade sector, a resilient service sector, and large remittances from the four- to five-million Filipinos who work abroad have helped cushion the economy from the current financial crisis.

Government – The Philippine constitution of 1987 (which replaced the Constitution of 1973, as amended in 1981 and 1984) vests executive power in the president, the head of the state, who is directly elected to a single six-year term. The President appoints the Cabinet, which is responsible for the day-to-day administration of the country. Legislative power is vested in the bicameral Congress of the Philippines, consisting of a 250-member House of Representatives and a 24-member Senate. The judicial system is headed by a politically independent Supreme Court.

1.2 Energy Overview

The Philippines' local reserves of traditional energy are relatively small with only about 24 million cubic meters of crude oil, 107 billion cubic meters of natural gas and 399 million tones of coal, mainly lignite (APERC, 2009). However, the country has extensive geothermal resources that could make the economy the world's largest producer and user of geothermal energy for power generation. In addition, there are other renewable energy sources (e.g. solar, wind, biomass, hydro and ocean) that are theoretically estimated to have a power generation potential of more than 250,000 MW.

1.2.1 Energy supply and demand

Energy security has been a major concern in the country with our strong dependence on imported sources. The country has always been and will continuously be vulnerable to international energy market situation unless this is addressed. The vulnerability illustrated is by the undue economic strains encountered by the country during the oil price shocks in 1973 and 1979, the Iran-Iraq tanker war in 1981-1988 and the gulf war in 1990. These episodes in the country's history elicited various actions to ensure the energy supply in the country. The 1973 crisis accelerated the search for local petroleum and other indigenous energy sources including geothermal, hydro and nuclear systems. In addition, programs on renewable energy systems development were launched as well to aid in the government's thrust towards energy security. Because of these efforts the domestic energy share increased to 31% in 1982. However, the local energy share of 38% in 1987 fell short of the 50% projections primarily due to the shelving of the nuclear energy program in the mid eighties. Nevertheless, these endeavors cushioned the impact of the succeeding world oil crisis.

The most recent global energy crisis however takes a different nature. In addition to the Middle East peace and security concerns, the drastic oil price surge, to a large degree, is attributed to the diminishing levels of fossil fuel reserves in the world. Currently, the country has the highest electricity and fuel price per GDP in Asia. While very recent figures have shown a big drop in world oil prices, it could go up anytime again in the future. Crude oil prices behave much as any other commodity with wide price swings in times of shortage or oversupply. The crude oil price cycle may extend over several years responding to changes in demand as well as OPEC and non-OPEC supply and World Events as illustrated in Figure 2.

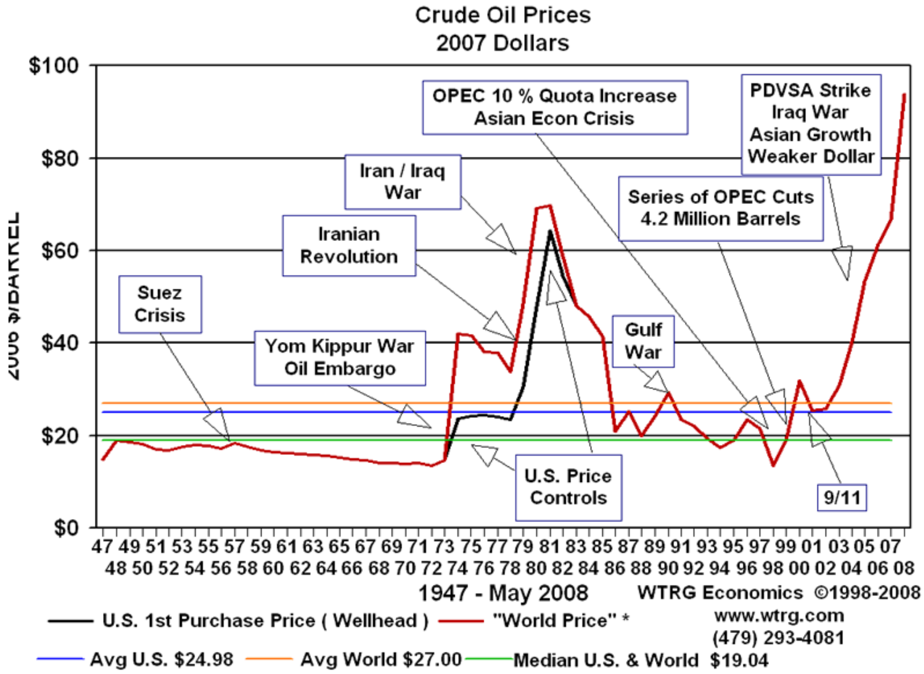


Figure 2 Crude Oil Prices from 1947 – May 2008 (WTRG Economics, 2009)

The recent drop in prices has been attributed to deteriorating demand due to the global economic crisis. The higher than expected U.S. crude oil inventories jump is further evidence that the recession is choking the economy's demand for oil. The IEA forecast for 2009 indicate that the world will consume a full 1 million barrels per day less this year than last year. OPEC however emphasizes that low world oil prices currently could choke upstream investments and could lead to another price hike in the future (Johnson, 2009). With these uncertainties, the country should strive to cut down on its dependence on foreign energy source.

Oil utilization in 2007 accounted for 35.6% of the primary energy use of the country, 96% of which is sourced externally (see Figure 3). Renewable sources on other hand accounts for 31.9% of the energy mix and is dominated by geothermal energy followed by biomass and hydro energy. Coal, which accounts for 14.9% of the mix, is largely imported while natural gas accounts for 7.7% of the primary energy.

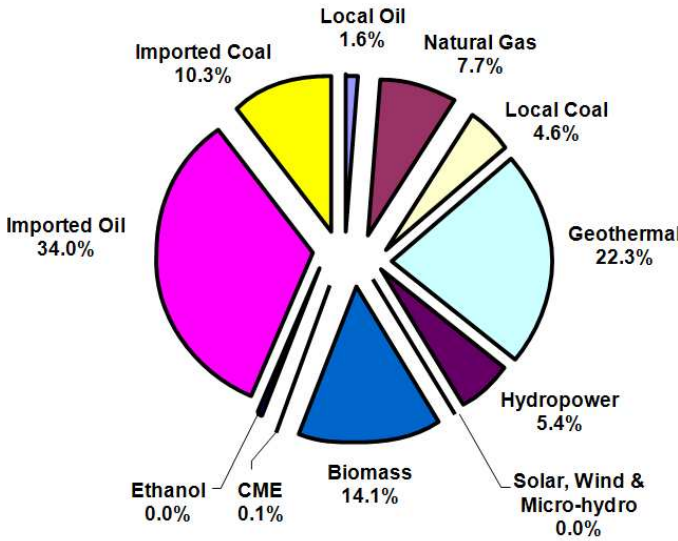


Figure 3. 2007 Philippine Energy Mix (DOE, 2008)

The construction of new natural gas and coal power plants are on the pipeline which is expected to increase their share in the country's power mix. Oil however is expected to continually play a major role in the country's primary energy requirements (see Figure 4) primarily to the continued dependence of the transport sector to fossil oil.

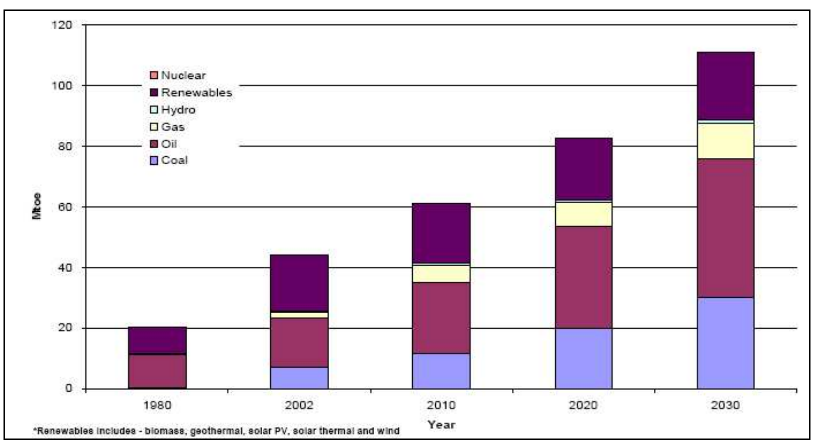


Figure 4. Primary energy projections (APERC, 2006)

On the demand side, figures indicated that primary energy consumption demand declined by 4.0 % in 2005 compared to the previous year (see Figure 4). This temporary demand downtrend was attributed to the continuing increase in the prices of petroleum products, which prompted the consumers to utilize energy in more prudent ways. In 2007, the transport sector accounted for the biggest share of energy use at 34.5%, followed by the residential sector at 28.9%, industrial sector at 25.2%, commercial sector at 9.9% and the agricultural sector at a meager 1.5% (DOE, 2008).

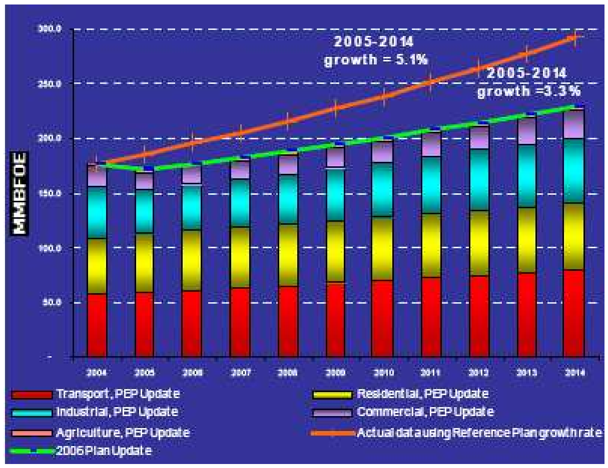


Figure 5. Philippine energy demand projections by sector (DOE, 2007)

Despite escalating oil prices, simulations indicate that final energy consumption shall increase between 3.3 to 5.1 % on the average for the period 2005-2014 (see Figure 3). Petroleum products will remain a dominant fuel due to the high demand of both the transport and industrial sectors. The share of LPG fuel is expected to increase in response to the increasing liquid fuel prices making the shift to LPG more viable. Meanwhile, demand for biofuels (CME and ethanol) is seen to increase as well by 4.4 percent annually. Residential sector demand is dominated by biomass burning for cooking at 70% while the rest is accounted by LPG, kerosene and electricity use. It is projected to increase at an annual rate of 1.4%. LPG share in the sector is projected to increase which could be additional pressure on its price. The sector's electricity use is expected to increase due to the growing population. Petroleum products (gasoline, diesel, oil, LPG and CNG) on the other hand dominate and will continue to dominate the industrial energy use. Electricity and biomass also accounts for a major portion of its requirement. Energy demand annual growth for the commercial sector on the other hand is expected to increase at an annual rate of 5.7% for the next 10 years with electricity use dominating the requirements. Agriculture sector energy demand is expected to increase annually at a rate of 2.5%. Petroleum accounts for bulk of the agricultural energy demand and are principally used in crop production, commercial fishing and irrigation. Installation of new power capacities is required to support the projected growth in electricity demand.

1.2.2 Environmental impacts of energy use

Energy security efforts come in the light of ensuring a cleaner environment. Data indicates that mean atmospheric temperature in the country is rising which could be traced to global warming (see Figure 6). This trend is expected to continue unless global efforts to reduce greenhouse gas emissions are successfully realized.

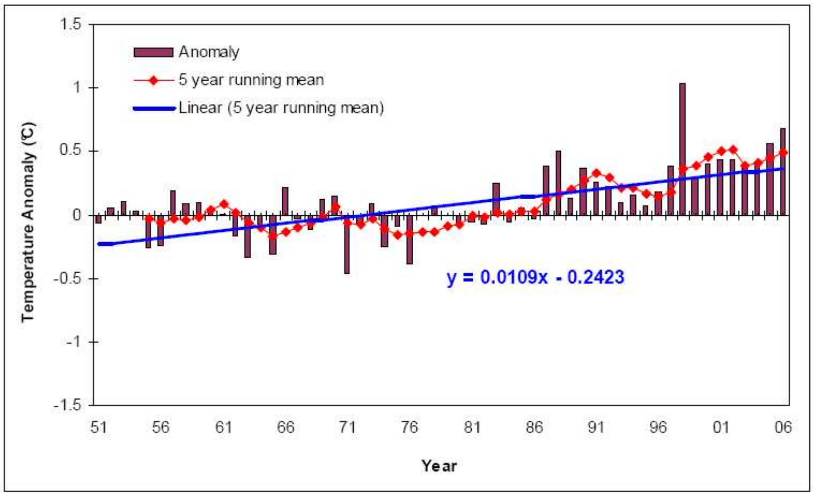


Figure 6. Observed annual temperature anomalies in the Philippines (Magturo et al., 2007)

APERC (2006) data, as shown in Figure 7, indicates that electricity generation and transport are the biggest sources of CO_2 emissions from energy utilization.

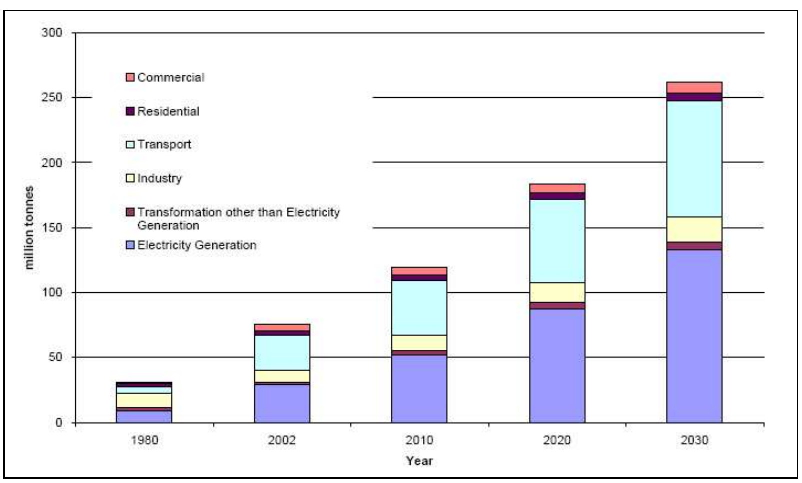
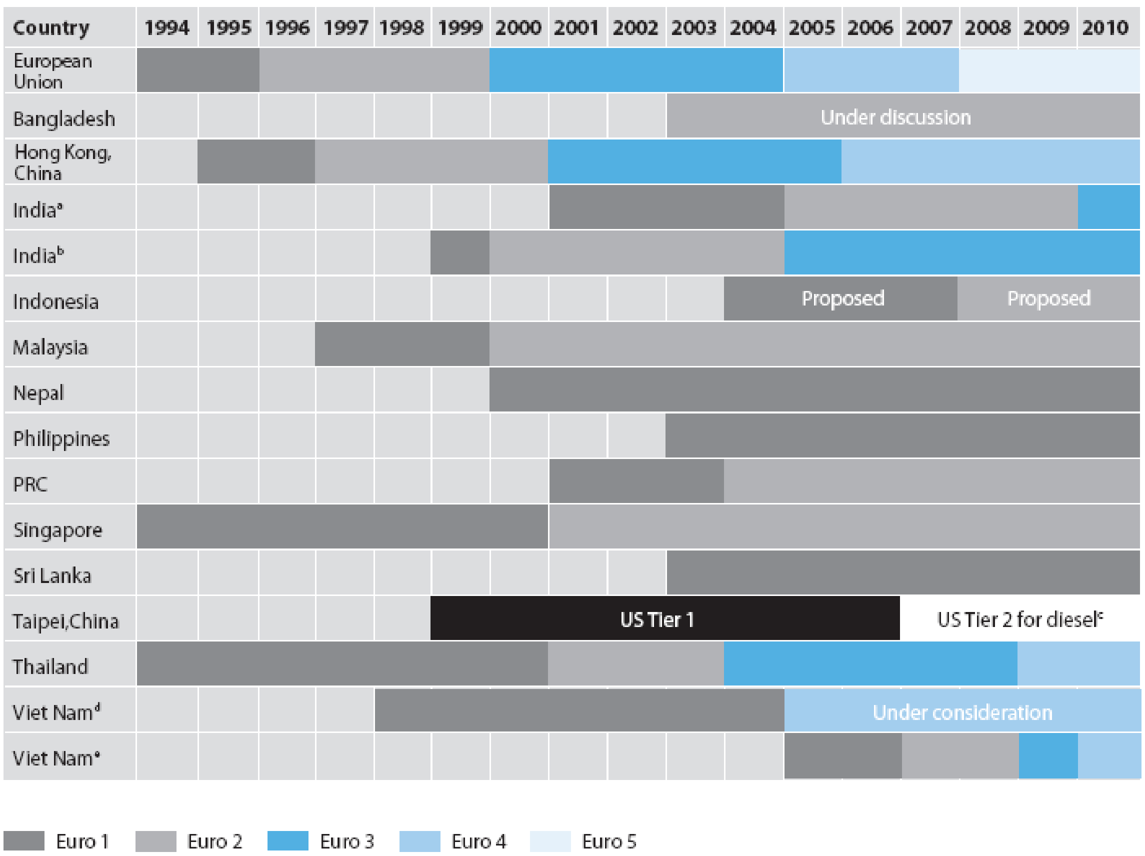


Figure 7. CO_2 emissions by sector (APERC, 2006)

The planned increase in coal power share could increase the country's greenhouse house gas emissions if not properly planned and managed. The country's vehicle reference standards continue to be lax compared with other countries (see Figure 8) slowing down the diffusion of cleaner vehicle technologies. It is encouraging to note however that the Department of Environment and Natural Resources (DENR) is set to upgrade these standards in the near future.

In addition to global warming, energy production and transport are leading causes of atmospheric acidity. Acidification impact concerns have increased in recent years such that plans are now being explored to set-up internationally a sulfur trading program in addition to carbon trading (Klaassen, 1995).



[a] Entire country
[b] Delhi and other cities; Euro 2 introduced in Mumbai, Kolkata and Chennai in 2001; Euro 2 in Bangalore, Hyderabad, Kanpur, Pune and Ahmedabad in 2003; Euro 3 to be introduced in Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad and Ahmedabad in 2005
[c] Gasoline vehicles under consideration
[d] For gasoline vehicles
[e] For diesel vehicles

Figure 8. Emission standards for new vehicles (light duty) in Asia (ADB, 2003)

Emissions from power generation and transport are major health concerns accounting for majority of particulate matter, volatile organic compounds and carbon monoxide emissions. It could be noted that a number of leading causes of death in the country are strongly linked with air pollution as shown in Table 1. Global warming related diseases such as malaria, dengue, cholera, diarrhea and typhoid are also part of the list.

Table 1. Top ten causes of morbidity in 2005 (Magturo et al., 2007)

DISEASE	Number	Rate/ 100,000 population
Acute Respiratory Tract Infection	690,566	828.0
Bronchitis/Bronchiolitis	616,041	738.7
Diarrhea	603,287	723.4
Influenza	406,237	487.1
Hypertension	382,662	458.8
TB Respiratory	114,360	137.1
Diseases of the Heart	43,898	52.6
Malaria	36,063	43.3
Chicken Pox	30,063	36.0
Dengue Fever	20,107	24.1

These global and local environmental concerns would have to take center stage in the country's energy security program and plan.

Chapter 2

Energy status, potential and research directions

Energy security has been a primary concern of the country because of our over-dependence on imported energy resource. In the past few years, crude oil prices have been very unstable, reaching high levels of over 140 USD per barrel in mid-2008. The Philippine government, recognizing the impacts of the erratic changes of prices in the oil market, has engaged in the development of suitable measures that will address the nation's energy problems. Numerous initiatives have been promoted by the government, such as the utilization of indigenous materials for fuel production and the use other renewable, clean energy technologies (e.g. biofuel, geothermal, solar, hydroelectric, ocean and wind energy systems). These programs endorsed aim to address the country's dependency on foreign fuel supply and simultaneously contribute to the preservation of our environment.

2.1 Oil and natural gas

The country is targeting to increase local petroleum exploration from 69.5 Mtoe in 2004 to 83.6 Mtoe by 2014. There is a potential for some 4,000 MW of additional gas-fired capacity and expanded use of natural gas in other sectors, including transport. The gas transmission and distribution infrastructure needs to be developed to reach these new markets and encourage new sources of gas supply. Research and development requirements in the oil and natural gas systems are mostly hinged on resource identification and exploration.

2.2 Coal

Unless more ambitious goals and innovative programs are adopted and implemented to accelerate the deployment of renewable energy, the country is still expected to depend mostly on fossil fuel for the years to come. The steep demand for energy, the highly indefinite oil price and the improving environmental impact of coal power systems provided the stimulus for active coal utilization in the country. In 2007, coal accounted for 14.9% of the primary energy use and 28% of the power mix. Latest figures indicate that about 75% of the coal production is utilized in the electrical power generation while the remaining 25% is consumed for cement making and by other industrial activities. With the planned additional coal-based power capacity, its utilization is expected to further rise at a rate of 8.8% annually. While the indigenous coal production reached record levels in 2007 posting a 47% increase from the production of the previous year, it only accounted for 37% of the total coal demand. This is largely attributed to the low quality of local coal, which makes it a less viable option for power generation unless blended with higher grade imported coal (USAID, 2007).

Increasing coal use however would cause environmental problems if not properly managed. The poor quality (high sulfur content and low heating value) of local coal adds to this challenge. Over the past decades, major progress has been made in reducing sulfur oxides, nitrogen oxides and particulates from coal combustion plants. Efforts are now focused on reducing and/or managing its CO_2 emissions. This could be achieved by improving conversion efficiency, co-firing coal with biomass, and employing carbon capture and storage (CCS). The choice of mitigation strategy depends on the existing power generation stock, the price of competing fuels and the cost of alternative technologies.

The Integrated Gasification Combined Cycle (IGCC) and the Super Critical Pulverized Coal (SCPC) technologies provide the highest potential to increase combustion efficiency and best fit for CCS systems (MIT, 2007). Large scale Integrated CCS system however is yet to be demonstrated but proposals have been forwarded to implement such programs internationally. The Circulated Fluidized Bed Combustion (CFBC) has also been demonstrated to burn low grade coals more efficiently thus should also be considered. Development of indigenous combustion technologies or localization of these state-of-the-art clean "coal technologies" to fit local coal properties should be explored. Preparatory work should be initiated to facilitate the adoption of

CCS should the technology becomes eventually viable. This would include the geological mapping to identify potential CCS sites and modeling of the economic, legal and environmental impacts of CCS locally. CCS is expected, though, to add cost for coal combustion and conversion. The increasing concern over global warming could possibly raise prices of CO_2 emissions to levels that would be able to offset this incremental increase in generation cost in the future.

Energy inertia dictates that existing coal power plants will stay for quite some time. Thus, efforts to reduce its emissions, increase operations efficiency and allowing the use of local coal in such systems should be developed. In addition, biomass-coal co-firing provides a very high potential considering the vast biomass reserves of the country.

2.3 Geothermal Energy

The Philippines is the second largest producer of geothermal energy in the world, next to the United States, with a reserve estimate of about 4,400 MWe (DOE, 2009). The country has an installed capacity of 1,930 MW as of 2006. Plans are in place to increase geothermal energy production by 820 MW from 2009 to 2014. Two companies, The Philippine Geothermal, Inc. (PGI) and the PNOC – Energy Development Corporation (PNOC – EDC), are involved in developing geothermal fields in the Philippines, both of which sell their steam to the National Power Corporation.

In spite of the numerous active geothermal areas in the Philippines, certain challenges and gaps still hinder the acquisition of substantial potential for geothermal energy. Therefore, more effort is still needed to pursue the utilization and development in this area.

2.4 New & Renewable Energy

With the enactment of the Renewable Energy Act of 2008, it is anticipated that research and development activities on the various renewable energy technologies (RETs) are to be accelerated for national energy self-reliance to be realized. Studies on the different research priority areas should be done to further the advancement of the RETs in the country. Moreover, renewable energy utilization would have to be expanded to the industrial and commercial sector for it to be sustained. In addition, rural electrification projects would have to be anchored on job and income generation.

The following section discusses the different renewable energy systems that are being promoted by the Philippine government, the state and applicability of these RETs and the needed research and directions for each.

2.4.1 Wind Energy

Potential investors are gaining interest in wind energy systems in the country. According to the study done by National Renewable Energy Laboratory (NREL), over 10,000 km² of land area, equivalent to about 76,600 MW, is estimated with good to excellent wind resource potential. There were six regions identified, with 47 provinces having at least 50 MW and 25 provinces with about 1,000 MW each. So far, the biggest project yet implemented is the 25 MW Bangui Bay Northwind wind farm in Ilocos Norte. Some 345 MW of capacity from 16 additional wind power sites is expected to be added between 2008 and 2010. Some of the investors in wind power development include the Energy Development Corporation, the country's leading geothermal energy developer, with prospective areas in Nagsurot, Burgos in Ilocos Norte, UPC Asia with potential areas located at Burgos and Pagudpod both in Ilocos Norte.

Wind power is a relatively mature technology. Globally, installed capacity increased from 2500 MW in 1992 to 59,200 MW at the end of 2005. This corresponds to an annual growth of about 30%. More than 75% of this new capacity has been installed in Europe. Wind energy generation cost in 1998 varies between 5 to 13 US cents/kWh (Qurashi and Hussain, 2005), including capital and maintenance costs, and are expected to reach and maintain a 3 US cents/kWh rate by 2010 (IEA, 2005). With the average urban and rural grid supply cost of 8-10 and 15 to 70 US cents/kWh, wind energy is considered viable and expected to become more competitive in the future. A comparison of its electricity generation cost with other sources is provided in Table 2.

Table 2. Use and comparable energy generation cost in 1998 (Qurashi and Hussain, 2005)

Technology	*Average cost (US cents per kilowatt*	*Comments*

	hour unless otherwise indicated)	
Wind (electric power)	5 – 13	Costs declined fivefold from 1985 to 1995
Biomass Electric power Ethanol	5 – 15 $ 2 – 3/ gallon ($ 15 – 25 gigajoule)	Steam cycle of 25 megawatts Brazil data. Declined by factor of three since 1980s.
Photovoltaic systems Insolation, 2500 kWh/m^2 Insolation, 2500 kWh/m^2 Insolation, 2500 kWh/m^2	 20 – 40 35 – 70 50 – 100	Based on costs of $ 5 – 10/peak watt. Costs have declined 5-fold since 1980, 2 fold since 1990. Medium and long-term storage a major issue. With battery storage, cost of $ 8 – 40/peak watt in off-grid, stand-alone applications are commonly reported.
Thermal solar (electric power)	10 – 18	Parabolic trough. Latest vintages, around 1990, in high insolation areas only).
Geothermal	3 – 10	Costs vary greatly with location.
Gas fired, combined-cycle power plant	3 – 5	Higher figure is for liquefied natural gas
Grid supplies Off-peak Peak Average, urban areas Average, rural areas	 2 – 3 15 – 25 8 – 10 15 to >70	Depends in spikiness of peak. Rural areas in developing countries

Large wind power energy technology in Europe and other countries are very much mature and in the advanced state of commercialization. Local adoption could be facilitated by focusing on the local production of as much of the parts and components. While the country's wind map has been formulated, a feasibility study should be pursued to examine data on extreme winds, and the probability distribution of winds in excess of 200 km/hour at potential turbine sites should be established.

Small wind systems have long been commercialized in other countries, though not in the same scale as large wind systems, but are yet to gain ground locally due to high capital cost. Development efforts would have to look at development of blade profiles specifically customized to local wind characteristics and locally available materials, production system development utilizing widely available fabrication equipments and localization of control systems technology. These efforts are expected to lower capital and operational cost and accelerate the adoption of wind energy in the country and possibly open up an export industry. While a number of medium scale wind pumps have been designed and installed locally most of which were based on traditional and less efficient designs, adoption of newer and more efficient technologies in local non-power generation applications such as pumping should be explored.

2.4.2 Solar Energy

Situated just above the equator, the Philippines have a great potential for solar energy applications. According to the Philippine Energy Security Plan, nationwide solar radiation has an annual potential average of 5.0 - 5.1 kWh/m^2/day. Solar potential is greatest during the summer months of May to July when the sun is positioned in the northern hemisphere, while weakest insolation occurs in November to January.

Solar photovoltaic systems

Solar photovoltaic (PV) systems are the most popular solar energy technology choice in the country. Applications of PV systems include water pumping, refrigeration, lighting, battery charging, domestic electric consumption, and grid-connection applications. Cost of solar PVs is likely to decrease with increasing production over time. Currently, prices are still high and commercial use is still not expected in the mass market, unless there is a significant price reduction. Nevertheless, solar PV technology is fast growing and hopefully it will gain more acceptances in the energy market. General projections indicate that it will start to gain more recognition between 2010 and 2015, as illustrated in the following figure.

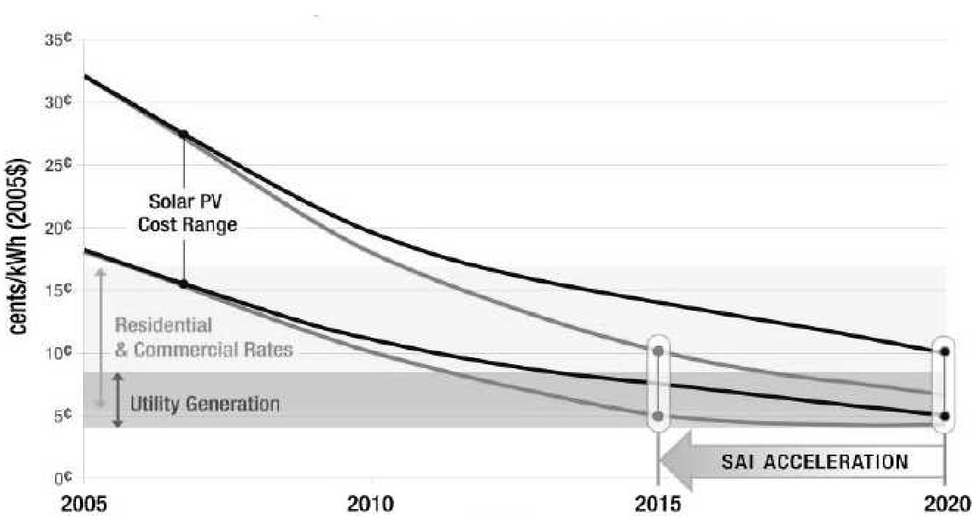


Figure 9 Projected solar PV cost (Stone, 2007)

Local solar PV experience has been limited to community demonstration and/or donor driven projects and telecommunication applications primarily due to high upfront cost. As of 2005, a total of 894 solar home systems were installed through the solar home distribution project of PNOC. Meanwhile, the USAID funded AMORE project has energized 224 rural villages suing PV systems. The country's first on-grid solar PV installation, the biggest so far, is the 1 MW plant using polycrystalline silicon solar panels on a 2-hectare area, connected to the distribution network of Cagayan Electric Power and Light Co., Inc. (CEPALCO) and is hybridized with a hydropower plant. Gaining from the experience, CEPALCO intends to expand its operations from its current production of 1,261.40 MWh to a larger solar park with a 10 MW plant on a 30 hectare lot, which is expected to be commissioned by 2012 (DOE, 2009). Its application however would have to be expanded to industrial, commercial and urban applications if the technology is to gain ground.

India has demonstrated that a strong R and D program could open up and accelerate the adoption of such systems in developing countries like the Philippines. India's R and D program have resulted in a strong indigenously developed solar industry greatly bringing down the technology cost. There are 9 solar cells, 22 solar PV modules and 50 PV system manufacturers in India utilizing either indigenous or imported technologies through joint ventures or technology transfer (WEC, 2000). So far, about 278,300 solar lanterns, 116,800 home lighting systems and 39,000 street lighting systems, about 1 MW aggregate capacity of small and standalone power plants and over 3,300 solar pumping systems have been installed in India. Roughly 50 percent of installed solar PV cost is embedded in the cost of the PV modules, and the remainder is in the balance-of-system (BOS) costs (ESMAP, 2001). The BOS components include the physical structures, wiring and interconnects, and power electronics and control system. BOS cost reduction plays an important role in the cost reduction road map of the solar PV industry as shown in Figure 10.

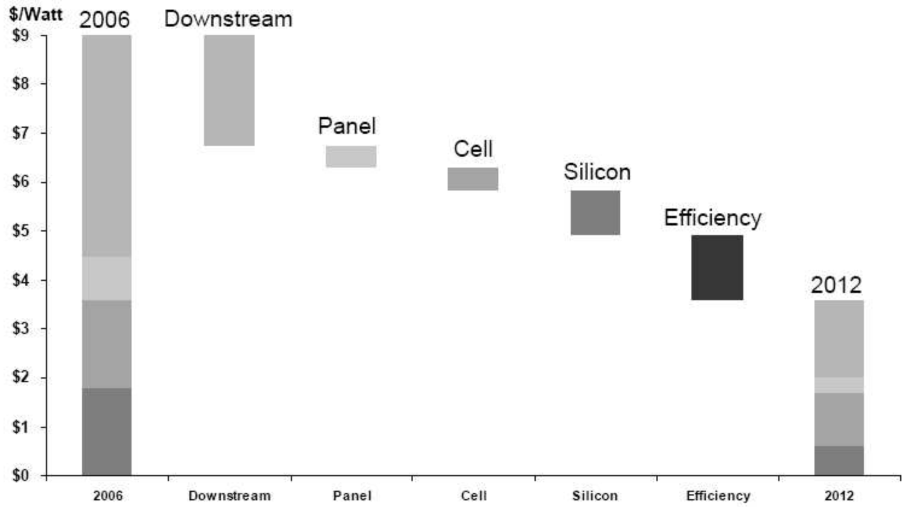


Figure 10 Sunpower solar PV cost reduction road map (Stone, 2007)

Considering the advance state and high cost of Solar PV development, local R and D efforts should focus on BOS integration and cost reduction. These efforts coupled with the projected costs reductions in Solar PV cells are expected to significantly lower down cost of PV systems.

Solar thermal systems

Solar water heaters are fully commercialized locally but market penetration has been minimal. Having a tropical climate, hot water does not come under the primary need of most of the medium or low income households and it is considered as a luxurious service thus the limited demand. It could however find wide applications in commercial facilities such as hotels, high end condominiums and hospitals. The high initial cost of such systems is an obstacle in promoting solar water heater technology. While solar thermal collector technologies have been well developed, the system design would have to be customized to the heating needs, local solar insolation characteristics and material availability.

Solar drying is a mature technology with applications and viability been demonstrated in a number of areas. Local applications for ceramic, fish and fruit drying have been developed and adopted (Del Mundo, 2000; Elepano and Satairapan, 2001; Elepano and Gratuito, 2003). The wider adoption of solar drying technologies could be partly attributed to the lack of solar thermal design specialists (Bhattacharya and Kumar, 2002). In addition, there is a need for further research in different applications of solar and sun drying. Basic experimental research is needed for the determination and control of the drying and material characteristics, the heat and mass transfer parameters and to establish the maximum allowable drying temperature of various products (Farkas, 2008). While developed as it is, there are still a lot of possible improvements on solar collector technology (Philibert, 2006). Further work is needed for design considerations, dimensioning of dryers, and developing new technical and technological solutions for solar dryers. Additionally, studies are required to establish the feasibility and applicability of solar drying for new materials, and economic evaluations are important as well.

Solar cooling systems

Climatic changes in recent years have made air cooling a must in buildings increasing air conditioning utilization. Technological developments have allowed commercial and viable adoption of hybrid solar-biomass dehumidification and adsorption cooling. Localization of said technologies could provide reductions in building cooling energy use in the country. In addition, passive solar cooling systems may also be adopted and promoted to provide additional reductions.

2.4.3 Biomass Energy

Being an agricultural economy, the Philippines have an abundant biomass resource that may be used for energy generation and other native products. The use of these local resources, predominantly in the form of residues from agricultural production and processing (e.g. bagasse, rice husk and straw, coconut husk and shell), forest biomass resources (e.g. woodfuels) and animal wastes, has a great potential in aiding our country towards the production of cleaner fuel substitutes, which is very much dependent on imported oil, and for power generation, particularly for the off-grid areas in our country.

Bagasse, rice hull and coconut waste accounts for a major portion of biomass residue production of the country (Baconguis, 2007). Biomass energy application accounted for 14.1% of the primary energy use of the country in 2007. In addition, 73% of this biomass use is traced to the cooking needs of the residential sector while industrial and commercial applications accounts for the rest. 92% of the biomass industrial use is traced to boiler fuel applications for power and steam generation followed by commercial applications like drying, ceramic processing and metal production. Commercial baking and cooking applications account for 1.3% of its use. These resources however are yet to be maximized. Data indicates that utilization factors for bagasse, rice hull and coconut waste in the country is limited only to 60-70%, 10-20% and 40-50% respectively (Elauria, undated).

Research and development activities on biomass energy focus more on its applications as feedstock for cleaner fuel alternatives in the transport sector. In addition, studies on residues from these biomass systems are also given importance, to further increase the viability of emerging biofuel energy systems. Some examples of these researches are the study on the potential use of jatropha seed husk as fuel for biomass cook stoves, the potential use of jatropha seed cake as fertilizer and detoxified press cake as animal feeds.

Biomass for biofuel production

With the signing of the Republic Act No. 9367, also known as the Biofuels Act of 2006, a one percent blend for diesel (B1) and five percent blend for gasoline (E5) were mandated for use in the transport sector. At present, the biodiesel used for blending in our diesel fuel is coco-methyl ester (CME), which is already locally produced. On the other hand, the ethanol blended into our gasoline fuel is still imported from other countries.

With the thrust of our government towards the use of cleaner fuel substitutes, the use of indigenous materials as feedstock for biofuel production has been promoted. Different local plants, such as jatropha and bitaog (for biodiesel), sugarcane and sweet sorghum (for bioethanol), has received attention as viable alternative sources of biofuel. Further and careful research on these alternative fuels poses a potential solution to the country’s over-dependence on imported petroleum-based fuel, especially in the transport sector.

Biomass for heating and cooking applications

The use of biomass energy, particularly for heating and cooking applications, has long been used, especially in rural areas in the Philippines (particularly for the residential sector). The development of these biomass energy systems has a very great potential in reducing the effect of the unstable and increasing cost of traditional fuels in the energy sector. Further research to increase the energy efficiency of these biomass systems may well be considered as a good alternative to the use of petroleum-based fuel.

However, the convenience and efficiency of biomass systems would have to be ensured before they find their way in a greater number of industrial systems. Research would have to be focused on the development of biomass control systems to increase their reliability and address the issues mentioned. The increasing cost of liquefied petroleum gas could facilitate the use of high efficiency and smokeless charcoal briquettes for cooking. While this shift to biomass cooking is highly desirable, performance and safety standards for biomass cook stoves should be set and enforced.

Biomass for heat and power generation

The use of residues from agricultural production and processing for heat and power generation may also be considered as a promising technology, especially in areas where large volumes of these residues are available (e.g. sugar and rice mills). According to Elauria, biomass energy technologies that have the highest application and benefit potential for the country includes biomass fired power plants and biomass integrated gasification combined cycle. These technologies are fairly mature and have been intensively applied already. A number of biomass power projects have been lined up to provide an additional total of 80MW power production by 2008 (Samson et al, 2001).

Cogeneration plants may well be installed in these areas, where there is a great amount of agricultural residues, to supply some, if not all, of the heating and power requirements of the energy system. However, assurance of the supply and other logistical concerns (e.g. collection and transport) for biomass energy systems may be a major consideration for large-scale systems, thus making a small-scale biomass energy system more attractive.

The Philippines have several years of research experience with small biomass gasifier systems in the late 1970s. Over-all, the experience was negative as their operation and maintenance proved too difficult. In the last decade however, significant technology advancement have been obtained resulting to the development of commercial systems outside the country. Considering that local resource and potential market of the technology is large, the country should keep abreast of the commercial developments, test and localize them whenever possible. Such systems require constant adjustments and modification and could benefit a lot from instrumentation and controls technology. Hybridization of these systems with small wind and solar PV systems could provide a reliable de-centralized power source.

Biomass for biogas production

Biogas technology is a mature technology that presents so much CDM potential. More than 653 biogas systems are installed in the Philippines since the 1970's. Such plants are equally attractive for their pollution mitigation abilities as they are for their energy production potential. The adoption of the technology in large livestock farms is already commercialized. Livestock production in the Philippines, in general however, has continued to be the domain of smallholders. In the hog industry for example, 77 percent of hog inventories remain in backyard production systems (Delgado et al., 2001). Biogas application in smaller farms and its compression and transport to fuel small scale gas powered generators could provide a reliable and low cost source of power in rural areas (Baron et al, 2008). Therefore, research and demonstration efforts would have to be put in place for its viable adoption in smaller farms. In addition, municipal solid waste disposal is a growing problem in the country which could open the doors to land fill gas generation and incineration technology options

2.4.4 Hydropower

Available hydropower potential is estimated at 13,097 MW, where 85% are classified as large hydros and the remaining 15% are shared by mini-, micro- and pico-hydros (ADB, 2003). Currently there are 134 hydropower plants broken down into 21 large hydropower plants, 52 mini-hydro and 61 micro-hydro power systems. In addition, the untapped potential however still remains at 2,603.5 MW. With the country's huge hydropower potential, more than 10% of the electricity requirements are supplied by hydropower generation (DOE, 2009). Hydropower technologies are already established, need minimal R&D involvement, and there are available design concepts that may be adapted for local utilization.

The Japan International Cooperation Agency (JICA) has financed several projects in 2003 complementing the DOE's Expanded Electrification Program. These include, among others, micro-hydropower projects, the Grassroots Grant Aid Program which involves the construction of the 35-kW Cagaluan micro-hydropower and the 18-kW Pantikian micro-hydropower plants in Kalinga Province; Development Study Program in Northern Luzon which identifies 40 micro-hydropower sites for possible inclusion in the DOE's micro-hydropower database; and the

Construction of Micro-hydro Plants for Electrification of Upland Dwellers in Northern Luzon which will install 14 micro-hydropower units costing P296 million for the benefit of 19 off-grid unenergized villages. These projects were mostly implemented in cooperation with universities and non-government organizations. The projects implemented have, to some degree, developed the local capability to fabricate and install such systems. Coupled with the incentives provided by the just approved RA 9513, further localization of advance micro- hydro and pico-hydro technologies could lead to the commercial viability of the technology and lowering of costs. The development of off the shelves pico hydro systems is of a particular interest. These types of system are widely used in Vietnam and China where they are available at affordable cost. There is an estimated 100,000 to 150,000 pico hydro systems installed in Vietnam (Bao, 2004). In the Philippines, a number of private sector initiative have been launched to popularize the technology but the initiative has been mostly confined to testing and has yet to translate to massive adoption of the technology. Most of these initiatives involve the use of Vietnam made equipments (Roaring, 2008; Howey, 2009). Potential demand for such systems has been estimated to be more than 24,000 units (Mariyappan et al., 2004). Rather than depend on the Vietnamese systems, it would be more beneficially for the Philippines to come up with and popularize its own off-the-shelves pico-hydro systems. Having learned from the Vietnamese and Chinese systems, locally designed system could possibly be cheaper and provide better performance. The local production of such would mean more available jobs locally.

The initial capital cost of hydropower technologies is considerably high, thus impeding the expansion of hydropower in the country. However, small hydropower projects are relatively less expensive because of its less complicated and lower cost technology, making it more attractive than their large-scale counterparts. Moreover, because of the incentives provided by the RA 9513, local utilization and adaptation of these small hydropower systems may lead to commercial viability and further lowering of costs of this RE technology.

Most hydropower energy projects in the country involve revisions of existing technology and systems design to adapt them to specific user or site requirements and are not solely R & D in nature. Majority of these are demonstration activities that show the viability and applicability of these RE systems. R & D endeavors are still in the pre-development stage and feasibility studies are still being undertaken for most projects.

2.4.5 Ocean Energy

Due to its archipelagic nature, the Philippines' ocean resource area consists of 1,000 km^2, with a potential theoretical capacity equivalent to about 170,000 MW, based on a study done by the Mindanao State University (2005). In view of this, the ocean technology option is a priority research area for renewable energy and may well be considered in the long term energy security plan of the country.

The International Energy Agency – Ocean Energy Systems (IEA-OES) cooperation project (Polaski and Melo, 2006) consider ocean energy technology as a nascent technology and could take some more time before it becomes commercially practicable. The present status of tidal and marine renewable technologies is given in Table 3. Efforts have been limited to a number of short-term demonstrations. Ocean energy conversion technologies currently are still in the pre-commercial technical demonstration phase. A number of cooperative programs have been launched such as the International Energy Agency ocean energy system cooperative project.

Table 3. Ocean Energy Technologies (Qurashi and Hussain, 2005)

Technology	Maturity	Load Factor (%)	Installed capital cost (c/kW)	Unit cost of electricity (Eurocent/kWh)
Tidal barrage	Mature	20-25	4000-5000	10-13
Wave-shoreline OWC	Demonstration (commercial-2000)	26	2100	-10
Wave-near-shore OWC	Demonstration (commercial-2003)	29	1500	-8
Wave-Offshore-point absorber	Demonstration (commercial-2005)	34-57	1800-3000	4-10
Tidal current turbine	Demonstration (commercial-2005)	21-25	1800-2100	4-10
OTEC	Research (demonstration-2005)	80% + (?)	Not clear	20+
Salt gradient	Not feasible	80% + (?)	Not predictable	-
Marine biomass	Not feasible	80% + (?)	Not predictable	-

It could be noted that its generation and installation cost is far higher than grid cost. Of particular interest is the Ocean Thermal Energy Conversion (OTEC) technology where some efforts are being planned locally. While it provides lots of potential, it is still in the infancy age with unclear capital operational cost requirements. Any development work on this area should be carefully evaluated and pursued only in cooperation with other countries. Pursuing the program under the international collaboration research framework of the International Energy Agency – Ocean Energy System (IEA-OES) project should be explored. The country could possibly offer to host demonstration projects under the program.

2.4.6. Summary of renewable energy resources available

Various renewable energy technologies already exist in the Philippines, as shown in Table 4. It can be noted that by now there are RETs which are commercially available, especially in the field of biomass and solar energy systems. Moreover, there are proven viable energy systems, which could be exploited to further the advance of the local renewable energy industry.

Table 4. Summary of RETs and their applications (DOE, 2009)

Technology	Resource	Application	Stage of Development
Biogas sytems	Animal manure	Commercial and household cooking	C
	Animal manure	Industrial process heat	C
Biomass-fired boilers,	Fuelwood	Cooking, steam, heating	C
Ovens,	Charcoal	Cooking, Process heating	C
Furnaces, Kilns	Bagasse	Cooking, heat,power	C
	Cocoshell/husk	Cooking, heat, power	C
	Ricehull	Cooking, heat, power	C,V
	Ricehull	Cooking, heat, power	D,V
Improved Cookstoves	Charcoal,ricehull	Cooking, heat, power	C
Gasification Systems	Charcoal	Process, heat, power	V
	Ricehull	Heat, power	D
	Wood/woodwaste	Heat, power	D
Pyrolysis, Liquefaction	Woodwastes	Heat, power	L
	Other biomass	Heat, power	L
Densification (Briquetting)	Ricehull	Heat	C
Alchohol-based fuels	Sugarcane	Transport, stationary engine	V
Coconut-based fuels	Coconut	Transport, stationary engine	V
			C
Photovoltaic systems	Solar insulation	Household electricity	C
		Telecommunication	C
		Water pumping	C
Solar water heaters	Solar heat	Water heating	C
Solar dryers	Solar heat	Drying of agricultural crops	D
Wind pumps	Wind	Pumping potable water	C
Wind turbine generators	Wind	Electricity generation	D
MH Battery		Charging storage battery	D
MH Power Plant		Power generation, grain milling	D
Ocean Thermal Systems	Ocean temperature	Power, steam	L
OceanCurrent Energy Systems	Ocean current	Power	P
Tidal Energy Systems	Ocean tides	Power	L
Wave Energy Systems	Ocean waves	Power	L
Hydrogen-based Fuels		Power	L
Landfill gas	Municipal solid waste	Power	P

Note: C – commercially available; D – technical feasibility proven by demonstration projects; P – technical feasibility proven by pilot studies; V – proven competitive with conventional systems, ready for commercialization; L – technical concepts/ laboratory studies ongoing

This shows a great possibility for RET commercialization in the country. To expand the promotion of renewable energy, the technology push approach, shown in the figure below, may be utilized.

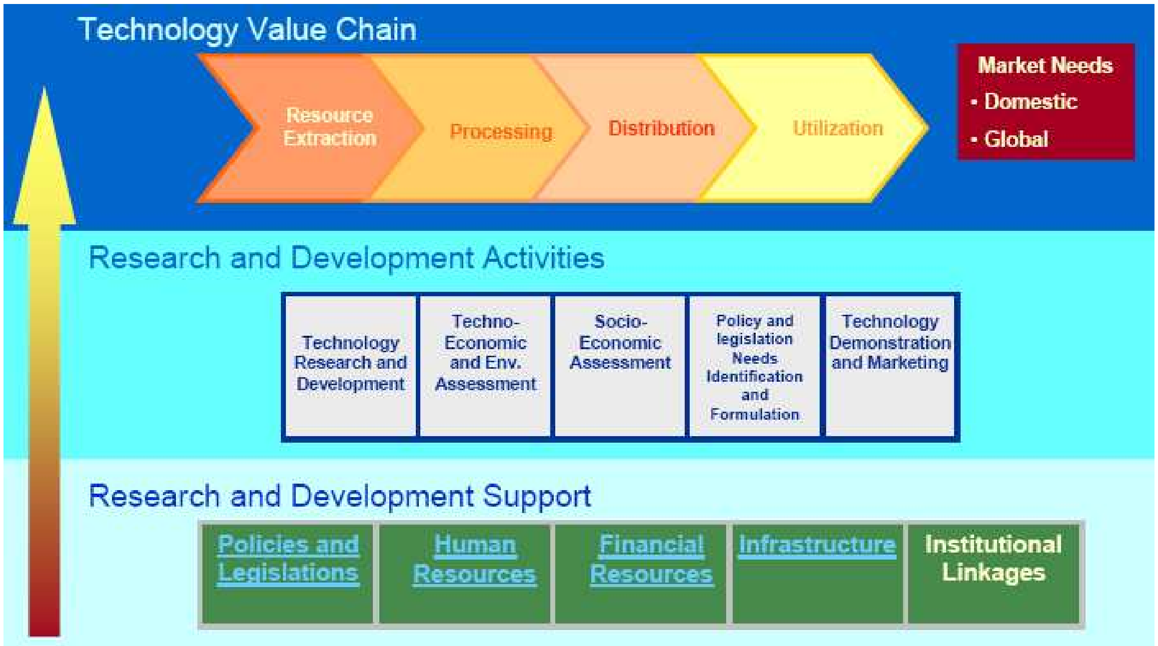


Figure 11. Technology-based framework for RE promotion (Culaba, 2009)

Given below is a list of the renewable energy performance highlights as of the year 2007. It indicates the installed capacities of the various renewable energy resources available in the country. For geothermal energy, installed capacity value given includes that of decommissioned plants. On the other hand, hydropower and solar energy includes those that are not connected to the grid.

Table 5. 2007 Renewable energy resource performance highlights

Resource	Accomplishments, in MW (as of 2007)
Hydropower	3,367.070
Geothermal	2,027.065
Wind	25.250
Biomass	20.930
Solar	5.161
Ocean	-
TOTAL	**5,445.476**

2.5 The Nuclear Energy Option

Today, nuclear power is faced with a negative public perception traced to safety, proliferation and waste management concerns. It should however be retained as an option because it is an important carbon-free source of electricity. Major steps have been implemented to make such systems safer including the development of new light water reactor systems that has increased safety levels five times. Experts have concluded that geologic depositories could safely isolate these wastes from the biosphere. The process, however, is yet to be demonstrated and tested due to some policy barriers. With all the uncertainties mentioned, the adoption and/or expansion of nuclear based power generation is not only a local issue but has become the focus of debates worldwide. Experts have proposed to launch an international cooperative program to initiate and implement a Nuclear System Modeling Project (MIT, 2003). Asian countries have varying nuclear energy directions. Just like Thailand and Vietnam, the Philippines don't see immediate role for Nuclear Power in the near future but should maintain it as a possible energy source in the future; thus, information dissemination, education, feasibility and risk assessment studies must be undertaken to enable future generations to make intelligent decisions on nuclear power. The country can also launch a geological mapping program to identify potential sites for geological repositories that would be capable to isolate nuclear waste from the biosphere.

2.6 Sustainable Transport Program

2.6.1 Vehicle technology evaluation and standards development

Estimates indicated that road transport accounts for a major portion of air emissions in Metro Manila (Ajero, 2002) thus needs to be controlled should the country want to reduce greenhouse gas emissions. Climate change and fuel cost issues brought a lot of attention to efficient and cleaner vehicle and fuel technologies. Fuel efficiency has now taken precedence over comfort and form in development priority. Car manufacturers have been racing to provide commercially viable hybrid and electric vehicles to the market. Locally, the high gasoline cost has catalyzed the shift of taxis to LPG fuel. LPG systems for diesel run vehicles are also now being introduced in the market together with waste cooking oil systems. The number of fuel additives and gadgets claiming to increase efficiency and improve vehicle emissions has also multiplied. To optimize the benefits of these research and development efforts and safeguard the interest of the public, there is a need for the following:

- Testing and evaluation of the vehicle technologies being offered in the market;
- Modeling and development of fuel and vehicle standards and policies to effect optimum energy savings and emission reduction; and
- Testing and development of standards for vehicle gadgets and fuel additives.

2.6.2 Public utility vehicles technology development

Despite the mass transport program laid out for major cities in the country, jeepney and buses are expected to continue to play an important role in the years to come. These vehicles account for a major portion of transport fuel use and are major sources of air emissions. They are mostly run by second hand diesel engines, utilized heavily and are often poorly maintained. So much could be desired from the efficiency and safety features of these vehicles. Likewise, the tricycle sector is dominated by two stroke engines which pose major fuel and emission concern. Retrofit and alternative fuel technologies should be pursued to reduce the fuel consumption and emissions from these vehicles. It is thus recommended that the country pursue a public utility vehicle technology assistance and development program focused on:

- Development of public utility vehicle design standards for enhanced efficiency and safety and reduced environmental impact; and
- Adaptation of hybrid and electric vehicle technologies on public utility vehicles.

2.6.3 Biofuels development

The Biofuels Act was a major step in reducing the dependence of transport sector on oil. Ensuring the adequate supply of bio-fuels however is another challenge. Currently, the major feedstock for local biodiesel production is coconut and palm oil while sugarcane provides the country's ethanol supply. This may not be feasible should their percentage blends are to be increased in the future as mandated by the law. It is encouraging to note that a biofuels development program have been established which seek to search, evaluate, develop processing technologies, test the performance and commercialize local biofuels feedstock. Research and development on ethanol from cellulosic material and jatropha-based biodiesel should thus be aggressively pursued as outlined in the country's Biofuels roadmap. It is also important to put its real benefits and challenges in the right perspective. The country's biofuels program would have to be properly supported by modeling efforts to asses its net environmental and economic benefits and optimize its resources. Of particular interest are its effects on the water and land resources and CO_2 terrestrial absorption of the country, as well as the potential adverse effects on food security and its social impacts. Jatropha has received a lot of attention and hype in the past years. Its successful biodiesel feedstock utilization will be made possible only by a series of agronomic, economic modeling, process development and performance testing studies among others. Its reliable and adequate supply would also still have to be established. High value usage of Jatropha press cake would also have to be developed to increase the viability of its methyl ester production.

2.7 Waste to Energy Systems

Waste to energy systems exist but may not be applied locally due to the Clean Air Act of 1999. Such systems have mostly been run using dry waste as in Europe and United States until recently when India put up its own. Waste in India is mostly wet similar to that in the Philippines. Their experience could be a basis for the decision to allow similar technologies locally.

2.8 Increasing Energy Efficiency Use

The benefits of a higher indigenous energy supply could be minimized by significant increases in energy demand. Improvement in energy efficiency and conservation thus is indispensable in the country's energy security program. While the Philippine primary energy intensity per GDP (i.e. the amount of energy utilized to per unit GDP generated) in 2004 is lower compared to its neighbors, it lags behind developed countries. In addition, it is projected that the country's primary energy intensity will eventually be surpassed by its ASEAN neighbors by 2030 (Nagayama, 2008). The Department of Energy initiated various energy efficiency and conservation programs through its National Energy Efficiency and Conservation Program (NEECP). It consists of five sub-programs namely: a) information, education and communication campaign, b) voluntary agreement programs, c) energy labeling and efficiency standards, d) energy management programs, and, (e) alternative fuels program. Private sector participation is voluntary except for the energy labeling program.

Despite the inroads in energy efficiency technologies, adoption has been limited due a number of factors including human resource limitations, high initial cost and uncertainties and lack of industry confidence in their net benefits (Ablaza, 2004). The energy efficiency industry has been mostly dominated by foreign technology thus the high cost. Localization of these technologies and development of indigenous approaches could reduce technology cost.

The small and medium scale industry needs technology assistance in identifying opportunities and strategies to increase their energy utilization efficiency. In addition, they would have to be continuously updated and exposed to modern energy saving strategies.

The rapid real estate growth in the country needs to be accompanied with building energy efficiency standards and program to ensure that it does not drastically bring up energy demand. Data in Malaysia indicated that lighting and air-conditioning, on the average, accounts for 34.5% and 35.8% of electricity utilized by residential and commercial buildings. Considering that the residential and commercial sector accounts for a combined 38.8% of the country's energy requirements, efficiency improvements in these buildings would provide significant benefits. Passive and active green building technologies need to be popularized with the end view of eventually becoming the norm.

Chapter
3

Government policies and incentives on renewable energy

The Philippine government, recognizing the need to address energy efficiency and self-sufficiency as well as climate change, has conceived different action plans for sustainable development, especially in the energy sector. According to the DOE (2009), current energy policies and measures include:

1. Ensure the continuous, adequate and economic supply of energy with the end-view of ultimately achieving self-reliance
2. Intensive exploration, production, management and development of the country's indigenous energy resources
3. Judicious conservation, renewal and efficient utilization of energy to keep pace with the country's growth and development
4. Consideration of the active participation of the private sector in the various areas of the government towards energy self-sufficiency and enhanced productivity in power and energy without sacrificing ecological concerns.

The general framework of the country's energy sector is defined by the Philippine Energy Plan, which is prepared by the DOE. It presents a two-point policy agenda listed as follows:

- *Energy independence and savings*

  It aims to achieve energy self-sufficiency of 60% beyond 2010. To realize this, resources of indigenous fossil fuel should be increased. In addition, renewable energy should be aggressively developed and the use of biofuels in the transport and industrial sector should be further promoted. Moreover, energy efficiency and conservation programs launched by the government should also be strengthened.
- *Power sector reforms*

  Reforms in the energy sector aim to promote fair and reasonable energy prices in a globally competitive environment. It intends to establish a transparent privatization process and create an investment atmosphere that is attractive to investors.

These strategies call for the optimized use of the country's coal and natural gas reserves and renewable energy resources. Estimates have shown that the country has only utilized 25.2 MW of its 76,600 MW wind energy potential. It also maintains a 500 kW identified micro-hydro and 1,784 MW mini-hydro site potentials and an approximated 235 MMBFOE biomass energy potential. It enjoys an estimated 170,000 MW ocean energy resource. A review of the state of each of the indigenous energy sources mentioned is provided in the succeeding sections. More efficient processes, products and practices would also have to be developed and adopted. While renewable energy provides a large clean energy potential, its wide scale adoption could take some time due to energy inertia, technology, infrastructure and viability issues. Unless more ambitious goals and innovative programs are adopted and implemented to accelerate the deployment of renewable energy, the country is thus expected still to depend mostly on fossil fuel for the years to come. Due to limited local oil reserves, efforts have been put in place to reduce the share of oil in the power mix by shifting to more natural gas and coal power sources. Emissions from the increasing number of coal power plants however could be a major concern if not properly taken cared of. Biofuels for transport use has also received significant attention in the past years.

3.1 Key laws, decrees and policies

A number of recent legislations have been established to facilitate the realization of agenda set and ensure a cleaner environment (USAID, 2007). An overview of these is given in the following sections.

3.1.1 Republic Act 9136: Electric Power Industry Reform Act of 2001

The Electric Power Industry Reform Act (EPIRA) introduced extensive provisions in the power sector, with the fundamental goal of promoting competition and efficiency. This Act has led to private sector participation in large scale renewable energy based power generation, particularly hydropower and geothermal, and resulted in the privatization of transmission assets via concession.

3.1.2 Renewable Energy Policy Framework (2003)

The Renewable Energy Policy Framework (REPF) embodies the over-all objectives, policies and strategies of the Department of Energy for promoting further development and utilization of renewable energy (DOE, 2003). The passage of the "Renewable Energy Act" is expected to boost its implementation.

3.1.3 Executive Order 462: Private Sector Participation in Ocean, Solar and Wind Energy Development

The EO 462 was enacted in 1997, enabling the private sector participation in ocean, solar and wind energy development. It provides guidelines for those who would like to venture in the fields of renewable energy mentioned. However, some critics said that this may cause some barriers to new renewable energy due to some legal technicalities in the power sector. Thus, EO 232 was enacted in 2000, amending the EO 462, such that renewable projects below 1 MW on private lands, public land or offshore areas of the public domain, are considered to be private power projects and not subject to production sharing requirements.

3.1.4 Republic Act 8749: Philippine Clean Air Act of 1999

The RA 8749 provides for a comprehensive air pollution policy. It is intended to prevent and control air pollution from mobile and stationary sources. It prohibits the incineration and burning of waste in any form which practically shut the door for waste to energy technologies. There is a need to review the provision concerned.

3.1.5 Republic Act 9275: Philippine Clean Water Act of 2004

The RA 9275 applies to water quality management in all water bodies, primarily the abatement and control of pollution from land-based sources. It seeks to designate specific water management areas "using appropriate physiographic units such as watersheds, river basins or water resource regions". This is particularly relevant to hydro projects and power plant effluents, among other water-related energy issues.

3.1.6 Executive Order 290: Ensuring Effective Implementation of the Natural Gas Vehicle Program for Public Transport (2004)

The EO 290 promotes the use of CNG as a clean alternative fuel for transport and provides incentives to NGVPPT participants.

3.1.7 Republic Act 9367: Biofuels Act of 2006

The RA 9367 mandates the blending of all liquid fuels for motors and engines sold in the country with locally produced biofuels. Specifically, it requires:

- 5 percent ethanol blending of gasoline by 2007 and 10 percent by 2010
- 1 percent biodiesel blending of diesel within 3 months of enactment and 2 percent by 2009.

If not properly managed and implemented, this could pose energy versus food concerns.

3.1.8 Republic Act 9513: Renewable Act of 2008

To provide a universal policy framework on the campaign towards the development, utilization and commercialization of renewable energy sources, the Republic Act No. 9513, also known as the Renewable Energy Act of 2008, was enacted by the Senate and the House of Representatives of the Philippines in December 2008. With this law, it is expected that there will be an advance in the growth of the renewable energy industry. But even with the passing of the Act, it is still imperative that there is proper implementation of the law for the RE industry to flourish.

According to this Act, it is declared the policy of the State to:

a. Accelerate the exploration and development of renewable energy resources through the adoption of sustainable energy development strategies to reduce the country's dependence on fossil fuels
b. Increase the utilization of renewable energy by institutionalizing the development of national and local capabilities in the use of renewable energy systems, and promoting its efficient and cost-effective commercial application by providing fiscal and non-fiscal incentives
c. Encourage the development and utilization of renewable energy resources as tools to effectively prevent or reduce harmful emissions and thereby balance the goals of economic growth and development with the protection of health and the environment
d. Establish necessary infrastructure and mechanisms to carry out the mandate specified in the Act and other existing laws.

USAID (2007) believes that the country has the required energy and environmental legislations to enhance and clean up energy production and use in the country. However, the implementation of these laws is weak. The same study indicated that training is needed on the identification of alternative energy technology potentials and technology assessment that should include academia to enable long-term capacity building.

3.2 Incentives

With the signing of the Renewable Energy Act of 2008, certain incentives are made available for developers who wish to venture into renewable energy projects and activities. In brief, these are:

a. Seven year income tax holiday.
b. Carbon credits generated from renewable energy sources will be free from taxes. A 10% corporate income tax, as against the regular 30%, is also provided once the income tax holiday expires.
c. Energy self-sufficiency to 60% by 2010 from 56.6% in 2005, by tapping resources like solar, wind, hydropower, ocean and biomass energy.
d. Renewable energy facilities will also be given a 1.5% realty tax cap on original cost of equipment and facilities to produce renewable energy.
e. The bill also prioritizes the purchase, grid connection and transmission of electricity generated by companies from renewable energy sources.
f. Power generated from renewable energy sources will be value added tax-exempt.
g. A net metering scheme will give capable consumers the option to generate their own power. Net metering will allow renewable energy producers to earn from the power they contribute to the grid, and are also charged for electricity drawn from the grid.

Aside from the incentives given to RE developers, incentives for farmers engaged in the cultivation of biomass resources are also made available. For ten (10) years, DOE-certified entities are entitled to duty-free importation and are VAT-exempt on all types of agricultural inputs, equipment and machinery.

Chapter
4

Institutional infrastructure for the promotion of renewable energy

With the government's thrust for the country's energy self sufficiency, there are leading agencies that are operating in the area of renewable energy and are involved in the capacity building, information dissemination, research and development, and demonstration programs. These key institutions come from different sectors, such as the state organizations, private companies, and non-government organizations (NGOs). The efforts of these institutions aid the promotion and utilization of new and renewable energy technologies, which may contribute largely to relieve our country from over-dependence on imported energy sources.

This section provides an overview of the leading organizations for clean energy according to three functions: (1) policy making, planning and program coordination, (2) regulation, and (3) resource development (USAID, 2007).

4.1 Policy making, planning and program coordination

The Philippine Department of Energy (DOE) is the lead agency for policy making and planning body in the energy sector. It is mandated to submit an annual update of the Philippine Energy Plan, and has also taken charge of the preparation of the Power Development Plan. It is its duty to consolidate the plans and programs of the distribution utilities and the rural electric cooperatives into a Distribution Development Plan. It is also tasked to prepare the Regional Energy Profiles in coordination with local planning authorities (USAID, 2007).

The DOE also takes on a range of programs to endorse and encourage the participation of the private sector in the advance of renewable energy, alternative transport fuels and energy efficiency, primarily through the Energy Utilization and Management Bureau (EUMB). The EUMB coordinates electrification projects of government and private entities and manages funding for grid-extension and off-grid electrification.

The Philippine Council for Industry and Energy Research and Development (PCIERD), an agency under the Department of Science and Technology, coordinates policy and programs concerning scientific and technological research, development, and demonstration of new and renewable energy technologies. It functions as a channel of financial support for research institutions and NGOs. The government also established two inter-agency and multi-sectoral bodies to coordinate national activities on sustainable development and climate change: the Philippine Council for Sustainable Development (PCSD) and the Philippine Inter-Agency Committee on Climate Change (IACCC).

The PCSD institutionalized the participation of members of civil society as counterparts of government representatives in pursuing sustainable development initiatives in the country. Among PCSD's tasks is to evaluate and ensure the implementation of the Philippine commitments to sustainable development principles made at the 1992 United Nations Conference on Environment and Development (UNCED).

The IACCC was established on 8 May 1991 as a response to the concern on global warming. According to the PAO No. 220, it is mandated to coordinate different climate change related activities and prepare the Philippine positions for the UNFCCC negotiations. IACCC is co-chaired by the secretaries of the Department of Environment and Natural Resources and the Department of Science and Technology, and has representatives from about 15 government agencies and NGOs.

4.1.1 The National Renewable Energy Board

With the enactment of RA 9513, a National Renewable Energy Board (NREB) was created. The NREB acts as a collegial body primarily tasked with the recommendation of policies to the DOE and the supervision of the implementation of the Act. The NREB has the following powers and functions:

- Evaluate and recommend to the DOE the mandated Renewable Portfolio Standards (RPS) and minimum RE generation capacities in off-grid areas;
- Recommend specific actions to facilitate the implementation of the National Renewable Energy Program (NREP) to be executed by DOE and/or other appropriate agencies of government and to ensure that there shall be no overlapping and redundant functions within the national government departments and agencies concerned;
- Monitor and review the implementation of the NREP, including compliance with the RPS and minimum RE generation capacities in off-grid areas;
- Oversee and monitor the utilization of the Renewable Energy Trust Fund (RETF)
- Cause the establishment of a one-stop shop facilitation scheme to accelerate implementation of RE projects; and
- Perform other functions as may be necessary.

4.2 Regulation

Aside from its policy making and planning functions, the DOE also performs regulatory tasks. These include the administration of contracts for upstream exploration and development of oil and natural gas, coal, and geothermal resources, issuance of permits to agencies that engage in the construction and operation of projects relating to energy activities.

Another agency that has energy regulatory functions is the Energy Regulatory Commission (ERC), which is a quasi-judicial regulatory body, directly under the Office of the President, created through the Electric Power Industry Restructuring Act (EPIRA). This body replaces the Energy Regulatory Board (ERB), its responsibilities and activities, which are more focused on the power sector.

Still another agency with regulatory function is the Philippine Department of Environment and Natural Resources (DENR), which regulates the energy industry through the implementation of environmental laws and regulations. The agency is the one who issues Environmental Clearance Certificates (ECCs) to entities that wish to venture into projects, which may affect the environment in one way or another, through the Environmental Management Bureau (EMB).

Lastly, the Bureau of Product Standards (BPS) supports the industry and protects consumers' interests through the development and promulgation of standards, product testing and certification, accreditation of testing and calibration laboratories, management system certification bodies, and private emission testing centers.

4.3 Resource development

The energy sector is made up of different organizations, both from the public and private sectors. Government-owned corporations are active in the development of renewable energy and clean energy sources, and at present there is an increase in the participation of the private institutions as well. In addition, there are non-government and industry associations that act as advocacy groups in the different aspects of the energy industry in the country.

The Philippine National Oil Company (PNOC) and its subsidiaries embark on various activities for the promotion of cleaner energy sources, since the 1970s. The PNOC Energy Development Corporation (PNOC-EDC) is the country's major geothermal energy producer, and is also engaged in the development of other renewable energy technologies such as solar and wind energy. The PNOC Exploration Corporation (PNOC-EC) is the arm of PNOC that is mainly concerned with oil, gas and coal exploration. The PNOC Alternative Fuels Corporation (PNOC-AFC) is actively involved in the promotion and utilization of biofuels in the country.

The Energy Council of the Philippines (ECP) is the local chapter of the World Energy Council (WEC), which is mainly composed of the CEOs of the different privately-owned energy companies. The ECP provides a venue for discussion and consolidation of the industry position on vital issues, and initiates dialogue with key energy officials. Moreover, it hosts seminars, both national and international, and roundtable discussions on important issues. Furthermore, it links the local energy industry to the regional and global energy networks, such as the ASEAN Energy Business Forum.

Other NGOs concerned with renewable energy include:

- Energy Management Association of the Philippines (ENMAP)
- Renewable Energy Association of the Philippines (REAP)

- Klima-Manila Observatory
- Preferred Energy Investments, Inc. (PEI)

The Cagayan Electric Power and Light Company (CEPALCO), a privately-owned company, is one of the private institutions that are involved in renewable energy. It distributes energy in Mindanao and is undertaking renewable energy projects. It has established a hybrid solar and hydropower plant, with partial financing by the Global Environment Facility (GEF) and the International Finance Corporation (IFC). Similarly, the Northwind Power Development Corportation commissioned a 25 MW wind power project in Ilocos Norte. Moreover, companies like Trans-Asia Renewable Energy Corporation and San Carlos Wind Power Corporation are expected to develop additional sites for wind energy systems. Likewise, private companies, such as Senbel Fine Chemicals and Chemrez, are now involved in the development of cleaner fuel substitutes, particularly the production of biodiesel (coco-methyl ester). The privatization of the National Power Corporation's generating assets has led the private sector's participation in large-scale hydropower development. First Generation Holdings Corporation (FirstGen).

First Generation Holdings Corporation (FirstGen) has acquired the 112 MW Pantabangan-Masiway Power Complex auctioned off by the Power Sector Assets and Liabilities Management Corporation (PSALM) in September 2006. FirstGen also owns and operates the two (out of three) natural gas-fired power plants in the country, with a combined capacity of 1,600 MW. *Aboitiz Power Corporation* in consortium with Norway's SN Power has also won the bidding for the 360 MW Magat Hydroelectric Power Plant in Ramon, Isabela (PSALM, 2006). The Aboitiz Group is also the parent company of HEDCOR, which is the major developer and owner of the majority of the mini-hydro installations in the country.

Chapter
5

Leading research and development agencies on renewable energy

Because of the government's direction towards energy self-sufficiency and sustainability, several bodies were created to facilitate the promotion, utilization and development of renewable energy technology in the country.

5.1 Congressional commission on science and technology and engineering

The Congressional Commission on Science and Technology and Engineering (COMSTE) was created by the joint resolution of the Philippine Senate and House of Representatives to review and assess the state of competitiveness of the science and technology, and engineering research and development sector in the country (Congress of the Philippines, 2007). The Commission is made up of six (6) panels, namely:

- Agriculture and food
- Electronics and semiconductors
- Energy and Environment
- Health Sciences
- IT and IT enabled services
- Science, mathematic and engineering education

The Commission is mandated to undertake a national review and assessment taking into consideration the:

a. improvement of the system to implement the legislations on science and technology
b. provision of the system with essential financial and infrastructural support
c. strengthening of the linkages with all concerned sectors on science and technology

d. policies and strategies that will help the science and technology, and engineering R & D sector to attain its goals

The Energy and Environment Panel is the group of experts under the COMSTE that deals with the advancement of renewable energy in the Philippines and other activities in relation to energy and environment. It works very closely with the Department of Energy, the Department of Science and Technology (DOST), academic institutions and other agencies that are involved in the endeavors towards energy self-reliance and sustainable development. The panel is composed of six (6) members, including the Chairman, former DOE Secretary Dr. Francisco Viray, Dr. Alvin Culaba of De La Salle University, Dr. Antonio La Vina of Ateneo de Manila University, Mr. Freddie Puno from Team Energy, Mr. Jose Maria Zabaleta of Bronze Oak, and former Congressman Nereus Acosta.

The Energy and Environment Panel was granted a 100 million peso budget by the DOST in 2009. This budget is allocated for use to establish the Renewable Energy R&D Institute (RERDI). The goals of this institute is to jumpstart innovative and R&D activities for energy-related small and medium enterprises (SMEs), to stimulate market for energy and environment goods and services, and to promote public-private partnerships. Currently, the panel is identifying and organizing existing R&D activities and infrastructures related to renewable energy in order to better figure out how RERDI will be best set up, established and implemented. The Energy Development Utilization Foundation, Inc. (EDUFI) was one of the existing entities which the panel is looking into as a possible "jump-off" entity for RERDI.

5.2 Affiliated Renewable Energy Centers

Various organizations in the country were identified as Affiliated Renewable Energy Centers (ARECs), initially called Affiliated Non-conventional Energy Centers (ANECs). These are predominantly academic institutions who are involved in research and development projects and activities in the field of renewable energy. ARECs function as an extension arm of the Department of Energy – Renewable Energy Management Bureau (REMB), serving as a link to the rural areas for the promotion of the use of new and renewable energy technologies. The following is a list of the ARECs in the country:

- Mariano Marcos State University

- Don Mariano Marcos Memorial State University
- Isabela State University
- Bicol University
- Camarines Sur State Agricultural College
- Central Philippine University
- Central Mindanao University
- Cavite State University
- Western Philippines University
- Benguet State University
- Kalinga-Apayao State Colege
- Central Luzon State University
- University of San Carlos
- University Extension Program, Siliman University
- College of Agriculture, Xavier University
- University of Southeastern Philippines
- Sultan Kudarat Polytechnic State College
- Visayas State University
- University of Eastern Philippines
- Mindanao State University

5.3 The Renewable Energy Management Bureau

Initially, the national research and development programs and activities in the energy sector were handled by the Energy Research and Development Bureau (ERDB) of the Department of Energy (DOE). However, there was reorganization in the DOE in the year 1993, and the Energy Utilization Management Bureau was formed (EUMB), replacing the ERDB. Under the umbrella of this bureau are three main divisions: the Energy Efficiency and Conservation Division (EECD), the Alternative Fuels and Energy Technology Division (AFETD), and the Renewable Energy Management Division (REMD). With the signing of the Republic Act 9513, a Renewable Energy Management Bureau (REMB) was established under the DOE, thereby dissolving the existing REMD. This bureau is mandated to effectively implement the provisions of the

Renewable Energy Act of 2008 and it also manages the various R & D activities with regards to the field of renewable energy, together with the various ARECs in the country.

Chapter 6

Governance and resource issues in the Philippine energy R & D

Ensuring an energy secured and sustainable future requires a wide range of interventions including research and development (R and D) programs. Structures and key elements would have to be put in place to ensure the success of the research and development program including funding, technical expertise, infrastructure, responsive institutional set-up, venture capital and information access and exchange among others.

6.1 Resources

6.1.1 Human Resources

Energy research enjoyed strong support in the late 70's and early 80's in response to the oil crisis of 1973. The country then pursued a massive energy human resource and research facility upgrading program to search for alternative sources of energy. While efforts have continued to strengthen energy research in the country, they failed to sustain the program as other national concerns took precedent. Science and technology took a boost again in the early 90s with the implementation of the Engineering and Science Education Program (ESEP) which saw scholars sent for further studies locally and abroad. The program was successful in increasing R and D capability in the country as shown in the increase of R and D manpower from 1992 to 1996.

Table 6. Comparative number of total R & D personnel in the Philippines by sector

Sectors	1992	1996	2002
All Sectors	15.610	15,837	8,692
Government	6.065	6,591	3,054
Higher Education	6.929	8.030	4,096
Public HEIs	5,720	7.508	3.147
Private HEIs	1,209	522	949
Private Non-Profit	922	510	242

Source: Paper entitled: "Improving the Philippine Research and Development Statistical System"

It could be noted however that generally the number of researchers significantly dropped in 2002. This could be attributed to the migration of a big number of science and technology workers abroad. This is particularly true in public higher education institutions (HEI) where the R&D manpower decreased drastically in 2002 by 46 %. The figure also covered the transfer of people from public HEIs to private HEIs. The 45% increase in R and D manpower in private HEI from 1996 to 2002 has indicated that the sector were able to hold on to their people better than in the public sector where salaries and benefits are usually lower. Of those who stayed behind, a big portion however were assigned administrative positions immediately upon return from their studies and currently spend very minimal time on research. Nevertheless, the ESEP project have facilitated the establishment and strengthening of local engineering graduate programs, considered a key to strengthening the local science and technology capability.

Recently, the DOST launched the Engineering Research and Development for Technology (ERDT) program which made available a significant number of graduate scholarships to the country's research and development priority areas including energy. While the scholarship benefits are quite modest, the available slots are yet to be maximized. There might be a need to reorient undergraduate students to pursue research and development careers and view it as a viable option for the future. This could be obtained through the establishment of viable and progressive research institutes and programs locally.

In reference to the strategic technology development potentials discussed, an assessment of the energy R and D human resource development requirements and recommendations are as follows:

Energy Technology	Technical Human Resource Development Assessment
Oil and Gas	Concern is more on producing the technical manpower required by the industry rather than on R and D.
Coal Energy	Over the years, local fuel and combustion R and D people have dwindled due to retirement and migration. A new crop of fuel and combustion experts would have to be developed by sending a pool of researchers in foreign universities to pursue graduate research studies the characterization of local coal and evaluation of its appropriateness with modern coal combustion technologies. The DOE or DOST could consider funding this program.
Geothermal	Human resource requirement is more on site assessment, operation and maintenance rather than on R and D.

Wind	Localization of high performance and low cost small wind energy systems requires high level expertise in materials engineering, fluid mechanics and power electronics. While expertise in these areas exists locally, the number is small. They have to be identified and pooled together to work on the project.
Solar PV	While there is enough fundamental expertise (power electronics, instrumentation, physics, etc.) to support Balance of System (BOS) R and D work, the number of people actually working on these programs is very few. It is thus recommended that ERDT develop and implement a long term and coordinated program on the localization of Solar PV system components (charge controllers, inverters, net meters, etc.) and development of innovative control systems.
Solar Thermal	As mentioned earlier, major barriers of the wide spread adoption of solar thermal applications (solar water heaters, solar thermal driers, etc.) include the lack of solar thermal design engineers, high initial cost and limited industry knowledge on the potential benefits and application of the technology. It is thus recommended that a pool of researchers from the academe and engineers from the industry be identified and trained by DOST on solar thermal system design.
Solar Cooling	Solar cooling and dehumidification research requires high level of expertise. While the country has very minimal capability and almost nil effort on this area, the potential benefits of the technology is very high that it would be worth pursuing. It is thus recommended that ERDT develop and implement a long term and coordinated program on the localization of solar cooling technologies in cooperation with leading institutes and organizations outside the country (ex. Hong Kong University, etc.).
Hydro-energy	Expertise to purse localization of off-the shelves pico-hydro systems exist. Accelerating the adoption of micro-hydro systems on the other hand requires the training of more engineers and institutions on micro-hydro system design, fabrication and construction. Training could be facilitated by local lead institutions such as DLSU and DOST.
Ocean	Local expertise on Ocean energy research is non-existent. As mentioned earlier, though still in the infancy stage, this area provides a lot of potential benefits for the country. While not formally starting an independent research program on Ocean energy, the country could start building up expertise by sending local researchers abroad for graduate studies and research.

Biomass Combustion and Gasification	While the number of fuels and combustion experts have dwindled in the past years, there are still a number of experts and institutions proactively pursuing biomass combustion and gasification research particularly ITDI – DOST and UPLB. Efforts of these two institutions however won't be enough to accelerate the adoption and popularize biomass combustion and gasification applications. It is thus recommended that a pool of researchers from the academe and engineers from the industry be identified and trained by these institutions on these technology areas.
Biogas	As discussed earlier, biogas technology is a mature technology and needs very minimal research. The technology could be popularized by training more technologists and institutions that could assist interested parties design and set-up biogas systems. The trainings could be spearheaded by UPLB, CLSU and DOST.
Energy Efficiency	Efforts on energy efficiency system have mostly been limited to the adoption of existing technologies and very rarely involve the development of new strategies and devices. The fundamental expertise to pursue localization of and development of new energy efficiency devices are present locally but is rarely tapped due to the absence of a structured and deliberate effort. It is thus recommended that ERDT develop and implement a long term and coordinated program on the localization of and development of new energy efficiency devices. Expertise on passive energy systems development and adoption on the other hand is quite limited and needs to be beefed up by sending a pool of researchers from the academe and engineers/architects from the industry to pursue graduate level study on these areas with special focus on tropical climates. Energy efficiency auditing plays a critical role in improving energy use performance. While expertise exist, the number of energy efficiency experts and auditors are not enough to support the needs of the industry. The energy efficiency audit training programs of DOE should be further popularized and accelerated. In addition, Universities should consider offering a Masters in Engineering Program (applied and non-thesis) with specialization on energy efficiency.
Vehicle Technology Development	The adoption and development of modern technologies to public utility vehicles could be best pursued through the implementation of a structure and coordinated ERDT program on this area.
Bio-fuels Development	The country has the expertise to pursue Bio-diesel conversion and testing research. There is already a network of government agencies (DOST, DOE, DTI, DA) and academic

institutions engaged in coordinated research on jatropha biodiesel.

While the country is fairly strong in biotechnology, limited local efforts have focused on the development of cellulosic ethanol technologies. Expertise on this area could be best obtained through research partnerships between DOST and UPLB, being lead biotech institution locally, and institutions leading these research programs in the US and Brazil.

Nuclear Engineering	The expertise gained by the country on nuclear engineering in preparation for the operation of the Bataan Nuclear Power Plant has now dwindled if not non-existent. This could be traced to retirement and migration. While the country is not pursuing nuclear energy as a research area, considering the potential application of nuclear engineering, it is highly advisable to start building up again this expertise by sending local researchers for graduate research and studies abroad particularly in Japan.

6.1.2 Funding

The energy R and D of the country share have been considered very minimal. DOST data (DOST R&D survey, 2002) indicate that only 1.29% of the country's R and D expenditure or 22.93 million pesos in 2002 went to energy related studies. The government accounted for the 20.89 million while the rest were supported by the academe. The study was not able to cover industry energy R and D efforts. The figure is dwarfed by the 4.8 and 3 billion USD 1995 energy R and D spending of Japan and the United States respectively (Mangilis and Kammen, 2000).

Support mechanisms have put in place to strengthen local research and development such as the Grant-In-Aid (GIA) of DOST. GIA applications received however have generally been few including those in energy related programs. This indicates lack of research and development people in the country. In addition, the whole technological development framework would have to be reviewed. Technological innovation is normally pursued through a number of stages and industry cooperation usually comes only in the Development stage where the risk is low enough for them. It could be noted that GIA research proposals requires industry partnerships which means that earlier stages (Idea Generation and initial experimentations, Concept Definition, Market Analysis, Technical Analysis and Business Planning) would have to be mostly shouldered by the proponent.

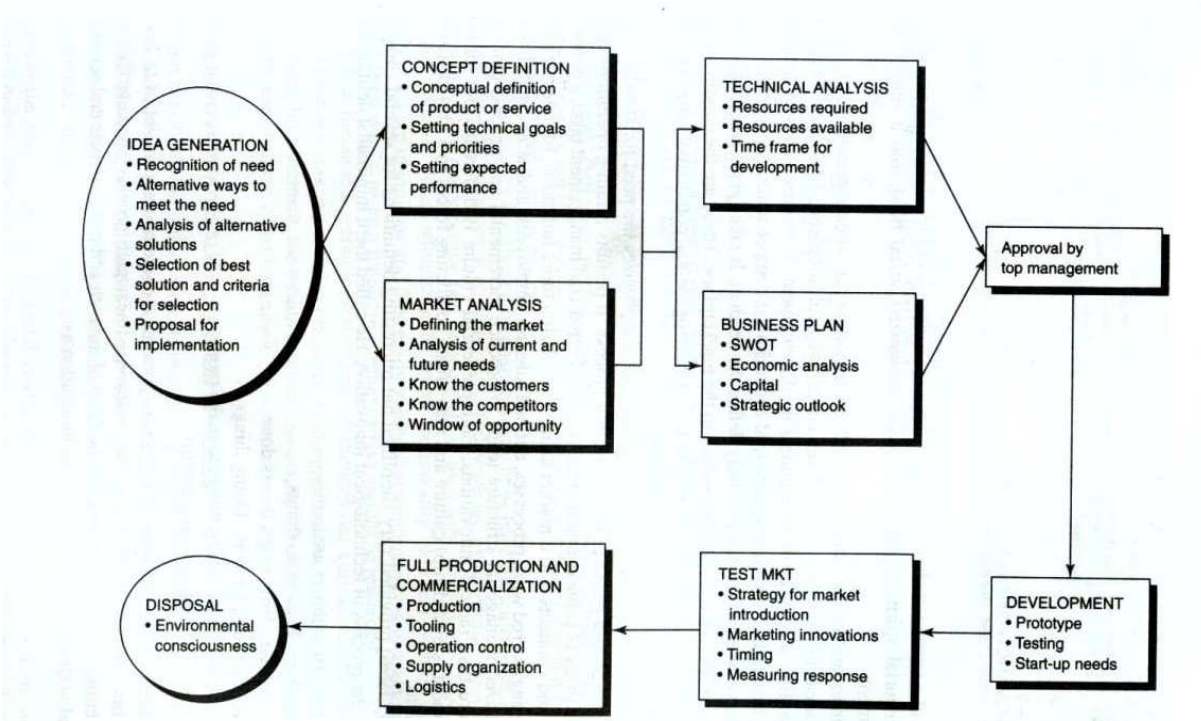


Figure 12. Technology innovation process (Ettlie, 2000)

Unfortunately, most individuals, academic and research institutions have very minimal financial capacity to work on these components. Idea generation requires seamless access to scientific information and constant networking with the scientific community. Very few institutions have access to scientific journals and regularly fund attendance and presentations to international conferences, and foreign research visits. In addition, the DOST study on Industry-Academe linkage indicated that industry is unlikely to support financially basic and developmental research (Tansinsin, 2006). The industries in the Philippines apparently look at research and development as an expense and not as an investment or insurance that may result to bountiful benefits in the future. The same study indicated that the industry research involvement is mostly limited to equipment donation or usage. The industry mostly view the academic sector as training centers to provide their manpower needs and seldom as research institutions that they could tap to address their technology develop needs. It would take a lot effort to turn around this industry perception. It could thus be expected that the government and the institutions would have to take the initial bulk of R and D funding requirements to demonstrate capability and potentials academic and local research institutions until industry trust is established. While the support for basic research should be provided, it should only be limited on a number of areas with very high local resource and application potential preferably through an international collaboration program.

The Commission on Higher Education (CHED) has also been active in strengthening research in the academe sector. Centers of Excellence (COEs) and Centers of Development (CODs) were identified to spearhead research in higher education. The COEs are units in the universities that have the qualified manpower, facilities, infrastructure and other requirements to undertake research and development and received a P 9 million support per year for 3 years. CODs on the other hand received P 3 million per year for 3 years. The latest assessment of the program indicated that it have generally improved instruction in all the recipient institutions in terms of teaching facility, equipment and reference material enhancements, curriculum development and innovations and board exam performance improvements (Magpantay, 2007). Generally, it also improved research activities in recipient institutions as measured by research publication production, research programs initiated and improvements in research facilities. Despite these improvements, so much effort and support however would be required to lift up research programs in local universities to international norms.

Foreign grants for cooperative, joint projects and other modes of research arrangements are also available provided the project proposal is in line with the priority area of the funding foreign country. One program that has benefited from this scheme is the Center for Micro-Hydro Technology for Rural Electrification (CeMTRE) of De La Salle University-Manila. The current global crisis however is expected to make foreign grant sourcing more competitive such that support would have to be extended to institutions during grant proposal development. Support could be in the form of technical assistance and / or funding to cover networking and manpower cost during proposal development.

Considering the pressing socio-economic concerns of the country, R and D funding would have to be efficiently utilized and directed to strategic areas that could provide the maximum benefits. Technological maturity and energy inertia would have to be considered in the identification of these areas. The country should deliberately pursue research on energy technologies nearing or has reached commercial maturity for higher R and D cost efficiency. The government however should refrain from providing grants to mass demonstration and adoption of commercially mature renewable energy technologies as this could compete with the private sector. The end-user should be made aware of, recognize, accept and bear the true cost of the technology to stimulate commercialization. Funding in such cases should instead be channeled to training and research to further improve and reduce the cost of the technology.

The high up front cost and uncertainty on the benefits and reliability of renewable energy and energy efficiency systems prevents its wide scale adoption by the industry. It is recommended that a "Build, Operate and Transfer (BOT) Fund" be set-up to provide soft loans to the local RE and energy efficiency industry in implementing BOT schemes. The fund will be made available until industry confidence on the technology increased and up-front cost decreased to attractive levels.

6.1.3 Infrastructures

To have a responsive and effective energy research and development program, the following infrastructures would have to be ensured:

- Availability of functional and well equipped research facilities
- Availability of energy related data gathering facilities and database (ex. climatic data, resource, etc.)
- Access to scientific information

Availability of local experimental facilities and equipment is a major concern. Basic fuel testing procedures such as ultimate analysis would have to be done elsewhere due to the absence of functional testing equipment. It is encouraging to note that increased realization of the importance of test and experimental facilities have exhibited with the establishment recently of the vehicle research and testing laboratory (VRTL) at the University of the Philippines. It is being recommended that lead universities and institutions be identified in the various strategic energy research areas where state of the art and complete research equipments will be stationed. Deterioration and decreased reliability of instruments due to high maintenance and calibration cost has always traditionally been a major issue. Interventions should thus be put in place to safeguard the facility from this concern. These facilities should be maximized by providing researchers from other agencies and institutions equal and affordable access to them.

Availability of reliable, complete and conveniently accessible climatic, geographical, energy resource and energy system statistical databases has always been an issue in the country. High resolution and complete solar insolation, wind velocities, ambient air temperature and humidity level data for example are non-existent due to non-functional data gathering stations and equipments. Historical databases are also mostly not digitized and not accessible through the web. The same is true for accurate and complete vehicle type and age data which are very important inputs in transport planning and simulation. It is thus recommended that a review and modernization of the climatic, geographical, energy resource and energy system statistics data gathering, storage and dissemination system be implemented.

One of reasons behind the seemingly lack of innovative ideas and poor energy research proposals from the scientific community is the lack of access to up to date scientific information and poor linkage with the international community. It is thus being proposed that a scientific information highway to be stationed either in the National Library or NERI be established to provide local researchers seamless access to top rated scientific journals. It is also recommended that a Scientific Linkage Fund be set-up by the government to be made available to the local scientific community by application to fund presentation in international conferences and meetings with their counterpart institutions abroad.

6.2 Governance

6.2.1 Institutional Analysis

A number of universities are doing significant work on specific areas. De La Salle University, for example, has been particularly known for its micro-hydro technology development program and energy and environment modeling work. University of the Philippines-Diliman and University of the Philippines-Los Banos are strong on biomass combustion and gasification and biomass feedstock agronomic research. The Technical University of the Philippines has been working on bio-fuels extraction technologies while the National Center for Transportation Studies is known for their transport policy development capability. A number of the Department of Energy (DOE) supported university based Affiliated Non Conventional Energy Centers (ANEC) have engaged in energy research such as the wind energy research program of the Central Philippine University. DOST, DOE and the Department of Agriculture (DA) have also run a number of research programs. The Renewable Energy Association of the Philippines (REAP) on the other hand has spearheaded renewable energy research in the private sector.

While energy research initiatives exist, they lack proper coordination greatly limiting their impacts. The country is yet to establish energy research institutes and laboratories similar to the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory (ANL) of the United States which could act as focal centers for specific technologies. The core activities of such centers include energy planning and research, energy efficiency and technological research, development and demonstration. In addition, they also function as a one-stop entity for linkages and energy data bank for the universities, research institutions, industries and other national and international institutions. These centers could play a key role in accelerating energy technology development and diffusion in the country.

It is recommended that a National Energy Research Institute (NERI) is established to manage energy research in the country with National Energy Research Laboratories (NERL) for specific technologies stationed in lead universities. Selection will be based on track records (e.g. projects, papers published, patents, etc.) and personnel profile. In this age of rapid technology development, technology cycles have become very short such that technology development would have to be continuous. Annual funding should thus be allotted to NERLs to sustain long term research programs. They will be also equipped with research facilities which will also be made available to researchers from the private sector and other universities. It shall also open adjunct research positions to sustain its programs and shall closely work with local and international research institutions.

6.2.2 Technology Commercialization Program

Technology development efforts will always remain missionary unless successfully commercialized. They should be anchored on the derivation of clear economic benefits to continue supporting itself (human resource, equipments, research funds, etc.). Though, initially, the programs would have to rely on grant and government funding, mechanisms should be put in place to attract venture capitalist to support their commercialization and further development.

The government has established several programs to support the commercialization of research outputs. DOST established the "Inventors Fund" under its Technology Assistance and Promotion Institute in 1992. The purpose of this fund is to grant incentives and financial assistance to the inventors provided a project proposal is submitted. The Development Bank of the Philippines (DBP) also has a window to support the commercialization of mature technologies including venture capital for projects that are viable. The then National Science Development Board (NSDB), now the Department of Science and Technology (DOST) worked out with the Development Bank of the Philippines an Inventors Guarantee Loan wherein NSDB has to guarantee up to 85% of the loan. This loan fund program is still open for use by the inventor. A number of inventors took advantage of the funding window while none from the academe did.

Venture Financing Program was also established by some private group with the objective to assist and accelerate the commercialization of new technologies by providing the necessary funding support for start-up projects. Private inventors however were more inclined to avail of government resources rather than tap these programs.

A new program of the Department of Science and Technology that was initiated in February 2003 is known as Technology Incubation for Commercialization (TECHNICOM). The initiative was designed as a technology transfer program that seeks to identify key technological breakthroughs that have excellent commercial potential. The program follows the principle of *laboratory to shelf* approach in providing support for the commercialization of research output and innovations. Jointly, the university researcher and the industry adopting the technology can request for financial grant from the DOST. It may also extend assistance in protecting and processing the intellectual property rights of the technology.

The academe, general, has not maximized these programs. This could be partly attributed to a number of factors including:

- Most research activities in the universities are viewed as academic exercises rather than a "wealth creation" endeavor;
- Lack of awareness of priority market and technology needs;
- Lack of information about the available commercialization assistance programs; and
- Lack of technology commercialization experts that could facilitate the process.

Unlike in other countries, industry has not tapped universities to provide their product development and other R and D needs. This has mostly been due to the lack of awareness of the said service that universities could offer and, in some cases, due to lack of trust and confidence. It could be noted also that most government R and D support funding comes only in the later stages of technology development efforts. Significant support however is needed in the early stages of the endeavor where the risk is high and where industries are usually reluctant to support. Most industry involvement in the early stages of the innovation process will be limited to needs identification and some technical assistance but would rarely cover funding.

The following are proposed to address these issues:

- Revise the university research program evaluation indicators to give importance to the number of products developed and have been successfully commercialized and the number of technology business incubated. To a higher level, this indicator could include " degree of contribution to economy" as introduced by Tamai and Nishimura (2004);
- Provide government support programs in the early stages of the innovation process;
- Provide fiscal incentives for industry to tap and support R and D services of universities to facilitate greater collaboration;
- Benchmark models and strategies adopted by other universities that have successfully facilitated industry R and D collaboration such as those at Graz University of Technology (Admetz and Hofe, 2004) and University of Tokyo (Tamai and Nishimura).
- Provide scholarship programs to university staff to pursue further studies and training on R and D commercialization and management.

6.2.3 Cooperative Work and Technology Acquisition

Considering the longer life cycle of energy and transport systems, energy research programs should continuously seek and adapt strategies to cut-down technology development cost and time. Cooperative work and technology acquisition should be viewed as a strategic tool and should be deliberately pursued whenever possible. No data however is available summarizing energy research cooperative work in the country. Joint programs should be pursued particularly with other ASEAN neighbors on areas of common interest. The country could also play active roles in research work on emerging energy technologies under the international collaboration program of the International Energy Agency and other similar institutions (Polaski and Melo, 2006). Cooperative work should not only be limited to foreign research institutions but among local institutions (academic, government agency, private sector) as well. Foreign researchers and experts may also be hired to train and assist local researchers on certain projects. Whenever applicable, foreign technology products maybe re-engineered to facilitate adaptation of the technologies locally. Based on the strategic directions, the following technology specific cooperative and technology acquisition programs are recommended:

Energy Technology	Recommended Cooperative and Technology Acquisition Strategy
Coal Energy	With the abundance of coal reserves in South East Asia, most of our Asian neighbors have also focused their research efforts on clean coal technology (Balce et al., 2000). Whenever applicable, cooperative research programs on clean coal technologies with these countries are expected to be beneficial. Experts from the clean coal research program of the International Energy Agency (IEA) and the Massachusetts Institute of Technology (MIT) may be commissioned to work with local researchers on advance projects. Multi-stakeholder involvement is required to ensure that the proper issues are addressed and findings and technologies developed are adopted by the industry. Specifically, PNOC, DOE, DOST, academe and private power producers should be involved.
Solar PV	The localization of solar PV BOS components would be greatly facilitated in partnership with power electronic companies stationed locally, such as ASTEC Custom Power, that help maintain R and D centers in the country, and Sunpower Phils. Inc. Acquisition of available components in the market for re-engineering purposes will also accelerate the effort.
Solar Thermal	A number of local institutions (UPD, UPLB, etc.) maintain strong linkage with their foreign counterparts (AIT, etc.) in the area of solar thermal technology. Collaboration with the hotel and food industry on the other hand will facilitate the adoption of technologies developed.
Solar Cooling	Hong Kong University and LIMSI-CNRS of France are lead institutions in Solar Cooling research. Collaboration with these institutions should be strongly considered. A number of commercially available solar cooling systems also exist and could be acquired for re-engineering purposes.
Wind	The development of small wind power locally will be best accelerated with the purchase and re-engineering of similar systems from Germany and China.
Hydro-energy	The purchase and re-engineering of Vietnamese and Chinese systems would accelerate the development of off the shelves pico-hydro systems in the country.
Ocean	As mentioned earlier, the country is not advised to start an independent research program on ocean energy due to its limited resources and the level of maturity of the technology. It could however take an active part in international research

cooperations such as the Ocean Energy Systems Cooperation Project of the International Energy Agency (Polaski and Melo, 2006). This would provide the country up to date information on the development and status of the technology and contribute in the development of expertise required should the country finally decide to pursue deliberate ocean energy system development programs.

Biomass Combustion and Gasification

Several of local institutions (UPD, UPLB, etc.) maintain strong linkage with their foreign counterparts (AIT, etc.) in the area of biomass combustion and gasification. Acquisition of available systems in the international market for re-engineering purposes will accelerate local R and D efforts.

Energy Efficiency

Considering climatic similarity, the development and adoption of passive energy efficiency strategies (obtained without the use of devices and are usually integrated in the design of the structure) in buildings could be best facilitated in partnership with other South East Asian Countries. Strong cooperation with the Philippine Green Building Council (www.philgbc.org) and the United Architects of the Philippines (www.united-architects.org) would greatly facilitate identification of research needs and potential strategies and accelerate market adoption of the technologies/strategies developed.

The localization of the energy efficiency devices could be aided with the purchase and re-engineering of imported systems.

Vehicle Technology Development

The development and adoption of modern vehicle technologies to public utility vehicles will be accelerated by the partnerships with other lead universities abroad. Some of these institutions are the Engines and Energy Laboratory of the Colorado State University, Internal Combustion Engine and Thermodynamics Institute of the Graz University of Technology, Queen’s University of Belfast, Hybrid Electric Vehicle Center of the University of California and a number of Japanese universities.

Bio-fuels Development

A number of countries in Asia are also pursuing Jatropha bio-diesel conversion research. Joint research work with relevant institutions in these countries would accelerate realization of outputs. As mentioned earlier, partnership with Ethanol research institutions in Brazil and United States would greatly help.

Nuclear Engineering

The state of nuclear energy technology is major factor in the decision whether the country adopts it or not in the future. The country thus should be always updated with the accurate information and developments in this area. As mentioned earlier, it could partner with Japanese institutions in the development of local human resource on nuclear engineering and take part in international cooperations focused on assessing nuclear energy status, benefits and risk.

Chapter 7

Barriers to the implementation of renewable energy technologies

The Philippine government has long been interested in the utilization and development of renewable energy, with the DOE as the leading agency in the promotion of the various programs and projects on RETs. Although there are a lot of efforts being done, there are still some concerns that need to be addressed. Some of the barriers to the implementation and utilization of renewable energy are:

- Institutional barriers
- Technical barriers
- Financial barriers
- Market barriers
- Information and training barriers
- Social barriers

7.1 Institutional barriers

Recognizing the need for energy self-reliance and sustainability, the Philippine government has initiated programs and enacted laws to promote the utilization and development of renewable energy. Among these are Republic Act No. 7156, which involves programs on the promotion of hydropower energy systems, Presidential Decree No. 1442, which promotes the exploration and development of geothermal resources, and the Executive Order Nos. 462 and 232, which promote the advancement of biomass, ocean, solar and wind energy technologies and systems.

To provide a universal policy framework on the campaign towards the development, utilization and commercialization of renewable energy sources, the Republic Act No. 9513, also known as the Renewable Energy Act of 2008, was enacted by the Senate and the House of Representatives of the Philippines in December 2008. With this law, it is expected that there will be an advance in the growth of the renewable energy industry, breaking one of the hindrances of RE in the country. But even with the passing of the Act, it is still imperative that there is proper implementation of the law for the RE industry to flourish.

In essence, our government already has suitable legislations concerning renewable energy in the Philippines. However, there are some factors that hinder the progress of the various RE programs. One of these is the inadequate coordination among agencies and institutions in the field of renewable energy. Currently, a lot of institutions are doing RE research and development but there is no centralized entity that handles these activities concerning RE. There is insufficient knowledge sharing and coordination among these institutions, causing a lack of a holistic outlook on the current status of RE in the country and overlapping of functions in the different RE agencies, both public and private. Another concern is the lengthy and difficult process in acquiring permits and certification that allows RE developers to carry on their projects, which may also be attributed to the lack of a focal entity that will serve as a one-stop-shop for RE developers. In addition, the reality in developing countries such as the Philippines is that the programs endorsed by the government greatly depend on the national budget.

7.2 Technical barriers

Another difficulty in the development of renewable energy in the Philippines is the lack of local technical expertise in the field of RE. We have limited technical capacity to design, install, operate, manage and maintain RE-based systems that may be implemented in the country. Acknowledging this deficiency, there should be a thrust for more research studies and collaborations with foreign experts and agencies to improve our knowledge on these new and renewable energy technologies. For instance, we can partner with Brazil for the development of the bioethanol industry in the county. We familiarize with the existing technologies that they have and gain information on how these are operated. Another technical barrier is the site-specific nature of RE resources. This requires a detailed analysis of specific local conditions that should be considered in adopting foreign RE technologies. With the acquisition of more data on RETs and the knowledge of the local settings, then we can modify and adjust these technologies to suit our needs and purpose. Yet another factor is the lack of domestic manufacturing of RETs, because most of these technologies are still produced in other countries. Moreover, there is a lack of standards for the different renewable energy areas that are being explored in the country.

7.3 Financial barriers

In any endeavor, there are always financial difficulties that arise, and the implementation of renewable energy projects is no exception. One of the main finance issues in RE is the high initial capital costs of RE products, thus hindering the promotion and utilization of RETs especially in the rural areas of the country where lack of funds exist. Another is the higher perceived risks in RETs. Because of the lack of technical knowledge on the implementation of RE, venturing into renewable energy projects are considered very uncertain, whether they are economically practicable or not. This causes investors to be very careful in financing RE activities in the Philippines. This lack of knowledge in RETs also extends to the financial institutions, which may provide loans to RE developers, and the inadequacy of appropriate funding poses a hindrance to RE promotion and utilization. To address this concern, different financial support mechanisms should be implemented and made available for RE project developers to assist in the development of RETs. Moreover, the existence of these financial support systems should also be made known to potential RE project developers that may have interest in engaging in activities that promote RE use in the country.

7.4 Market barriers

Another hindrance to RE development in the Philippines is the limited knowledge of the potential RE market and the non-availability of up-to-date and comprehensive RE data. Project developers who wish to venture into business in RE do not have enough information that can aid them in the assessment of potential RE enterprise, thus holding back the growth of the RE industry. In addition, market distortions exist by way of subsidies or grant-based installation programs, and there is limited allocation for RET subsidies. Moreover, the high upfront costs of RETs and the absence of dedicated financing for RETs also add to the delay in the promotion of renewable energy in the market.

7.5 Information and training barriers

The unavailability of current facts and figures on RE in the country is a key factor that impedes the promotion of RETs. There is inadequate information on RE potential, technical and economic information on RETs, equipment suppliers and potential financiers. A thorough collection of up-to-date information is imperative to establish a comprehensive database that may be used by stakeholders such as potential investors, project developers and policy makers.

Moreover, there is a lack of awareness about renewable energy in various sectors of our society (e.g. the public, the industry, financial institutions, etc.). The public does not have enough understanding on the long-term benefits of RETs, particularly the life-cycle costs and environmental trade-offs of such technologies. Information and education campaigns must be implemented to raise appreciation and recognition of the potential these RE systems have in achieving national energy security.

In addition, training programs regarding the installation of RE technologies must also be implemented to aid in the promotion and utilization of RE systems. This addresses the capacity building needs of the different stakeholders and thus promotes the commercialization of RETs.

7.6 Human resource barriers

A further barrier to the advance of renewable energy systems in the country is the inadequate human resource in the field of renewable energy. There is limited number of experts who are knowledgeable in various aspects of the RE industry. One of these aspects is in business management and marketing skills with respect to RETs, which may also be considered as market barriers in RE promotion. There is also a lack of expertise and services in system design, installation and maintenance of these new and renewable energy systems. Moreover, because of the lack of human resource, there is limited capacity for RE data collection and analysis that is needed for RE project development.

Therefore, there is a need for capacity building in the different sectors concerned in the field of renewable energy. Training programs should be done to increase the number of persons who may work on the equipment and machinery involved in these RETs. In addition, linkages with countries and institutions that are well-learned in RE systems should be made and maintained. This will allow for knowledge sharing and transfer of technologies to be realized and thus thrust the development of renewable energy utilization in the country.

7.7 Social barriers

The Republic Act No. 8371, or the Indigenous Peoples Rights Act of 1997, promotes, protects and recognizes the rights of cultural communities and indigenous peoples to their domains to ensure their economic, social and cultural well being. It also recognizes the applicability of customary laws governing property rights or relations in determining the ownership and extent of ancestral domains. The enactment of this law poses a significant barrier to the access of potential locations that may be explored for RE applications.

In addition, local conflict situations may exist that make some areas unsafe, especially in the rugged mountainous countryside and very remote locations in the rural regions. This may also pose as a hindrance to the implementation of RE programs in potential areas in the country.

Chapter 8

Renewable energy development priority programs

The Energy and Environment Panel of the COMSTE has identified certain areas in renewable energy that needs priority attention. These fields are the ones that are very much promising, especially in terms of applicability to local settings and potential contribution to the energy security of the country.

8.1 Biofuel energy systems

Interest in renewable energy and alternative fuels started since the late 1970s, as a response to the oil crisis and the need for the security of energy supply during that time (Poulton, 1994). Initially, the government's interest was mainly on alcogas, a mixture of alcohol and gasoline, which would have been used primarily in the transportation sector, but alcohol became more expensive than pure gasoline. Thus, projects on alcogas then were not realized and interest in unconventional fuels slowly diminished. However, in the 1980s, there was a renewed interest in coco methyl ester (CME) or coconut biodiesel. Since then, various studies about the utilization of CME as diesel substitute have been conducted. Moreover, numerous CME initiatives in the government, particularly in the agriculture and energy departments, have been promoted to help alleviate our dependency on foreign fuel resources.

Biofuel energy systems have numerous advantages. The main sectors that benefit from biofuel utilization are the transport and agriculture sector. Studies show that biofuels are at par with the conventional diesel and gasoline currently being used in the market. Also, engine modification is not necessary in the consumption of biofuels up to a certain percentage by volume. Moreover, the development of the biofuel industry creates a new market for the indigenous materials available in the country. This would provide a sustainable domestic market, particularly for coconut oil and sugar, which ultimately contributes to the national economic growth. The advance in the biofuel industry also means additional employment opportunities for growers and producers. According to the DOE, this translates to an additional 3.5 million jobs for coconut farmers and 87,000 jobs for sugar planters and manufacturers. Moreover, biofuels have a considerable environmentally friendly potential due to a very low net release of carbon dioxide (CO_2), a greenhouse gas that contributes to climate change, and near zero sulfur content, which contributes to acidification of water resources. Furthermore, it is a renewable resource that could be sustainably developed in the future, thus preserving the capability of the future generations to meet their needs.

With the signing of the Biofuels Act of 2006, there was a thrust to develop and do further research on the potential local biofuel feedstock. One such indigenous raw material considered by the Philippine government is *Jatropha curcas*, locally known as "tuba-tuba" or "tubang bakod." An integrated R & D program on *Jatropha curcas* for biodiesel is being implemented, which includes the following components (Villancio, 200_):

- Germplasm management, varietal improvement and seed technology research and development
- Development of GIS-aided suitability assessment for commercial production of *Jatropha curcas*.
- Development of component technologies in various production systems
- Development of farming systems models
- Development of post-production management systems
- Process and Equipment Development for the Production of Esterified *Jatropha curcas* oil
- Biofuel research and enterprise development in 17 state universities and colleges (SUCs)

Another raw material being considered is sweet sorghum, which is a potential source of bioethanol. Similar to the program on jatropha, project components of the research and development of sweet sorghum for bioethanol include:

- Germplasm collecting, characterization and conservation, varietal improvement and seed system
- Development/Adaptation of appropriate production technologies
- Development of downstream processing and equipment
- Capacity building of research personnel and target clients for sustained ethanol production and utilization

Furthermore, the use of biofuels has been mandated by RA 9367. At present, various liquid fuels used for transportation already has biofuel blends, a minimum of 1 percent biodiesel (B1) for diesel and 5 percent bioethanol (E5) for gasoline. Currently, locally produced coco-biodiesel is being used as diesel blend. On the other hand, imported ethanol is being used for gasoline blend since there is no bioethanol produced locally that can supply the large demand of transport sector.

8.2 Solar energy systems

With an increasing demand for renewable energy, the use of solar energy is considered as a potential substitute to petroleum-based sources for a range of energy applications. Research and development activities on solar energy focuses on three main applications: solar photovoltaics, solar thermal and solar cooling. In particular, the government is eyeing the use of solar energy for the electrification of rural communities, particularly in the setting up of off-grid power systems.

A significant project in solar energy in the Philippines is the country's first on-grid solar PV installation is the 1 MW plant using 6,500 polycrystalline silicon solar panels on a 2-hectare area, connected to the distribution network of Cagayan Electric Power and Light Co., Inc. (CEPALCO) and is hybridized with a hydropower plant. Gaining from the experience, CEPALCO intends to expand its operations from its current production of 1,261.40 MWh to a larger solar park with a 10 MW plant on a 30 hectare lot, which is expected to be commissioned by 2012 (DOE, 2009).

Another milestone in solar energy development in the Philippines is the installation of the first solar cell fabrication plant in Southeast Asia. Sunpower Philippines operates two facilities that manufacture high-efficiency PV cells. One is located in Sta. Rosa, Laguna and the other in Batangas, with a capacity of 110 MW and 400 MW, respectively. Currently, these high-efficiendy PV cells produced are exported to other countries.

Another achievement in solar energy technology in the country is the Philippines' first solar-powered car called *Sinag*, designed and built by students from the De La Salle University in Manila. It utilized back-contact monocrystalline solar cells produced by Sunpower Philippines. It was the country's first entry in the 3,000 km race in the World Solar Challenge held in Australia. It finished 11th among the 40 solar car entries from other countries.

Figure 13. Sinag – Philippines' first solar car

Aside from these, there are still a range of applications that are market opportunities for solar energy systems, such as solar water heating for hotels and hospitals, and solar drying of fruits and other local materials. Indeed, solar energy has a great potential and further research should be done in order to exploit this sustainable energy source.

8.3 Small-scale wind energy systems

Wind power in the country is gaining interest from investors due to its large potential for energy systems. Various large-scale wind systems are already in line to be installed and various programs on these RETs are being implemented for its promotion and utilization.

Wind energy systems are relatively mature technologies. These have long been commercialized in other countries, especially the large-scale systems. Small-scale energy systems are also produced on a business level; however, due to its high initial costs, these are not as popular as their large-scale counterparts. But a great potential can be seen in the utilization of these RETs and these are expected to gain acceptance in the local market in the future. Development efforts should be made especially in the modification of the blade profiles to suit local wind conditions. Research on the production system utilizing locally available materials, fabrication equipments and control systems should also be done. With these efforts, initial and operations costs of these RETs are expected to decrease, thus promoting the adoption of wind energy in the country.

Aside from the power generating application of wind energy systems, other applications being considered are wind power for domestic water, irrigation, and hybrid wind and solar systems for the telecommunications industry.

8.4 Hydroelectric energy systems

According to the DOE, more than 10 percent of the country's electricity requirements, and there has been an increase in the utilization of hydropower in the past years. Due of the interest shown by the private sector, it is expected that more hydroelectric energy systems will be used in the years to come. Because of its great contribution to the country's power generation mix, the development of our hydropower resources is considered essential to supply the energy demand over the next decade.

At present, there are numerous hydropower projects that were given reconnaissance permits by the DOE and there are about a hundred more applicants of pre-development service contracts. Most of the projects given reconnaissance permits are still in the pre-development stage (i.e. conduct of feasibility studies), while some 6 hydropower projects have already been issued with an operating contract.

8.5 Energy efficient technologies and systems

It is a declared policy of the government to promote the conservation and efficient utilization of energy resources through adoption of the cost-effective options toward the efficient use of energy to minimize environmental impact. Thus, energy efficiency and conservation (EE & C) programs are being implemented by the DOE. These programs include the following:

- Use of compressed natural gas (CNG) for transport buses
- Use of biofuels as mandatory blends
- Expansion of the scope of energy labeling
- Shift to energy efficient lighting in residential, commercial and industrial establishments

It is the goal of the Philippine government to make energy efficiency and conservation a way of life. Thus the information, education and communication (IEC) campaign called the "EC Way of Life" was launched. This program aims to cushion the impact of the rising energy prices, reduce expenditures on fuel and electricity without sacrificing productivity, and contribute to the protection of the environment. In addition, various infomercials and publications were created to increase the public awareness on energy efficiency and conservation. Moreover, agreements were made with some private companies to voluntary monitor their energy consumption and implement EE & C programs. Participating companies in the Partnership for Energy Responsive Companies (PERC) and the Partnership for Energy Responsive Economic Zones (PEREZ) include:

- DOLE Philippines Inc.
- Passi Iloilo Sugar Central Inc.
- Richmonde Hotel
- Manila Galleria Suites
- Corinthian Plaza Condominium
- Makati Prince Tower Condominium Corp.
- Microtel Inn & Suites
- SHI Mfg. & Services Philippines
- Integrated Device Technology
- Toshiba Information Eqpt. Phils. Inc.
- Pentax Luzon Philippines Inc.
- Hello Snack Foods Corp.

8.6 Ocean energy systems

The oceans are considered one of the best potential sources of renewable energy, especially for the Philippines, with its archipelagic nature. Our country is surrounded by waters which can provide excellent conditions for ocean thermal energy conversion (OTEC) systems. However, these technologies are not yet competitive relative to conventional energy systems. Nevertheless, it is noteworthy to regard ocean energy systems as a cleaner energy alternative source for the country. The DOE working with Japanese scientists has identified 16 potential sites that could be suitable for the development of OTEC systems. Moreover, a US-based ocean energy firm eyes ocean potential energy and is currently evaluating at least 36 sites in the Philippines (Deparine, 2009). These sites are concentrated in the provinces of Isabela, Laoag, Mindoro, Negros, Panay, Zambales, and in some parts in the Mindanao region and are reportedly amounting to 21,450 hectares. The DOE however has yet to verify the ocean energy potential in these sites.

Another ocean energy source considered in the Philippines is the tidal energy. Harnessing of tidal energy has occurred only in a very limited number of areas such as Canada and France, where commercial power generation from tidal energy has been done for the past years (WEC, 2009). Projects on tidal energy have also progressed in countries such as the United Kingdom and the United States of America. Prospective tidal energy projects, particularly tidal barrage schemes, are very often planned to be sited where the ecology is finely balanced and many environmental impact studies are currently being undertaken.

Still another clean energy alternative being considered is the wave energy. Although global wave resource is still in the R & D stage, a great potential can be seen in this relatively nascent technology. Prototype devices are already available and are being tested across the world particularly in Portugal and the United Kingdom, which are the two leading countries in wave energy development (WEC, 2009). A significant amount of time is still needed for this technology to fully mature and be available for commercialization.

Chapter 9

Recommendations and conclusions

9.1 Recommendations

The following recommendations are put forward to address the issues cited earlier:

- Institution: Establish a National Energy Research Institute (NERI) to manage energy research in the country with National Energy Research Laboratories (NERL) for specific technologies based in selected universities and research institutions to serve as focal centers and one stop center for energy research, linkages and energy data bank for the universities, research institutions, industries and other national and international energy organizations. Each Laboratory will be equipped with state of the art research facilities. This would involve establishment of the following among others:
  - Biomass and Combustion Laboratory
  - Solar Energy Laboratory
  - Biofuels Laboratory
  - Wind Energy Laboratory
  - Micro-hydro Laboratory
  - Energy Efficiency Laboratory
  - Vehicle Technology Laboratory
  - Clean Coal Laboratory

  The Institute will be linked with foreign institutional counterparts to accelerate research efforts. It will be guided by a board of advisers with representatives not only from the scientific community but from the business sector and civil society to facilitate needs identification and commercial adoption of the technologies.

- Commercialization: Establish technology commercialization offices in selected universities linked to the various business incubation programs of the government. These offices would have to be manned by personnel properly trained on product patenting and commercialization and well oriented on the support provided by the government. Mechanisms (e.g. innovation conference and exhibit, symposia, web announcement, etc.) to efficiently communicate the technologies being planned to be developed, being developed and completed to the venture capitalist community would to be introduced. University assessment should significantly take into account product commercialized and technology based business incubated.

- Set-up an "Energy Innovation Idea Generation Program" to expose local researchers to the developments in their research fields and facilitate linkage with institutions and experts from other country. This could consist of a fund that could be access by local researchers to finance attendance to international conferences and research linkage visits. It shall also involve the establishment of science and engineering information hubs per region to provide the scientific community a wider access to up to date scientific information; e.g. research journal on-line access, international networking, international research partnerships, etc.. (Currently, only a small number of universities and research institutions have access to scientific research journals due to high cost).

- Human Resources: Increase the pool of local energy researchers by making the said career more attractive. Provide tax exemptions or discounts and other incentives to energy R and D scientist in the academe and public and private research institutions to make energy R and D an attractive and viable long term career option. The establishment of well structured and organized energy research program will be helpful. The need for researchers on this area could also be hyped in the media. Human resource interventions required vary from one energy technology area to another.

- Cooperative Work and Technology Acquisition: Whenever possible, research should be pursued in partnership with other countries. Re-engineering should be considered whenever possible to accelerate realization of output. Cooperative research programs of international agencies should be explored and maximize to leverage local funds and expertise. In principle, emerging energy technologies should be pursued only through international cooperative programs. Suggested partnership and technology acquisition strategies were provided in Section 4.2.2.

- Focus: Adoption of highly mature renewable energy technologies should focus on industrial and commercial applications. Rural electrification should be anchored on job and income creation. As summary of the suggested strategic research programs are as follows:

Energy Technology	**Technical Human Resource Development Assessment**
Coal Energy	• Characterization of local coal vis a vis cleaner coal combustion technologies. • Modification/Development of cleaner coal combustion technologies for cleaner coal • Geological mapping to identify possible CCS sites in the country.
Wind	• Localization and commercialization of small wind turbine systems
Solar PV	• Localization and commercialization of balance of system components
Solar Thermal	• Localization and commercialization of low cost solar water heating system. • Further improvement to improve performance and bring down cost of solar dryers.
Solar Cooling	• Localization and commercialization of solar adsorption cooling systems.
Hydro-energy	• Localization and commercialization of off the shelves pico-hydro systems.
Ocean	• Take part in international ocean energy research cooperation projects.
Biomass Combustion and Gasification	• Development and commercialization of small scale biomass gasifiers • Popularization of biomass based heating systems
Biogas	• Popularization of biogas energy
Energy Efficiency	• Localization and commercialization of energy efficiency devices and technologies. • Development and popularization of passive energy efficiency technologies for tropical climates.
Vehicle Technology Development	• Localization and adoption of modern vehicle technologies to PUVs (jeepneys, tricycles and buses) • Transport sustainability modeling
Bio-fuels Development	• Development and commercial adoption of Jatropha Bio-diesel.

	• Development and commercial adoption of cellulosic ethanol technology. • Sustainability modeling of Philippine Biofuel's program.
Nuclear Engineering	• Take part in nuclear power assessment cooperative programs. • Geological mapping for the assessment and identification of potential nuclear plant sites and waste storage.

- Legislations: ***While not reopening the broader debate on the environmental and health impacts of incineration technologies***, it is recommended a team be formed to study the logic behind amending the Clean Air Act of 1999 to allow waste to energy systems. The experience of India could provide vital inputs in the study. Moreover, biogas technologies would require the review of the Clean Air Act which prohibits burning of solid waste.

Cross-cutting Areas of Collaboration Among The Panels

- Creating an Environment for Commercialization of Technologies (e.g. startup /
- incubation environment);
- Public-Private-Partnerships for R&D all the way to Commercialization;
- Creating a Critical Mass of R&D Workers;
- Strengthening the Brain Gain and Balik Scientist Program;
- "ITRI-type" Research Organization;
- Priority / Niche / Products Services;
- Government as a Major Market for Technology and Innovation-based Products;
- Identification of International Collaborative Linkages (e.g. Spain-Philippines on
- Wind Energy); and
- Productivity, Innovation and Competitiveness Studies in Universities at the Graduate Level (similar to those undertaken by the MIT Sloan School).

9.2 Conclusions

Technological innovation plays an important role in the country's sustainable energy program. Each stage of the energy innovation chain, consisting of R and D, demonstration, early deployment and full commercialization has various human resources, support, infrastructures and program pre-requisites. Currently, the country has weaknesses relative to these requirements. It does not have the required mass of scientist and technologist to support energy R and D to maximize its indigenous energy resources. The existing research facilities are inadequate to respond to these technology development challenges. There is inadequate access for most local energy R and D community to up to date scientific information, research equipment and facilities and international research exposure and linkages. In addition, local energy R and D efforts have been project based and short term thus lacks continuity and fails to build on its gains. To date, very limited significant energy R and D technologies have been developed locally and commercialized.

There is also a lack of cooperative efforts across the various sectors to guide and support energy technology development in the country. It must be stressed that for research programs to be truly and continuously beneficial, they should eventually lead to "wealth creation". This is best ensured through a multi-stakeholder research management approach involving the private sector, government and the academe. This will ensure that the right research problems area addressed, relevant products are developed, the required policy instruments are put in place to maximize benefits of the research, outputs are translated to products and/or adopted by the industry, contribute to the development of the country and eventually funds are flowed back again to the program to sustain future efforts.

The government would have to play a key role in supporting these efforts and catalyzing this cooperation. In general, it could stimulate R and D activity through the formulation of priority R and D areas, provide direct funding, set technology forcing standards, facilitate corporate or international technology development agreements and initiate linkage among key players. Policy instruments can also play a leading role in the early deployment and commercialization phase by setting targets and standards, conducting resource assessment, setting technology standards, providing financial support and fiscal incentives.

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