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RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT: LESSONS LEARNED FROM APEC FOR THE PREPARATION OF RIO+10*

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Since the Earth Summit in 1992, significant progress has been made toward the goal of reconciling the impact of human activities on the environment. It is appropriate to ask what has been learned over the last ten years in our efforts to foster sustainable development. This article examines the lessons that can be learned from some APEC economies' views on the potential role of renewable energy systems in their energy future. It appears that major issues associated with the low adoption rate predicted for renewable energy technologies in a country are a combination of four kinds of factors—resource, technological, economic, and institutional. Together, these issues are more important than the need for further development of specific renewable energy technologies.

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The Earth Summit: An Attempt at Global Sustainable Development

The first international conference that focused world attention on the idea that social, environmental, and economic needs must be met in balance with each other for sustainable outcomes in the long run was the United Nations Conference on Environment and Development (UNCED), also known as the "Earth Summit," held at Rio de Janeiro, Brazil in 1992. The Earth Summit brought together policy makers, diplomats, scientists, media personnel, and nongovernmental organization (NGO) representatives from 179 countries in an effort to reconcile the impact of human activities on the environment. It also underscored the point that the smallest local actions or decisions, good or bad, have potential worldwide repercussions. The Summit's primary aim was to produce an extended agenda and a new plan for international action on environmental and developmental issues that would help guide international cooperation and policy development into the next century. The major outcome of the Earth Summit was Agenda 21—a program of actions that demanded new ways of investing in the future to reach sustainable global development in the 21st century.

A five-year review of the Earth Summit was made in 1997—known as the Earth Summit + 5. A ten-year review of the Earth Summit—the World Summit on Sustainable Development, also known as Rio+10—will be held in Johannesburg, South Africa in September 2002. Rio+10 has set the goals of reviewing the accomplishment of the participating countries with regard to the sustainable development mission since 1992, the obstacles they encountered, the lessons they have learned about what works and what does not, the new factors that have emerged to change the picture, the mid-course corrections that need to be made to reach goals, and the further efforts that should be concentrated upon.[1]

The twenty-one Asia-Pacific Economic Cooperation (APEC) economies collectively consume about 58 percent of world energy consumption and generate about 59 percent of the world's total energy-related carbon emissions.[2] They will thus have an important role in determining the state of the global environment in the 21st century. The success in promoting sustainable development in the APEC economies will contribute greatly to the global environment and social well-being. As the world moves toward another major international conference meant to mark the progress being made toward sustainable development, it is important to look carefully at past efforts in APEC economies for possible lessons to be learned.

Energy and Sustainable Development

There are strong linkages between energy systems, environmental protection, economic development, human health, and social issues. Energy is crucial to economic growth. Reliable and affordable energy enhances human productivity and living standards. At the same time, energy production and consumption can also have high negative impacts on human health as well as on the local, regional, and global environment. A United Nations Environment Programme (UNEP) report says that much of the air pollution that kills an estimated 500,000 people each year comes from burning fossil fuels in electric power generation stations, industrial furnaces, and motor vehicles. Air pollution also causes an estimated 4 to 5 million new cases of chronic bronchitis as well as millions of cases of other serious illnesses. The economic burden of this pollution is estimated at 0.5 to 2.5 percent of world GNP, some $150-750 billion a year.[3] Production and use of fossil energy produces anthropogenic greenhouses gases (GHG).

The question of whether or not current GHG emissions are impacting the global environment seems to have been put to rest. The Intergovernmental Panel on Climate Change (IPCC) released a report that indicated that regional changes in climate, particularly increases in temperature, have already affected a diverse set of physical and biological systems in many parts of the world.[4] In addition, a recent U.S National Research Council report stated that "Greenhouse gases are accumulating in the Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise."[5] On human development and social issues, statistics show that at present 2 billion people—one-third of the world's population—still do not have access to affordable modern energy supplies.[6] It is clear that the current global patterns of energy production, distribution, and consumption are unsustainable since they cannot satisfactorily support social, economic, and environment aspects of human development over the long term.

One of the options available to meet the challenge of energy and sustainable development is to increase the use of renewable energy. The use of renewable energy resources provides benefits to a country as it helps lower oil imports, diversify energy use, increase local jobs, and reduce GHG emissions. Renewable energy thus has the potential to foster sustainable development by providing affordable and reliable energy through the use of non-environmentally degrading indigenous resources. Renewable energy sources supplied about 14 percent of the total world primary energy consumption in 1998, including 9.5 percent from conventional biomass, 2 percent from modern biomass, 2 percent from large hydropower, and about 0.5 percent from wind, solar, and small hydropower combined.[7] Although the utilization of modern renewable energy technologies has been increasing, their use is still small as compared with total world energy demand.

Energy can definitely be a tool for supporting sustainable development if appropriate policies and measures are implemented to increase access to reliable and affordable energy supplies, encourage energy efficiency, and promote new and renewable energy technologies, all of which decrease negative human health and environmental impacts.

Multi-Country Studies and GHG Emission Reductions

The linkages between energy and sustainable development have been recognized since the Earth Summit in 1992. One of the Earth Summit outcomes was the UN Framework Convention on Climate Change (UNFCCC), an agreement signed at the summit by 154 governments. The ultimate objective of the UNFCCC is to stabilize atmospheric concentrations of greenhouse gases at safe level. UNFCCC came into force on March 21, 1994. At present 181 governments and the European Union are parties to the convention. All signatory countries of the convention have a general commitment to address climate change, adapt to its effects, and report on the action they are taking to implement the convention. The signatory countries are divided into two groups—Annex I Parties and non-Annex I Parties. The Annex I Parties are the industrialized countries that have historically contributed the most to climate change.[8] Their *per capita* emissions are higher than those of most developing countries, and they have greater financial and institutional capacity to address the problem. Therefore, they are committed to take the lead in modifying longer-term trends in emissions and to adopt national policies and measures aiming to return their GHG emissions to 1990 levels. They must also submit regular reports, known as National Communications, detailing their climate change policies and programs, as well as annual inventories of their greenhouse gas emissions.[9]

Non-Annex I Parties are, basically, the developing countries. These countries must report in more general terms on their actions to address climate change and adapt to its effects. The time frame for the submission of their initial National Communications, including their Emission Inventories, is less tight than for Annex I Parties and is contingent on the receipt of funding from the convention's financial mechanism, operated by the Global Environment Facility (GEF).

The UNFCCC was modified by the Kyoto Protocol in December 1997. The Kyoto Protocol calls for commitment of Annex I countries to legally binding reductions in emissions of six greenhouse gases.[10] The Protocol contains several mechanisms to help reduce greenhouse gas emissions. These include the ability to trade GHG carbon credits, undertake joint emissions reduction projects to the benefit of both countries involved, and implement new policy instruments such as the Clean Development Mechanism. As of February 2000, eighty-four countries had signed, and twenty-two countries had ratified, the Protocol.[11]

Major international efforts supporting the principles and objectives of the UNFCCC include the U.S. Country Studies Program (USCSP), and the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) project. The USCSP is supported by the U.S. government and has supported fifty-six developing countries and countries with economies in transition to assist them technically and financially in developing inventories of their anthropogenic emissions of GHG, assessing their vulnerabilities to climate change, and evaluating response strategies for mitigating and adapting to climate change.[12] The first round of two-year studies began in October 1993, and a second round followed in October 1994. In addition, by building on the USCSP, the United States initiated a new activity called Support for National Action Plans (SNAP). SNAP provides financial and technical assistance to help countries use the results of their climate-change country studies and to develop action plans for implementing a portfolio of mitigation and adaptation measures.

The ALGAS project was carried out between 1995 and 1998. The project was executed by the Asian Development Bank (ADB) with funding from the Global Environment Facility (GEF) through the UN Development Programme (UNDP). Supplemental funding for the ALGAS Project was also provided by the ADB, Norway, and the governments of the ALGAS participating countries. The objective of the project was to enhance the existing national and regional capability to prepare national GHG inventories and develop least-cost GHG abatement strategies that promote sustainable development.[13] This was to enable the ALGAS countries to carry out their commitments under the UNFCCC. The ALGAS project was the largest technical assistance project administered by ADB to date, with a total budget of over $10 million for the studies in the twelve countries.[14]

Both the USCSP and the ALGAS programs were well funded, multi-year efforts directed at enhancing the understanding of the complex interactions that determine energy and environment linkages at a national level. Since both programs also included several APEC member economies, they provided a wealth of information from which to gain insights into the potential for renewable energy use in the APEC region and the subsequent environmental benefits.[15]

APEC as a Large Potential Contributor to GHG Emission Reduction

APEC is a consortium of twenty-one Pacific-rim economies. It was created in 1989 to strengthen the open multilateral trading system, enhance trade and investment liberalization in the Asia-Pacific, and intensify Asia-Pacific development cooperation. The current members of APEC include Australia, Brunei

Darussalam, Canada, Chile, China, Hong Kong China, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Singapore, Chinese Taipei, Thailand, the United States, and Vietnam. Together, APEC members account for almost 50 percent of the world's total merchandise trade and 49 percent of world population.

In 1998, APEC economies consumed 220 quadrillion Btu of energy or about 58 percent of world energy consumption, and generated over 3.6 billion metric tons of energy-related carbon emissions or 59 percent of the world's total. In 1998 APEC economies collectively consumed about 57 percent of the world's oil, 57 percent of the world's natural gas, and 66 percent of the world's coal consumption.[16] Energy demand is increasing more rapidly in the Asia-Pacific region than in any other part of the world. Demand for primary energy in Asia is expected to double every twelve years during 1997 to 2020, compared with the worldwide average of every twenty-eight years.[17]

APEC has abundant renewable energy resources. Indonesia, the Philippines, and Mexico are well endowed with geothermal energy. China has high potential for using wind and solar energy. APEC also has large hydroelectric potential. Several areas in the APEC economies are still unelectrified. Most of the unelectrified areas are remote with little prospect of connecting to an electrical grid, and are good candidates for renewable energy-based power generation. According to the World Bank, in the next four decades, developing countries will need 5 million megawatts of new electrical generating capacity.[18] If a significant portion of this need is met by renewable energy, the countries will greatly improve their local environment as well as lower global greenhouse gas emissions.

The APEC Energy Working Group and its Role in Sustainable Energy Use

APEC implements its activities through ten groups, one of which is the Energy Working Group (EWG).[19] The role of EWG is to maximize the energy sector's contribution to the region's economic and social well being. The EWG is assisted by five Expert Groups, each of which concentrates on a specific theme of strategic importance to the economies of the region from an energy perspective.[20] The Expert Group on New and Renewable Energy Technologies (EGNRET) was formed by the APEC EWG with the mission to facilitate the increase in the use of new and renewable energy technologies in the APEC region. The objectives of EGNRET are related to the removal of specific barriers to renewable-energy development and associated issues. In addressing these objectives, EGNRET is involved in various types of activities, such as implementing renewable energy resource assessments, promoting the commercialization of renewable energy technologies, promoting the development of the renewable-energy technological and services infrastructure, identifying and mobilizing industry and government sources of financing, providing technical assistance and education programs, and developing effective policy recommendations for addressing impediments to the increased use of renewable energy technologies and for including renewable energy in domestic energy plans.[21]

As the central goal of EGNRET is to promote and facilitate the expanded use of cost-effective new and renewable energy technologies in the Asia-Pacific region, based on funding from the APEC Secretariat in Singapore, EGNRET recommended that the APEC EWG support a number of studies on renewable energy with the purpose of promoting a better understanding of renewable energy opportunities and problems in APEC member economies. Recent studies include *Asia-Pacific Economic Cooperation High Value End-Use Applications Analysis*,[22] *Overview of the Quality and Completeness of Resource Assessment Data for the APEC Region*,[23] *Analysis of Renewable Energy Retrofit Options to Existing Diesel Mini-Grids*,[24] *Development of Analytic Methodologies to Incorporate Renewable Energy in Domestic Energy and Economic Planning*,[25] and *Wide-Spread Implementation of Renewable Energy Projects in APEC Member Economies: Road Maps for Success*.[26]

Renewable Energy Futures: Case Studies of APEC Economies

Recent major international studies indicate significant growth potential for renewable energy, particularly in scenarios where environmental constraints are imposed, for example on

CO2 emissions. A study by the International Energy Agency indicated 7.5 percent to 8.5 percent annual growths in the commercial use of energy from "new" renewables to 2010.[27] The World Energy Council forecast that renewable energy would rise from 18 percent to 21 percent of world needs by 2020 in the Business-As-Usual scenario, and from 18 percent to 30 percent in the ecologically driven scenario.[28] The United Nations Solar Energy Group on Environment and Development forecast that 30 percent of world energy needs would be met by renewable energy by 2025, and 45 percent by 2050.[29] In addition, the Group Chief Executive of BP[30] and a Managing Director of the Royal Dutch/Shell Group[31] have commented that renewable energy could be providing up to half of the world's total energy needs within fifty years.

Though the advantages of using renewable energy are acknowledged, and the world consumption of renewable energy is forecast to significantly increase in the future, its use in developing economies has not progressed as rapidly as expected. Renewable energy options are not widely adopted in APEC member economies' energy and economic planning, and the role of renewable energy in their total economy energy supply is expected to decline in the future. As seen in international studies such as those of the USCSP and the ALGAS project, renewable energy is expected to provide a reduced share of the economies' future energy supply. In addition, renewable energy received only minor recognition as a potential GHG mitigation option.

The study *Development of Analytic Methodologies to Incorporate Renewable Energy in Domestic Energy and Economic Planning* was funded by the APEC EWG to examine why the major multi-country studies such as those of the USCSP and ALGAS did not show much promise of renewable energy technologies in the future.[32] It was suspected that existing energy models were not adequate tools for evaluating the penetration of renewable energy technologies in an economy. Thus it was thought that the models could not show the currently cost-effective renewable energy technology options to policy makers. This would make renewable energy technologies not receive a fair evaluation in the economy's fuel mix when it came to energy planning. The objective of the project was to identify, assess, and improve analytic methodologies to incorporate renewable energy options in an economy's energy and economic planning.

Four Selected APEC Economies As Case Studies

In order thoroughly to understand how choices of renewable energy systems were made in a country's energy and economic planning, a three-step process was followed. The first step was to obtain and verify the operation of the selected energy models. The second step involved obtaining the actual model results and the original computer data sets to obtain those results. The third step was to review the data and assumptions used in the models to understand the forecast penetration rates of future renewable energy technologies in the economies. Case studies for the project were selected based on the criteria that they involve APEC member economies, they have participated in economy-level energy system modeling, they provide examples of different energy models, they provide examples of various renewable energy resources to be included in the models, and they make available reports and data sets utilized in the actual economy-level modeling projects. It was not easy to find case studies that met all the set criteria. The main problem was that some countries that could be good case studies in the projects were not willing to provide the data set for anyone's review—which posed questions of how accurate the data and information used in those countries' energy models and consequently how reliable the results of renewable energy potential in their energy and economic planning.

The four APEC member economies that best met all the criteria and were used as case studies in the project were China, Indonesia, the Philippines, and Thailand. These four countries used different renewable energy resources. They also employed different energy models in their studies, and each model utilized a different solution algorithm. Thailand used the Energy and Power Evaluation Program (ENPEP), Indonesia and the Philippines used the Market Allocation Program (MARKAL), and the PRC utilized the Long-Range Energy Alternatives Planning System (LEAP). This diversity provided us with good case studies since it ensured that any low forecast of renewable energy adoption rate was not due to the problem of any specific model algorithms.

When this study began, the stated preference was to review the energy models that were constructed for work in the USCSP and/or ALGAS, since these programs were directly related to domestic energy planning, which was concerned with the use of fossil fuel and renewable energy to reduce GHG emissions. The problem in following this preference was that the work in both programs had been delayed, the economies' reports were not available, and the data sets used in the models could only be obtained from the economies themselves. There was no central point of contact to obtain the work and the data sets from these two programs. Therefore, due to the unavailability of the reports and data sets within the time constraints of the project, the energy models for Indonesia[33] and China[34] were not from the USCSP or ALGAS projects; they were developed as part of the economies' own domestic energy planning projects. The energy model for the Philippines was the Philippines National Report for the ALGAS project.[35] The energy model for Thailand was from the study in preparation for Thailand National Strategies on Global Climate Change funded by the USCSP.[36]

Energy Models As Case Studies

The energy models that were reviewed in the project—ENPEP, MARKAL, and LEAP—were selected because they are widely used in many APEC member economies as well as non-APEC member economies worldwide, for their own domestic economic planning and at the international level of energy analysis. ENPEP, MARKAL, and LEAP represent three different types of energy models. Each model takes a different overall approach to the analysis of energy and environmental systems. Thus, they collectively provided a broad understanding of how various energy models handle existing and potentially new renewable energy technologies in an economy.

ENPEP was developed by Argonne National Laboratory of the United States, with support from the U.S. Department of Energy, International Atomic Energy Agency, the World Bank, and the Hungarian Electric Board. It is composed of nine sub-modules. Each sub-module has automated connections to other ENPEP modules, but it also has stand-alone capability. BALANCE and IMPACTS are the ENPEP sub-modules reviewed in the project. BALANCE is the sub-module used for estimating domestic energy supply and demand; IMPACTS is used to estimate the consequential pollution emissions for all activities relating to fuel combustion in the fuel supply system. BALANCE is a system of simultaneous non-linear equations and inequalities. It is based on the approach of generalized equilibrium modeling, which is applicable to model the energy systems of economies having different energy-sector characteristics.[37]

MARKAL was developed in 1978 in a joint effort by the Brookhaven National Laboratory in the United States and Kernforschungsanlage-Julich in Germany for the Energy Technology Systems Analysis Programme (ETSAP) of the International Energy Agency (IEA). The primary objective was to assess the long-term role of new technologies in the energy systems of the seventeen IEA member countries. Since that time the model has evolved and has been applied to a wide range of energy and environmental issues in many countries other than IEA member countries. MARKAL is a dynamic linear-programming model of a generalized energy system. Its main function is therefore to optimize a linear objective function under a set of linear constraints. The problem is to determine the optimum activity levels of processes that satisfy the constraints at a minimum cost.[38]

LEAP was developed by the Stockholm Environment Institute-Boston Center at the Tellus Institute, with support from the United Nations Environment Programme and various other organizations.[39] LEAP is an energy accounting framework. It is structured as a series of integrated programs that contains a full energy system which enables consideration of both demand-side and supply-side technologies and accounts for total system impacts.

Findings

In these four economies, renewable energy was earlier recognized as an important resource in the energy sector. The shares of renewable energy in the total primary energy of each economy varied from 25 percent to 42 percent. The principal renewable energy resources included in all models were biomass and hydropower. Geothermal resources were included by the Philippines, Indonesia, and China. Wind and solar were included in the China base case scenario, and in the Philippines in the mitigation scenarios. In both the China and the Philippines models, wind and solar were used for power generation only.

The renewable energy technologies included in all economies were simple technologies. Their uses included power generation, cooking, and ironing in the residential sector, and heat and steam production in the industrial sector. Other renewable energy technologies such as solar water heating, solar thermal power generation, or renewable-based transport fuels were not considered in any model reviewed. There was no use of renewable energy technologies in the commercial, services, transport, or agricultural sectors.

In contrast to the aforementioned forecasts of high renewable energy utilization, all four economies reviewed expected only a small increase in renewable energy consumption in their economies. In fact, over time the share of renewable energy in their total energy supplies declined over time—to between 8 percent and 14 percent. The question raised was that why renewable energy could not compete with conventional energy in these economies' future energy plans.

Flaws in the Energy Models?

Renewable energy has several characteristics and attributes that are different from fossil fuels and are difficult to capture for a fair evaluation in selecting renewable resource over other fuel options. For example, renewable energy resources such as wind and solar are time dependent. Electricity can be generated from them only if the wind blows and the sun shines. The hour-to-hour delivery of power from wind and solar resources is thus difficult to forecast, particular on the long-term basis. As another example, modularity is an advantage that some renewable resources have over many conventional resources. Modularity is defined by the incremental sizes of resources and the lead times required for adding them. Due to their small module size and short construction time, utilities can add only enough wind turbines each year to more closely match load growth requirements and avoid the chance of having temporary overcapacity from adding a large, new coal power plant. Short lead times for constructing renewable facilities also enable utilities to delay making decisions on adding resources until additional information about uncertain load and fuel availability factor are known. The time dependency and modularity are among several key attributes of renewable energy resources that are difficult to capture and/or predict, yet need to be taken into consideration when modeling renewable energy.[40]

Due to the special characteristics of renewable energy and the fact that important attributes involved with the use of renewable energy are more difficult to assess and quantify, it poses some limitations in modeling renewable energy technologies in the existing energy models. The existing energy models such as MARKAL, ENPEP, and LEAP are designed to be used for long-term energy planning. Although LEAP was first applied to a developing country, MARKAL and ENPEP were originally designed and applied in developed countries where renewable energy accounted for only a small portion of the overall energy use. Renewable energy systems are thus not the central focus of the models.

In general, energy models can be divided in three categories—technology-level, sector-level, and economy-level energy models. These three levels of models have different objectives. The technology-level model is used to select individual components of a single system—for example, to select the most cost-effective system of wind turbines, PV panels, and battery backup, to make up a hybrid electric system that can generate electricity to satisfy the demand at a specific site, or for a specific application. The sector-level model, such as an electric utility model, is adopted to define the least-cost fuel mix for electricity generation to meet an economy's future electricity demand. In comparison, the economy-level energy model is utilized to facilitate the decision to provide the economy energy supplies to satisfy future energy demand at the least cost by taking into consideration issues such as energy security, energy diversification, and environmental related problems. Energy demand in the economy-level model covers demand for all fuels in all economic sectors. In addition, while in the electric utility model the competition of renewable energy is with conventional fuels and demand-side management options, the use of renewable energy at the economy-level involves the competition of renewable energy among various applications in all end-use sectors. Due to the difference in the model objectives, information required and factors influencing the decisions in the planning process are different among these models.

The economy-level model could not be utilized to conduct an energy system design like the technology-level model. Neither could the economy-level model capture all attributes of renewable energy that were significant in the comparison of renewable energy resources with conventional supply-side and demand-side options for a utility's integrated resource planning. This is not surprising. Given the broad scope and objectives of economy-level energy models, it is not realistic to expect such models to incorporate the technical detail of technology-level or even sector-level models. In addition, some of the renewable energy attributes are more important for the sector-level models but less critical for the economy-level models. Therefore, those attributes could be ignored for the economy-level model without any significant impact on overall model results.

The economy-level models such as ENPEP, MARKAL and, to some extent, LEAP can serve the purposes for which models are normally used by energy policy analysts. Those are to show the impacts of various energy supply and demand scenarios on resource consumption, technology choices, environmental implications, and policy decisions. An attempt to capture in the economy-level energy model all the attributes of renewable energy, as characterized in the technology-level models, would not be practical, nor is it required to accomplish the objectives of the economy-level model. However, it is fair to say that the existing economy-level models like ENPEP and MARKAL have high capabilities for capturing most of the important factors and attributes of renewable energy and could present a reasonable picture of renewable energy potential in an economy, if the necessary information is made available and the models are utilized to their full potential.[41]

Factors Contributing to Renewable Energy Development Impediment

The inadequacies of the existing economy-level energy models in characterizing renewable energy technologies were only a minor impediment to showing the potential penetration of renewable resources into an economy's resource mix. The other factors contributing to the same problem are non-modeling factors. These may be classified into four groups—resource factors, technological factors, economic factors, and institutional factors. It is difficult to say which factor is the most important. To varying degrees, these four factors were important in each of the four countries reviewed. One factor could be relatively more important for a given economy than the other factors. However, lack of any one of these factors would significantly obstruct the penetration of renewable energy in an economy.

A Need for Resource Assessment

The availability of renewable energy resources in an economy is a critical factor to determine the use of renewable energy in that economy. This is due to a fundamental difference in resource availability between conventional energy resources (such as coal, oil, and gas) and renewable energy resources (such as wind, solar, geothermal, and hydro), namely, that conventional energy resources can be imported but renewable energy resources, in general, cannot. An economy can have diesel power plants although diesel is not produced in that economy. In contrast, an economy cannot use wind energy if wind resources are not available there. Biomass can be imported from neighboring economies, but in most cases it is not an economic option. The renewable energy projects to be selected in an economy thus depend on domestically available resources.

Besides the availability, location is also an important factor. Renewable energy resources cannot be transported and must be used at the site. Site selection is thus a crucial step in project implementation to ensure the availability of resource supply and sufficient energy demand in the same area. Geographical constraints thus play a critical role in renewable energy utilization.

Renewable energy resource assessment provides the benefit of determining renewable energy resource potential at different locations and for different time periods. It also determines the availability of energy for specific renewable energy technologies, as well as provides input to optimal design of systems at specific location. Resource assessment is the important first step in renewable energy development since the information on renewable energy resources is crucial for the successful implementation of renewable energy technologies.

A recent study sponsored by the APEC Expert Group on New and Renewable Energy Technologies surveyed the quality and completeness of resource assessment data for the APEC economies.[42] It concluded that "a basis for understanding renewable energy resources is currently available for essentially all the economies, although there is a significant need to apply improved and updated resource assessment techniques in most." As an example, most wind resource assessments rely on data collected at national weather stations, which often results in underestimates of the true potential wind resource within an economy. It was also found that solar resource assessments in most economies rely on an analysis of very simple sunshine record data, which results in large uncertainties in accurately quantifying the resource. In addition, national surveys are often not available for biomass, geothermal, and hydro resources.

Therefore, addressing the issues identified in the APEC report cited above is a good first step in developing better modeling capabilities. In addition, the level or detail of resource assessment required needs to be better matched to the level of modeling anticipated. It should not be expected that an initial wind assessment at the economy level would require the same level of detail as a site specific planning study that would occur prior to project implementation.

The Importance of Technical Expertise

Cost-effective and reliable technology is needed in order to make use of renewable energy resources. Identifying the appropriate technology is a key step in developing a successful renewable energy project. Besides the technologies needed to utilize renewable energy resources, other technology related factors include the knowhow to install, operate, and maintain the technologies being adopted. Technical training to improve local capabilities is necessary because oftentimes the project fails due to improper use and lack of understanding and maintenance of the technology. Technical training is especially important for medium- and large-scale projects.

Technology characterization involves obtaining information on performances and costs of various renewable energy technologies. This information is necessary for determining cost-effectiveness of a renewable energy project. The costs and performances of some renewable energy technologies can be shared among economies. For example, a developing economy could utilize the information on cost and performance of a solar PV technology from a developed economy (which is both a producer and consumer of the technology) since this technology might have to be imported from abroad anyway. However, costs of some renewable energy technologies (such as solar thermal) could easily vary by a factor of two or three across economies by using local labor and materials.

A recent study by the World Bank on renewable energy development in China mentioned that lack of awareness among decision makers of the potential for commercial applications of renewable energy technologies was a major constraint on renewable energy development.[43] This stems from lack of awareness of recent technical advances and existing successful commercialized applications in other economies.

Lack of information has consistently been identified as a major constraint that slows the adoption of cost-effective renewable energy technologies. Although much information is available over the Internet, there is often an inability to match the information to real problems. There is a real need to develop cost information on renewable energy technologies, which takes into consideration economy-specific factors such as local content and local labor rates. The U.S. Department of Energy has made a good start by putting together a summary of costs for renewable energy technologies for power generation.[44] However, other types of renewable energy technologies need to be covered. If centralized databases are developed, they should include adjustments for local factors. This would affect the evaluation of technologies such as solar thermal (both for hot water heating and power generation), which have the potential for high local content, much more than technologies such as photovoltaic electricity generation, which requires sophisticated production techniques (although cost advantages could still be seen with this technology based on local production).

Call for Detailed Economic Analysis

The use of renewable energy is preferable to conventional energy if it is economically competitive since renewable energy is often an indigenous resource and environmentally friendly. Competitiveness of renewable energy over conventional energy greatly depends on resource abundance, and efficiency and suitability of the renewable energy technologies selected for the project. A detailed economic analysis needs to be performed to identify competitiveness between renewable energy technologies and conventional energy technologies before encouraging actual renewable energy projects. In addition, energy prices need to reflect the full cost of producing energy. All costs related to the project need to be taken into account, including environmental costs to society in producing and delivering energy to consumers. Subsidizing fossil fuels and/or ignoring their environmental costs will restrict the competitiveness of renewable energy, and reduce renewable energy potential in an economy.

Case studies need to be developed on an economy-specific basis for each of the basic sources of renewable energy, identifying which is the most cost-effective for a given economy. These case studies could then be used by economy-level modelers to generalize the potential of renewable energy technologies across their economies.

Lack of Institutional Support

Government policies and institutional support are important for promotion of renewable energy projects in an economy. For example, a government's high import tax policy will make a renewable energy project that requires imported components or technology less attractive to an investor. Inefficient permitting processes needed to implement renewable energy systems will defer project implementation.

Institutional factors include activities such as end user financing, development and strengthening of the in-country renewable energy industry and entrepreneurs, development of renewable energy policies, in-country training (which would include training financial institution staff for making renewable energy technology loans), and improvement of information dissemination mechanisms. A recent study for the U.S. Agency for International Development (USAID) to assess the potential for renewable energy deployment in the key global climate change countries and regions identified such institutional factors as key constraints to renewable energy implementation.[45]

Renewable energy technologies normally require high up-front capital investment but have low operation and maintenance (O&M) costs. The same USAID study emphasized that lack of capital is the most critical barrier to improved use of renewable energy technology in the countries/regions.[46]

Lessons Learned for the Rio+10

The focus of Rio+10 is on carrying out overall sustainable development. The most commonly used definition of sustainable development—"development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs"—covers just about all aspects of social and economic development.[47] There is an important intersection between sustainable development and the issue of climate change when it comes to the field of energy. This is because energy is a key driver for economic development, and how it is used has a lot to do with the sustainable nature of development. In addition, energy is the largest contributor to the formulation of greenhouse related climate change forcing gases. Of all of the areas of energy which could be examined, the use of renewable energy is particularly interesting since it holds the promise to satisfy energy needs in a manner that both benefits sustainability (by not compromising social, economic, and environment aspects of human development over the long term) and climate change (by producing little or no net climate forcing gases).

Capital costs of renewable energy technologies are high, and in many applications still cannot be competitive with conventional fuels. However, many renewable energy technologies are cost effective at current prices. The cost of wind-generated electricity has dropped seven-fold, which makes wind power competitive with most fossil fuel technologies in many situations. At the beginning of the 21st century, 14,000 megawatts (MW) of wind turbines generate electricity in more than thirty countries.[48] The world's largest wind farm—it has 300 MW capacity and is located on the border between Oregon and Washington in the northwestern United States—is under construction and is expected to begin its operation by the end of 2001. At that time, it is expected to produce electricity for less than 2.5 cents per kilowatt hour. Costs of renewable energy technologies have been reduced by half over the last decade and are expected to be halved again over the next ten years.[49] Renewable energy could probably become more competitive with conventional fuels in the future and could play an increasingly important role in a country's energy mix. However, whereas past use of renewable energy was based on very simple technologies, the future use of renewable energy will be based on sophisticated technologies, which can require significant expertise to design and implement. Therefore, in order fully to capture the benefits of the new technologies, increased effort must be spent on all aspects of renewable energy development.

Renewable energy is an important option for global GHG emission reduction. APEC economies are large energy consumers, and will continue to be large GHG producers in the future. APEC member economies have abundant renewable energy resources and thus have a high potential to be clean energy consumers that help mitigate global greenhouse gas emissions and foster sustainable development. The results from the major international studies such as the USCSP and ALGAS, which projected a minor role for renewable energy in the APEC economies in the future, may disguise the true potential of future use of renewable energy technologies in the APEC region.

The potential for using renewable energy technologies in developing countries is challenged by several factors besides the high up-front costs of installing equipment. Lack of information has consistently been identified as a priority constraint that slows the adoption of cost-effective renewable energy technologies. As found in the APEC study discussed above, when modeling renewable energy, all economies reviewed faced the same problems, though in varying degrees.[50] First of all, renewable energy was expected to make a declining contribution to the economy's energy mix as industrialization gave rise to the demand for higher quality energy resources. Therefore, because of time and budget constraints in doing research, government leaders did not look in detail at renewable energy for their economy energy models. The limitation in modeling renewable energy was also influenced by the fact that necessary information to model renewable energy, such as resource data, technology characterization, technology performance, and costs, was not available to most economies.

In all cases, the business-as-usual scenario follows the government's energy plans. If there are no government plans to implement renewable energy projects, a modeler will not volunteer to include them in his/her model. In the mitigation scenario, although the modeler is not precluded from suggesting renewable energy technology options, if the economy has not already completed detailed resource assessments and economy-specific renewable energy technology cost estimates, the modeler as part of his/her work cannot be expected to develop the needed information.

Defining the cost-effective use of renewable energy technology cannot be done on a one-time basis due to the changing nature of the technologies. A process needs to be established that will link country-level energy planning into capabilities of new technologies so that as new technologies become available, both their costs and benefits will be clearly identified to government and private sector decision makers. Although renewable energy technologies account for a small portion of most countries' primary energy supply, the difficulties involved in estimating their true potential at a national level provide valuable insights into the problem involved in estimating the penetration and benefits of new and advanced technologies produced in developed countries into the economies of developing countries. Institutional issues also play a critical role in determining the overall penetration rates when introducing new technologies into developing countries.

There is a need for an institution that will be a focal point to work with developing countries in helping them understand and quantify the overall benefits of sustainable energy systems to their economies. Such an institution would identify resource options and economic implications, and provide information and expertise on recent technology advances, successful applications, and costs on energy efficient and renewable energy technologies. The institution would take into consideration economy-specific factors such as local content and local labor rates, identify cost-effectiveness of sustainable energy projects and systems, and identify cost-effective technologies for specific applications. It would also provide the know-how to install, operate, and maintain the technology being adopted.

The ultimate goal of such an institution is to help developing countries define sustainable energy paths that maximize the use of energy efficient technologies and cost-effective development of their renewable energy resources. Countries should then be able to increase the availability, reliability, and affordability of energy services while minimizing the local and global negative environmental consequences.

To accomplish this goal, the institution would invite government, NGO, university, and private sector representatives to play an integral role in its activities on a visiting scholar basis. By sharing information and approaches across all countries, a de facto institutional memory would be developed that would transcend changes in government officials. The institute would also become a mechanism for sharing best practices in renewable and sustainable energy development.

NOTES

1. For more information on the Earth Summit, see online at www.un.org/rio+10/default.htm.
2. United States Energy Information Administration, *Regional Overview: Asia-Pacific Economic Cooperation (APEC)*, June, 2001, online at www.eia.doe.gov/emeu/cabs/apec.html.
3. United Nations Environment Programme, *Natural Selection: Evolving Choices for Renewable Energy Technology and Policy* (2000) online at www.uneptie.org/energy/publications/naturalselections.htm.
4. Intergovernmental Panel on Climate Change Working Group II, *Climate Change 2001: Impacts, Adaptation and Vulnerability* (Third Assessment Report, February 13-16, 2001), online at www.ipcc.cc.
5. National Research Council, *Climate Change Science: An Analysis of Some Key Questions* (Washington, D.C.: National Academy Press, 2001).
6. United Nations Development Programme, United Nations Department of Economic and Social Affairs and World Energy Council, *World Energy*

Assessment: Energy and the Challenge of Sustainability (New York: United Nations Development Programme, 2000), p. 3.

7. Ibid., p. 220.
8. The Annex I Parties include both the countries that were members of the Organization for Economic Cooperation and Development (OECD), and countries with "economies in transition" (EITs). The countries listed in Annex I are as follows: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and the United States. The OECD members of Annex I are also listed in the Convention's Annex II. These countries have a special obligation to provide "new and additional financial resources" to developing countries to help them tackle climate change, as well as to facilitate the transfer of climate-friendly technologies to both developing countries and EITs.
9. The Convention allows EITs some flexibility in implementing their commitments, due to the major economic and political upheavals that have taken place in these countries. Several EITs have invoked this clause to choose a baseline earlier than 1990, that is, before the economic changes that led to big reductions in their emissions.
10. The six gases covered by the Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFC_s), per fluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
11. For more information on the Kyoto Protocol, see online at www.unfccc.de/resoŭrce/docs/convkp/kpeng.pdf.
12. For more information on the U.S. Country Studies Program, see online at www.gcrio.org/csp/.
13. For more information on ALGAS project, see online at ntweb03.asiandevbank.org/oes0019p.nsf
14. The Executive Summaries of all country reports besides the Democratic People's Republic of Korea's are presented online at ntweb03.asiandevbank.org/oes0019p.nsf/pages/outputs6
15. The APEC economies that have been participating in the USCSP include China, Chile, Indonesia, Malaysia (technical cooperation only), Mexico, Peru, the Philippines, Russia, and Thailand. Eighteen countries currently participate in the Support for National Action Plans (SNAP) Phase of the USCSP, of which six are the APEC member economies including China, Indonesia, Mexico, the Philippines, Russia, and Thailand. The APEC economies that participated in the ALGAS project are China, Indonesia, Republic of Korea, the Philippines, Thailand, and Vietnam.
16. U.S. Energy Information Administration, *Regional Overview.*
17. United Nations Environment Programme, Division of Technology,

Industry and Economics, "Energy: Facts and Figures," *UNEP Industry and Environment*, vol. 23, No. 3 (July-September, 2000), p. 5.

18. *Renewable Energy: GEF Partners with Business for a Better World* (February 6, 2001). The text can be downloaded from the "What's New" section of the GEF website online at www.gefweb.org.
19. For more information on the APEC Energy Working Group, see online at www.dpie.gov.au/resources/apec.ewg.
20. The five Expert Groups of the APEC Energy Working Group include: Expert Group on Clean Fossil Energy, Expert Group on Energy Efficiency and Conservation, Expert Group on Energy Data and Analysis, Expert Group on New and Renewable Energy Technologies, and Expert Group on Minerals and Energy Exploration and Development.
21. For more information on EGNRET, see online at www.apecnetwork.org.
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