Experience with Promotion of Renewable Energy: Successes and Lessons Learned

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Abstract: Renewable energy is becoming economic in all markets as its rapid growth results in more competitive prices. It is particularly appropriate and increasingly being adopted for providing electric power services to rural areas in developing countries unlikely to be served by grid electricity. Policies needed to implement renewable energy systems in rural areas are discussed in this paper. Most prominent are removal of subsidies to traditional energy primarily benefiting the wealthiest; involving the local populace in decision making; educating financial institutions about the economics of investing in renewable energy systems and creating investment vehicles appropriate to financing them in poor localities; training personnel on management, maintenance and drafting contracts; requiring vendor provision of maintenance and parts; and effective regulation and oversight of system management and financing.

I. INTRODUCTION

The recent sharp increases in the prices of oil, natural gas, uranium and coal underline the importance for all countries to focus on development of alternative energy resources. For developing countries, these price increases can have ruinous economic consequences; for many countries already plagued by poverty this means a choice between fuel and food, health care, education and other essentials. Renewable energy resources need priority because: 1) the overwhelming scientific evidence that anthropological emissions of greenhouse gases from carbon combustion threaten catastrophic results from rapid climate change; 2) the severe health and environmental consequences from fossil fuel combustion being experienced in every major developing country city; and 3) the high cost, environmental damages and security threats of nuclear power.

The world already is responding to these imperatives. "Annual investment in renewable energy was an estimated $17 billion worldwide in 2002, up from $6 billion in 1995. And cumulative investment of at least $80 billion was made in renewable energy during the period 1995 – 2002."[1]

Virtually all those who have addressed the energy aspects of sustainable development have concluded that renewable resources should play a major role. Thus in the latest international pronouncement of the Plan of Implementation of The World Summit on Sustainable Development, Article 20 (e) states:

"(e) …With a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply,

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recognizing the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that energy policies are supportive to developing countries' efforts to eradicate poverty, and regularly evaluate available data to review progress to this end;"[2]

Yet, in both developed and developing countries, renewable resources, while they are the most rapidly growing energy resource, still have not reached anywhere near their technical and economic potential. Indeed, world-wide, the share of renewable resources accounts for only about 3% of total global energy supply.[3]

There are a host of economic, social and legal barriers that account for the failure of renewable resources to reach their potential. Those barriers can be overcome. They have been overcome successfully in many jurisdictions. There are successful examples in many developing countries. Legislation can remove these barriers, get the price signals right, and encourage successful utilization of renewable resources anywhere. This paper explores mechanisms that can be used and that have been used successfully in developing countries in various parts of the world to remove those barriers and to promote greater use of renewable resources, particularly in rural areas of developing countries.

II. RESOURCES COVERED

Renewable resources covered here include: electricity produced from the light of the sun via photovoltaic cells on individual buildings or for communities of buildings, or for the production of central station power in vast arrays; from the heat of the sun, again for localized tasks like providing homes and businesses with hot water or space heating, or providing central station power using fields of parabolic collectors focused on a fixed hot water source[4] or solar ponds; from the power of the wind; from the heat below the earth through various geothermal applications; from the power of ocean tides and waves; from the temperature variations between ocean surfaces and depths; from small hydroelectric installations; from agricultural wastes through biomethanation; and from biomass crops grown for energy use or from crop waste cellulose; the biomass can be refined to produce ethanol or gasified for heat, electric and transportation applications.

Traditional biomass in the form of firewood is not covered as a renewable resource, however, because it most often involves the cutting down of ecologically valuable forests that act as protection against floods and erosion and as sinks for carbon dioxide and because the gathering of firewood is so debilitating to women and children who also suffer serious health hazards when the firewood is burned in enclosed spaces for heating and cooking. The same is true of burning animal dung for heating and cooking. However, so-called modern biomass consisting of crops to ethanol and gasified wood and crop wastes is included.

Nuclear energy is excluded from this analysis as a development option because of its high capital and operating costs, complex technical requirements for operation and maintenance, and its unresolved problems of proliferation and waste disposal. After the attacks on the World Trade Center in New York of September 11, 2001, an over-riding

problem with nuclear plants is their great vulnerability to terrorist attack, particularly on the control rooms and spent fuel pools that are located outside the containment vessels. Nuclear energy at any rate is not renewable because of the limits on supply of uranium unless reprocessing of spent fuel is utilized, an even more prohibitively expensive and technologically challenging option for developing countries. Reprocessing is a technology that is particularly vulnerable to proliferation because of its resulting plutonium that can readily be used in weapons and is virtually detection-proof.

Waste-to-energy power from trash incineration is excluded because it is so highly polluting and because recycling options for wastes are so much cleaner and more economic.

Large hydroelectric dams also are excluded because of their expense, their unreliability because of vulnerability to droughts as recently demonstrated in Brazil and the west coast of the United States, because of their potential hazard in breaching, and because of their environmental damages both from flooding large areas of productive and often populated lands and their carbon dioxide releases from decaying vegetation in their reservoirs, particularly in shallow reservoirs.

III. RENEWABLE RESOURCES AND DEVELOPING COUNTRIES

Renewable resources hold great promise for meeting the energy and development needs of all countries throughout the world, but particularly for developing countries where in many areas commitment has not been made to fossil fuel dominance and where rural areas may be served more economically than with traditional resources like kerosene and diesel fuel.

Use of renewable resources in developing countries has grown markedly in the past decade. Many countries have significant renewable installations and programs as demonstrated in Table 1 below.

TABLE 1 Renewable energy markets in developing countries

Application Indicators of existing installations and markets (as of 2000)
1. Rural residential and community lighting, TV, radio and telephony: Over 50 million households are served by small-hydro village-scale and community mini-grids. 10 million households get lighting from biogas. 1.1 million households have solar PV home systems or solar lanterns. 10,000 households are served by solar/wind/diesel hybrid mini-grids. 2. Rural small industry, agriculture other productive uses:[b] Up to 1 million water pumps are driven by wind turbines, and over 20,000 water pumps are powered by solar PV. Up to 60,000 small enterprises are powered by small-hydro village scale minigrids. Thousands of communities receive drinking water from solar PV-powered purifiers/pumps. 3. Grid-based bulk power:[c] 45,000 MW installed capacity produces 130,000 GWh/year (mostly small hydro and biomass, with some geothermal and wind). More than 25 countries have regulatory frameworks for independent power producers. 4. Residential/ commercial cooking and hot water: 220 million households have more-efficient biomass stoves. 10 million households have solar hot water systems. 800,000 household have solar cookers. 5. Transport fuels: 14 billion liters per year ethanol vehicle fuel is produced from biomass. 180 million people live in countries mandating mixing of ethanol with gasoline.

[a]Figures are authors' estimates based on tabulations of country-level statistics from sources cited in the text and other sources. Very few of these indicators are summarized well in a single source. Figures are approximate.
[b]Agriculture and productive-use applications are difficult to estimate because little published data exists.
[c]A share of stated grid-based power capacity serves small village mini-grids.
MARTINOT, E. *ET AL*, *Global Renewable Energy Markets and Policies*, http://www.martinot.info/Martinot_NAR.pdf

India's renewable energy program is exemplary, demonstrating many measures that can make programs successful. As a result, India today is a world leader in use of renewable energy. It has pioneered in renewable energy applications research through its internationally renowned Tata Energy Research Institute. India is the only country in the world to have created a cabinet-level department for promotion of renewable energy technology, the Ministry of Non-Conventional Energy Sources (MNES).[5] Technology support centers have been created in India's universities to provide renewable technology

support to manufacturers and to certify the quality of technology procured by the government.[6] India has embarked on manufacturing itself a number or renewable technologies. India also created as far back as 1987 a Renewable Energy Development Agency (IREDA) to fund renewable energy projects.[7]

The results of these efforts in India have been remarkable. India now has cumulative installations of 3.02 million family-size biogas plants; 32 million modern cook stoves, including 485 thousand solar cookers; half a million solar hot water systems; 57 megawatts of photovoltaic installations including 3,371 water pumps, 1920 kilowatts of electric power systems, 40,000 community and street lighting units, 100,000 home electric systems and 250,000 home and community lighting systems; 34.36 megawatts of biomass gasifier electric systems; 222 megawatts of bagasse cogeneration units; 1,167 megawatts of wind farms; and 217 megawatts of mini and micro hydroelectric generating units.[8]

Major increases in these installations were achieved since the creation of MNES in 1993. This increased penetration of renewables is largely attributable to the conversion of a technology-oriented subsidy program to one that focuses on fostering of markets through indirect subsidies -- fiscal and financial incentives such as low interest loans, financing packages, 100% depreciation allowance for equipment during the first year, waiver of excise duties for renewable technologies and their components, exemption from central and state sales taxes—to meet the end-use needs of the communities such as for lighting, communications, pumping and industrial uses.[9] MNES now is organized into sectoral groups of rural energy, urban/industrial energy and power generation (rather than by technology).[10] Quality control, maintenance of systems and personnel training also have contributed to these successes.[11] It should be noted, however, that India still gets the preponderance of its electricity from coal and large hydroelectric projects,[12] as is the case for most countries.

In rural areas of all countries, renewable resources often are far cheaper than traditional resources with their transmission and distribution requirements on top of heavy capital costs for generating equipment. The most advantageous and widely used renewable resources for energy in developing countries today are wind, photovoltaic, biomass and small hydroelectric resources.[13]

WIND

Wind energy for electricity production today is a mature, competitive and virtually pollution-free technology widely used in many areas of the world. Wind also still is used to some extent for pumping water. Wind electric systems have some siting problems involving their aesthetics, and some wind machines have problems with killing raptor birds that fly into the blades, though this problem has been minimized with more modern slower-rotating blades and the siting of wind farms outside raptor flying zones. Wind power is the fastest growing energy technology in the world. Total world-wide capacity was 18,000 MW in 2000, about 10% of it in developing countries. India is the world leader with 1,300 MOW of installed capacity. Chine is second with over 350 MW.[14]

SOLAR

Solar energy presents great development opportunities in developing countries, particularly since most of them are in the Sun Belt. Solar photovoltaic energy is uniquely useful in rural areas unserved by electric grids to provide basic services such as refrigeration, irrigation, communications and lighting. An estimated 1.1 million solar photovoltaic home systems and solar lanterns existed in rural areas of developing countries as of 2000.[15] Solar thermal energy is particularly suited to the large demand for heat and hot water in the domestic, agricultural, industrial and commercial sectors of the economy. It is applied successfully for water heating, industrial process heating, drying, refrigeration and air conditioning, cooking, water desalination and purification (through use of solar ponds), pumping and power generation.[16] "Hot water for residential and commercial uses, both in rural and urban areas, can be provided cost-effectively by solar hot water heaters in many regions. An estimated 15 million domestic solar hot water collectors are installed worldwide, about two thirds of them in developing countries. China's solar hot water industry has mushroomed in the 1990s, with growth rates of 10%–20% and up to 10 million households now served with solar hot water. Markets with hundreds of thousands of households served include Egypt, Israel, India, and Turkey."[17]

Solar energy often is far more efficient than existing energy uses. For lighting, a photovoltaic compact fluorescent light system is 100 times more efficient than kerosene, used in the rural areas of many developing countries to provide night lighting.[18] Photovoltaic systems also avoid the high costs and pollution problems of standard fossil-fueled power plants.[19]

BIOMASS

Utilization of biomass is a very attractive energy resource, particularly for developing countries since biomass uses local feedstocks and labor. Crop wastes, cellulosic biomass and crops raised to provide energy feedstocks on otherwise barren lands are good energy sources for industry, electricity production and home heating and cooking if used in efficient modern stoves or gasified. Technologies for efficient biomass cookstoves in developing countries have developed rapidly, with close to 220 million improved biomass stoves in use in 2000. The largest program is in China, where between 1982 and 1999, the Chinese National Improved Stoves Program disseminated 180 million improved biomass stoves. This program established local energy offices to provide training, service, installation support, and program monitoring. It also fostered self-sustaining rural energy enterprises that manufacture, install, and service the stoves. Users pay the full direct costs of the stoves (about $10), and government subsidies are limited to the indirect costs of supporting the enterprises. In Africa in the 1990s, over 3 million improved biomass stoves were disseminated.[20]

Brazil supplies 60% of its primary energy requirements from renewable energy sources, most of which comes from hydropower and biomass.[21] The biomass produced in Brazil largely results from an ethanol fuel production program started in 1975 from sugar cane crops grown specifically for fuel use, presently occupying 2.7 million hectares of land and employing about 350 distilleries. Ethanol currently provides over 40% of the fuel

consumed by cars and light trucks.[22] It is estimated to have saved Brazil over $40 billion in oil imports, excluding the costs of the program. Ethanol was heavily subsidized by the government until 1998 when it was deregulated and taxes from gasoline sales were substituted to subsidize its costs. To get the program started, the state-owned oil company guaranteed ethanol purchases on a cost plus basis and tax incentives were provided for the purchase of neat ethanol-using vehicles. The subsidies have now been phased out and the program thrives on its own. In 1999, almost thirteen mega-tonnes of carbon emissions were reduced as a result of the program, and local emissions of lead, sulfur and carbon monoxide have been greatly reduced.[23] In addition, the ethanol production supports about 700,000 rural jobs.[24]

In 1985, Brazil established a very successful national electricity conservation and renewable energy program, known as PROCEL, housed at the national electricity utility. PROCEL funds energy efficiency and renewable projects carried out by state and local utilities, state agencies, private companies, universities and research institutes.[25]

In Africa, ethanol is produced in Kenya, Malawi and Zimbabwe for blending with gasoline, but Zimbabwe is the only one to mandate blending of ethanol with all gasoline sold.

GEOTHERMAL

Geothermal power is a relatively pollution-free energy resource derived from naturally occurring reservoirs of hot water or steam that occur below the earth's surface and is tapped to drive a turbine to create electricity. It is an established and economic energy source used in many parts of the world. Its use is expanding in Indonesia, the Philippines, Mexico, Kenya and Central America. Global electricity generating capacity is about 8,500 MW as of 2000, about 45% of it in developing countries.[26] A more experimental pollution-free geothermal energy resource, requiring further research to become economic, hot rock energy is obtained by drilling intersecting holes deep into the center of the earth, pouring water down one of the holes and obtaining steam to drive a turbine up the other hole.

HYDROELECTRICITY

Hydroelectricity is the largest renewable resource in use today, but mostly utilizing large dams with their environmental problems described above. Adding power to existing dams, however, does not create these problems. Also, the placement of generating equipment at existing dams has great worldwide potential and no environmental consequences. Run of the river hydro systems are technologically more complex but also have minimal environmental consequences. Lastly, small dams can reduce the environmental harms of large dam hydroelectric power production. Small hydropower uses the flow of water in small rivers and streams to run electricity-producing turbines. Plants classified as small hydropower generally produced less than 10MW.World-wide small hydropower production is about 43,000 MW as of 2000, about 60% in developing countries. China alone accounted for 21,000 MW of that capacity.

HYDROGEN

Hydrogen, while not an energy resource in itself, is the most promising alternative fuel for the future. It currently is produced from natural gas in a process less polluting than oil or coal-fired power plants. With improved and more economic technology, hydrogen can be produced from photovoltaic or wind-powered electrolysis, separating hydrogen from water – the focus of current EU research.[27] Most hydrogen utilization research in the U.S. is centered on fuel cells that are pollution-free, involving no combustion. Fuel cells can power vehicles or stationary electric generators, but they still require substantial research to bring down their costs and are not expected to be available commercially for approximately twenty years.

However, hydrogen can be used directly in today's motor vehicles without further research. Hydrogen combustion is virtually pollution free with a byproduct primarily of pure water. The principal challenge for its widespread adoption is to create an infrastructure to transport the hydrogen to wholesale markets -- although existing natural gas pipelines can be used if treated or lined – and a retail infrastructure for fueling vehicles at service stations. This infrastructure work will involve very large initial capital expenses. There is a circular problem in accomplishing this infrastructure investment since hydrogen manufacturers don't want to invest in production without a transportation and distribution system and established market, while pipeline manufacturers and utilities don't want to invest in pipelines without an assured supply and distribution system in place. Hydrogen is sufficiently developed today so that a number of major vehicle manufacturers are planning to market fuel cell vehicles in the next few years and it is beginning to be used as an electric power source, but virtually no attention has been devoted to use of hydrogen in existing vehicle engines.[28]

IV. RENEWABLE ENERGY BARRIERS

There are many barriers to wider spread use of renewable energy resources; while they can be overcome and have been in many countries, doing so will require a large, concerted, prioritized effort. The main constraints to the more widespread use of renewable resources are:

- Lack of information by the public, and even many government, commercial and industrial energy officials, about the availability, costs and benefits of renewable energy technologies;

- Lack of knowledge by project initiators and managers of the social and energy related needs of rural communities, how to adapt projects to meet these needs, and involvement of the communities in the design of projects. Failure of public involvement may be the most significant barrier. If projects fail to meet the local needs for which they are intended, such failures can impede renewable energy applications for decades. Rural community residents can ill afford unsuccessful experiments;

- Failure to get the prices right, particularly distorting the energy market when heavily subsidized traditional energy is compared to renewable energy options -- and the failure to value all resources on a life-cycle cost basis taking into account externality costs to society.

- Preference for known fossil resources over newer renewable resources by government, commercial and industrial officials responsible for making energy decisions and by banking and other financing officials;

- Discrimination against intermittent energy sources such as solar and wind power by pool power dispatchers, utilities and government procurement agencies, even though these resources often are available at peak times of power needs. Dispatchers often require commitments of availability with penalties for failure to comply that are unreasonable for intermittent resources. Utilities place unreasonable interconnection requirements such as excessive standby rates, cost recovery through fixed unavoidable charges which lengthen the payback period to intermittent r source providers, and exit fees charged the intermittent generator to compensate for stranded costs that are over-stated or even fictitious. Government agencies also often require excessively burdensome approval requirements for interconnection of intermittent resources. Dispatchers, utilities and government procurement regulators all usually fail to credit intermittent resources with the benefits they provide such as elimination of pollution emissions, prevention of power surges, fuel diversity and absence of fuel costs.

- Huge well-financed sales forces for traditional energy sources and frequently a financial stake by energy decision makers in these sources;

- Paucity of sales forces for renewable energy resources and lack of financial and political clout to promote them effectively;

- Lack of personnel trained in the installation, operation and maintenance of renewable energy equipment;

- Lack of knowledge and personnel trained in financing mechanisms available to support renewable energy projects;

- Import duties on renewable equipment and other barriers to foreign investment generally and as related to renewable energy resources; and

- The small amount of R&D effort and funding being devoted to improving renewable technologies.

Renewable energy resources require substantial up-front capital costs, but solar, wind, geothermal and small hydroelectric technologies achieve considerable savings from costless fuels, low maintenance requirements, and elimination of future fuel price and

availability risks.[29] For those technologies that are not yet commercially competitive, financing of initial capital costs is required in developing countries.

Despite this formidable list of constraints, renewable energy is the fastest growing energy supply resource in the world today.[30] The barriers listed can be and have been overcome. Today, small hydro, geothermal generation, biomass, wind farms, and photovoltaics in niche applications are well established technologically and sufficiently inexpensive to be competitive even in providing grid electricity in many countries and applications.[31]

V. MECHANISMS FOR RENEWABLE ENERGY IMPLEMENTATION

Many mechanisms have been successfully used around the world for achieving renewable energy utilization by both the public and private sectors and in both developed and developing countries and their municipalities. The mechanisms discussed include economic and market mechanisms, government procurement, utility regulatory measures and programs, standards, government-encouraged voluntary programs, and citizen suit enforcement. These measures are by no means mutually exclusive, and in many cases more than one mechanism has been applied.

A. *Education and Training*

Education is vital to inform the public, energy decision-makers, NGOs and the private sector about the available renewable energy options, their application and their costs and benefits. Such knowledge also is essential to build the political support necessary for enactment of appropriate legislative measures to promote renewable resource use. Education of the public really should start at the primary and secondary school levels and continue as a part of professional and technical training for those whose jobs will involve energy related-decisions.[32]

Education is particularly important for architects, engineers, builders, commercial enterprise managers, trades people, and government officials at all levels, to inform them of available economic renewable energy technologies and applications, and also of the requirements of laws that have been adopted to promote energy efficiency and renewable resources and of the costs and benefits of the measures they can take either voluntarily or pursuant to legal requirements.[33] It is important that retail sales staff, contractor installers and maintenance/service personnel understand the benefits of renewable technologies and that they can personally benefit from promoting these products to end users.

It is essential that technical staff be trained and available in sufficient quality and quantity to maintain and operate all renewable systems installed. Contracts with vendors should require provisions for inclusion of long term servicing and furnishing of spare parts. Failure to perform these training and servicing functions can discourage rather than promote renewable energy projects. Often the staff of equipment providers can provide some or all of this requisite training; but there must be rigorous government supervision of maintenance and operation training and performance of the systems where done by the private sector.

Much of the necessary renewable energy education must be conducted or contracted by governments that must create a legislative framework for this educational effort and appropriate or seek grants for the necessary funding. Governments also need to provide for staff to do mailings, conduct workshops and conferences, and do media education. As commercial enterprises learn of the economic advantages of renewable energy measures that can be profitable for them, they also will participate in the educational efforts. NGOs advocating for renewable energy measures can perform an important part of the educational effort; many international, national and local NGOs have created internet sites and listserves to inform advocates and the public of renewable and efficiency resource opportunities, advantages and costs. Political leaders can play an important educational role as well and governments can demonstrate technologies and set an example by installing renewable energy in their own facilities and vehicles, publicizing their use and requiring their procurement on government projects...

B. Assessment and Adaptation to Local Needs

No aspect of renewable energy promotion is more important than assessment of local needs, adaptation of projects to meet those needs and inclusion of local communities in design of projects. While these requisites may seem obvious, they are far too often overlooked – and not just for renewable projects. And while they may be burdensome, failure to involve the affected public in project planning and implementation are inevitably more burdensome. Too often well meaning international and national agencies, equipment suppliers, and project funders and promoters are ignorant about community needs, customs and cultures. They ignore local input to the peril not only of their projects but also to successful introduction of renewable resources throughout their countries and even regions.

Renewable energy can be an important instrument of advancing economic and social development in communities, but only if the projects are knowledgeably designed and carefully planned with full local input and cooperation. Particularly in poor rural areas, the costs of renewable energy projects will absorb a significant part of the small incomes of participants. They can not afford unsuccessful projects that may not only fail to meet development objectives, but also leave participants destitute.

The governments promoting renewable energy projects should institute absolute requirements of assessment of local needs and participation by local communities in the design of projects. All project designers, architects, engineers, suppliers, technical operation and maintenance personnel, educators, trainers, project funders, government officials, NGOs and others having a say in design and execution of renewable energy projects must be required to participate in such local assessment and participation efforts and should undergo training to prepare them adequately to meet these needs.

C. *Environmental Assessments & Disclosure*

One of the most effective means of promote renewable resources is adoption of a requirement for an environmental impact assessments or statements (EIS) for all major energy related projects. Such an EIS is required for all major "federal actions significantly affecting the quality of the human environment" by the National Environmental Policy Act of 1969 in the U.S.[34] The EIS must detail the environmental impacts of any proposed action; any adverse environmental effects, including cumulative impacts from other related projects (as with several polluting resources on the same body of water); alternatives that may have less environmental impacts than the proposed action; short vs. long term effects; and any irreversible commitments of resources. EIS assessments that do not conform to the Act must be subject to court challenge, a measure that has been very effective in assuring that the consequences of proposed actions be considered before they are implemented in the U.S...

More than 175 countries have enacted their own environmental impact assessment legislation and such assessments have been required in a number of international environmental treaties such as in Article 206 of the UN Convention on the Law of the Sea.[35] The World Bank and other multilateral banks require such assessments in evaluating support for projects.[36]

Also, a requirement for disclosure by utilities and industrial plants of their emissions and their sources can be very useful.[37] Information required typically includes the reporting of generation sources, fuel mix, fuel emissions, kWh price, price volatility, and contract terms. Market studies and polls consistently show that consumers want clean energy resources. In competitive retail markets, this disclosure requirement enables consumers to make informed decisions about the environmental consequences of their choice among suppliers, advantaging pollution-free renewable resources.

VI. ECONOMIC AND MARKET MECHANISMS – GETTING THE PRICES RIGHT

A. *Removal of Fossil Fuel and Nuclear Subsidies*

Legislation to repeal and remove subsidies for production and use of fossil fueled and nuclear power is the most direct measure to promote renewable energy. Subsidy removal not only is a costless measure, but by definition, it is a certain revenue enhancing one. In many countries fossil fuel subsidies amount to tens or more billions of dollars.[38] Global annual fossil fuel subsidies are estimated at about $250-300 billion in the mid-1990s, and that doesn't count the huge U.S. subsidies required to secure the supply of oil imports which has been estimated to produce a true oil cost of over $100 per barrel.[39] Revenues saved from subsidy-removal can be used to promote renewable energy alternatives internally.

The problem in achieving subsidy removal is political—recipients of subsidies usually are rich and powerful. They get addicted to the subsidies and feel they can not survive

without them. But these subsidies both encourage increased use of fossil and nuclear fuels and discourage the use of clean alternatives by making them less economically competitive.

Subsidies usually are granted by governments under the pretext of protecting domestic jobs, promoting use of domestic resources and protecting the poor from high energy prices. In fact, the subsidized traditional resources usually create fewer domestic jobs than renewable resources; they require very expensive imports of equipment and expert personnel, displacing funds available to invest in basic needs such as education, health care and the environment; and they do virtually nothing for the poor, being enacted under pressure from the wealthiest elements of society to reduce their energy costs. In developing countries, the poor do not even have electricity or automobiles and thus receive virtually no benefit from the subsidies.[40]

Developing countries like China are eliminating coal subsidies, downsizing coal production, and creating major renewable energy industries that can be exported worldwide. China's actions are particularly remarkable. Between 1990 and 1997, annual fossil fuel subsidies in China fell from $24.5 billion to $10 billion.[41] Coal subsidy rates fell from 61% in 1984 to 37% in 1990 to 29% in 1995, and further since then.[42] Petroleum subsidies fell from 55% in 1990 to 2% in 1995.[43] Over 40,000 coal mines were closed between 1999 and 2000.[44] However, to furnish the electricity required to fuel China's galloping economic growth, the Government now projects substantial increases in coal use despite the phase out of subsidies.

Poland has decreased its fossil fuel subsidies by $3 billion per year. These reductions led to an overall 30% decrease in the amount of coal used between 1987 and 1994. Since 1990, Russia has lowered fossil fuel subsidies by more than 50%. The United Kingdom decreased coal subsidies from $7 billion in 1989 to zero in 1995.[45]

The political difficulties of eliminating subsidies and the transition problems for local economies in fossil-producing countries can not be minimized. Nevertheless, countries as diverse as Brazil, China, the Czech Republic, India, the Netherlands, Poland, the United Kingdom and Russia have reduced or eliminated fossil subsidies successfully.[46] Eliminating fossil subsidies really is a sine qua non of promoting renewable resources.

B. *Inclusion of Externality Costs*

A legislative or regulatory requirement for consideration of externality costs can materially promote clean energy use. When the costs of fossil fuel use are compared to the costs of clean energy resources, the costs to society from fossil fuel emissions are generally ignored, thus effectively placing a zero value on these costs.[47] Numerous studies now have shown that these external costs are substantial, especially with respect to the increased incidence of human health problems and early mortality.[48] Some of these studies calculate that, in developed countries, the externality costs of burning coal for electricity can be greater than the generation costs.[49] In many developing countries, fossil fuels are used not only for vehicles electric power and commercial and industrial energy,

but also for the heating of homes and commercial buildings and for home cooking, posing horrific health threats because the pollution is in a confined area. No accurate assessment can be made of the comparative costs of clean energy without inclusion of externality costs.

C. *Use of Life-Cycle Costs*

The costs of introducing clean energy resources often entail substantial first cost capital investments, but the savings over the life of these resources make them cheaper compared to fossil fuel generation over time. This phenomenon is particularly evident with efficiency measures and with solar, hydroelectric and wind energy resources where the first cost of equipment acquisition can be considerable, but the total absence of fuel costs and very low maintenance costs result in their being much more economically competitive to fossil fuels over the anticipated life of their use.[50] The costs of fossil fuels should always be compared to efficiency and renewable resource costs on a life-cycle basis. Legislative or regulatory requirements for the utilization of life cycle costing are feasible and costless.

C. *Removing Investment and Import Restrictions*

In many developing countries there are high duties on import of equipment, including equipment required for renewable energy.[51] Such duties should be eliminated if renewable energy use is to be promoted. Many restrictions also exist on investment of foreign capital that need to be removed to create a climate encouraging investment. But wherever possible, local manufacture of renewable energy equipment should be encouraged, eliminating the need for imports altogether.

D. *Imposing Pollution Taxes*

Taxing pollutants or polluting fuels can be not only an effective way of promoting emission reductions in the marketplace, but also of making the polluters pay the externality costs of the damages to society from their pollution. They raise the price of emissions-intensive goods and lower profits for use of polluting fuels, thus allowing market forces to encourage adoption of renewable resources.

Taxing pollution that causes harm to society also makes far better sense for raising revenues than does taxing income and labor, the usual government revenue sources. Far better to discourage pollution that society seeks to avoid than to tax income and labor that society seeks to promote.

Taxation of polluting fuels is one of the most direct ways of promoting renewable resources.[52] Pollution taxes (including carbon emission taxes) have been imposed in Brazil, Denmark, Finland, Italy, Latvia/Lithuania, Sweden and the United Kingdom.[53]

Pollution taxes are politically difficult since inevitably some energy-intensive industries and jobs are affected. However, if the pollution taxes are offset by reductions in other

business taxes, they can produce a net economic benefit.[54] The political difficulty is illustrated by the fact that in a number of the countries that have legislated such taxes, major industries have been exempted to avoid competitive disadvantage to domestic production. Ideally, pollution taxes should be imposed internationally to eliminate adverse competitive effects. However, the competitive effects of pollution taxes can be ameliorated with border tariffs and rebates. An international tax on fossil fuels or on carbon dioxide emissions would be a good means of funding technology transfer and acquisition of sustainable energy resources by developing countries.

VII. PROMOTION MEASURES

A. *Technology Incentives*

While long-term subsidization of any fuel, technology or product distorts the market and is therefore undesirable if sustained, temporary subsidies to bring new technologies into the marketplace can be effective, useful, and often essential to accelerate their market acceptance. Also, where fossil fuel subsidies persist, non-fossil fuel subsidies are justifiable to level the playing field for them.

The Poland Efficient Lighting Project, financed by the Global Environment Fund (GEF) of the World Bank and administrated by the International Finance Corporation established a 3-year program to subsidize compact fluorescent lamp sales.[55] At the end of the program in 1997 some 1.6 million lamps had been installed and 97% of the buyers indicated intent to buy these efficient lights again, despite the termination of the subsidy.[56]

Germany has had great success with its Electricity Feed Law (EFL) subsidizing the purchase of renewable resources. EFL requires utilities to pay 90% of the retail residential price for electricity produced by wind, solar, hydropower and biomass resources.[57] For wind resources, the law also provides subsidies based on electricity output or capital costs. By the end of 1997, Germany had an installed wind capacity of 2,081 MW, the highest in the world. EFL also stimulated a 450% increase in photovoltaic installations from 1991 to 1997, with a 37% drop in prices. German companies such as Siemens now lead the world in PV sales. Germany has begun a 100,000 Roofs PV program, with low interest loans to be issued by private banks, which promises to be the largest single PV subsidy program in the world.[58]

Sweden used a competition among suppliers to encourage manufacturers to improve the efficiency of a wide variety of home appliances. The improved performance of the winning model of a refrigerator-freezer was remarkable, using more than 30% less electricity than the most efficient model then on the market. There have been similar successful competitions run by the U.S. Department of Energy under its “Golden Carrot” program discussed below.[59] Such competitions can be just as well used to promote renewable energy applications.

B. *Standards*

Standards are a particularly effective way of assuring that emission reductions will be achieved. They result in higher costs for polluting fossil fuels, thus promoting renewable energy applications. Standards for minimum efficiency performance of products like appliances, light fixtures, ballasts and electric motors are effective in removing from the marketplace the least efficient products.

Politically, standards can only be set where technological and economic feasibility has been demonstrated and where the businesses affected can be persuaded to agree to the level of control. They therefore generally represent minimum rather than maximum feasible efficiency achievements. Other incentives are required to reach maximum penetrations. Such incentives may include temporary subsidies, tax incentives, government procurements, information programs, labels and other measures discussed below. Also, many products involve rapid technological change so that standards become quickly obsolete. Regular updating of the standards is therefore required.

Standards also must be set with care as to their applicability. For example, it makes sense to require installation of compact fluorescent lamps only where usage is reasonably high; they may be uneconomic where lamps are only used a few hours a day. Also, it is difficult to use standards for new technologies that are still relatively unproven and costly, in which case information, incentive and R&D programs may be more appropriate. Lastly, standards are ineffective if not enforced, so regular reporting, inspections and enforcement mechanisms must be included, as well as training of the personnel who will be involved with their application.

However, standards are one of the most effective means of promoting renewable technologies if properly applied.

1. *Renewable Portfolio Standards and Goals*

In U.S. states and many countries, renewable portfolio standards have been adopted or are being considered. These standards require electric utilities to purchase a certain percentage of their power from renewable resources. At present fifteen U.S. states have adopted some form of renewable portfolio standard utility requirement.[60] Going even further, Massachusetts and Connecticut regulatory commissions have required a Generation Portfolio Standard requiring each distribution company to offer a mix of generation sources that will meet federal and state air pollution standards. [61] If such standards were to be widely adopted, they would allow mass production of renewable energy generation equipment, substantially reducing their costs, thus making them more competitive against fossil fuels.

The setting of formal goals for achievement of renewable energy expansion also can be helpful to spur implementation action. A number of countries have used this device. For example, Indonesia established a goal of providing 1 million solar homes and already has

delivered 200,000 systems towards this goal with the assistance of World Bank and Global Environmental Facility (GEF) loans.[62]

2. ***Pollution Standards***

Standards for air polluting emissions from power plants and tailpipe emissions from vehicles can be very effective in promoting renewable energy resources. The United States (through its Clean Air Act[63]), most European countries and many developing countries have adopted such standards. Power plant standards are usually adopted for emissions of sulfur dioxide, nitrogen oxides, particulates and sometimes mercury. These standards, make fossil fuels pay for their pollution externalities and thus encourage the use of cleaner alternatives such as renewables. Of course, the standards also reduce the health, mortality and environmental effects of air pollutants, so there is a double dividend. The costs in terms of more expensive electricity have been slight.

3. ***Building Codes and Standards***

Most countries and all U.S. states have adopted standards for construction of new buildings. Many have now included energy efficiency requirements in these building standards. All the IEA countries and many U.S. states have energy efficiency requirements as a part of their building codes and many recently are strengthening them.[64]

4. ***Standards' Enforcement***

Effective enforcement is critical to the success of any standards program. Theoretically, the governments adopting the standards should enforce them, and any standards program, to be effective, should incorporate substantial resources for training, inspection and enforcement. In practice, however, governments and their regulatory agencies often come to identify with the industries or companies that they regulate. Also, political pressures often prevent effective government enforcement. Citizen enforcement, adopted in the U.S. in the Clean Air Act[65] and most other U.S. environmental statutes has been found to be a most effective enforcement mechanism. NGOs in the U.S. are able to hold regulators' feet to the fire very effectively by filing suit to enforce standards, with the award of attorney's fees for such litigation; the very presence of citizen suit provisions enables the NGOs to influence government enforcement policies.

C. *Government Procurement*

All governments are major energy users. Legislation or regulation to require purchase by national, state and/or municipal governments of clean energy products and processes can do much to promote the use of renewable resources. Government procurements of green products also create markets to bring down their prices and set an example of the feasibility of their use for the private sector.

Governments also can aggregate procurements to make production of renewable energy technologies and other energy superior equipment more economic for manufacturers. The

International Energy Agency has sponsored a number of efficient technology procurement projects.

D. *Technology Transfer and Research, Development & Demonstration*

Government-sponsored research, development and demonstration projects (RD&D) in the U.S. have dramatically reduced the cost and increased the performance of renewable resources. For example, resulting technology improvements have reduced PV generation costs from $1.50/kWh in 1980 to a range of $.30-$.40/kWh today.[66]

For developing countries, technology transfer is a critical factor in enabling them to take advantage of renewable technologies used in industrialized countries. Technical assistance and education of key energy players is essential to success. There are many such efforts being conducted around the world sponsored by governments and international agencies.[67]

Improved technology offers great potential for developing countries to leapfrog to use of modern renewable technologies. They can adopt these cleaner technologies from the start, avoiding the economic and pollution costs of using more expensive traditional polluting fuels and then having to replace or retrofit them to meet pollution standards, as has been done in the industrialized countries.

One particularly successful effort has been the establishment of Energy Outreach Centers in the formerly planned economies of Eastern Europe and China, a project overseen by the U.S. Department of Energy's Pacific Northwest National Laboratory.[68] Start-up funding was provided by the U.S. Environmental Protection Agency and Department of Energy, the World Wildlife Fund, the Charles Steward Mott Foundation and the John D. and Catherine T. MacArthur Foundation, and uniquely, each of the centers has been successful in becoming self-funded after the initial project funding ended.[69] Some 250 local and international companies now participate in center projects. The centers partner with suppliers of modern renewable and energy efficient equipment and services and in-country collaborators. Six centers were established as not-for-profit, non-governmental independent entities in Poland, The Czech Republic, Russia, Bulgaria, China and The Ukraine. In the nine years since the first center was established they have achieved remarkable results in reforming local laws to promote energy efficiency and renewables and effectuate technology transfers.[70]

A few examples of Center successes: The Russian center helped develop the first regional level code for energy building construction incorporating energy efficiency and renewables; The Czech Center helped draft a national energy policy and legislation for energy labeling and standards provisions. The Polish center developed a program for utility energy efficiency and renewable investments. The Beijing Center provided expertise in instituting Integrated Resource Planning for a major utility. The centers have focused on policy reform, private sector assistance for joint energy technology and

service ventures, demonstration and training, and public education and information dissemination.[71]

E. *Recycling Programs*

Many countries today have laws providing for the recycling of their waste paper, glass and metal products. For example, in Denmark, half of all waste is recycled and 80% of new paper is made from used paper.[72] Almost every municipality in the U.S. has established a recycling program for paper, glass, plastic and metal wastes, with either curbside pickup or establishment of a central recycling municipal facility. Many businesses and institutions not required by law to do so recycle their waste products on a voluntary basis.

In the industrial and commercial sectors, the recycling of wastes also is economically and environmentally advantageous. For example, the U.S. throws away enough aluminum to rebuild the country's commercial aircraft fleet every three months, even though recycling aluminum takes 95% less energy than manufacturing it.[73] Interface, the world's largest carpet-tile maker, estimates it cuts its materials flow by about tenfold by leasing floor-covering services instead of selling carpets and by remanufacturing old carpets.[74] Land and coal mine gas recovery turns heat-trapping and hazardous methane emissions into the voluble fuel that also displaces fossil fueled power plants.[75]

F. Industry-Government Partnerships

Many industries recently have undertaken major programs to promote efficiency measures and renewable energy use, often in partnership with sponsoring governments on a shared funding basis.[76] Some of these efforts are in anticipation of Kyoto Protocol requirements and credits. Large international companies such as Dupont, Shell Oil, BP and others have instituted such programs.[77]

G. *Utility Programs and Regulatory Requirements*

1. *Utility Incentives*

Utilities in many states of the U.S. have been required by regulatory commissions to undertake integrated resource planning (IRP), including detailed assessment of the costs and benefits of renewable resource use.[78] The utilities are required to provide incentives to their customers to purchase energy efficiency and renewable resources where economically justified.[79]

In the U.S. states that have deregulated their utility generation, environmental advocates have been quite successful in getting utility regulators or legislators to impose a "systems benefit charge" on the distribution utility, which remains a regulated monopoly, to fund efficiency, renewable and other public benefit investments.[80] The revenues from these charges often are placed in independently administered public benefit funds. As of July 1999, fifteen U.S. states have adopted utility system benefit charges and benefit funds.[81]

2. *Utility Purchases*
A number of U.S. utilities have acquired renewable resources for their own use. For example, Pacific Gas and Electric Company (PG&E) uses 1,100 PV systems to produce a combined total of 44 MW of energy, the majority of which provides power for gas flow computers, automated gas meters, and water level sensors.

Utilities benefit by using PV systems that are often the most cost-effective solution for specialized applications because of their reliability, modularity, low maintenance, and independence from transmission and distribution systems. The systems have successfully powered small off-grid loads and have been installed on transmission towers and switching stations in place of transformers to handle small loads.[82]

3. *Green Marketing*
A number of U.S. utilities offer an option to customers to purchase a package of green generation products at a slight premium in cost. The programs are too new to have a good assessment of their effectiveness in reducing pollutants. Other countries such as The Netherlands have created a green pricing program permitting consumers to purchase renewables at a small premium.[83]

A particularly ingenious and promising "Green Power for a Green LA" program was announced in June of 1999 by the Los Angeles, California municipal utility. It commits to customers that choose a 6% rate increase (about $3 per month on average) to use the entire rate increase proceeds to invest in new renewable generation sources, combined with a commitment to install free energy efficiency measures for subscribers, assuring that participating customer bills will as a result experience a net decrease – a strong incentive for participation. Several thousand subscribers have selected this option. The utility president, David Freeman, one of the world's clean energy pioneers, has thus found a way to finance new renewable resources in a way which demonstrably will be at no cost to the customers, creating a unique win-win financing arrangement.[84]

VIII. FINANCING MECHANISMS

The financing of the renewable energy measures is of course vital to their achievement. While many of the measures undertaken are cost-effective in the long run, the capital investments needed for their accomplishment can be very great. A review of the methods that have been used to fund the capital costs of renewable energy projects therefore is important.

A. *Internal Resources*

1. Subsidy Removal, Pollution Taxes, Government and Utility Financing
As indicated previously, there are a number of financial resources that can be generated internally. The largest of these in most countries is removal of fossil fuel subsidies. Many

energy efficiency measures achieve such large savings over time as to provide very substantial revenue resources. Taxes on pollutants and fossil fuels have been used in many countries to help finance renewable energy measures. Emission trading rights have been utilized to lower the costs of pollution reduction measures. Governments have used general tax revenues to support efficiency and renewable programs and R &D for new technologies. They also have initiated programs to require purchase of renewable for their own use. And they have required their electric utilities to do integrated resource planning which includes efficiency and renewable resources and to assist customers in acquiring them.

2. ***Utility Programs Funded from Electricity Charges***

As mentioned earlier, many utilities in the U.S. have been required by state regulatory commissions to assist in the financing of energy efficiency and renewable resources for their customers. These programs were usually in the form of rebates for renewables and efficient equipment and energy audits of customers' homes or places of business.[85] In some cases, the utilities provided loan programs repayable by a charge on customer utility bills. Similar programs have been enacted in other countries.[86] In a few cases, the utility may act as retailer of renewable and energy efficiency equipment.

In many instances, renewable energy measures can be funded internally by electricity charges. Thus, Japan's successful 100,000 Roofs solar PV program was funded by electricity surcharges to pay one-third the installation costs of household PV systems, with utilities purchasing any excess power at retail electricity prices.[87]

Consumer incentives have the advantage of educating the end-user, putting the sponsor in direct contact with consumers and giving the sponsor recognition for promotion of efficient products. Manufacturer incentives can reduce paperwork and administrative costs and assist with transformation of the market by lowering the price of renewables and efficient projects and making them more widely accepted.

3. ***Commercial Loans***

Renewable projects such as biomass combustion/cogeneration, geothermal, hydropower and wind farms are considered to be mature, low risk and commercially ready technologies which have a reasonably established cost basis, and thus often have access to commercial lenders. However, renewable projects tend to have higher capita to operation and maintenance cost ratios than conventional systems and require longer-term debt financing, making them harder to finance. They also have difficulty establishing project cash flow because often their revenues are not secured by enforceable fuel supply or power purchase contracts. Also, it is difficult to get non-recourse financing because many of the suppliers are new and do not have extensive financial performance records.[88]

Nevertheless, commercial banks often do make loans to finance energy efficiency and renewable installations where the projects produce sufficient net revenues to justify commercial financing.[89]

The U.S. Department of Energy has joined with top finance firms to create the International Performance Measurement and Verification Protocol.[90] The Protocol standardizes streams of energy savings in buildings so that they can be aggregated and

securitized. The Protocol as of November 1997 had been adopted by more than 20 countries including Brazil, China, India, Mexico, Russia, the Ukraine and the U.S. The Protocol has been successful in stimulating a market in which loans to finance energy savings and use of renewables can be originated and can be affordably financed without use of internal capital or competition with other internal investment needs.[91]

4. ***Aggregated Loans***

One way to overcome the problems with small loans for distributed resources is to aggregate the loans in various ways; examples follow:

a. Installment Loans. An innovative credit arrangement to overcome these problems has been adopted by several countries, to make loans to credit-worthy institutions like local utilities which set up revolving funds to manage installment loans to individual and small business basis on relatively attractive terms. Such arrangements have been adopted in Indonesia for its Solar Home Systems Project, in India for a solar photovoltaic program, in Kenya for its wood stove upgrading program and for off-grid photovoltaic systems, and in Bangladesh, the Dominican Republic and Honduras.[92]

b. Micro Utilities. Another innovative mechanism is financing service providers with the creation of renewable energy micro utilities which sell energy services, permitting financing to be aggregated to the service provider, the end-user being required to make payments based on the level of energy services received. This approach has been successfully demonstrated in the Dominican Republic and is now being implemented in a 10,000 solar home system program by a rural electric cooperative in Bolivia; and mortgage financing, allowing homeowners to incorporate the costs of installing renewable systems into the overall costs of their homes through mortgage financing.[93] This approach is being tested in a rural housing/electrification program in South Africa.[94]

c. Grameen Bank. A particularly fascinating development is the creation of micro lending organizations in some of the poorest countries for their most impoverished populations. Thus, Grameen Bank ("village bank" in Bengali) in Bangladesh has started a lending program for people earning on average less than $1 a day. Today, Grameen is established in nearly 39,000 villages in Bangladesh, lending to approximately 2.4 million borrowers. Established in 1986, it reached its first $1 billion cumulative loans in 1995. It took only two more years to reach $2 billion. The repayment rate hovers between 96 and 100%. In a typical year, 5% of Grameen borrowers, representing 125,000 families, rise above the poverty level. The Grameen model has now been applied in 40 countries. In all, about 22 million poor people around the world now have access to small loans. Grameen has now established more than a dozen enterprises, often in partnership with other entrepreneurs. One such enterprise is Grameen Skakti (Energy) that has been helping to install solar energy systems in village households.[95]

5. ***Leasing Programs***

Leasing equipment is an innovative approach to overcoming the financing problems for small systems and to make them affordable. For example, the French government and France's largest utility developed the largest leasing program for compact fluorescent

lights (CFLs) on the island of Guadeloupe, seeking to reduce evening peak electricity demand. The leasing program's incentive was a coupon allowing customers to lease CFLs at no initial cost, the lease payments being identical to the electric bill savings. Thirty-four percent of all households redeemed the coupons for an average of 7.8 CFLs each.[96] This success stimulated an identical program for Martinique, which resulted in distribution of 345,000 CFLs in just a few months.[97] The two programs resulted in 7 MW of peak demand savings on each island and 29-33 GWh of annual electricity savings.[98] The same kinds of lease arrangements are appropriate for renewable resources. Thus, in the Dominican Republic, the U.S. company, Soluz operates a photovoltaic leasing program.[99]

6. ***Vendor Financing***

Sometimes equipment suppliers not only will construct, install and operate systems, but also offer equipment financing on favorable financing terms. A vendor may be the manufacturer, the wholesaler or retail distributor or a contractor. The vendor is motivated to offer financing in order to sell its equipment. The vendor often becomes the aggregator of capital demand for individual installations and may provide maintenance or warranty support, particularly with equipment leases, to assure the equipment remains in good working order.[100] A relatively new innovation is the bundling of vendor financing, combining the financing of renewable energy with the purchase of other related items such as farm equipment.

7. ***Performance Contracting***

Performance contracting, involving third party financing, has been widely used to finance energy efficiency and renewable projects in the U.S. and Europe.[101] The customer contracts with an Energy Service Company (ESCO) to provide the desired energy efficiency or renewable improvements, financing, and often other related services like operations and maintenance. The financing is repaid, at least in part, from savings achieved by the measures or equipment installed; often, the ESCO also participates in the savings. To date, ESCOs have not been very successful in the U.S., however, filling only niche efficiency applications for large industrial, commercial and institutional customers.[102] Adequate long-term financing for ESCO operations is critical, since the ESCO must put up initial capital that may not be paid off from savings for several years. ESCO financing is particularly important to establish ESCOs in developing countries.

8. ***Concessions***

A relatively new approach to the financing applications of renewable energy to rural populations not served or likely to be served by electric power grids is through "energy-service concessions granted by the government to a renewable energy developer for exclusive rights for sales in a designated area. This concession approach is being pioneered by the World Bank, UNDP and The Global Environment Facility. The World Bank has published a Working Paper on concession program case studies in six developing countries: Argentina, Benin, Bolivia, Cape Verde, Peru and Togo.[103]

The most extensive and developed program is the Programa de Abastecimiento Electrico de la Poblacion Rural Dispersa de Argentina, "PAEPRA". "The PAEPRA program aims

to supply electricity to 1.4 million rural residents (about 300,000 households) and more than 6,000 public facilities (e.g. schools and hospitals) through private rural energy-service concessions.[104] The World Bank said that 'this public/private partnership for the provision of electricity service to remote, low-income areas is unique in the world and considered internationally as a highly innovative approach to the problem."[105]

"Under PAEPRA, the provincial government sets tariffs for particular types of electricity services. A competitive tender is held, under which companies bid for a 15-year monopoly concession contract. Under the contract, the concessionaire is obligated to service all households and public facilities within the province at tariffs set by the provincial government (although concessionaires have the right to discontinue service if customers do not pay in a timely manner). Concessions receive subsidies from the provincial government; companies compete for this contract partly on the basis on how little subsidy they are willing to accept."[106]

The contemplated advantages of the concession approach are creation of a sufficient market to attract commercial participation by granting exclusive rights over a large area; attracting larger companies with their own sources of financing; ease of administration and regulation; ability for relatively quick delivery; potential for reducing equipment costs through volume purchasing, and to reduce transaction, operation and maintenance and overhead costs through economies of scale; and assurance of customer service over the 15-year period of the concession.

The projects in the other countries are similar in structure. In Benin and Togo there is a key difference in that the administering government agency purchases and owns the equipment and leases it to the concessions. The Cape Verde project contemplates encouragement of the formation of consortia of international firms experienced with off-grid rural energy supply working in partnership with local entities who will bid for concessions; the concessions are to act as agents for publicly owned equipment and are to supply installation and maintenance, set tariffs and provide for fee collection. Tariffs generally are set at approximately existing customer energy expenditures, sometimes scaled according to customer ability to pay with government subsidies providing the difference between tariffs and costs.

An essential element of all the concession arrangements is adoption of codes, standards and certifications to assure the quality of equipment and service and provision for supervision by a government designated regulatory authority. Service bundling has been encouraged by the World Bank with provision of other existing services such as water, communications, financial services or electronic sales and services. Participation by local residents in the design and implementation of projects is considered essential. Equipment may be purchased or leased. Governments may provide technical assistance for regulatory agencies re bidding, contracting, training, monitoring and regulation of concessions.[107] While concessions are promising, the projects are all too new to allow evaluation of results or useful comparison to other funding arrangements.

B. *External Resources*

In the past few years, the international lending organizations: the World Bank, regional banks, the International Financing Corporation (IFC), the UN Development Program (UNDP) and the UN Global Environmental Facility (GEF) have started major programs of financing energy efficiency and renewable projects in developing countries.[108] They must do more, but their resources will never be sufficient to meet developing country requirements. The capital requirement of electric power growth in developing countries has been estimated to be $1.7 trillion over the next two decades.[109] Unfortunately, the World Bank currently lends less than $4 billion per year to the energy sector, while commercial lending stands at about $16 billion per year (as of 1991).[110] It is clear that private and public internal sources also will be required if the need is to be met.

The World Bank and its sister international lending institutions, which had for many years made wasteful investments in highly capital-intensive energy inefficient traditional, polluting technologies, have started to change direction and are now making major funding available for energy efficiency and renewable technologies. For example, the World Bank has established the Asia Alternative Energy Unit (ASTAE) to develop only renewable and energy efficiency projects; ASTAE has helped the Bank to lend over $500 million for renewable projects in the Asia region.[111] The World Bank also financed a Renewable Energy Small Power Project in Indonesia, a component of which funds medium-scale/isolated grid systems there.[112] A World Bank Market Transformation Initiative loan of $5 million fosters a photovoltaic industry in Kenya that is selling over 20,000 systems annually with a 300kW capacity, and has already sold over 80,000 systems providing electricity for some 250,000 rural dwellers.[113]

Recent examples in other international financing institutions: The International Finance Corporation has recently launched a $100 million Renewable Energy and Energy Efficiency Fund.[114] And the Asian Development Bank approved a $100 million loan to the Indian Renewable Energy Development Agency for biomass cogeneration projects in India.[115] The Global Environmental Facility (GEF) donated $10 million to Argentina to assist Argentinean cooperatives in the removal of barriers to installation of windpower and solar photovoltaic development, including subsidies for equipment investment and technical assistance and studies.[116] GEF has been a major funder of renewable energy for developing countries, initiating many significant financing innovations such as establishment of a fund for small renewable project financing.

A problem that these international lending facilities have had to overcome is administering small loans because of the small size of many efficiency and renewable projects. They have started to assist in the creation of local and regional lending institutions to manage the smaller loans on their behalf.

C. *Kyoto Protocol Mechanisms*

Article 12 of the Kyoto Protocol provides for Emissions Trading, Joint Implementation, and a new Clean Development Mechanism (CDM) for encouraging industrial countries and companies to invest in greenhouse gas emission reductions in developing countries. By participating in these measures that generate greenhouse gas reductions in a developing country, an industrialized country or its companies can earn carbon emission reduction credits to meet the country's Kyoto protocol obligations.[117] Some companies have made such investments already in anticipation of the adoption of rules for utilization of these mechanisms under the Protocol and national credit legislation.[118]
These trading measures offer great promise of providing the means by which developing countries can acquire the resources needed by them to cover the up front costs of renewable energy technologies to promote sustained carbon dioxide emission reductions. These measures are vital to assure that these countries can acquire the necessary capital, information and training to permit them to participate fully in global warming solutions through the use of renewable and other clean energy resources.

***Clean Development Mechanism*.** The Clean Development Mechanism (CDM) is the most promising means for developing countries not targeted for emission reduction by the Protocol to acquire the resources and expertise necessary to promote renewable and other clean energy resources. The CDM provides carbon reduction credits to developed countries that are targeted for reductions, for investment in carbon reduction measures, including renewable energy resources, in non-targeted developing countries. It thus will provide a substantial incentive for developed countries and their industries to invest in renewables in developing countries.

Here, too, even during the process of adoption of the final Protocol rules for implementation of CDM measures, some developed countries and several of their industrial companies already have made CDM investments. The regulations to date for CDM implementation are very complex and costly; they will have to be streamlined to reach their full potential.

D. *Donor and Foundation Programs*

A number of countries and large corporations have been very generous in funding renewable energy programs in developing countries. As well, several charitable foundations in the U.S. have funded renewable energy efforts. For example, The MacArthur, Pew and Rockefeller Foundations joined together to create a new Energy Foundation about eight years ago... Several years ago it joined with the Packard Foundation to promote clean energy systems in China.[119] Winrock International has been a major initiator and funder of renewable energy projects.[120]

There are some problems with Foundation and other donor programs, however. A major World Bank study found that:

> "One important lesson emerging is that donations without any cost recovery destroy markets. Despite bad experience with unsustained use of donated renewable energy equipment in developing countries donors still are undermining markets with large capital cost subsidies and donated equipment."[121]

Another problem found is that when equipment is donated it can inhibit commercial markets by creating expectations of more donor aid. And donor-subsidized equipment can create perceptions that the renewable power is not commercial and requires continued donor aid. Also prices for the equipment can be increased because of the perception that the equipment is not commercial and requires donor aid. Further, the funding of equipment without provision for training, maintenance and spare parts can result in program failures.[122]

"Smart subsidies" have been advocated that are given only for a limited time duration to introduce new technology and "to build up initial market volume, local expertise, user awareness, appropriate technology adaptation, quality standards and entrepreneurial activities."[123] The study also found that subsidies based on operational performance are more effective than those based on capital investment.[124] Thus a successful Nepal biogas program provided subsidy payments for operational milestones over periods of up to three years. Recent GEF-funded renewable energy projects have adopted these approaches.[125]

IX. CONCLUSION

There are abundant examples, only a few of which have been identified here, in both developed and developing countries, of successful adoption of cost-effective renewable energy measures to ameliorate pollution while aiding their economies. A wide variety of legislative and voluntary programs have been undertaken and the legal and financial mechanisms for doing so also are many and varied. It is possible to meet the world's energy, development and environmental needs. This achievement can even be done on a basis of long term profitability. But achieving these goals will take determined action and political will among all the governments and international institutions of the world. For the developed countries and international institutions, achieving these goals will require a vast increase in the resources they devote to funding sustainable energy, technology transfer and education and training in the developing countries. For developing countries, achieving these goals will require an increased commitment to eliminating the barriers to adoption of sustainable energy measures and creating a climate and legislation to encourage private investment in them.

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[1] Martinot, E., *Global Renewable Energy Markets and Policies*, http://www.martinot.info/Martinot_NAR.pdf at p. 1...

[2] See www.johannesburgsummit.org/html/ documents/summit_docs/2309_**plan**final.htm.

[3] Martinot, *supra* note 1 at p. 1.

[4] The largest solar thermal project was constructed by Luz International, Ltd., which constructed nine (I-IX) Solar Electric Generating System (SEGS) plants in the Mojave Desert. Generation costs have decreased by more than half since building the first plant. The cost of the SEGS I plant was $62 million ($4,500/kW), generation costs were 24 cents/kWh (in 1988 real levelized dollars). Investing $3,400/kW in improving technology reduced the generation costs of SEGS III-VI to 12 cents/kWh; investing $2,875/kW reduced

costs further to between 8 and 10 cents/kWh for SEGS VIII and IX. Luz was able to finance the SEGS plants by raising over $1 billion and taking advantage of the available federal and state tax credits.

In the end, Luz International was forced to file for bankruptcy and turn over the SEGS plants to its investors. The following factors contributed to Luz's financial difficulties: the piecemeal fashion of extending energy tax credits for solar energy property, building SEGS IX in 7 months to obtain the tax credit, the fact that the credit could not be applied against the alternative minimum tax established in the 1986 Tax Reform Act, and the size limitation of PURPA's Qualifying Facility specifications for mandatory utility renewable purchases. *See Profiles in Renewable Energy: Case Studies of Successful Utility-Sector Projects,* National Renewable Energy Laboratory (Denver, Colorado 1999), *available at* http://www.nrel.gov/documents/profiles.html#luz.

[5] Ministry of Non-Conventional Energy Sources, India, *available at* http://mnes.nic.in/.

[6] TATA Energy Research Institute, Overview of Renewable Energy Sector in India, *available at* http://www.teriin.org/renew/overview.htm.

[7] *Id.*

[8] TATA Energy Research Institute, Estimated Potential and Installed Capacity of Major Renewable Energy Technologies in India, *available at* http://www.terrin.org/renew/estpot.htm.

[9] TATA Energy Research Institute, *supra* note 11.

[10] *Id.*

[11] *Id.*

[12] Y P Abbi, *Thermal power generation: Key issues in India*, TERI NEWSWIRE 7(19), 1-15 October 2001, *available at* http://www.teriin.org/features/art145.htm.

[13] UNITED NATIONS DEVELOPMENT PROGRAM, WORLD ENERGY ASSESSMENT (2000).

[14] Martinot, E. *et al*., *Renewable Eenrgy Markets in Developing Countries,* Annu. Rev. Energy Environ. 2002, 27:309–
348.

[15] "The largest existing markets for solar home systems are India (450,000), China (150,000),Kenya (120,000), Morocco (80,000),Mexico (80,000), and South Africa (50,000). Kenya and China are probably the fastest growing markets, with annual growth rates of 10%–20% in recent years. Other notable emerging markets include Argentina, Bangladesh, Botswana, Bolivia, Brazil, Dominican Republic, Indonesia, Namibia, Nepal, Philippines, Sri Lanka, Tunisia, and Zimbabwe. Many of the components for solar home systems—such as batteries, controllers, and lights—are manufactured in these countries. Often local systems integrators adapt and match components to suit local conditions. PV module manufacturers now exist in India (23 firms), China (7 firms), Thailand (3 firms), and Namibia (1 firm). PV cells are manufactured in India (9 firms) and China (7 firms)."
Id at pp. 315, 316.

[16] TATA Energy Research Institute, Solar Thermal Technology, *available at* http://www.teriin.org/renew/tech/solth/about.htm.

[17] Martinot *supra* note 14 at p. 315.
[18] Fredrik Lundberg, *PV Lighting,* International Association for Energy-Efficient Lighting (IAEEL) Newsletter, February, 1996, *available at*

http://www.iaeel.org/IAEEL/NEWSL/1996/tva1996/LiRen_a_2_96.html.

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[29] UNITED NATIONS DEVELOPMENT PROGRAM, WORLD ENERGY ASSESSMENT (2000).

[30] Lovins, *supra* note 9, at 8.

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[32] For a homespun example of the importance of public education to a successful renewable energy program in Chile, see http://wwww.changemakers.net/journmal/03may/bornstein.cfm.

[33] The usual means of compensating architects and engineers worldwide, as a percentage of building and equipment costs, has the perverse incentive of discouraging least cost solutions. It has been estimated that this incentive design has led the U.S. to misallocate about $1 trillion in air conditioning equipment and the energy needed to operate it than had the buildings been optimally designed to produce the same or better comfort at least cost. Lovins, *supra* note 8, at 18.

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