RENEWABLES 2005

GLOBAL STATUS REPORT

REN21 Renewable Energy Policy Network for the 21st Century
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Renewable Energy Policy Network for the 21st Century

REN21 is a global policy network aimed at providing a forum for international leadership on renewable energy. Its goal is to allow the rapid expansion of renewable energies in developing and industrial countries by bolstering policy development and decision making on sub-national, national, and international levels.

Open to all relevant and dedicated stakeholders, REN21 is a network of the capable and the committed which creates an environment in which ideas and information are shared and cooperation and action are encouraged to promote renewable energy worldwide. REN21 connects governments; international institutions and organizations; partnerships and initiatives; and other stakeholders on the political level with those "on the ground." REN21 is not an actor itself but a set of evolving relationships oriented around a commitment to renewable energy.

The establishment of a global policy network was embraced in the Political Declaration of the International Conference for Renewable Energies, Bonn 2004 (Renewables 2004), and formally launched in Copenhagen in June 2005.

REN21 Steering Committee

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(*) Full notes and references are available on the REN21 Web site, www.ren21.net.

EXECUTIVE SUMMARY

This report provides an overview of the status of renewable energy worldwide in 2005. It covers markets, investments, industries, policies, and rural (off-grid) renewable energy in developing countries. By design, the report does not provide analysis, recommendations, or conclusions. An extensive research and review process over several months involving more than 100 researchers and contributors has kept inaccuracies to a minimum. REN21 sees this report as the beginning of an active exchange of views and information.

This report reveals some surprising facts about renewable energy, many reflecting strong growth trends and increasing significance relative to conventional energy.

- About $30 billion was invested in renewable energy worldwide in 2004 (excluding large hydropower), a figure that compares to conventional power sector investment of roughly $150 billion. Investment in large hydropower was an additional $20–25 billion, mostly in developing countries.
- Renewable power capacity totals 160 gigawatts (GW) worldwide (excluding large hydropower), about 4 percent of global power sector capacity. Developing countries have 44 percent of this capacity, or 70 GW.
- Renewable energy generated as much electric power worldwide in 2004 as one-fifth of the world's nuclear power plants, not counting large hydropower (which itself was 16 percent of the world's electricity).
- The fastest growing energy technology in the world is grid-connected solar photovoltaic (PV), which grew in existing capacity by 60 percent *per year* from 2000–2004, to cover more than 400,000 rooftops in Japan, Germany, and the United States. Second is wind power capacity, which grew by 28 percent per year, led by Germany, with almost 17 GW installed as of 2004.
- Rooftop solar collectors provide hot water to nearly 40 million households worldwide, most of these in China, and more than 2 million geothermal heat pumps are used in 30 countries for building heating and cooling. Even so, biomass-fueled heating provides five times more heat worldwide than solar and geothermal combined.
- Production of biofuels (ethanol and biodiesel) exceeded 33 billion liters in 2004, about 3 percent of the 1,200 billion liters of gasoline consumed globally. Ethanol provided 44 percent of all (non-diesel) motor vehicle fuel consumed in Brazil in 2004 and was being blended with 30 percent of all gasoline sold in the United States.
- There were more than 4.5 million green power consumers in Europe, the United States, Canada, Australia, and Japan in 2004, purchasing power voluntarily at the retail level or via certificates.
- Direct jobs worldwide from renewable energy manufacturing, operations, and maintenance exceeded 1.7 million in 2004, including some 0.9 million for biofuels production.
- Renewable energy, especially small hydropower, biomass, and solar PV, provides electric power, heat, motive power, and water pumping for tens of millions of people in rural areas of developing countries, serving agriculture, small industry, homes, schools, and other community needs. Sixteen million households cook and light their homes with biogas, and two million households use solar lighting systems.

Policies to promote renewables have mushroomed over the past few years. At least 48 countries worldwide now have some type of renewable energy promotion policy, including 14 developing countries. By 2005, at least 32 countries and 5 states/provinces had adopted feed-in policies, more than half of which have been enacted since 2002. At least 32 states or provinces have enacted renewable portfolio standards (RPS), half of these since 2003, and six countries have enacted national renewable portfolio standards since 2001. Some type of direct capital investment subsidy, grant, or rebate is offered in at least 30 countries. Most U.S. states and at least 32 other countries offer a variety of tax incentives and credits for renewable energy. The U.S. federal production tax credit has applied to more than 5.4 GW of wind power installed since 1995.

Policy targets for renewable energy exist in at least 45 countries worldwide, including 10 developing countries, all 25 European Union (EU) countries, and many states/provinces in the United States and Canada. Most targets are for shares of electricity production, typically 5–30 percent, by the 2010–2012 timeframe. There is an EU-wide target of 21 percent of electricity production by 2010. China's target of 10 percent of total power capacity by 2010 (excluding large hydropower) implies 60 GW of renewables capacity by 2010, up from today's 37 GW.

Municipalities around the world are also setting targets for future shares of renewable energy for government consumption or total city consumption, typically in the 10–20 percent range. Some cities have established CO_2-reduction targets. Many cities are enacting a variety of policies for promoting solar hot water and solar PV, and conducting urban planning that incorporates renewable energy.

Brazil has been the world leader in promoting biofuels for the past 25 years. All gasoline sold must be blended with ethanol, and all gas stations sell both pure ethanol and ethanol blends. In addition to Brazil, mandates for blending biofuels into vehicle fuels have been enacted in at least 20 states/provinces worldwide and two countries (China and India).

Renewable energy has become big business. Large commercial banks are starting to take notice, and several are "mainstreaming" renewable energy investments in their lending portfolios. Other large investors are entering the renewable energy market, including venture capital investors and leading investment banks like Morgan Stanley and Goldman Sachs. Major investments and acquisitions have been made in recent years by leading global companies, such as GE, Siemens, Shell, BP, Sanyo, and Sharp. Five of the largest electrical equipment and aerospace companies in China have decided to enter the wind power business. Combined, 60 leading publicly-traded renewable energy companies, or renewable energy divisions of major companies, have a market capitalization of at least $25 billion.

Half a billion dollars goes to developing countries each year as development assistance for renewable energy projects, training, and market support, with the German Development Finance Group (KfW), the World Bank Group, and the Global Environment Facility (GEF) providing the majority of these funds, and dozens of other donors and programs providing the rest.

Government support for renewable energy was on the order of $10 billion in 2004 for the United States and Europe combined, including direct support ("on-budget") and support from market-based policy mechanisms ("off-budget"). This includes more than $700 million per year in research and development spending.

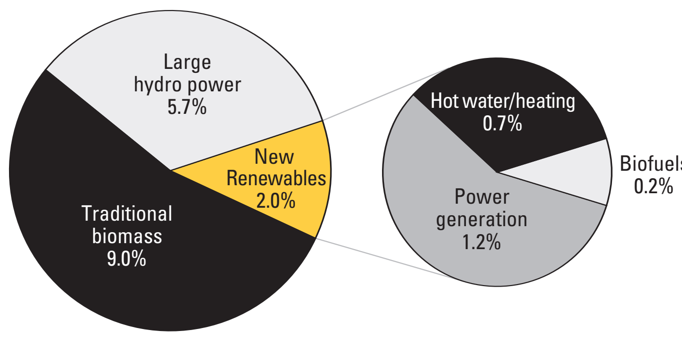
The costs of many renewable energy technologies are declining with technology improvements and economies of scale in production. Solar and wind power costs are now half what they were 10–15 years ago. Many renewable technologies can compete with retail and even wholesale prices of conventional energy under good conditions, even as conventional technology costs also decline (offset by increased fuel prices).

Market facilitation organizations (MFOs) are supporting the growth of renewable energy markets, investments, industries, and policies through some combination of networking, information exchange, market research, training, partnering, project facilitation, consulting, financing, policy advice, and other technical assistance. A preliminary list shows at least 150 such organizations around the world, including industry associations, non-governmental organizations, multilateral and bilateral development agencies, international partnerships and networks, and government agencies.

1. GLOBAL MARKET OVERVIEW

Renewable energy supplies 17 percent of the world's primary energy, counting traditional biomass, large hydropower and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels).*† (See Figure 1.) Traditional biomass, primarily for cooking and heating, represents about 9 percent and is growing slowly or even declining in some regions as biomass is used more efficiently or replaced by more modern energy forms. Large hydropower is slightly less than 6 percent and growing slowly, primarily in developing countries.‡ New renewables are 2 percent and growing very rapidly in developed countries and in some developing countries. Clearly, each of these three forms of renewable energy is unique in its characteristics and trends. This report focuses primarily on new renewables because of their large future potential and the critical need for market and policy support in accelerating their commercial use.§[N1, N2]**

Figure 1. Renewable Energy Contribution to Global Primary Energy, 2004



Renewable energy competes with conventional fuels in four distinct markets: power generation, hot water and space heating, transport fuels, and rural (off-grid) energy. (See Table 1.) In power generation, renewable energy comprises about 4 percent of power-generating capacity and supplies about 3 percent of global electricity production (excluding large hydropower). Hot water and space heating for tens of millions of buildings is supplied by solar, biomass, and geothermal. Solar thermal collectors alone are now used by an estimated 40 million households worldwide. Biomass and geothermal also supply heat for industry, homes, and agriculture. Biomass transport fuels make small but growing contributions in some countries and a very large contribution in Brazil, where ethanol from sugar cane now supplies 44 percent of automotive (non-diesel) fuel consumption for the entire country. In developing countries, 16 million households cook and light their homes from biogas, displacing kerosene and other cooking fuel; more than 2 million households light their homes with solar PV; and a growing number of small industries, including agro-processing, obtain process heat and motive power from small-scale biogas digesters.††[N3]

The fastest growing energy technology in the world has been grid-connected solar PV, with total existing capacity increasing from 0.16 GW at the start of 2000 to 1.8 GW by the end of 2004, for a 60 percent average annual growth rate during the five-year period. (See Figures 2 and 3, page 8.)

* Unless indicated otherwise, the use of "renewable energy" in this report refers to "new" renewables. There is no universally accepted definition of renewable energy, but referring to "new" renewables as "renewable energy" in written work is a generally accepted semantic practice. For example, BP in its annual statistical review of world energy defines "renewable energy" to exclude large hydro. And the landmark International Energy Agency book *Renewables for Power Generation* (2003) also excludes large hydro. Common practice is to define large hydro as above 10 MW, although small hydro statistics in this report include plants up to 50 MW in China and 30 MW in Brazil, as these countries define and report small hydro based on those thresholds.

† Depending on the methodology for how large hydro and other renewable power generation technologies are counted in the global energy balance, renewables' total contribution to world primary energy can also be reported as 13–14 percent rather than 17 percent. The basic issue is whether to count the energy value of equivalent primary energy or of the electricity; see Note 2 [N2] for further explanation.

‡ "Developing country" is not an exact term, but refers generally to a country with low per-capita income. One metric is whether it qualifies for World Bank assistance. Developing countries in this report are non-OECD countries plus OECD members Mexico and Turkey, but excluding Russia and other formerly planned economies in transition.

§ This report covers only renewable energy technologies that are in commercial application on a significant global scale today. Many other technologies are showing commercial promise for the future or are already being employed in limited quantities on a commercial basis, including active solar cooling (also called "solar assisted air conditioning of buildings"), concentrating solar electric power (with Fresnel lenses), ocean thermal energy conversion, tidal power, wave power, hot dry/wet rock geothermal, and cellulose-derived ethanol. Solar cookers were reportedly in use by almost one million households but data on current trends were not readily available. In addition, passive solar heating and cooling is a commercially proven and widespread building design practice, but is not covered in this report. Future editions of this report could cover more of these technologies and practices.

** Notes and references for this report are designated in brackets following the paragraph to which they refer, e.g. [N1]. Full notes and references can be found on the REN21 Web site, at www.ren21.net/globalstatusreport.

†† Solar PV for off-grid includes residential, commercial, signal and communications, and consumer products. In 2004 globally, there were 70 MW used for consumer products, 80 MW used for signal and communications, and 180 MW used for residential and commercial off-grid applications.

During the same period, other renewable energy technologies grew rapidly (annual average) as well: wind power 28 percent (see Figure 4, page 9), biodiesel 25 percent, solar hot water/heating 17 percent, off-grid solar PV 17 percent, geothermal heat capacity 13 percent, and ethanol 11 percent. Other renewable energy power generation technologies, including biomass, geothermal, and small hydro, are more mature and growing by more traditional rates of 2–4 percent per year. Biomass heat supply is likely growing by similar amounts, although data are not available. These growth rates compare with annual growth rates of fossil fuel-based electric power capacity of typically 3–4 percent (higher in some developing countries), a 2 percent annual growth rate for large hydropower, and a 1.6 percent annual growth rate for nuclear capacity during the three year period 2000–2002.[N3]

Existing renewable electricity capacity worldwide totaled 160 GW in 2004, excluding large hydro. (See Figure 5, page 9.) Small hydro and wind power account for two-thirds of this capacity. This 160 GW compares to 3,800 GW installed capacity worldwide for all power generation. Developing countries as a group, including China, have 70 GW (44 percent) of the 160 GW total, primarily biomass and small hydro power. The European Union has 57 GW (36 percent), a majority of which is wind power. The top five individual countries are China (37 GW), Germany (20 GW), the United States (20 GW), Spain (10 GW), and Japan (6 GW).[N4, N5]

Large hydropower remains one of the lowest-cost energy technologies, although environmental constraints, resettlement impacts, and the availability of sites have limited further growth in many countries. Large hydro supplied 16 percent of global electricity production in 2004, down from 19 percent a decade ago. Large hydro totaled about 720 GW worldwide in 2004 and has grown historically at slightly more than 2 percent per year (half that rate in developed countries). Norway is one of several countries that obtain virtually all of their electricity from hydro. The top five hydropower producers in 2004 were Canada (12 percent of world production), China (11.7 percent), Brazil (11.4 percent), the United States (9.4 percent), and Russia (6.3 percent). China's hydro growth has kept pace with its rapidly growing power sector. China installed nearly 8 GW of large hydro in 2004 to become number one in terms of installed capacity (74 GW). Other developing countries also invest significantly in large hydro, with a number of plants under construction.

Small hydropower has developed worldwide for more than a century. More than half of the world's small hydropower capacity exists in China, where an ongoing boom in small hydro construction added nearly 4 GW of capacity in 2004. Other countries with active efforts include Australia, Canada, India, Nepal, and New Zealand. Small hydro is often used in autonomous (not grid-connected) village-

Table 1. Renewable Energy Indicators

Indicator	Existing Capacity End of 2004	Comparison Indicators
Power generation	**(GW)**	
Large hydropower	720	World electric power capacity=3,800
Small hydropower	61	
Wind turbines	48	
Biomass power	39	
Geothermal power	8.9	
Solar PV, off-grid	2.2	
Solar PV, grid-connected	1.8	
Solar thermal power	0.4	
Ocean (tidal) power	0.3	
Total renewable power capacity (excluding large hydropower)	160	
Hot water/space heating	**(GWth)**	
Biomass heating	220	
Solar collectors for hot water/heating (glazed)	77	
Geothermal direct heating	13	
Geothermal heat pumps	15	
Households with solar hot water	40 million	Total households worldwide=1,600 million
Buildings with geothermal heat pumps	2 million	
Transport fuels	**(liters/yr)**	
Ethanol production	31 billion	Total gasoline production=1,200 billion
Biodiesel production	2.2 billion	
Rural (off-grid) energy		
Household-scale biogas digesters	16 million	Total households off-grid=360 million
Small-scale biomass gasifiers	n/a	
Household-scale solar PV systems	2 million	
Solar cookers	1 million	

power applications to replace diesel generators or other small-scale power plants or to provide electricity for the first time to rural populations. In the last few years, more emphasis has been put on the environmental integration of small hydro plants into river systems in order to minimize environmental impacts, incorporating new technology and operating methods.

Wind power markets are concentrated in a few primary countries, with Spain, Germany, India, the United States, and Italy leading expansion in 2004. (See Figure 6, page 10.) Several countries are now taking their first steps to develop large-scale commercial markets, including Russia and other transition countries, China, South Africa, Brazil, and Mexico. In the case of China, most wind power investments historically have been donor- or government-supported, but a shift to private investment has been underway in recent years. Several other countries are at the stage of demonstrating wind farm installations, looking to develop commercial markets in the future.[N6]

Offshore wind power markets are just emerging. About 600 MW of offshore wind exists, all in Europe. The first large-scale offshore wind farm (170 MW) was completed in 2003 in Denmark, and ambitious plans exist for over 40 GW of development in Europe, particularly in Germany, the Netherlands, and the United Kingdom.[N6]

Biomass electricity and heat production is slowly expanding in Europe, driven mainly by developments in Austria, Finland, Germany, and the United Kingdom. A boom in recent years in converting waste wood in Germany is now levelling off, as the resource base is mostly used. The United Kingdom has seen recent growth in "co-firing" (burning small shares of biomass in coal-fired power plants). Continuing investments are occurring in Denmark, Finland, Sweden, the United States, and several other OECD countries. The use of biomass for district heating and combined heat-and-power has been expanding in some countries, including Austria and Germany. In Sweden, biomass supplies more than 50 percent of district heating needs. Among developing countries, small-scale power and heat production from agricultural waste is common, for example from rice or coconut husks. The use of sugar cane waste (bagasse) for power and heat production is significant in countries with a large sugar industry, including Brazil, Columbia, Cuba, India, the Philippines, and Thailand. Increasing numbers of small-scale biomass gasifiers are finding application in rural areas (and there are also demonstrations of biomass gasification for use in high-efficiency combined-cycle power plants in developed countries). Interest in bioenergy "coproduction," in which both energy and non-energy outputs (for example, animal feed or industrial fiber) are produced in an integrated process, is also growing.[N6]

Like small hydro, geothermal energy has been used for electricity generation and heat for a century. There are at least 76 countries with geothermal heating capacity and 24 countries with geothermal electricity. More than 1 GW of geothermal power was added between 2000 and 2004, including significant increases in France, Iceland, Indonesia, Kenya, Mexico, the Philippines, and Russia. Most of the geothermal power capacity in developed countries exists in Italy, Japan, New Zealand, and the United States.[N6]

Geothermal direct-heat utilization capacity nearly doubled from 2000 to 2005, an increase of 13 GWth, with at least 13 new countries using geothermal heat for the first time. Iceland leads the world in direct heating, supplying some 85 percent of its total space-heating needs from geothermal. Turkey has increased its geothermal direct-heating

Figure 2. Average Annual Growth Rates of Renewable Energy Capacity, 2000–2004

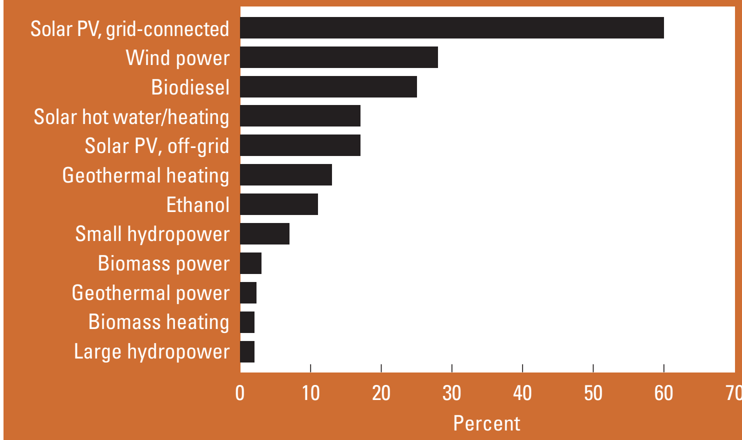


Figure 3. Solar PV, Existing World Capacity, 1990–2004

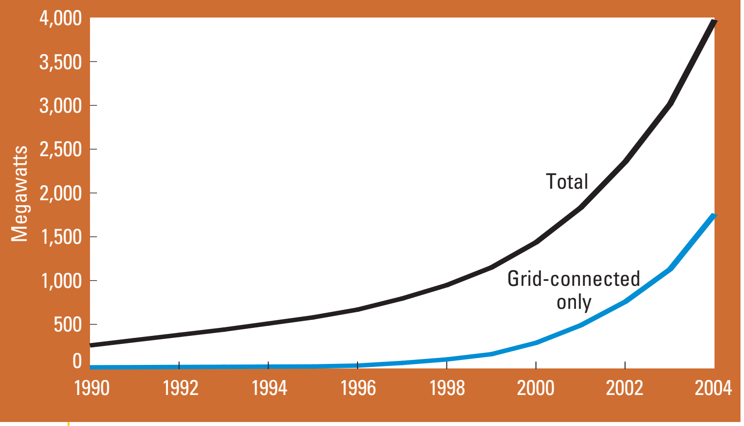


Figure 4. Wind Power, Existing World Capacity, 1990–2004

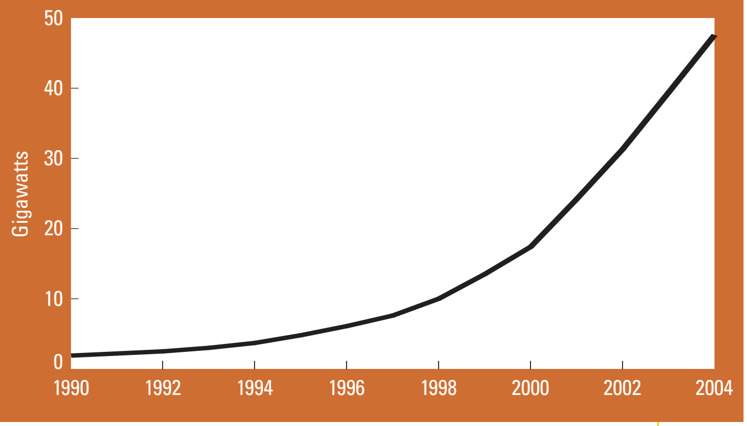
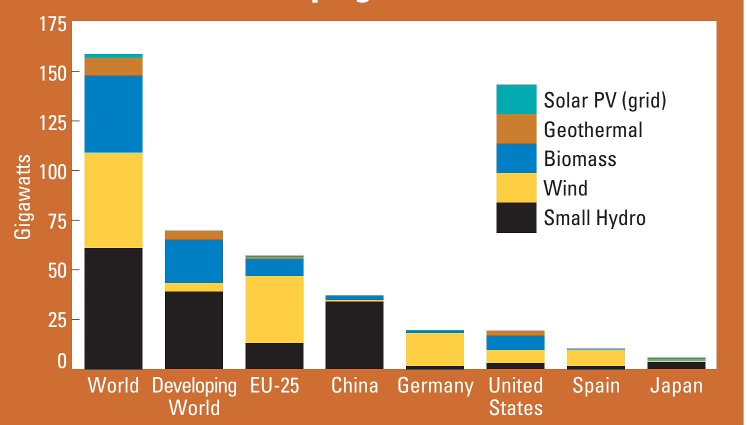


Figure 5. Renewable Power Capacities, EU,Top 5 Countries, and Developing World, 2004



capacity by 50 percent since 2000, which now supplies heat equivalent to the needs of 70,000 homes. About half of the existing geothermal heat capacity exists as geothermal heat pumps, also called ground source heat pumps. These are increasingly used for heating and cooling buildings, with nearly 2 million heat pumps used in over 30 countries, mostly in Europe and the United States.

Grid-connected solar PV installations are concentrated in three countries: Japan, Germany, and the United States, driven by supportive policies. By 2004, more than 400,000 homes in these countries had rooftop solar PV feeding power into the grid. This market grew by about 0.7 GW in 2004, from 1.1 GW to 1.8 GW cumulative installed capacity. Around the world, there are also a growing number of commercial and public demonstrations of building-integrated solar PV. Typical examples include a subway station (100 kW), gas station (30kW), solar PV manufacturing plant (200kW), fire station (100kW), city hall (50kW), exhibition hall (1000 kW), museum (10kW), university building (10kW), and prison (70kW).[N7]

The concentrating solar thermal power market has remained stagnant since the early 1990s, when 350 MW was constructed in California due to favorable tax credits. Recently, commercial plans in Israel, Spain, and the United States have led a resurgence of interest, technology evolution, and potential investment. In 2004, construction started on a 1 MW parabolic trough in Arizona, the first new plant anywhere in the world since the early 1990s. Spain's market is emerging, with investors considering two 50 MW projects in 2005. Some developing countries, including India, Egypt, Mexico, and Morocco, have planned projects with multilateral assistance, although the status of some of these projects remains uncertain.

Solar hot water/heating technologies are becoming widespread and contribute significantly to the hot water/heating markets in China, Europe, Israel, Turkey, and Japan. Dozens of other countries have smaller markets. China accounts for 60 percent of total installed capacity worldwide. (See Figure 7, page 10, and Figure 8, page 11). The European Union accounts for 11 percent, followed by Turkey with 9 percent and Japan with 7 percent (all figures are for glazed collectors only). Total sales volume in 2004 in China was 13.5 million square meters, a 26-percent increase in existing capacity. Vacuum tube solar water heaters now dominate the Chinese market, with an 88-percent share in 2003. In Japan, existing solar hot capacity continues to decline, as new installations fall short of retirements. In Europe, about 1.6 million square meters was installed in 2004, partly offset by retirements of older existing systems. The 110 million square meters of installed collector area (77 GWth of heat production capacity) worldwide translates into almost 40 million households worldwide now using solar hot water. This is 2.5 percent of the roughly 1,600 million households that exist worldwide.*[N8]

Space heating from solar is gaining ground in several countries, although the primary application remains hot water. In Sweden and Austria, more than 50 percent of the annually-installed collector area is for combined hot water and space heating systems. In Germany, the share of com-

* Solar hot water/heating is commonly called "Solar Heating and Cooling" to emphasize that solar cooling (solar-assisted air conditioning) is also a commercial technology. This report uses solar hot water/heating because hot water alone constitutes the vast majority of installed capacity. Some capacity worldwide, particularly in Europe, does serve space heating, although space heating is a small share of total heat even in combined systems. Solar cooling is not yet in widespread commercial use but many believe its future is promising.

bined systems is 25–30 percent of the annual installed capacity. Less than 5 percent of systems in China provide space heating in addition to hot water.

Biofuels production of 33 billion liters in 2004 compares with about 1,200 billion liters annually of gasoline production worldwide. (See Figure 9, page 11.) Brazil has been the world's leader (and primary user) of fuel ethanol for more than 25 years. It produced about 15 billion liters of fuel ethanol in 2004, contributing slightly less than half the world's total. All fueling stations in Brazil sell both pure ethanol (E95) and gasohol, a 25-percent ethanol/75-percent gasoline blend (E25). In 2004, almost as much ethanol as gasoline was used for automobile (non-diesel) fuel in Brazil; that is, ethanol blended into gasohol or sold as pure ethanol accounted for 44 percent of total automobile fuel sold in Brazil. Demand for ethanol fuels, compared to gasoline, was very strong in 2005. In recent years, significant global trade in fuel ethanol has emerged, with Brazil being the leading exporter. Brazil's 2.5 billion liters of ethanol exports accounted for more than half of global trade in 2004.[N9]

Brazil's transport fuels and vehicle markets have evolved together. After a sharp decline in the sales of pure-ethanol vehicles during the 1990s, sales were climbing again in the early 2000s, due to a significant decline in ethanol prices, rising gasoline prices, and the introduction of so-called "flexible fuel" cars by automakers in Brazil. These cars can operate on either pure ethanol or ethanol/gasoline blends. By 2003, these cars were being offered by most auto manufacturers at comparable prices to pure ethanol or gasohol cars. Flexible-fuel cars have been widely embraced by drivers, some out of concern for fuel-supply uncertainties (such as an ethanol shortage that happened in 1989 or future oil shocks). Sales increased rapidly, and by 2005 more than half of all new cars sold in Brazil were flex-fuel cars.[N10]

The United States is the world's second-largest consumer and producer of fuel ethanol. The growth of the U.S. market is a relatively recent trend; ethanol production capacity increased from 4 billion liters per year in 1996 to 14 billion liters per year in 2004. Recent annual growth has been in the 15–20 percent range. By 2005, there were nearly 400 fueling stations (mostly in the upper Midwest) that sold E85, an 85-percent ethanol/15-percent gasoline blend, and many more selling gasohol (E10). By 2005, about 3 percent of the 140 billion gallons of vehicle fuel (non-diesel) consumed annually in the U.S. was ethanol. In addition, 30 percent of all gasoline sold in the United States was being blended with ethanol (E10) as a substitute oxygenator for MTBE (methyl tertiary-butyl ether), which more and more states were requiring be discontinued. Other countries producing fuel ethanol include Australia, Canada, China, Columbia, the Dominican Republic, France, Germany, India, Jamaica, Malawi, Poland, South Africa, Spain, Sweden, Thailand, and Zambia.[N9]

Figure 6. Wind Power Capacity, Top 10 Countries, 2004

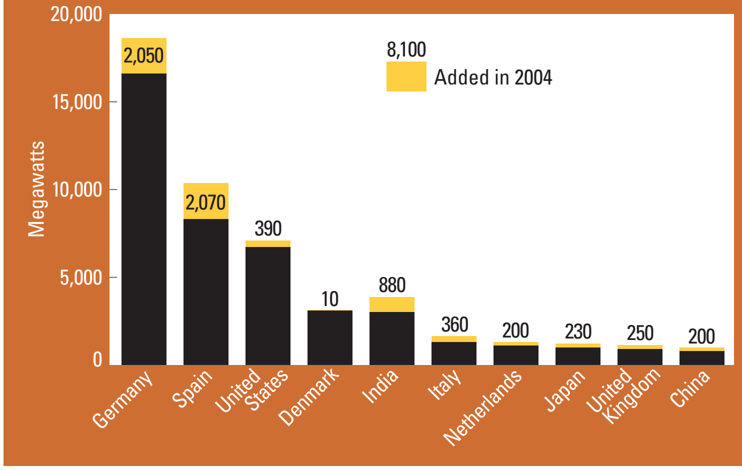
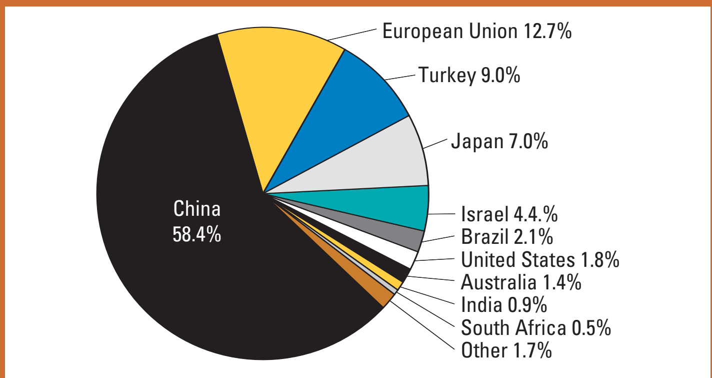


Figure 7. Share of Existing Solar Hot Water/Heating Capacity, Selected Countries, 2004



Biodiesel production grew by 50 percent in Germany in 2004, bringing total world production to more than 2 billion liters. Pure biodiesel (B100) in Germany enjoys a 100-percent fuel-tax exemption, and the country now has over 1,500 fueling stations selling B100. Other primary biodiesel producers are France and Italy, with several other countries producing smaller amounts, including Austria, Belgium, the Czech Republic, Denmark, Indonesia, Malaysia, and the United States. Several countries are planning to begin biodiesel production or to expand their existing capacity in the coming few years.[N9]

Costs of the most common renewable energy applications are shown in Table 2 (page 12). Many of these costs are

Figure 8. Solar Hot Water Existing per 1,000 Inhabitants

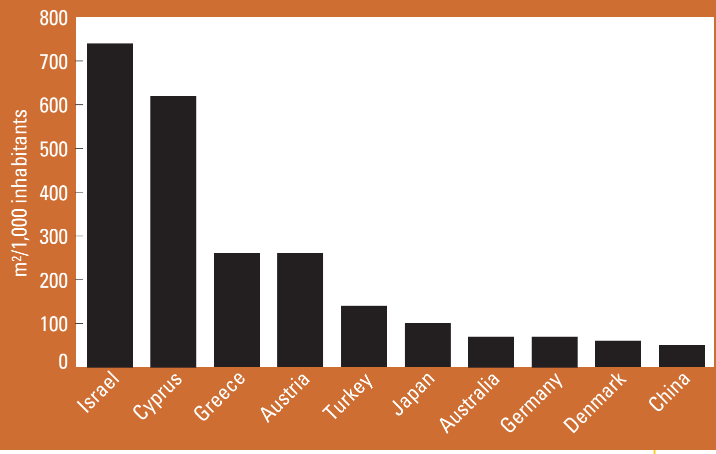
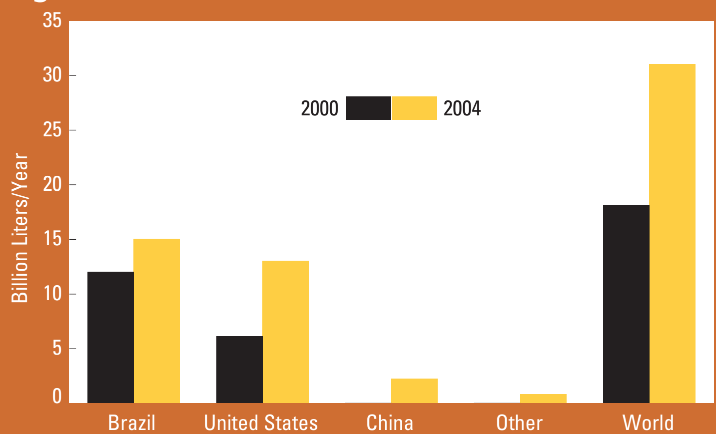


Figure 9. Fuel Ethanol Production, 2000 and 2004



still higher than conventional energy technologies. (Typical conventional power generation costs are in the US$ 2–5 cents/kWh range for baseload power, but can be considerably higher for peak power and higher still for off-grid diesel generators.*) Higher costs and other market barriers mean that most renewables continue to require policy support. However, economic competitiveness is not static: just as renewables' costs are declining, conventional technology costs are declining as well (for example with improvements in gas turbine technology). The fundamental uncertainty about future competitiveness relates to future fossil fuel prices, which affect conventional power costs but not the costs of renewables.

For the present, the International Energy Agency has portrayed the cost-competitiveness of renewables in this way: "Except for large hydropower and combustible renewables and waste plants, the average costs of renewable electricity are not widely competitive with wholesale electricity prices. However, depending on the technology, application and site, costs are competitive with grid [retail] electricity or commercial heat production. Under best conditions—optimized system design, site and resource availability—electricity from biomass, small hydropower, wind and geothermal plants can produce electricity at costs ranging from 2–5 cents/kWh. Some biomass applications are competitive as well as geothermal heat production in specific sites." In regions where the technology is well-established, solar water heaters are fully competitive with conventional water heaters, although less so in cooler climates where the solar resource is poorer and heating demand is higher. Grid-connected solar PV is not yet competitive, except in locations with extremely high retail power rates (i.e., exceeding 20–25 cents/kWh). Ethanol in Brazil is now fully competitive with gasoline.† [N11]

* Unless otherwise noted, all dollar figures are in U.S. dollars.

† Cost comparisons are based on economic costs excluding external costs. Financial cost comparisons can be fairly complex, as they must take into account policy support, subsidies, tax treatment, and other market conditions. Historical cost reductions are due to an array of factors beyond the scope of this report. As one example. Brazil's ethanol costs have declined over more than two decades with increases in production efficiency and market growth.

Table 2. Status of Renewables Technologies—Characteristics and Cost

Technology	Typical Characteristics	Typical Energy Costs (cents/kWh)	Cost Trends and Potential for Cost Reduction
Power Generation			
Large hydro	*Plant size:* 10 MW–18,000 MW	3–4	Stable.
Small hydro	*Plant size:* 1–10 MW	4–7	Stable.
On-shore wind	*Turbine size:* 1–3 MW *Blade diameter:* 60–100 m	4–6	Costs have declined by 12–18% with each doubling of global capacity. Costs are now half those of 1990. Turbine size has increased from 600–800 kW a decade ago. Future reductions from site optimization, improved blade/generator design, and electronics.
Off-shore wind	*Turbine size:* 1.5–5 MW *Blade diameter:* 70–125 m	6–10	Market still small. Future cost reductions due to market maturity and technology improvement.
Biomass power	*Plant size:* 1–20 MW	5–12	Stable.
Geothermal power	*Plant size:* 1–100 MW *Type:* binary, single-flash, double-flash, or natural steam	4–7	Costs have declined since the 1970s. Costs for exploiting currently-economic resources could decline with improved exploration technology, cheaper drilling techniques, and better heat extraction.
Solar PV (module)	*Cell type and efficiency:* single-crystal: 17%, polycrystalline: 15%, thin film: 10–12%	—	Costs have declined by 20% for each doubling of installed capacity, or by about 5% per year. Costs rose in 2004 due to market factors. Future cost reductions due to materials, design, process, efficiency, and scale.
Rooftop solar PV	*Peak capacity:* 2–5 kW	20–40	Continuing declines due to lower solar PV module costs and improvements in inverters and balance-of-system components.
Solar thermal power (CSP)	*Plant size:* 1–100 MW *Type:* tower, dish, trough	12–18 (trough)	Costs have fallen from about 44 cents/kWh for the first plants in the 1980s. Future reductions due to scale and technology.
Hot Water/Heating			
Biomass heat	*Plant size:* 1–20 MW	1–6	Stable.
Solar hot water/heating	*Size:* 2–5 m² *Type:* evacuated tube/flat-plate *Service:* hot water, space heating	2–25	Costs stable or moderately lower due to economies of scale, new materials, larger collectors, and quality improvements.
Geothermal heat	*Plant capacity:* 1–100 MW *Type:* binary, single- and double-flash, natural steam, heat pumps	0.5–5	See geothermal power, above.
Biofuels			
Ethanol	*Feedstocks:* sugar cane, sugar beets, corn, or wheat (and cellulose in the future)	25–30 cents/liter gasoline equivalent	Declining costs in Brazil due to production efficiencies, now 25–30 cents/equivalent-liter (sugar), but stable in the United States at 40–50 cents (corn). Other feedstocks higher, up to 90 cents. Cost reductions for ethanol from cellulose are projected, from 53 cents today to 27 cents post-2010; modest drops for other feedstocks.
Biodiesel	*Feedstocks:* soy, rapeseed, mustard seed, or waste vegetable oils	40–80 cents/liter diesel equivalent	Costs could decline to 35–70 cents/liter diesel equivalent post-2010 for rapeseed and soy, and remain about 25 cents (currently) for biodiesel from waste oil.

Table 2. *continued*

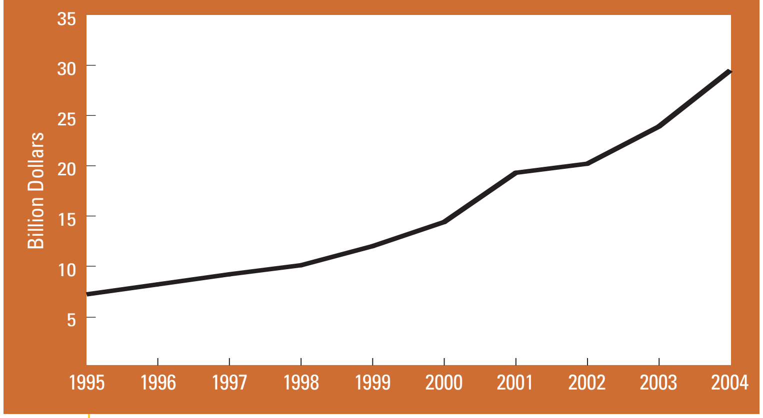
Technology	Typical Characteristics	Typical Energy Costs (cents/kWh)	Cost Trends and Potential for Cost Reduction
Rural (off-grid) Energy			
Mini-hydro	*Plant capacity:* 100–1,000 kW	5–10	Stable.
Micro-hydro	*Plant capacity:* 1–100 kW	7–20	Stable to moderately declining with efficiency improvements.
Pico-hydro	*Plant capacity:* 0.1–1 kW	20–40	Stable to moderately declining with efficiency improvements.
Biogas digester	*Digester size:* 6–8 m^3	n/a	Stable to moderately declining with economies of construction and service infrastructure.
Biomass gasifier	*Size:* 20–5,000 kW	8–12	Excellent potential for cost reduction with further technology development.
Small wind turbine	*Turbine size:* 3–100 kW	15–30	Moderately declining with technology advances.
Household wind turbine	*Turbine size:* 0.1–1 kW	20–40	Moderately declining with technology advances.
Village-scale mini-grid	*System size:* 10–1,000 kW *Options:* battery back-up or diesel	25–100	Declining with reductions in solar and wind component costs.
Solar home system	*System size:* 20–100 W	40–60	Declining with reductions in solar component costs.

Note: All costs are economic costs, exclusive of subsidies and other policy incentives. Typical energy costs are under best conditions, including system design, siting, and resource availability. Some conditions can yield even lower costs, e.g. down to 2 cents/kWh for geothermal and large hydro and 3 cents/kWh for biomass power. Less-optimal conditions can yield costs substantially higher than the typical costs shown. Typical solar PV grid-connected costs are for 2,500 kWh/m^2 per year, typical for most developing countries. Costs increase to 30–50 cents/kWh for 1,500 kWh/m^2 sites (i.e., Southern Europe) and to 50–80 cents for 1,000 kWh/m^2 sites (i.e., UK).

2. INVESTMENT FLOWS

In 2004, about $30 billion was invested in renewable energy capacity and installations. (See Figure 10.) An additional $4–5 billion in new plant and equipment was invested in 2004 by the solar PV manufacturing industry, and at least several hundred million dollars was invested by the ethanol industry in new production plants. These numbers compare to roughly $110–150 billion invested annually in power generation worldwide. Thus, renewables are now 20–25 percent of global power-sector investment. Indeed, the International Energy Agency, in its most recent *World Energy Investment Outlook*, estimates that fully one-third of new power generation investment in OECD countries over the next thirty years will be renewable energy. Annual renewable energy investment has grown steadily from about $7 billion in 1995. Investment shares in 2004 were roughly $9.5 billion for wind power, $7 billion for solar PV, $4.5 billion for small hydro power, $4 billion for solar hot water/heating, and $5 billion for geothermal and biomass power and heat. In addition to these investments, an estimated $20–25 billion is being invested in large hydropower annually.[N12]

Figure 10. Annual Investment in Renewable Energy, 1995–2004



Renewable energy investments now come from a highly diverse range of public and private sources. Investment flows are being aided by technology standardization and growing acceptance and familiarity by financiers at all scales, from commercial finance of hundred-million-dollar wind farms to household-scale micro-financing. One of the most recent trends is that large commercial banks are starting to notice renewable energy investment opportunities. Examples of large banks that are "mainstreaming" renewable energy investments are HypoVereins Bank, Fortis, Dexia, Citigroup, ANZ Bank, Royal Bank of Canada, and Triodos Bank, all of which are very active in financing renewable energy. Investments by traditional utility companies, which historically as a group have been slow to consider renewables investments, are also becoming more "mainstreamed." Examples of utilities active in renewable energy include Electricité de France, Florida Power and Light (USA), Scottish Power, and Endesa (Spain).*

Other large investors are entering the renewable energy market, including leading investment banks. There is a growing belief in the mainstream investment community that renewable energy is a serious business opportunity. For example, Morgan Stanley is now investing in wind power projects in Spain. Goldman Sachs, one of the world's largest investment firms, bought Zilkha Renewable Energy, a wind-development firm currently developing 4 GW of wind capacity in the United States. GE commercial and consumer finance arms have started financing renewable energy. And commercial re-insurers are developing new insurance products targeting renewable energy.

Venture capital investors have also started to notice renewable energy. Venture capital investments in U.S.-based clean energy technology companies totaled almost $1 billion in 2004. In particular, solar PV saw a 100-percent compound annual growth in venture capital and equity investment from 2001 to 2004. Venture capital is being driven partly by future market projections, some of which show the solar PV and wind industries growing to $40–50 billion each sometime during 2010–2014.[N13]

Financing by public banking institutions has played an important role in stimulating private investments and industry activity. The European Investment Bank is the leading public banking institution providing finance for renewable energy, with finance averaging $630 million per year during the three-year period 2002–2004 (almost all for projects in the EU). The European Investment Bank plans to double its share of energy-sector loans to renewables between 2002 and 2007, from 7 percent to 15 percent by 2007. The bank also plans to increase renewable power-generation lending to 50 percent of total financing for new electricity-generation capacity in the EU by 2008–2010, up from the current 15 percent.[N14]

Multilateral, bilateral, and other public financing flows

* This report does not cover carbon finance or Clean Development Mechanism (CDM) projects. Subsequent editions can hopefully address these emerging financing vehicles. There were plans for renewable energy projects incorporating these financing vehicles in several countries, and countries were establishing administrative rules and procedures.

SIDEBAR 1. Bonn Action Programme in International Context

An analysis of the Bonn Action Progamme adopted in 2004 gives five key metrics for the program's content. Below, these metrics are compared with the existing global context. [N15b]

Metric	Bonn Action Programme Content	Global Context (2004)
1. Installed capacity	Adds 163 GW of renewable electricity capacity if fully implemented.	Existing global capacity of renewable energy was 160 GW (plus 720 GW for large hydro).
2. Investments	Implies total investment of $326 billion.	Global annual investment in renewable energy was $30 billion (plus $20–25 billion for large hydro).
3. CO_2 emissions	Implies CO_2 reductions totaling 1.2 billion tons/year by 2015.	CO_2 reduction from renewable energy was 0.9 billion tons/year (plus 3.7 billion tons/year from large hydro).
4. Donor financing	Donor funding pledged and needed totals 16% of financing, or about $52 billion.	Almost $500 million/year in donor financing flowed to developing countries.
5. Access to electricity in rural areas	Endorses Millennium Development Goal estimates that up to 1 billion people could have access to energy services from renewables by 2015.	Tens of millions of rural homes served by small hydro, 16 million using biogas, 2 million with solar home lighting, and many others served by biomass gasifiers.

for new renewables in developing countries have reached almost $500 million per year in recent years. A significant portion of these funds supports training, policy development, market facilitation, technical assistance, and other non-investment needs. The three largest sources of funds have been the German Development Finance Group (KfW), the World Bank Group, and the Global Environment Facility (GEF). KfW approved about $180 million for renewables in 2004, including $100 million from public budgetary funds and $80 million from market funds. The World Bank Group committed an average of $110 million per year to new renewables during the three-year period 2002–2004.* The GEF allocated an average of $100 million each year from 2002 to 2004 to co-finance renewable energy projects implemented by the World Bank, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), and several other agencies. Indirect or associated private-sector financing is often equal to or several times greater than the actual public finance from these agencies, as many projects are explicitly designed to catalyze private investment. In addition, recipient-country governments also contribute co-financing to these development projects.[N15]

Other sources of public financing include bilateral assistance agencies, United Nations agencies, and the contributions of recipient-country governments to development assistance projects. Several agencies and governments are providing aid for new renewables in the range of (typically) $5–25 million per year, including the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the Inter-American Development Bank (IDB), UNDP, UNEP, the U.N. Industrial Development Organization (UNIDO), Denmark (Danida), France (Ademe and FFEM), Germany (GTZ), Italy, Japan (JBIC), and Sweden (SIDA). Other donors contributing technical assistance and financing on an annual basis include the U.N. Food and Agriculture Organization (FAO), Australia (AusAid), Canada (CIDA), the Netherlands (Novem), Switzerland (SDC), and the United Kingdom (DFID). Some of these donors are establishing specific-purpose investment funds and credit lines that combine additional private financing.[N15]

These public investment flows have remained relatively constant over the past few years, although recent commitments by a number of organizations suggest the total will increase in the coming years. In 2004, at the Renewables 2004 conference in Bonn, Germany, 170 countries adopted the Bonn Action Programme, with many future commitments by governments, international organizations, and non-governmental organizations. (See Sidebar 1.) At the same time, the German government committed 500 million euros over five years to KfW for renewable energy and energy efficiency investments in developing countries. Also in 2004, the World Bank Group committed to double financing flows for new renewables and energy efficiency within five years, which would add another $150 million in annual financing for renewable energy. The EU, together with the Johannesburg Renewable Energy Coalition (JREC), will establish a "Global Renewable Energy Fund of Funds" to provide patient equity capital, with initial financing of

* World Bank Group financing for new renewables plus average GEF co-financing of $45 million per year for World Bank Group projects (2002–2004) made total World Bank Group/GEF financing more than $155 million per year. The World Bank Group also committed an average of $170 million per year during the three-year period 2002–2004 to large hydropower (without GEF co-financing), bringing average annual World Bank Group/GEF financing for all renewables to more than $325 million.

about 75 million euros.

Local financing sources for renewable energy in developing countries, once the province of international development agencies, have also been growing. There is an increasing emphasis by donors and market facilitators on helping to increase these local financing sources for renewable energy and finding ways to mitigate financing risks for private investors. One of the best examples is the India Renewable Energy Development Agency (IREDA), which has provided almost $1.5 billion in financing for 2.5 GW of renewables since its inception in 1987. On the rural side, Grameen Shakti in Bangladesh, a local purveyor of credit and sales of rural solar home systems, is one of the best known examples. There are many others. The Development Bank of Uganda is providing rural micro-loans with support of the Shell Foundation. UNEP, the U.N. Foundation, and E+Co are experimenting with approaches to financing small- and medium-scale renewable energy enterprises through the Rural Energy Enterprise Development (REED) program in Africa, Brazil, and China. Triodos Bank's "Renewable Energy for Development Fund" provides seed capital, loans, and business development support for renewable energy entrepreneurs in Asia and Africa. In 2003, two of the largest commercial banks in India, Canara and Syndicate Banks, together with their regional associate banks, started to provide thousands of loans for rural households to use renewable energy, offered through 2,000 participating bank branches in two states. In general, capacity building for financial services for households and businesses has become a higher priority of many agencies.

These financing flows are augmented and facilitated by the efforts of many other industry associations, non-governmental organizations, international partnerships and networks, and private foundations. These so-called "market facilitation organizations" number in the hundreds and are active worldwide and locally. (See Note 45 for a listing of websites.) Five examples of international partnerships are the Global Village Energy Partnership (GVEP), the Renewable Energy and Energy Efficiency Partnership (REEEP), the Global Network on Energy for Sustainable Development (GNESD), the UNEP Sustainable Energy Finance Initiative, and the REN21 Renewable Energy Policy Network.

Government support for renewable energy was on the order of $10 billion in 2004 for the United States and Europe combined. Such support can take several forms. "On-budget" support includes such mechanisms as research and development funding, direct investment, capital-cost subsidies, tax credits, and export credits.* Research and development is a significant part of on-budget support, averaging $730 million per year during 1999–2001 for all International Energy Agency countries. "Off-budget" support includes the costs of market-based incentives and regulatory mechanisms that do not materially affect government budgets (for example, feed-in laws and renewables portfolio standards). The European Environment Agency estimated at least $0.8 billion in on-budget support and $6 billion in off-budget support for renewable energy in Europe in 2001. A large share of the off-budget support was due to feed-in tariffs, with purchase obligations and competitive tendering representing other forms of off-budget support. In the United States, federal on-budget support for renewables was $1.1 billion in 1999, including federal ethanol tax exemptions of $720 million and $330 million in RD&D. By 2004, RD&D spending declined but ethanol tax exemptions increased to $1.7 billion, which along with the production tax credit (perhaps another $200 million) increased total on-budget support to over $2 billion per year. U.S. state-level policies and programs, including public benefit funds providing an estimated $300 million per year (off-budget), might add another $1 billion dollars or more. In comparison with these figures, total energy subsidies/support for fossil fuels on a global basis are suggested by the United Nations and the International Energy Agency in the range of $150–250 billion per year, and for nuclear about $16 billion per year.[N16]

* Export credits have rarely applied to renewables in the past, but this situation appears to be changing. The OECD recently decided to give special treatment to renewable energy within the OECD Arrangement on Officially Supported Export Credits, including extending repayment terms from 12 to 15 years. This special status may help bring export credit agency terms in line with other financing going to developing country renewable energy projects, potentially increasing export credit agency investment in renewables.

3. INDUSTRY TRENDS

These investment flows mean that renewable energy has become big business. Worldwide, at least 60 publicly traded renewable energy companies, or renewable energy divisions of major companies, had a market capitalization greater than $40 million in 2005. The estimated total market capitalization of these companies and divisions was more than $25 billion. The next largest 100 renewable energy companies or divisions would add several billion dollars more of market capitalization to this figure. Solar PV is becoming one of the world's fastest growing, most profitable industries. Capacity expansion plans for 2005–2008 total several hundred megawatts, and an estimated $5–7 billion of capital investment will be made in 2005.[N17]

Perhaps the best illustration of how renewable energy has become big business is the entrance of the largest industry players into the wind power market, historically dominated by dedicated wind-turbine manufacturing companies. GE and Siemens are prominent examples of large electrical-equipment companies that have entered the wind market in recent years, both through acquisition (GE bought Enron Wind in 2003 and Siemens bought Bonus in 2004). In China, five of the largest electrical, aerospace, and power generation equipment companies began to develop wind turbine technology in 2004. Four signed technology-transfer contracts with foreign companies and were planning to produce their first prototype turbines in 2005. Such big players are bringing new competencies to the market, including finance, marketing, and production scale, and are adding additional credibility to the technology.

The wind power industry produced more than 6,000 wind turbines in 2004, at an average size of 1.25 MW each. The top six manufacturers are Vestas (Denmark, merged with NEG Micon in 2004), Gamesa (Spain), Enercon (Germany), GE Energy (USA), Siemens (Denmark, merged with Bonus in 2004), and Suzlon (India). In China, there are two primary turbine manufacturers, Goldwind and Xi'an Nordex, with market shares of 20 percent and 5 percent respectively (75 percent of the market being imports). Global industry progress has been closely related to turbine size, with the average installed turbine increasing from 500 kW in 1995 to 1,300 kW in 2004. The U.S. and European wind industries now produce turbines in the 1,000–3,000 kW range, but production of 600–1,000 kW sizes is still common in India and China. European manufacturers have introduced prototype wind turbines in the 5,000 kW range. Making larger turbines is still the number-one technological issue in the turbine industry. The industry has continued to make innovations in materials, electronics, blade and generator design, and site optimization, and these innovations offer further potential for cost reduction.[N18]

The solar PV industry celebrated its first gigawatt of global cumulative production in 1999. Five years later, by the end of 2004, cumulative production had quadrupled to more than 4 gigawatts. Production expansion continued aggressively around the world in 2004, and annual production exceeded 1,100 MW. Announced plans by major manufacturers for 2005 included at least a 400 MW increase in production capacity and several hundred megawatts further capacity in the 2006–2008 period. The top three global manufacturers in 2004 were Sharp, Kyocera, and BP Solar (though rapid capacity expansions by many players lead to changes in the top positions year to year).[N19]

China and other developing countries have emerged as solar PV manufacturers. Chinese module production capacity doubled during 2004, from 50 MW to 100 MW, and cell production capacity increased to 70 MW. Production capacity could double again in 2005 due to announced industry plans. India has 8 cell manufacturers and 14 module manufacturers. India's primary solar PV producer, Tata BP Solar, expanded production capacity from 8 MW in 2001 to 38 MW in 2004. In the Philippines, Sun Power planned in 2004 to double its cell production capacity to 50 MW. Solartron in Thailand announced plans for 20 MW cell production capacity by 2007. Across the whole industry, economies from larger production scales, as well as design and process improvements, promise further cost reductions.

Industries for biomass power and heat and small hydro are much more mature, localized, and diverse than those for wind and solar PV. Biomass heat and power investments tend to be made by the same companies generating waste biomass resources, such as timber and paper companies and sugar mills. European industry has maintained a leading position in the field of small hydropower manufacturing, with particular concern in recent years for upgrading and refurbishing existing plants. Small hydro technology improvements are focused on exploiting low heads (less than 15 meters) and small capacities (less than 250 kW). China's small hydro industry numbers at least 500 enterprises producing hydro generators. In contrast, five large firms dominate the international geothermal power industry (Ansaldo, Fuji, Mitsubishi, Ormat, and Toshiba).[N20, N21]

The global ethanol industry is centered in Brazil and the United States. There were more than 300 sugar mills/distilleries producing ethanol in Brazil in 2004, and 39 new distillers were licensed in early 2005. In the United States, construction of 12 new ethanol plants was completed in 2004, bringing the total to more than 80. Also in 2004, construction of 16 new plants was started. Several large ethanol plants will begin production in 2005 in Germany and the United States. Brazil's ethanol industry has also become a major ethanol exporter, accounting for about half of international shipments of ethanol during 2004. There was also considerable biofuels trade (of both ethanol and biodiesel) within the EU, and several other countries planned to expand their ethanol industries.[N22]

The sophistication of many segments of the renewable-energy industry increases year by year. For example, small wind turbine manufacturers are offering easier set-up and hybridization options with solar and other technologies. The off-grid solar PV industry is beginning to develop standardized "plug and play" packages for lanterns and full-scale household systems. Some companies are innovating with packaging hybrid systems; for example, one U.S. company is blending PV and small wind turbines on shipping containers with advanced batteries and controls to offer complete pre-packaged systems. More sophisticated controls, performance monitoring, and communications are being integrated into systems, allowing better energy accounting and more sophisticated billing and payment schemes.

The renewable energy industry continues to grow rapidly. Direct jobs worldwide from renewable energy manufacturing, operations, and maintenance exceeded 1.7 million in 2004, including some 0.9 million for biofuels production. Indirect jobs are likely several times larger. These estimates are preliminary, as published job estimates exist for only a few specific industries and countries. Examples of country-specific estimates include: 400,000 jobs in the Brazil ethanol industry; 250,000 jobs in the China solar hot water industry; 130,000 jobs in Germany from all renewables; 75,000 jobs in the European wind industry; 15,000 jobs in the European solar PV industry; 12,000 jobs in the U.S. solar PV industry; 11,000 jobs in the Nepal biogas industry; 3,400 jobs in Japan from renewables; and 2,200 jobs in the EU for small hydro.*[N24]

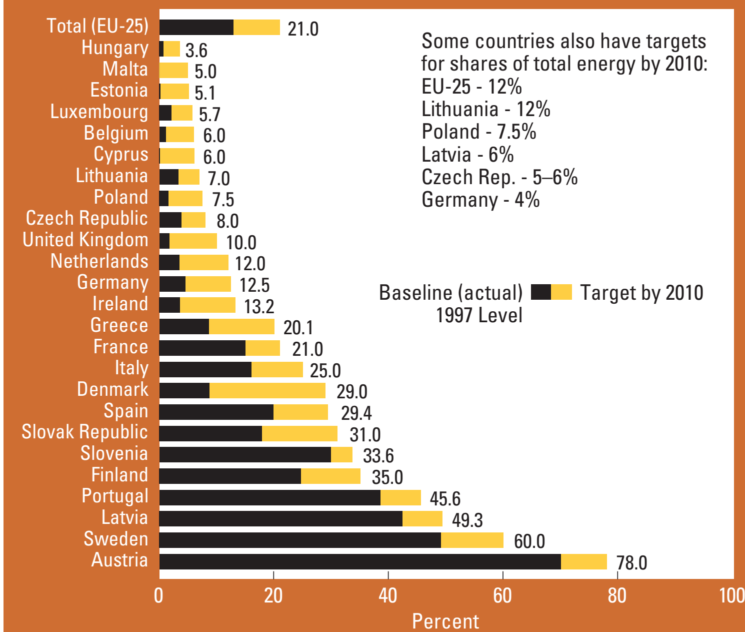
* No estimates exist in the literature for total jobs from renewable energy worldwide. See Note 24 for details of the analysis used for this report, which includes small hydro, biomass power, wind power, geothermal power, solar PV, solar hot water, ethanol, and biodiesel, but does not include geothermal and biomass heating.

4. POLICY LANDSCAPE

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s, but renewable energy policy began to emerge in many more countries, states, provinces, and cities during the late 1990s and early 2000s. Many of these policies have exerted substantial influence on the market development reviewed in the previous section. This section discusses existing targets and policies to promote renewable power generation, solar hot water/heating, and biofuels. It also discusses municipal-level policies and voluntary green power/pricing.*

It is beyond the scope of this report to provide detailed analysis of policy impacts and lessons. Nevertheless, the policy literature clearly shows that policies have had a major impact on the speed and extent of renewable energy development, despite a myriad of design and implementation problems. The International Energy Agency observed in 2004, in its milestone book on market and policy trends in IEA countries, that significant market growth has always resulted from combinations of policies, rather than single policies, that longevity and predictability of policy support is important, that local and state/provincial authority and involvement are important, and that individual policy mechanisms are evolving as countries gain more experience. Although a wealth of experience exists for older policies, the IEA suggests that it is still too soon to assess the impacts of many policies because most have been established since 2000.

Figure 11. EU Renewable Energy Targets—Share of Electricity by 2010



Policy Targets for Renewable Energy

Policy targets for renewable energy exist in at least 45 countries worldwide. By mid-2005, at least 43 countries had a national target for renewable energy supply, including all 25 EU countries. (See Figure 11 and Table 3, page 20.) The EU has Europe-wide targets as well: 21 percent of electricity and 12 percent of total energy by 2010. In addition to these 43 countries, 18 U.S. states (and the District of Columbia) and 3 Canadian provinces have targets based on renewables portfolio standards (although neither the United States nor Canada has a national target). An additional 7 Canadian provinces have planning targets. Most national targets are for shares of electricity production, typically 5–30 percent. Electricity shares range from 1 percent to 78 percent. Other targets are for shares of total primary energy supply, specific installed capacity figures, or total amounts of energy production from renewables, including heat. Most targets aim for the 2010–2012 timeframe.[N25]

The 43 countries with national targets include 10 developing countries: Brazil, China, the Dominican Republic, Egypt, India, Malaysia, Mali, the Philippines, South Africa, and Thailand. A few other developing countries are likely to announce targets in the near future. China's target of 10 percent of total power capacity by 2010 (excluding large hydropower) implies 60 GW of renewables capacity given projected electric-power growth. China also has targets for 2020, including 10 percent of primary energy and 12.5 percent of power capacity, 270 million square meters of solar hot water, and 20 GW each of wind and biomass power.†

* This section is intended to be indicative of the overall landscape of policy activity. Policies listed are generally those that have been enacted by legislative bodies. Some of the policies listed may not yet be implemented, or are awaiting detailed implementing regulations. It is obviously difficult to capture every policy, so some policies may be unintentionally omitted or incorrectly listed. Some policies may also be discontinued or very recently enacted. Updates will be posted to the Web-based notes for this section, which contain more policy details.

† China's targets are present in a draft renewable energy development plan that is pending approval by the government, but were announced publicly at the Renewables 2004 conference in Bonn, Germany, in June 2004. The Chinese renewable energy law of February 2005 requires the government to publish the renewable energy development plan, including targets, by January 2006.

Table 3. Non-EU Countries with Renewable Energy Targets

Country	Target(s)
Australia	9.5 TWh of electricity annually by 2010.
Brazil	3.3 GW added by 2006 from wind, biomass, small hydro.
Canada	3.5% to 15% of electricity in 4 provinces; other types of targets in 6 provinces.
China	10% of electric power capacity by 2010 (expected 60 GW); 5% of primary energy by 2010 and 10% of primary energy by 2020.
Dominican Republic	500 MW wind power capacity by 2015.
Egypt	3% of electricity by 2010 and 14% by 2020.
India	10% of added electric power capacity during 2003–2012 (expected 10 GW).
Israel	2% of electricity by 2007; 5% of electricity by 2016.
Japan	1.35% of electricity by 2010, excluding geothermal and large hydro (RPS).
Korea	7% of electricity by 2010, including large hydro, and 1.3 GW of grid-connected solar PV by 2011, including 100,000 homes (0.3 GW).
Malaysia	5% of electricity by 2005.
Mali	15% of energy by 2020.
New Zealand	30 PJ of added capacity (including heat and transport fuels) by 2012.
Norway	7 TWh from heat and wind by 2010.
Philippines	4.7 GW total existing capacity by 2013.
Singapore	50,000 m^2 (~35 MWth) of solar thermal systems by 2012.
South Africa	10 TWh added final energy by 2013.
Switzerland	3.5 TWh from electricity and heat by 2010.
Thailand	8% of total primary energy by 2011 (excluding traditional rural biomass).
United States	5% to 30% of electricity in 20 states (including DC).

Thailand is targeting 8 percent of primary energy by 2011 (excluding traditional biomass). India is expecting 10 percent of added electric power capacity, or at least 10 GW of renewables, by 2012.* The Philippines is targeting nearly 5 GW total by 2013, or a doubling of existing capacity. South Africa in 2003 set a target of 10 TWh of additional final energy from renewables by 2013, which would represent about 4 percent of power capacity. The Mexican legislature was considering in 2005 a new law on renewable energy that would include a national target.

Power Generation Promotion Policies

At least 48 countries—34 developed and transition countries and 14 developing countries—have some type of policy to promote renewable power generation. (See Table 4.) The most common existing policy is the feed-in law, which has been enacted in many new countries and regions in recent years. The United States was the first country to enact a national feed-in law (PURPA), in 1978. (Several states actively implemented PURPA but most implementation was discontinued in the 1990s.) Feed-in policies were next adopted in Denmark, Germany, Greece, India, Italy, Spain, and Switzerland in the early 1990s. By 2005, at least 32 countries and 5 states/provinces had adopted such policies, more than half of which have been enacted since 2002. (See Table 5, page 23.)

Among developing countries, India was the first to establish feed-in tariffs, followed by Sri Lanka and Thailand (for small power producers only), Brazil, Indonesia, and Nicaragua. Three states in India adopted new feed-in policies in 2004, driven by a 2003 national law requiring new state-level policies (the old feed-in laws during the 1990s were gradually discontinued). In the first half of 2005, feed-in policies were enacted in China, Ireland, Turkey, and the U.S. state of Washington. China's feed-in policy was part of a comprehensive renewable energy promotion law enacted in February 2005.[N26, N27]

Feed-in tariffs have clearly spurred innovation and increased interest and investment, notably in Germany, Spain, and Denmark over the past several years. For example, power from eligible forms of renewable generation under Germany's feed-in law more than doubled between 2000 and 2004, from 14 TWh to 37 TWh. In several coun-

* India's national target is a planning or indicative target but is not backed by specific legislation.

Table 4. Renewable Energy Promotion Policies

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Developed and transition countries										
Australia		✓	✓			✓			✓	
Austria	✓		✓	✓		✓				
Belgium		✓	✓	✓		✓		✓		
Canada	(*)	(*)	✓	✓	✓			(*)	✓	(*)
Cyprus	✓		✓							
Czech Republic	✓		✓	✓	✓	✓		✓		
Denmark	✓			✓		✓		✓		
Estonia	✓				✓					
Finland			✓		✓	✓	✓			
France	✓		✓	✓	✓	✓			✓	✓
Germany	✓		✓	✓	✓				✓	
Greece	✓		✓	✓						
Hungary	✓				✓	✓			✓	
Ireland	✓		✓	✓		✓				✓
Italy		✓	✓	✓		✓		✓		
Israel	✓									
Japan	(*)	✓	✓			✓		✓	✓	
Korea	✓		✓		✓					
Latvia	✓								✓	
Lithuania	✓		✓	✓					✓	
Luxembourg	✓		✓	✓						
Malta					✓					
Netherlands	✓		✓	✓		✓	✓			
New Zealand			✓						✓	
Norway			✓	✓		✓				✓
Poland		✓	✓		✓				✓	✓
Portugal	✓		✓	✓	✓					
Slovak Republic	✓			✓					✓	
Slovenia	✓									
Spain	✓		✓	✓					✓	
Sweden	✓	✓	✓	✓	✓	✓	✓			
Switzerland	✓									
United Kingdom		✓	✓		✓	✓				
United States	(*)	(*)	✓	✓	(*)	(*)	✓	(*)	(*)	(*)
Developing countries										
Argentina			✓				✓			
Brazil	✓								✓	
Cambodia			✓							
China	✓		✓	✓	✓				✓	✓
Costa Rica	✓									
Guatemala				✓	✓					

Table 4. *continued*

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
India	(*)	(*)	✓	✓	✓				✓	✓
Indonesia	✓									
Mexico				✓				✓		
Nicaragua	✓			✓						
Philippines				✓	✓				✓	
Sri Lanka	✓									
Thailand	✓	✓	✓					✓		
Turkey	✓		✓							

Notes: (a) Only enacted policies are included. However, for some policies shown, implementing regulations may not yet be developed or effective, leading to lack of implementation or impacts. (b) Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national level policy. (c) Some policies shown may apply to other markets beside power generation. (d) The table omits policies known to be discontinued; for example Norway's feed-in policy for wind discontinued in 2003, Denmark's capital grants discontinued in 2002, and Belgium's feed-in tariffs (Green Frank system) discontinued in 2003. (e) Several African countries have subsidy policies supporting modest amounts of rural solar PV, including Mali, Senegal, Tanzania, and Uganda (also micro-hydro). South Africa had a policy for subsidies to rural energy service concessions for solar PV that now appears dormant. (f) Several developing countries are planning renewable energy strategies and/or are expected to enact new or additional policies in the future, including Algeria, Armenia, Colombia, Egypt, Guatemala, Jordan, Macedonia, Mexico, Peru, South Africa, Vietnam, and Yemen.

tries, feed-in policies have had the largest effect on wind power, but have also influenced biomass and small hydro development. (Most laws set a limit on maximum size of eligible hydro, for example 5 MW in Germany.) Most recently, Spain's feed-in tariff has helped new investment plans for solar thermal power generation (decisions for two 50 MW plants were expected in 2005).

Feed-in tariffs vary in design from country to country. Some policies apply only to certain technologies or maximum capacity. Most policies establish different tariffs for different technologies, usually related to the cost of generation, for example distinguishing between off-shore and on-shore wind power. Some policies also differentiate tariffs by location/region, year of plant operation, and operational season of the year. Tariffs for a given plant may decline over time, but typically last for 15–20 years. Some policies provide a fixed tariff while others provide fixed premiums added to market- or cost-related tariffs (or both, as in the case of Spain).

Renewables portfolio standard (RPS) policies are expanding at the state/provincial level in the United States, Canada, and India. (See Table 6.) At least 32 states or provinces have enacted RPS policies, half of these since 2003. Eight new U.S. states (and the District of Columbia) enacted RPS policies in 2004–2005, bringing to 20 the number of U.S. states with RPS. Likewise in India, five new states enacted RPS policies in 2004–2005, bringing the total number of states to six (the Indian 2003 Electricity Act allows states to set minimum shares from renewables). Canada has three provinces with RPS policies (and several more with planning targets). Most of the above RPS policies require renewable power shares in the range of 5–20 percent, typically by 2010 or 2012. Most RPS targets translate into large expected future investments. One study estimates that state RPS laws currently existing in the United States would require an additional 52 GW of renewable energy by 2020, which would more than double existing U.S. renewables capacity.*[N28]

There are also six countries with national RPS policies, all enacted since 2001. Australia's RPS (2001) requires utility companies to submit a certain number of renewable energy certificates each year (1.25 percent of generation was required for 2004, or about 2,600 GWh total); this requirement will be adjusted each year to eventually lead

* RPS percentages don't necessarily correspond to ambitiousness or level of effort required, as some states/provinces already have capacity close to their targets, while others are far below their targets. Further, some RPS policies set upper limits on the size of hydro eligible to fulfill the requirement. See Note 25 for a list of mandated percentages or capacity targets for individual countries.

Table 5. Cumulative Number of Countries/States/Provinces Enacting Feed-in Policies

Year	Cumulative Number	Countries/States/Provinces Added That Year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark, India
1994	8	Spain, Greece
1995	8	
1996	8	
1997	9	Sri Lanka
1998	10	Sweden
1999	13	Portugal, Norway, Slovenia
2000	14	Thailand
2001	16	France, Latvia
2002	20	Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	27	Cyprus, Estonia, Hungary, Korea, Slovak Republic, Maharashtra (India)
2004	33	Italy, Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India)
2005	37	Turkey, Washington (USA), Ireland, China

Note: Figure for 2005 is for first half of the year only.

Table 6. Cumulative Number of Countries/States/Provinces Enacting RPS Policies

Year	Cumulative Number	Countries/States/Provinces Added
1997	1	Massachusetts (USA)
1998	3	Connecticut, Wisconsin (USA)
1999	7	Maine, New Jersey, Texas (USA); Italy
2001	12	Arizona, Hawaii, Nevada (USA); Flanders (Belgium); Australia
2002	16	California, New Mexico (USA); Wallonia (Belgium); United Kingdom
2003	20	Minnesota (USA); Japan; Sweden; Maharashtra (India)
2004	34	Colorado, Maryland, New York, Pennsylvania, Rhode Island (USA); Nova Scotia, Ontario, Prince Edward Island (Canada); Madhya Pradesh, Karnataka, Andhra Pradesh, Orissa (India); Poland; Thailand
2005	38	District of Columbia, Montana, Delaware (USA); Gujarat (India)

to Australia's national target of 9,500 GWh by 2010. The United Kingdom's RPS (2002) will lead to 10 percent by 2010 and then to 15 percent by 2015, continuing to 2027. Japan's RPS (2003) also requires a certain percentage from utilities, which increases over time to reach 1.35 percent by 2010. Sweden's RPS (2003) requires consumers, or electricity suppliers on their behalf, to purchase a given annual percentage, which increases yearly, through either electricity purchases or renewable certificate purchases. (Sweden sets penalties for non-compliance at 150 percent of the average certificate price of the prior period.) Poland's RPS (2004) will reach 7.5 percent by 2010. Thailand's RPS (2004) requires that 5 percent of all additional future generation capacity be renewables.*

There are many other forms of policy support for renewable power generation, including direct capital investment subsidies or rebates, tax incentives and credits, sales tax and VAT exemptions, direct production payments or tax credits (i.e., per kWh), green certificate trading, net metering, direct public investment or financing, and public competitive bidding for specified quantities of power generation. (See Table 4, p. 21.) Some type of direct capital investment subsidy, grant, or rebate is offered in at least 30 countries. Tax incentives and credits are also common ways of providing financial support. Most U.S. states and at least 32 other countries offer a variety of tax incentives and credits for renewable energy.

Energy production payments or tax credits exist in several countries, with the U.S. federal production tax credit most significant in this category. That credit has applied to more than 5,400 MW of wind power installed from 1995 to 2004. Indexed to inflation, that credit started at 1.5 cents/kWh in 1994 and increased over time, through several expirations and renewals, to 1.9 cents/kWh by 2005, with expiration extended to 2007. The production tax credit has helped to make wind power a "mainstream"

* National targets from Table 3 and Figure 11 may be considered "binding," "planning," or "indicative" targets, but do not imply national RPS policies, which are legal mandates on specific classes of utility companies or consumers.

investment in the U.S. in recent years, capturing financier interest in the sector. Other countries with production incentives include Finland, the Netherlands, and Sweden.*

Policies to promote rooftop grid-connected solar PV exist in a few countries and utilize either capital subsidies or feed-in tariffs, or both (along with net metering). These policies have been clearly responsible for the rapid growth of the grid-connected market in recent years. Japan's rooftop solar PV policies, which were to end in 2005, provided capital subsidies which started at 50 percent in 1994 but declined to around 10 percent by 2003 and 4 percent by 2005. Those policies resulted in over 800 MW—more than 200,000 homes. Germany, with more than 160,000 rooftop solar homes and almost 700 MW installed, provides a guaranteed feed-in tariff, and until 2003 also provided low-interest consumer loans. Continuing policies in California, other U.S. states, and several other countries (including France, Greece, Italy, Korea, Luxembourg, the Netherlands, Portugal, and Spain) provide capital subsidies (typically 30–50 percent) and/or favorable power purchase tariffs. Korea expects 300 MW by 2011 through its 100,000-rooftop program, which initially provides 70-percent capital subsidies that will decline over time. New solar PV rooftop programs have been announced in several countries, including Hungary and Thailand.[N29]

Some countries or states/provinces have established renewable energy funds used to directly finance investments, provide low-interest loans, or facilitate markets in other ways, for example through research, education, standards, and investments in public facilities. The largest such funds are the so-called "public benefit funds" in 14 U.S. states. These funds, often applied to energy efficiency as well as renewable energy, are collected from a variety of sources, with the most common being a surcharge on electricity sales. These 14 funds, all initiated between 1997 and 2001, are collecting and spending more than $300 million per year on renewable energy. It is expected that they will collect upwards of $4 billion for renewable energy through 2012. The India Renewable Energy Development Agency (IREDA) similarly provides loans and other project financing. China's 2005 renewable energy law calls for establishing a fund, and Mexico was considering a "green fund" in 2005 to finance renewable energy projects.[N30]

Net metering laws exist in at least 7 countries, 35 U.S. states, and several Canadian provinces. Four additional U.S. states had one or more electric utilities offering net metering. A form of net metering is also occurring in Japan on a voluntary basis. Net metering laws are being enacted regularly, with six new U.S. states passing such laws in 2004. Most recently, a 2005 U.S. federal law requires all U.S. electric utilities to provide net metering within three years. Net metering has been particularly instrumental in facilitating grid-connected solar PV markets in the United States and Japan.[N30]

Policies for competitive bidding of specified quantities of renewable generation, originally used in the United Kingdom in the 1990s, now exist in at least seven other countries: Canada, China, France, India, Ireland, Poland, and the United States. China bid and awarded 850 MW of wind power in 2003–2004 and planned another 450 MW of bidding in 2005. The province of Ontario in Canada bid 1,000 MW of wind power in 2004, and other Canadian provinces were following suit. Utilities in many countries use competitive bidding to meet RPS requirements.[N31]

Other policies include tradable renewable energy certificates, typically used in conjunction with voluntary green power purchases or obligations under renewables portfolio standards. At least 18 countries had schemes and/or markets for tradable certificates. Many other regulatory measures, such as building codes, administrative rules and procedures, and transmission access and pricing, also serve important roles in promoting renewable power generation. Such regulatory measures can be steps towards future renewable energy markets, particularly in developing countries (Mexico and Turkey are examples of countries taking such regulatory measures). Policies for power-sector restructuring, carbon taxes, fossil fuel taxes, and many others can also affect the economic competitiveness of renewable energy.

Solar Hot Water/Heating Promotion Policies

The world's largest market for solar hot water collectors is China, with 80 percent of the global additions in 2004. China's national goal is 65 million square meters by 2005 (which was almost met in 2004) and 230 million square meters by 2015. With its origins in small towns and villages in the 1980s, the market has been driven mainly by unmet demand for hot water, economics, and systems that sell for a small fraction of prices found in developed countries. Although there are no explicit policies for promoting solar hot water in multi-storey urban buildings, building design and construction by developers has begun to incorporate solar hot water as energy costs rise and public demand increases, particularly during the current construction boom. There are also government programs for technology standards, building codes, and testing and certification centers to help the industry mature.[N32]

* Energy production incentives, which offer producers a payment per unit of energy produced (i.e., kWh), may appear similar to, and even be called, feed-in tariffs. The distinction is not simple, as the financing for production incentives may come from explicit utility surcharges or foregone tax revenues. The U.S. production tax credit could be considered a feed-in law under some definitions. The definition used here is that feed-in tariffs should be revenue neutral to the government, with the difference paid implicitly by utility customers (as in the case of Germany and Spain), rather than explicitly through a special levy (as in the case of the Netherlands) or foregone tax revenue (as in the case of Finland).

Beyond China, at least 18 countries, and probably several more, provide capital grants, rebates, or investment tax credits for solar hot water/heating investments, including Australia, Austria, Belgium, some Canadian provinces, Cyprus, Finland, France, Germany, Greece, Hungary, Japan, the Netherlands, New Zealand, Portugal, Spain, Sweden, the United Kingdom, many U.S. states, and the U.S. federal government. Capital grants are typically 20–40 percent of system cost. Investment tax credits may allow deduction of all or part of the investment cost from tax liability. (Italy's renewable energy certificates also apply to solar hot water, so-called "white certificates.") Israel appears to be the only country with a national-level policy mandating solar hot water in new construction. Since 1980, most buildings in Israel have been required to have solar hot water collectors. The technical requirements vary by size and type of building. Certain industrial, medical, and high-rise buildings are exempt. The European Commission was to consider promotion policies for renewable heating, including solar, potentially leading to a new directive.

At the local level, a number of major cities around the world have enacted ordinances requiring solar hot water in new buildings or providing incentives or subsidies for solar hot water investment. Examples are Barcelona (Spain), Oxford (UK), and Portland, Oregon (USA). Barcelona in particular has enacted one of the most far-reaching of such policies. Starting in 2000, the Barcelona Solar Thermal Ordinance has represented a major milestone in urban energy policy. The ordinance requires all new buildings above a specific size category (292 MJ/day hot water energy consumption) to provide at least 60 percent of their domestic hot water energy demand from solar thermal collectors. Swimming pool heating must be 100-percent solar. Buildings undergoing major refurbishment are also subject to the ordinance. The size category means typically that all commercial buildings, and all residential buildings of 16 or more households, are subject to the ordinance. Due to the ordinance, 40 percent of all new buildings now include solar hot water, and per-capita installed capacity (m^2/1,000 people) has leaped 15-fold, from 1.1 in 2000 to 16.5 in 2004. The city's objective is about 100,000 square meters installed by 2010.

Following Barcelona's lead, other cities and towns in Spain adopted solar thermal ordinances as well, including Madrid, Valencia, Seville, Burgos, and Pamplona. The strong interest by municipalities prompted the Spanish Institute for Energy Diversification and Saving (IDAE) in 2003 to elaborate a solar ordinance template, largely based on Barcelona's solar ordinance, which could be used by cities and towns as a basis for their own such rules. By November 2004, 34 municipalities and one region had adopted solar ordinances, with additional ordinances in the pipeline for 10 more regions (out of a total of 17). Results have been significant. For example, Pamplona's solar ordinance, which entered into force in mid-2004, caused a 50-percent increase in solar thermal collectors in one year. A nationwide solar ordinance was under consideration and expected to be enacted in 2005.

Biofuels Promotion Policies

Brazil has been the world leader in promoting biofuels for 25 years under its "ProAlcool" program. Policies have included blending mandates, retail distribution requirements, production subsidies, and other measures. Since 1975, Brazil has mandated that ethanol be blended with all gasoline sold. Although the required blend level is adjusted frequently, it has been in the range of 20–25 percent. All gas stations are required to sell gasohol (E25) and pure ethanol (E100). Tax preferences have been given to vehicles that run on pure ethanol. The recent introduction and soaring sales of so-called "flex-fuel" vehicles by several automakers was not driven primarily by policy, but the government did extend the preferential vehicle licensing tax to cover flexible-fuel cars, beyond the original coverage of pure ethanol cars.* Brazil has more recently begun to target increased use of biodiesel fuels, derived primarily from domestically produced soybean oil. A recent law in Brazil allows blending of 2-percent biodiesel in diesel fuels since January 2005. This percentage may be increased to 5 percent or more by 2013.[N33]

In addition to Brazil, mandates for blending biofuels into vehicle fuels have been appearing in several other countries in recent years. In particular, at least 20 states/provinces and two countries now have mandates for blending ethanol and/or biodiesel with all vehicle fuels sold. In India, the government mandated 10-percent ethanol blending (E10) in 9 out of 28 states and 4 out 7 federal territories (all sugar cane producing areas), starting in 2003. In China, four provinces mandate E10 blending, and five additional provinces were slated for a similar mandate in 2005.† In the United States, three states also mandate E10 blending: Hawaii (most gasoline by 2006), Minnesota (increasing to 20 percent by 2013), and Montana. Minnesota also mandates 2-percent blending of biodiesel (B2), a policy that other states and countries are considering. In Canada, the province of Ontario mandates

* This turning point, in which half of all new cars sales by 2005 were flex-fuel vehicles, was driven by the voluntary initiative of national automotive manufacturers, lead by Volkswagen. Producing flex-fuel cars rather than separate pure-ethanol and gasohol models has allowed automakers to simplify supply and assembly chains.

† Due to poor cane crop yields during 2003–2004, India had to import ethanol in order to meet state blending targets, and has had to postpone broader targets until sufficient supplies of domestic ethanol reappear on the market. Chinese provinces have also had to suspend blending mandates due to ethanol shortages.

E5 (average) blending by 2007. National blending mandates have appeared in Columbia (E10) and the Dominican Republic (E15 and B2 by 2015). Thailand has a target for biofuels as a share of total energy by 2011, for which it is considering E10 and B2 blending mandates. Japan is considering an E5 blending mandate based on imports from Brazil.[N33]

Tax incentives for biofuels are most prominent in the United States, where a number of policies have been enacted at the state and federal levels over the past 25 years. The Energy Security Act of 1979 created a federal ethanol tax credit of up to 60 cents per gallon, proportional to the blend percentage of the fuel (e.g., 6 cents/gallon for E10). In 2004, this tax credit was extended through 2010. A tax credit for biodiesel was also added, of about 1 cent per percentage point of biodiesel blended (i.e., 2 cents per gallon for B2). Several U.S. states also offer tax and other incentives for ethanol production and sales. Canada provides a national fuel tax exemption of 10 cents per liter, and many provinces offer similar or higher exemptions (up to 25 cents/liter). A number of European countries provide fuel or VAT tax exemptions for biofuels, including Austria (95 percent exemption for biodiesel), France, Germany (100 percent exemption for biodiesel), Hungary, Italy (100 percent exemption for biodiesel), Spain, Sweden, and the United Kingdom.

Several other European countries have been considering biofuels policies as part of efforts to achieve the EU biofuels target of 5.75 percent of transport fuels by 2010. An EC Directive in 2003 provided targets for each country to meet by 2005 (2 percent) and 2010 (5.75 percent). Although the targets are voluntary, countries have had to submit plans for meeting targets, or justifications for why they won't. Some EU members have recently enacted biofuels promotion laws or binding targets, including Hungary, which mandates 2 percent of total energy from biofuels by 2010, and the Netherlands, with a target of 2 percent of transport fuels.

Green Power Purchasing and Utility Green Pricing

There were more than 4.5 million green power consumers in Europe, the United States, Canada, Australia, and Japan in 2004. Green power purchasing and utility green pricing programs are growing, aided by a combination of supporting policies, private initiatives, utility programs, and government purchases. The three main vehicles for green power purchases are utility green-pricing programs, competitive retail sales by third-party producers allowed through electricity deregulation (also called "green marketing"), and tradable renewable energy certificates. Community-organized green power programs also exist in Japan. As markets expand, the price premiums for green power over conventional power have continued to decline. In the United States, retail green power premiums are now typically 1–3 cents/kWh.[N34]

In Europe, green power purchasing and utility green pricing have existed in some countries since the late 1990s. By 2004, there were almost 3 million green power consumers in the Netherlands, supported by a tax exemption on green electricity purchases. Other countries in Europe with retail green power markets include Finland, Germany, Switzerland, and the United Kingdom. Germany's green power market has grown steadily since 1998, with more than 600,000 consumers purchasing 2,000 GWh in 2004. Eighteen European countries are members of RECS, a renewable energy certificates system founded in the late 1990s to standardize and certify renewable energy certificates and trading. By 2005, a cumulative total of 33,000 GWh of renewable energy certificates had been issued, with nearly 13,000 GWh of certificates used for consumer purchases of green electricity.*

The United States has an estimated half-million green power consumers purchasing 4,500 GWh of power annually. Green power purchasing began in earnest around 1999. By 2004, at least 2 GW of additional renewable energy capacity was built in the United States to accommodate this market.† The federal government is the largest single buyer of green power, with the U.S. Air Force purchasing 320 GWh annually. By 2004, more than 600 utilities in 34 states had begun to offer green-pricing programs. Most of these offerings were voluntary, but regulations were enacted in five states between 2001 and 2003 that require utilities to offer green power products to their customers. Utility green pricing accounted for almost half of green power sales in 2004.

Many large companies in the United States, from aerospace contractors to natural foods companies, are voluntarily buying green power products. Among these corporate buyers are IBM, Dow, Dupont, Alcoa, Intel, HP, Interface, Johnson & Johnson, Pitney Bowes, Staples, Baxter, FedEx Kinkos, General Motors, and Toyota. Public and non-governmental initiatives have facilitated these buyers. The U. S. Environmental Protection Agency's "Green Power Partnership" had 600 partners by 2005, purchasing 2,800 GWh of green power annually. And a voluntary "Green-e" certifica-

* In the United Kingdom, the distinction between voluntary green power purchases and renewable energy obligations by utilities has been questioned. There are claims that green power voluntary purchases in the United Kingdom are not always "additional" to existing utility obligations. In Germany, more than 50 percent of the green power market is served by hydropower plants, predominantly those put into operation well before the German electricity market was liberalized.

† Green power purchases in the United States are separate from and additional to any renewable energy mandates, for example renewables portfolio standards.

Table 7. Selected Major Cities with Renewable Energy Goals and/or Policies

City	Renewable Energy Goals	CO_2 Reduction Goals	Policies for for Solar Hot Water	Policies for Solar PV	Urban Planning, Pilots, and Other Policies
Adelaide, Australia	✓	✓			✓
Barcelona, Spain	✓	✓	✓	✓	✓
Cape Town, South Africa	✓	✓			✓
Chicago, United States	✓				
Daegu, Korea	✓	✓			✓
Freiburg, Germany	✓	✓		✓	✓
Göteborg, Sweden					✓
Gwangju, Korea	✓	✓			✓
The Hague, Netherlands		✓			
Honolulu, United States					✓
Linz, Austria					✓
Minneapolis, United States	✓				✓
Oxford, United Kingdom	✓	✓	✓	✓	✓
Portland, United States	✓	✓	✓	✓	✓
Qingdao, China					✓
San Francisco, United States					✓
Santa Monica, United States					✓
Sapporo, Japan		✓			✓
Toronto, Canada		✓			
Vancouver, Canada		✓			

tion program has helped build credibility in the market.

In Japan, there were an estimated 60,000 green power consumer-participants by early 2005. These are utility customers who voluntarily contribute to green power through cooperatives, community organizations, and utility programs. Green power in Japan initially developed through voluntary community organizations. The first green power program was initiated by a consumer's cooperative union, Seikatsu Club Hokkaido. Working with the regional utility, the union collects electricity bills, along with voluntary contributions from its members and the general public, and invests in renewable energy projects. Members can purchase shares in wind power projects, thus creating the first "citizen-owned" wind turbines. Similar green funds have been established elsewhere in Japan, and ten Japanese electric utilities now offer customers an option to contribute to a green power fund to support wind and solar systems. As of early 2005, there were 57,000 customers making monthly voluntary contributions to their electricity bills.

Renewable energy certificate markets have also emerged in Japan. The Japan Natural Energy Company (JNEC) now sells green power certificates to commercial and industrial customers, including more than 50 large Japanese companies like Sony, Asahi, Toyota, and Hitachi. JNEC will sell certificates to these companies representing a total of 60 GWh over 15 years, at premiums of 2.4–3.4 cents/kWh (3–4 Yen/kWh).

Australia has over 100,000 green power consumers purchasing from a variety of retailers. And green power purchasing is spreading to other countries. One example is China, where twelve enterprises in Shanghai began to voluntarily purchase green electricity from three local wind farms in 2005, the first such purchases in China. The price premium was high—6 cents/kWh (0.53 yuan) higher than conventional power.

Municipal-Level Policies

Many local governments around the world are enacting their own renewable energy policies. Cities are setting future renewable energy targets and CO_2 emissions-reductions goals, enacting policies to support solar hot water and/or rooftop solar PV, modifying their urban planning methods or processes to incorporate future energy consumption, constructing demonstrations or pilot installations, and enacting a variety of other policies and programs. (See Table 7.)[N35]

A number of cities have decided to purchase green power for municipal government buildings and operations. Examples are Portland, Oregon, and Santa Monica, California, in the United States, which purchase 100 percent of their power needs as green power. Other U.S. cities purchasing 10–20 percent of municipal government power are Chicago, Los Angeles, Minneapolis, and San Diego.

Many cities are adopting future targets of 10–20 percent of electricity from renewables for all consumers in the city, not just the municipal government. Examples are Adelaide, Australia; Cape Town, South Africa; Freiberg, Germany; and Sacramento (California), United States. Targets typically aim for some year in the 2010–2020 timeframe. Some targets are for share of total energy consumption, such as Daegu, Korea, with a target of 5 percent by 2012. Other city targets address installed capacity. Both Oxford, United Kingdom, and Cape Town, South Africa, are targeting 10 percent of homes with solar hot water by 2010 (and solar PV as well in Oxford). Barcelona, Spain, is targeting 100,000 square meters of solar hot water by 2010. Some local governments in the UK are requiring on-site renewables for all new buildings over specific size thresholds.

Some cities have also proposed or adopted CO_2 emissions-reduction goals, typically a 10–20 percent reduction over a baseline level (usually 1990 levels), consistent with the form of Kyoto Protocol targets. (However, at the city level, such target setting is complicated by industrial production, as emissions associated with industry are not necessary attributable to residents of the city.) Examples are Freiburg, Germany (25 percent); Gwangju, Korea (20 percent); Sapporo, Japan (10 percent); Toronto, Canada (20 percent for municipal government energy); and Vancouver BC, Canada (6 percent). The Hague, Netherlands, plans for municipal government consumption to be "CO_2 neutral" by 2006 and for the whole city to be "CO_2 neutral" in the long term. Adelaide, Australia, plans "zero net emissions" by 2012 in buildings and by 2020 in transport.

Urban planning that incorporates future clean-energy visions is gaining hold in many cities, often with participation from a variety of stakeholders. Göteborg, Sweden, is an example of a city creating a long-term vision, through a project called Göteborg 2050. That project is a collaborative effort between universities, the city government, and the city's energy utility. It includes research, scenario development, strategic planning, dialogue with the public, and demonstration projects. In Japan, where renewable energy policy has been quite active at the local level, 800 local governments have laid out future urban visions over the past 10 years, with support from a national government program. These Japanese cities are creating advanced and unique visions taking into consideration their local characteristics, and incorporating renewable energy into their visions.

Cities worldwide are collectively organizing and participating in a variety of global initiatives that support renewable energy development at the local level, such as the Cities for Climate Protection campaign of ICLEI (Local Governments for Sustainability), the International Solar Cities Initiative, the European Solar Cities Initiative, the European Green Cities Network, and the European Climate Alliance.

5. RURAL (OFF-GRID) RENEWABLE ENERGY

The most common applications of renewable energy for rural (off-grid) energy services are cooking, lighting and other small electric needs, process motive power, water pumping, and heating and cooling. These applications are described in Table 8 (page 30), which blends "first-generation" or "traditional" applications and technologies (i.e., unprocessed biofuels and small-scale hydro) with "second-generation" applications and technologies (i.e., wind, solar PV, biomass gasification, and pico-scale hydro). Although much development attention has focused on second-generation technologies, rural development professionals are continually reminding the development and renewable energy communities about the continued importance of first-generation technologies, especially in the least-developed countries. This section discusses some of the rural energy applications from Table 8 and then discusses rural electrification policy.[N36]

"Traditional" applications mean primarily burning fuel wood, agricultural and forestry wastes (residues), dung, and other unprocessed biomass fuels for home cooking and heating and other process-heating needs. Some biomass is converted to charcoal and sold in commercial markets. Biomass accounts for a large share of total primary energy supply in many developing countries. In 2001, this share was 49 percent in Africa, 25 percent in Asia, and 18 percent in Latin America. In 2000, households in sub-Saharan Africa consumed nearly 470 million tons of wood fuels (0.72 tons per capita) in the form of wood and charcoal. In comparison, India and China together consumed 340 million tons. In sub-Saharan Africa, wood or crop residues are the primary source of household energy for 94 percent of rural households and 41 percent of urban households. Charcoal is the primary source of household energy for 4 percent of rural households and 34 percent of urban households. And kerosene is the primary source of household energy for 2 percent of rural households and 13 percent of urban households.[N37]

The costs and health impacts of traditional biomass use (and the corresponding benefits of improved biomass stoves and other technologies) are beyond the scope of this report but still highly significant. Much of the biomass fuel is collected outside of the commercial economy, with collection time being a large non-monetary expenditure, especially for women. Researchers Ezzati and Kammen, in a comprehensive literature review, state that "conservative estimates of global mortality as a result of exposure to indoor air pollution from solid fuels show that in 2000 between 1.5 million and 2 million deaths were attributed to this risk factor, accounting for 3–4 percent of total mortality worldwide."[N37]

Cooking: Improved Biomass Cook Stoves

Improved biomass stoves save from 10–50 percent of biomass consumption for the same cooking service provided and can dramatically improve indoor air quality. Improved stoves have been produced and commercialized to the largest extent in China and India, where governments have promoted their use, and in Kenya, where a large commercial market developed. There are 220 million improved stoves now in use around the world, due to a variety of public programs and successful private markets over the past two decades. This number compares with the roughly 570 million households worldwide that depend on traditional biomass as their primary cooking fuel. China's 180 million existing improved stoves now represent about 95 percent of such households. India's 34 million improved stoves represent about 25 percent of such households.*[N38]

In Africa, research, dissemination, and commercialization efforts over the past few decades have brought a range of improved charcoal—and now wood-burning—stoves into use. Many of these stove designs, as well as the programs and policies that have supported their commercialization, have been highly successful. There are now 5 million improved stoves in use. In Kenya, the Ceramic Jikko stove (KCJ) is found in more than half of all urban homes and roughly 16–20 percent of rural homes. About one-third of African countries have programs for improved biomass cook-stoves, although there are few specific policies in place. Non-governmental organizations and small enterprises continue to promote and market stoves as well.

Cooking and Lighting: Biogas Digesters

An estimated 16 million households worldwide receive energy for lighting and cooking from biogas produced in household-scale plants (called anaerobic digesters). This includes 12 million households in China, 3.7 million households in India, and 140,000 households in Nepal. In addition to providing energy for cooking and lighting, biogas

* Improved biomass cook stoves are more properly considered a fuel-efficiency technology rather than a renewable energy production technology. Nevertheless, they are clearly a form of rural renewable energy use, one with enormous scope and consequences of use. Policies and programs to promote efficient stoves are therefore not renewable energy "promotion" policies, as is typical with other renewables covered in this report, but rather are designed to improve the health, economic, and resource impacts of an existing renewable energy use (and thus closely linked to sustainable forestry and land management). The number of existing and operating improved stoves may be significantly less than reported figures given here; for example, in India some estimates say a majority of stoves have passed their useful lifetimes and no longer operate.

Table 8. Common Existing Applications of Renewable Energy in Rural (Off-Grid) Areas

Energy Services	Renewable Energy Applications	Conventional Alternatives
Cooking (homes, commercial stoves and ovens)	• biomass direct combustion (fuel wood, crop wastes, forest wastes, dung, charcoal, and other forms) • biogas from household-scale digester • solar cookers	LPG, kerosene
Lighting and other small electric needs (homes, schools, street lighting, telecom, hand tools, vaccine storage)	• hydropower (pico-scale, micro-scale, small-scale) • biogas from household-scale digester • small-scale biomass gasifier with gas engine • village-scale mini-grids and solar/wind hybrid systems • solar home systems	candles, kerosene, batteries, central battery recharging, diesel generators
Process motive power (small industry)	• small hydro with electric motor • biomass power generation and electric motor • biomass gasification with gas engine	diesel engines and generators
Water pumping (agriculture and drinking)	• mechanical wind pumps • solar PV pumps	diesel pumps
Heating and cooling (crop drying and other agricultural processing, hot water)	• biomass direct combustion • biogas from small- and medium-scale digesters • solar crop dryers • solar water heaters • ice making for food preservation	LPG, kerosene, diesel generators

has improved the livelihood of rural households in indirect ways. For example, analysis of the benefits of biogas in Nepal shows a reduction of workload for women and girls of 3 hours/day per household, annual savings of kerosene of 25 liters/household, and annual savings of fuel wood, agricultural waste, and dung of 3 tons/household.[N39]

In China, household-scale biogas for rural home lighting and cooking is a widespread application. A typical digester, sized 6–8 cubic meters, produces 300 cubic meters of biogas per year and costs 1,500–2,000 RMB ($200–250), depending on the province. Because digesters are a simple technology, there is no need for advanced expertise, and they can be supplied by local small companies. Farmers, after receiving proper training, can build and operate the digesters themselves. A new government program, started in 2002, provides 1 billion RMB annually as subsidies to farmers who build their own digester. The subsidy is 800 RMB per digester. Some estimate that more than 1 million biogas digesters are being produced each year. Beyond household scale, a few thousand medium and large-scale industrial biogas plants were operating in China, with a recent national biogas action plan expected to expand the numbers of such plants.

In India, the Ministry of Non-conventional Energy Sources has been promoting household-scale biogas plants since the early 1980s. The ministry provides subsidies and financing for constructing and maintaining biogas plants, training, public awareness, technical centers, and support to local implementing agencies. The well-known Khadi and Village Industries commission also supports biogas plants.

In Nepal, the SNV/Biogas Support Programme has provided technological innovation, financing, engineering, and market development for household-scale biogas plants (sized 4–20 cubic meters, with the most popular being 6 cubic meters). During the program, 60 private biogas companies increased their technical and market capabilities, 100 micro-credit organizations provided loans, quality standards were adopted, and a permanent market facilitation organization, Biogas Sector Partnership/Nepal, has been created.

Electricity, Heat, and Motive Power: Biomass Gasification

Small-scale thermal biomass gasification is a growing commercial technology in some developing countries, notably China and India. Gas from a gasifier can be burned directly for heat or used in gas turbines or gas engines for electricity and/or motive power. In a few Chinese provinces, biogas from thermal gasifiers also provides cooking fuel through piped distribution networks. The total installed capacity of gasifiers in India was estimated at 35 MW in 2002, and ten manufacturers are selling small-scale gasifiers together with engines up to 300 kW. In the Philippines, gasifiers have been coupled to dual-fuel diesel engines and used for rice-milling and irrigation since the 1980s. Gasifiers have also been demonstrated in Indonesia, Thailand, and Sri Lanka.[N40]

In India, projects involving biomass gasification in silk and other textile production and processing have been demonstrated on a commercial basis, involving local entrepreneurs and short payback periods. Spice (cardamom) drying, also with gasifiers and no reliance on electricity, yields a higher-quality product in a shorter drying period. In this application, the investments pay for themselves in one season. More than 85 percent of the beneficiaries are small producers who own less than two hectares. The drying of rubber, again with gasifiers, also demonstrates the capability to displace conventional energy and deliver a payback of less than one year. Gasifiers are also used to dry bricks before firing in a kiln. The use of a gasifier reduces fuel consumption and associated smoke and decreases the drying time (increasing productivity) while improving working conditions.

Electricity: Village-Scale Mini-Grids/Hybrid Systems

Village-scale mini-grids can serve tens or hundreds of households. Traditionally, mini-grids in remote areas and on islands have been powered by diesel generators or small hydro. Generation from solar PV, wind, or biomass, often in hybrid combinations including batteries and/or a supplementary diesel generator, is slowly providing alternatives to the traditional model, mostly in Asia. Tens of thousands of mini-grids exist in China, primarily based on small hydro, while hundreds or thousands exist in India, Nepal, Vietnam, and Sri Lanka. The use of wind and solar PV technologies in mini-grids and hybrid systems is still on the order of a thousand systems worldwide, mostly installed in China since 2000. China's "Township Electrification Program" from 2002–2004 electrified one million rural people in one thousand townships, about 250,000 households, with electricity from solar PV, wind-solar PV hybrid systems, and small hydropower systems. During 2002–2004, almost 700 townships received village-scale solar PV stations of approximately 30–150 kW (about 20 MW total). A few of these were hybrid systems with wind power (about 800 kW of wind total). India, the other main location for village-scale power systems, has 550 kW of solar/wind hybrid systems installed, which serve on the order of a few thousand households in several dozen villages.[N41]

Water Pumping: Wind and Solar PV

Solar PV and wind power for water pumping, both irrigation and drinking water, are gaining widespread acceptance, and many more projects and investments are occurring. On the order of one million mechanical wind pumps are in use for water pumping, primarily in Argentina, following decades of development. Large numbers of wind pumps are also used in Africa, including in South Africa (300,000), Namibia (30,000), Cape Verde (800), Zimbabwe (650), and several other countries (another 2,000). There are now more than 50,000 solar-PV pumps worldwide, many of these in India. Over 4,000 solar pumps (ranging from 200–2,000 W) were recently installed in rural areas as part of the Indian Solar PV Water Pumping Programme. There are an estimated 1,000 solar water pumps in use in West Africa. Donor programs for PV-powered drinking water have appeared in Argentina, Brazil, Indonesia, Jordan, Namibia, Niger, the Philippines, Tunisia, and Zimbabwe, among others.[N42]

A growing cohort of commercial projects for solar PV-powered drinking water, including both pumping and purification, has appeared in recent years, notably in India, the Maldives, and the Philippines. In the Maldives, a commercial pilot project anticipates sales of 1,000 liters/day, with a long-term delivered price of water to households expected to reach 0.2–0.5 cents per liter. Another recent example is on the Philippine island of Cebu. A 3-kW solar PV water pump distributes filtered and chlorinated surface water to 10 village locations. The 1,200 residents use prepaid debit cards to purchase potable water at a cost of about 3 PHP (5.5 cents) for 20 liters, or 0.3 cents/liter, a tenth of the cost of bottled water supplies. Fees collected from water sales are used to pay back an unsubsidized 10-year bank loan. The scheme could be duplicated on 10 more Philippine islands, providing potable water to 200,000 people in 40 municipalities.

Electricity: Solar Home Systems

By 2005, more than 2 million households in developing countries were receiving electricity from solar home systems. Most of these systems, and most of the global growth in recent years, is occurring in a few specific Asian countries (India, Sri Lanka, Nepal, Bangladesh, Thailand, and China), where the affordability problem has been overcome either with micro-credit or by selling small systems for cash, and where government and international donor programs have supported markets.* In each of these countries, hundreds or thousands of new household installations are now occurring monthly (10,000 per month reported in China in 2005). Total installations were more than 200,000 in 2004 alone. Indonesia has about 40,000 solar home systems installed through several donor programs, but macroeconomic difficulties of past years have dampened continued growth. Outside Asia, other large markets include Kenya, Morocco, and

* Projects by the GEF, the World Bank, and UNDP supported about 410,000 solar home systems installed worldwide by 2004, including 230,000 in China, 75,000 in Sri Lanka, 45,000 in India, 40,000 in Bangladesh, 10,000 in Zimbabwe, and perhaps another 10,000 through other projects combined. This has been the largest single donor-support program for solar home systems. Projects by these agencies and other government programs have also employed a rural energy-service concession approach, or "fee-for-service" business model, for example in South Africa, Cape Verde, Argentina, Senegal, and Botswana, but such business models are still in the early stages of demonstrating their viability.

Mexico. The plans of a number of Latin American countries may shift solar home system growth towards that region if promising approaches to affordability, including government subsidies and/or fee-for-service models, continue to be followed.* [N43]

Africa, with its very low rural-electrification rates and low per-capita income, has not seen significant growth in solar home systems, with the exception of a few countries. Kenya has 150,000 solar home systems, almost half of the installed base in Africa, and continuing market growth. Growth has been driven by cash sales of small modules to households in rural and peri-urban areas. Morocco is targeting 150,000 solar home systems by 2010. Uganda has a major 10-year program that targets solar home systems and other productive uses in education and health care. South Africa has been planning for several years to provide solar home systems to 200,000 rural households through "fee-for-service" concessions operated by private firms. Other countries like Mali, Tanzania, and Senegal are providing limited subsidies for rural renewables like solar home systems. In general, however, earlier expectations that millions of homes would obtain solar home systems in Africa have failed to materialize. Affordability is still a critical issue, as the cost of a typical low-end solar home system is high relative to average incomes in most African countries.

Solar home systems sales by private dealers have been the cornerstone of markets in five countries: China, Sri Lanka, India, Bangladesh, and Kenya. In China and Kenya, systems are almost exclusively sold for cash. In India, Sri Lanka, and Bangladesh, credit sales have improved affordability and fostered markets. Significant innovation is occurring with NGO-based microfinance, dealer-supplied credit, and consumer credit through commercial banks. In India, along with many cash purchases, credit for solar home systems purchases is now offered through more than 2,000 rural bank branches as part of a commercial solar loan program. Indeed, the estimated 120,000 solar home systems sold on credit in India, Sri Lanka, and Bangladesh during the past five years represents virtually the entire stock of credit-based installations worldwide. Kenya also has a very active private market, with more than 20 major PV import and manufacturing companies, and hundreds of rural vendors and urban distributors, many of which sell a range of brands.

Other Productive Uses of Heat and Electricity

Productive uses of heat and electricity for small-scale industry, agriculture, telecommunications, health, and education in rural areas are a growing area of attention for applying modern renewable energy technologies. Examples of industrial applications include silk production, brick making, rubber drying, handicraft production, sewing, welding, and wood working. Examples of agricultural and food processing applications include irrigation, food drying, grain mills, stoves and ovens, ice making, livestock fences, and milk chilling. Health applications include vaccine refrigeration and lighting. Communication applications include village cinema, telephone, computers, and broadcast radio. Other community applications include school and street lighting, and drinking water purification. Despite this diversity of potential applications, existing projects are still small demonstrations. For the most part, large-scale development of these applications on sustainable or commercially replicable terms has yet to occur.

Even as applications of renewable electricity for lighting, water pumping, medical refrigeration, and motive power are beginning to receive greater attention, application of modern renewables to heating needs is still much less discussed or practiced. Traditional biomass fuels are used to produce heat and heat-related services such as cooking, space heating, crop drying, roasting, agricultural processing, kilns, ovens, and commercial food-processing. Applications of solar heating and advanced biomass technologies are just beginning to attract the attention of the development community. Developing-country governments are focusing more on these areas as well. For example, the Indian government has launched comprehensive programs promoting biomass for electricity, heat, and motive power in rural areas, including combustion, co-generation, and gasification. These rural energy programs target all forms of household, community, and productive needs in hundreds of rural districts.

A good example of applications in health and education is the World Bank/GEF Uganda Energy for Rural Transformation project. The project is providing energy for medical equipment, staff quarters, lighting, cold chain, sterilizing, and telecom, and demonstrating to the Ministry of Health the viability of such applications. For education, solar PV will power equipment for vocational training, lighting for night classes, and staff housing. Other applications include water pumping and small enterprises. Mexico's "telesecundaria" program is another good example. This program is designed to enhance rural schools through distance education programs, and many remote schools rely on solar PV to power communications and other equipment for distance learning. In Guatemala, Honduras, and Bolivia, a new model for "telecenters" is emerging, combining public-service centers with for-profit telephone services.

Approaches to financing small and medium-scale enter-

* Solar home system totals include more than half a million households in India and other countries with "solar lanterns" in addition to fixed household-scale systems. Compact fluorescent lights are commonly used with solar home systems, but there is growing interest in low-wattage LEDs and cold-cathode fluorescent lamps for low-cost solar lanterns and solar home systems requiring less solar-PV capacity.

prises engaged in renewable energy-related productive business have gained considerable attention in recent years through programs like the UNEP/UN Foundation "rural energy enterprise development" (REED) program in Africa, Brazil, and China and other finance initiatives. These enterprises are providing a variety of services and products, including solar home systems, water pumping, solar crop drying, biofuels-powered engines for grinding and milling, solar bakeries, biomass briquettes and pellets, and other income-generating uses. The number of such enterprises is growing in rural areas, led by both donor programs and greater access to commercial bank credit.

Rural Electrification Policies and Programs

National rural electrification policies and programs, together with international donor programs, have employed renewable energy as an adjunct to "access" strategies. That is, serving increasing percentages of rural populations who don't have access to central electric power networks. An estimated 360 million households worldwide still lack such access. The main electrification options include power grid extension, diesel generators connected in mini-grids, renewable energy connected in mini-grids (solar, wind, and/or biomass gasification, sometimes combined with diesel), and household-scale renewable energy (solar home systems and small wind turbines). Often the cost of traditional grid extension is prohibitive; in Kenya, for example, the average cost of a new connection for a rural home is seven times the national per-capita income.[N44]

Interest in using renewable energy technologies to provide electricity to rural and remote areas as a cost-effective alternative to grid extension is gathering momentum in many developing countries. At the same time, there is a growing recognition that private investment alone is insufficient, and that public subsidies and policies play a key role, justified by development goals and public mandates for universal electricity access. "All our client countries in Latin America have told us that they have realized that they need subsidies and regulatory measures for reaching the 'last 20 percent' of their rural unelectrified populations, including with renewable energy," said a World Bank project manager.

Rural electrification programs in several countries, particularly in Latin America, are explicitly incorporating large-scale investment in solar home systems for some of the homes to be electrified. Governments are recognizing geographic rural areas that are non-viable for grid-extension, and enacting explicit policies and subsidies for renewables in these areas to supplement line-extension electrification programs. For example, Brazil plans to electrify 2.5 million households by 2008 under the "Luz para Todos" program (about 700,000 have already been electrified), and has targeted 200,000, or about 10 percent of these households for renewable energy. As mentioned before, China's "Township Electrification Program," which was substantially completed during 2004, provided power to 1 million people in rural areas with renewable energy. The Indian government's "Remote Village Electrification Programme" has identified 18,000 villages for electrification, partly with renewable energy technologies like biomass gasifiers.

Several other Latin American countries have recently launched or revamped new rural electrification programs, including Bolivia, Chile, Guatemala, Mexico, Nicaragua, and Peru. Most of these countries have launched efforts to "mainstream" renewable energy as a standard option of new rural electrification efforts. For example, Chile has recently recognized renewables as a key technology as it enters a second phase of a national rural electrification program. Given this planned scale-up of renewables for rural electrification, regulators and utilities have realized that legal and regulatory frameworks need to be adopted quickly. Indeed, new laws or regulations appeared during 2004 and 2005 in Argentina, Bolivia, Brazil, Chile, Guatemala, and Nicaragua.

Asian examples of countries with explicit mandates for renewable energy for rural electrification include Bangladesh, China, India, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam. Some of these countries are financing programs with multilateral assistance, as well as conducting other technical assistance and support measures. The Philippines launched a strategy in 1999 to achieve full rural village electrification by 2007, including renewable energy explicitly in that strategy. Sri Lanka is targeting 85 percent of the population with access to electricity and has started to directly subsidize rural solar home systems. Thailand decided in 2003 to electrify the remaining 300,000 off-grid households in the country with solar home systems by the end of 2005, and accomplished almost half of that goal in 2004.

GLOSSARY

Biodiesel. A vehicle fuel for diesel-powered cars, trucks, buses, and other vehicles. Biodiesel is produced from oilseed crops such as soy, rapeseed (canola), and mustard, or from other vegetable oil sources such as waste cooking oil.

Biogas digester. Converts animal and plant wastes into gas usable for lighting, cooking, heating, and electricity generation.

Biomass power and heat. Power and/or heat generation from solid biomass, which includes forest product wastes, agricultural residues and waste, energy crops, and the organic component of municipal solid waste and industrial waste. Also includes power and process heat from biogas.

Capital subsidies or consumer grants. One-time payments by the government or utility to cover a percentage of the capital cost of an investment, such as a solar hot water system or rooftop solar PV system.

Ethanol. A vehicle fuel made from biomass (typically corn, sugar cane, or wheat) that can replace ordinary gasoline in modest percentages (see "gasohol") or be used in pure form in specially modified vehicles.

Feed-in tariff. A policy that sets a fixed price at which power producers can sell renewable power into the electric power network. Some policies provide a fixed tariff while others provide fixed premiums added to market- or cost-related tariffs. Some provide both.

Gasohol. A blend of gasoline and ethanol, typically 10–25 percent ethanol (called E10, E25, etc.).

Geothermal power and heat. Heat energy emitted from within the Earth, usually in the form of hot water or steam, which can be used to produce electricity or direct heat for buildings, industry, and agriculture.

Gigawatt (GW)/Gigawatt-hour (GWh)/Gigawatt-thermal (GWth). See megawatt, kilowatt-hour, megawatt-thermal.

Green power purchasing. Voluntary purchases of green power by residential, commercial, government, or industrial customers, from utility companies (see "utility green pricing"), from a third-party renewable energy generator (also called "green marketing"), or with "renewable energy certificates." With utility green pricing or competitive sales, a customer's electricity demand is matched by an equivalent amount of renewable energy generation feeding into the power grid. Green certificates allow the renewable energy production to be located anywhere.

Investment tax credit. Allows investments in renewable energy to be fully or partially deducted from tax obligations or income.

Kilowatt-hour (kWh). A unit of produced or consumed electricity. Also the most common unit for the retail price of electricity, as in cents/kWh.

Large hydropower. Electricity from water flowing downhill, typically from behind a dam. No international consensus exists on the threshold that separates large from small hydro power, but the upper limit varies from 2.5–50 MW, with 10 MW becoming more standard.

Megawatt (MW). A unit of power-generating capacity. Represents an instantaneous power flow and should not be confused with units of produced energy (i.e., MWh, or megawatt-hours).

Megawatt-thermal (MWth). A unit of heat-supply capacity used to measure the potential output from a heating plant, such as might supply a building or neighborhood. More recently used to measure the capacity of solar hot water/heating installations. Represents an instantaneous heat flow and should not be confused with units of produced heat (i.e., MWh(th), or megawatt-hours-thermal).

Modern biomass. Biomass-utilization technologies other than those defined for traditional biomass, such as biomass co-generation for power and heat, biomass gasification, biogas anaerobic digesters, and production of liquid biofuels for use in vehicles.

Multilateral agency. Commonly refers to public agencies that work internationally to provide development, environmental, or financial assistance to developing countries, such as the World Bank, or to broker international agreements and treaties, such as the United Nations.

Net metering. Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. When instantaneous consumption exceeds self-generation, the meter runs forward. When instantaneous self-generation exceeds consumption, the meter runs backward and power flows to the grid. The customer pays for the net electricity used in each billing period and may be allowed to carry over net generation from month to month.

Production tax credit. Provides the investor or owner of qualifying property with an annual tax credit based on the amount of electricity generated by that facility.

Renewable energy target. A commitment, plan, or goal by a country to achieve a certain level of renewable energy by a future date. Some targets are legislated while others are set by regulatory agencies or ministries. Can take many forms with varying degrees of enforcement leverage. Also called "planning targets," "development plans," and "obligations."

Renewables portfolio standard (RPS). A standard requiring that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated utilities are required to ensure that the target is met, either through their generation, power purchase from other producers, or direct sales from third parties to the utility's customers.

Small/mini/micro/pico hydropower. (See "large hydropower.") Small hydropower is commonly defined as below 10 MW, mini below 1 MW, micro below 100 kW, and pico below 1 kW. Pico hydro will typically not involve a dam but just captures the power of flowing water.

Solar home system. A rooftop solar panel, battery, and charge controller that can provide modest amounts of power to rural homes not connected to the electric grid. Typically provides an evening's lighting (using efficient lights) and TV viewing from one day's battery charging.

Solar hot water/heating. Rooftop solar collectors that heat water and store it in a tank for use as domestic hot water or for space heating.

Solar photovoltaic (PV) panel/module/cell. Converts sunlight into electricity. Cells are the basic building block, which is then manufactured into modules and panels.

Tradable renewable energy certificates. Each certificate represents the certified generation of one unit of renewable energy (typically one MWh). These certificates allow trading of renewable energy obligations among consumers and/or producers, and in some markets like the United States allow anyone to purchase separately the green power "attributes" of renewable energy.

Traditional biomass. Unprocessed biomass, including agricultural waste, forest products waste, collected fuel wood, and animal dung, that is burned in stoves or furnaces to provide heat energy for cooking, heating, and agricultural and industrial processing, typically in rural areas.

Utility green pricing. A utility offers its customers a choice of power products, usually at differing prices, offering varying degrees of renewable energy content. The utility guarantees to generate or purchase enough renewable energy to meet the needs of all green power customers.

RENEWABLES 2005 GLOBAL STATUS REPORT

Notes and References Companion Document

October 20, 2005 Version
Companion to the main report: www.ren21.net/globalstatusreport

NOTES

[N1] Coverage of Report and General Notes

Most figures of global capacity, growth, and investment are not exact, but rather approximate to two significant digits at most (i.e., 630 but not 632; 1,300 but not 1,350, etc.). Sometimes only one-and-half significant digits may apply; for example, a number could be given as 15 rather than 10 or 20, but 17 would be too precise based on the data available and assumptions made.

This report generally covers those technologies with high technology maturity and either high or low levels of market maturity. These categories follow an analysis by Navigant Consulting, which groups renewable power generation technologies into three categories: *1.High technology maturity and high market maturity:* small hydro, biomass direct combustion, landfill gas, geothermal, and on-shore wind (just emerging into high market maturity); *2.High technology maturity but low market maturity:* biomass co-firing, crystalline silicon PV, waste-to-energy (combustion), anaerobic digester biogas, parabolic trough solar thermal power (just emerging into high technology maturity), and offshore wind (just emerging into high technology maturity); *3. Low technology maturity and low market maturity (technologies to watch):* tidal barrage, thin-film PV, concentrating PV, biomass integrated gasification combined-cycle (BIG/GT), dish stirling, wave power, solar thermal power tower, biomass pyrolysis, tidal current OTEC, and nano solar cells.

This report does not cover policies and activities related to technology transfer, capacity building, carbon finance, and CDM projects. Hopefully subsequent editions, if published, could cover these topics.

For a general treatment of market, policies, and barriers to renewable energy, see IEA 2004b; EREC 2004; Beck & Martinot 2004; Komar 2004; Fulton et al. 2004; UNDP et al. 2000; Goldemberg & Johansson 2004; Johansson & Turkenburg 2004; Sawin & Flavin 2004; and Sawin 2004.

[N2] Primary Energy from Renewable Energy

Table N2 shows the relative energy contributions from new renewables, large hydro, and traditional rural biomass. The primary energy attributed to electricity supply is adjusted to reflect fossil fuel energy required to produce an equivalent about of electricity. This type of adjustment is made in some but not all published global energy statistics. The best example is BP's annual *Statistical Review of World Energy*. In BP statistics, "the primary energy value of hydroelectricity generation has been derived by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38% (the average for OECD thermal power generation)" (BP 2005). BP gives hydropower as 634 Mtoe in 2004, or 6.2% of global primary commercial energy. Other statistics not using this methodology will give hydropower as 2.4% of global primary commercial energy, so there will be significant discrepancies between numbers here and some other published numbers. In addition, this correction makes total primary energy higher, with BP's number of 10,224 Mtoe commercial primary energy in 2004 higher than some other published figures.

Traditional biomass was given as 1,035 Mtoe for 1999 from World Resources 2002-2004, Table 8 (UNDP et al. 2002). Assuming 2% growth per year in traditional biomass use gives 1,140 Mtoe for 2004. This reflects population growth minus fuel switching minus more efficient use of resources. There are no definitive sources of information on traditional biomass use, and a fairly wide range of estimates can be found, reflecting the plausible range of assumptions, methodologies, and data quality. Traditional biomass fuels are commonly estimated in the literature at 9-10% of global primary energy (see Goldemberg & Johansson 2004; Kartha et al. 2004). The typical range in the literature for traditional biomass is 28-48 EJ. The WRI estimate of 1,035 Mtoe for 1999 is 43 EJ, which is at the higher end of the range. Goldemberg & Johansson 2004 give 950 Mtoe for 2001 (Figure 5), which is 40 EJ. Applying 2% growth from 2001 to 2004 would give 1,010 Mtoe in 2004, which is the figure assumed for purposes of this report. There is no consensus on how fast traditional biomass use is growing. Traditional biomass users should grow at the rate of growth of rural populations in developing countries, except for those countries where adoption of modern fuels in rural areas is becoming more widespread. Growth of biomass fuel use will be related, but not the same.

So total world primary energy in 2004 was 10,224 Mtoe (commercial) + 1,010 Mtoe (traditional) = 11,234 Mtoe. Renewables share of 1,876 Mtoe is 16.7%. (1 Mtoe = 41.9 PJ).

Electricity production from renewables in Table N2 is calculated from capacity figures in Table N2 by scaling energy production figures provided in Table 4 of Johansson & Turkenburg 2004, which gives 2001 figures of 2600 TWh large hydro from 690 GW, 43 TWh wind from 23 GWe, 170 TWh biomass electricity from 40 GWe, 730 TWh biomass heat from 210 GWth, 53 TWh geothermal from 8 GW, 55 TWh geothermal heat from 16 GWth, 57 TWh solar hot water from 95 million m^2, 450 PJ ethanol from 19 billion liters/year, and 45 PJ from 1.2 billion liters/year. Thus, average capacity factors in 2004 are assumed similar to those implied by Johansson & Turkenburg for 2001.

Energy content of avoided fossil fuels for Table N2 assumes global average power generation efficiency from fossil fuels of 36% (BP's *Statistical Review of World Energy* uses 38% as the average for OECD thermal power generation in their primary energy conversion, but developing countries will be less). Energy content of avoided fossil fuels assumed to be parity for biofuels and hot water/heating.

BP (2005) shows 17,450 TWh of electricity produced worldwide in 2004. Large hydro, at 2,800 TWh, is 16.0%. Renewables, at 540 TWh, are 3.1%. World electricity production in 1994 was 12,850 TWh and large hydro was 2,380 TWh, so the share of large hydro in 1994 was 18.5%.

IAEA (2005) gives electricity production from nuclear power at 2,619 TWh in 2004. The estimated 550 TWh from renewables (excluding large hydro) in 2004 (see Table N2) is 21% of this figure.

Table N2. Relative Energy Contribution of Different Forms of Renewable Energy, 2004

	Primary energy supply based on direct energy output		Adjusted energy supply based on energy content of avoided fossil fuels (Mtoe)	Share of total renewable energy supply
	natural units	Mtoe		
Power generation				
Biomass power	150 TWh	12.9	35.8	
Wind power	95 TWh	8.2	22.7	
Small hydro	240 TWh	20.6	57.3	
Geothermal power	60 TWh	5.2	14.3	
Total			**130**	**6.9%**
Hot water/heating				
Solar hot water	290 PJ	6.9		
Geothermal heat	200 PJ	4.8		
Biomass heat	2,600 PJ	62.1		
Total		73.7	**73.7**	**3.9%**
Biofuels				
Ethanol	700 PJ	16.7		
Biodiesel	80 PJ	1.9		
Total		18.6	**18.6**	**1.0%**
Other renewables				
Traditional biomass		1,010	**1,010**	**53.8%**
Large hydro power	2,700 TWh	232	**644**	**34.3%**
Total				
Total			**1,876**	**100%**

[N3] Added and Existing Capacities and Growth Rates

Table N3 presents installed capacities, added capacities, and growth rates of renewable energy. Growth rates are author's estimates based on compilations of global installed capacity figures for all renewable technologies from 1995 to 2004. According to compiled figures, grid-connected solar PV grew from 190 MW in 1999 to 1,760 MW in 2004, and 630 MW were added in 2004 (adapted from Maycock 2003, 2004, 2005a). Off-grid solar grew from 990 MW to 2,200 MW (same). Wind power grew from 13.5 GW to 48 GW (GWEC 2005 and BTM Consult 2005). Ethanol grew from 18.8 billion liters to 31 billion liters (author's spreadsheet based on Lichts 2005 and other data). Biodiesel grew from 0.7 billion liters/year to 2.3 billion liters/year (same). Geothermal power grew from 8.0 GW in 2000 to 8.9 GW in 2005 (Lund 2005a). Geothermal heat grew from 15.2 GWth in 2000 to 27.8 GWth in 2005 (same). The average growth rate for the five-year period 2000-2004 is calculated as the average compound rate for each of the five years, using end-1999 data and end-2004 data.

The table is compiled from author's database of country-by-country capacities and installations by year, including data from individual country statistics and submissions from report contributors, also AWEA 2005 ; EWEA 2005a; GWEC 2005; EREC 2004; Maycock 2004 and 2005a; Fulton 2004 plus updates; Lichts 2005; Weiss et al. 2005; ESTIF 2005; Johansson & Turkenburg 2004; Martinot et al. 2002 plus updates; Martinot 2004a; Karekezi et al. 2004; IEA 2004a; IEA 2004c; Graham 2001; TERI 2001; D'Sa & Murthy 2004; Goldemberg and Johansson 2004; World Geothermal Council 2005; and Lund 2005a and 2005b.

Table N3. Renewable Energy Capacities and Installations, 2004

		Added during 2004	Existing at end of 2004	Growth rate of existing in 2004	Average growth rate 2000-2004
Power generation					
Large hydro power		---	740 GW	---	2%
Wind turbines		8.1 GW	48 GW	20%	29%
Small hydro power		4.5 GW	61 GW	8%	7%
Biomass power		---	39 GW	---	3%
Solar PV, grid-connected	(GW)	0.63 GW	1.8 GW	54%	61%
	(homes)	150,000	400,000	---	---
Solar PV, off-grid		0.33 GW	2.2 GW	17%	17%
Geothermal power		---	8.9 GW	---	2.4%
Solar thermal power		---	0.4 GW	---	---
Ocean (tidal) power		---	0.3 GW	---	---
Hot water/space heating					
Biomass heating		---	220 GWth	---	2%
Solar collectors for hot water and space heating, glazed	(GWth)	12 GWth	77 GWth	---	---
	(m^2)	17 mil m^2	110mil m^2	17%	17%
	(homes)	6.5 million	39 million	---	---
Geothermal heating		---	28 GWth	---	13%
Transport fuels					
Ethanol production		2.3 billion liters/year	31 billion liters/yr	8%	11%
Biodiesel production		0.4 billion liters/year	2.2 billion liters/yr	26%	25%
Rural household energy					
Biomass cooking stoves in use	(total, all types)	---	570 million	---	---
	("improved" types)	---	220 million	---	---
Household-scale biogas digesters in use		---	16 million	---	---
Household-scale solar PV systems in use		0.3 million	2 million	---	---

Notes:

(a) PV existing capacity is based on cumulative production since 1990, neglecting retirements.

(b) Number of homes for solar hot water collectors estimated based on 2.5 m^2/home average for developing countries and 4 m^2/home for developed countries, neglecting commercial use. Li (2002) suggests closer to 2 m^2 in China, the largest market, so the actual number of homes is probably higher than the figures in the table.

(c) Total number of biomass cooking stoves is estimated based on assuming 4.4 persons per household and 2.4 billion people still using traditional biomass. Improved biomass cooking stoves based on Martinot et al. 2002 with updates from Karekezi et al. 2004, IEA 2002a, Graham 2001, TERI 2001, and D'Sa & Murthy 2004, but still reflect figures that are at least a few years old.

(d) Biomass power-generation capacity figures do not include electricity from municipal solid waste (MSW). Many sources include MSW in biomass figures, although there is no universally accepted definition. If MSW were to be included in the numbers in this table, biomass power generation might increase from 36 GW to 43-45 GW. OECD power generation from MSW was 6.7 GW in 2002 (IEA 2005a). Developing country numbers for MSW are difficult to estimate.

(e) Growth rates for biomass heating and large hydro are taken from Johansson & Turkenburg 2004 and reflect growth rates for the period 1997-2001. More recent worldwide growth rates are not available. The average annual capacity increase for all hydro in OECD countries was 1.2% from 1990-2002 (IEA 2004a).

(f) Geothermal heat figures include shallow geothermal energy and geothermal heat pumps.

(g) "---" means data not available or not reliable enough to state.

(h) Total installation of solar PV in 2004 was reported by Maycock (2005b) as 960 MW compared to total solar PV production of 1,100 MW.

(i) The "hot water/heating" category includes solar hot water, solar space heating, and solar cooling in residential, commercial, and industrial applications. The number of homes shown in the table assumes that a high proportion of installed capacity is for residential solar hot water systems. Active solar space heating is provided by a significant share of installations in some countries, although not in China, which is now two-thirds of the global market. Technically, this category is called "Solar Heating and Cooling" by the International Energy Agency, but this report uses the terminology "solar hot water/heating."

(j) Geothermal power capacity has grown by an average of 2.4% from 2000-2004. Geothermal heating capacity has grown by an average of 12.9% from 2000-2004 (World Geothermal Council 2005 and Lund 2005a.

(k) Solar hot water household estimation: 2.4 m^2/system in China (70% of systems sold are small 2 m^2 size) and 3.8 m^2/system in rest of world. So 13.5 million in China equals 5.6 million homes, and 3.5 millon m^2 elsewhere equals 0.9 million homes. 64 million m^2 in China equals 26.7 million homes, and 46 million m^2 elsewhere equals 12.1 million homes.

(l) SHW growth rate for 2004 is net, based on annual additions minus retirements.

(m) Solar PV for off-grid includes residential, commercial, signal, and communications, and consumer products. In 2004 globally, there were 70 MW used for consumer products, 80 MW used for signal and communications, and 180 MW used for residential and commercial off-grid applications (Maycock 2005a).

(n) Where 2004 data are not available, 2004 numbers are determined based on assumed growth rates from year(s) of last reported data and considering differing or conflicting data from multiple sources.

(o) Solar PV is separated into grid-connected and off-grid to reflect the different market characteristics of each application, such as costs relative to competing alternatives and types of policy support.

(p) Lund (2005) reports 1.7 million geothermal heat pumps with 56% of total geothermal heat capacity (27,600 GWth). But he notes the data are incomplete. Geothermal heat pumps grew by 24% per year from 2000-2005, a tripling of capacity in five years.

[N4] Electric Power Capacities

Table N4 presents installed electric power capacities. The table is based on author's database compiled from individual country statistics and submissions from report contributors, also IEA 2003a, 2004b; IEA 2004c; EREC 2004; AWEA 2005; EWEA 2005; GWEC 2005; Maycock 2004 and 2005a; Johansson & Turkenburg 2004; Martinot et al. 2002 plus updates; Martinot 2004a. Many figures in the table are approximate, valid at best to two significant figures. These sources also provide information for much of the capacity discussion of Section 1.

Small hydro totals reflect reported small hydro, generally according to a definition of 10 MW, but higher in some countries such as China, which officially defines small hydro as less than 50 MW.

Municipal solid waste is commonly reported in biomass power generation statistics for OECD countries. However, municipal solid waste is not included in the biomass power generation capacity figures here because equivalent statistics from developing countries are not available and because municipal solid waste is not considered a form of renewable energy by some. There was 6.7 GW of municipal solid waste in OECD countries in 2002 (IEA 2004a), so including this figure increases world total biomass power capacity to 46 GW.

Table N4. New Renewable Electric Power Capacity, GW existing as of 2004

Technology	World Total	Developing Countries	EU-25	China	Germany	U.S.	Spain	Japan
Small hydropower	61	39	13	34	1.6	3.0	1.6	3.5
Wind power	48	4.3	34.2	0.8	16.6	6.7	8.3	0.9
Biomass power	39	22	8	2.3	0.9	7.2	0.3	> 0.1
Geothermal power	8.9	4.5	0.8	< 0.1	0	2.5	0	0.5
Solar photovoltaic-grid	1.8	0	0.9	0	0.7	0.1	0	0.8
Solar thermal electric	0.4	0	0	0	0	0.4	0	0
Ocean (tidal) power	0.3	0	0.3	0	0	0	0	0
Total renewable power capacity (excluding large hydro)	160	70	57	37	20	20	10	6
For comparison:								
Large hydropower	740	330	90	70	n/a	90	n/a	45
Total electric power capacity	3,800	1,400	580	440	n/a	860	n/a	260

Notes:

(a) There is no international consensus on the definition of small hydropower (SHP). In China, it officially refers to capacities of up to 50 MW, in India up to 15 MW, and in Brazil up to 30 MW. In Europe, capacity of up to 10 MW total is becoming generally accepted by ESHA (European Small Hydropower Association) and the European Commission. Many published figures for small hydropower apply a definition of 10 MW maximum, which tends to exclude capacity from China, Brazil, and some other countries. Thus other published figures can be substantially smaller than the figures presented here, which represent data according to each country's definition.

(b) Grid-connected solar PV exists in small quantities of a few MW in some other countries, primarily as small demonstration projects. Zero is given in the table because these numbers are much smaller than 0.1 GW, thus not significant enough to register.

(c) Comparison of "new" renewable power capacity to total electric power capacity does not provide a good comparison of actual energy produced. Capacity factors for conventional electric power generation are much higher than for most "new" renewable energy sources. So even though global "new" renewable capacity is roughly 4% of the world total capacity, electricity produced from renewables is about 2% of world total electricity production.

(d) These figures should not be compared with previous versions of this table or similar tables to get growth rates. Adjustments from previous versions are a combination of real growth plus adjustment due to improved data.

[N5] Large Hydropower Capacity and Growth Rate

IEA (2004c) shows OECD hydro was 393.8 GW in 1999 and increased to 407.9 GW in 2002, for a 1.2% annual growth rate for the three-year period 2000-2002, or an average of 4.7 GW per year. China's large hydro capacity has been increasing by 6-8 GW per year in recent years. (China installed 7.6 GW of large hydro capacity in 2004, according to Water Conservation Information Network (www.hwcc.gov.cn). China's total hydro capacity went from 53 GW in 1999 to 105 GW in 2004, with 14 GW of the increase being small hydro. So large hydro increased by 38 GW, or 7.5 GW per year average during the five-year period 2000-2004.) Other developing countries probably represent another 3-5 GW per year, for total capacity additions of probably 14-16 GW per year. Thus, given the current installed large hydro capacity of 760 GW, the global average growth rate is on the order of 2%.

US EIA *International Energy Annual 2003* (EIA 2005a) gives world total of 15,852 TWh of electric power generation in 2003, including 2,654 TWh from all hydro. Allowing for 3% annual growth in 2004 (2% for hydro) results in 16,328 TWh total and 2,707 TWh for all hydro in 2004. Subtracting 160 TWh of small hydro from this (assuming a third of small hydro doesn't appear in global statistics), gives 2,540 TWh large hydro in 2004. EIA gives 2,461 TWh hydro in 1995 and 12,634 GWh total generation. Total hydro is thus 16.6% of global total for 2004 and 19.5% in 1995. Subtracting small hydro, large hydro alone is roughly 16% in 2004 and 19% in 1995.

Altinbilek et al. 2004 gives 730 GW and 2,650 GWh of hydro worldwide based on a 2003 source, so this number is presumed to be 2002 data. This is consistent with an IEA (2004b) figure of 2,676 TWh of hydro in 2002. Given the other sources, this number appears correct for large hydro, excluding all (or most) of small hydro. Allowing a 2% growth rate in 2003 and 2004 gives 760 GW in 2004.

Hydropower production statistics for 2004 from BP (2005).

There is a basic conflict between hydro statistics reported by the International Hydropower Association and World Energy Council, and those from the International Energy Agency. IHA and WEC statistics suggest total hydro worldwide was around 750 GW in 2004. The IEA shows hydro in OECD at 425 GW in 2002, which when added to reported small and large hydro in developing countries from several sources yields a total in the range of 800-820 GW allowing for modest growth since 2000 (most other data are for 1999-2000). It is believed that the former set of statistics misses some installed capacity due to reporting channels used. This report places more credibility in the later set of figures, with a total of 800 GW hydro, 740 GW large hydro, and 60 GW small hydro.

[N6] Wind, Geothermal, Biomass Power

Table N6 shows added and existing wind power. There is some variation of statistics depending on source, with data from the Global Wind Energy Council (2005) and BTM Consult (Cameron 2005) differing by about 200 MW world total added in 2004 and also in cumulative existing capacity (EWEA cites GWEC data of 47,317 MW total installed at end of 2004). Other sources include the AWEA (2005) and EWEA (2005a).

Offshore wind power 0.6 GW installed comes from New Energy Finance, www.newenergyfinance.com, as reported in RenewableEnergyAccess.com, "Blustery Conditions for European Wind Power
New Energy Finance White Paper Outlines Difficulties in European Wind Power Market," 22 July 2005. www.newenergyfinance.com/NEF/HTML/Press/Offshore-wind-funding.pdf and www.renewableenergyaccess.com/rea/news/story?id=34645. (Note: China is also beginning to develop off-shore wind, with plans for the first wind farm off-shore of Shanghai in 2006.)

Information on biomass power and heat from IEA (2004b), Kartha et al. (2004), and submissions from report contributors. Also IEA 2005c.

Information on geothermal power and heat from Lund (2005a and 2005b). Information on biomass power generation is the most difficult to develop and generally relies on more informal data collection from in-country sources. In reporting on geothermal heating, Lund notes: "the world direct utilization of geothermal energy is difficult to determine; as, there are many diverse uses of the energy and these are sometimes small and located in remote areas. Finding someone, or even a group of people in a country who are knowledgeable on all the direct uses is difficult. In addition, even if the use can be determined, the flow rates and temperatures are usually not known or reported; thus, the capacity and energy use can only be estimated. This is especially true of geothermal waters used for swimming pools, bathing and balneology."

Some of the biomass used for power generation around the world is urban and industrial residues, what the IEA calls "combustible renewables and waste." Urban residues, landfill gas (LFG), and digester gas from municipal water treatment and concentrated animal feeding operations (CAFOs) are currently very important and are becoming more so—they provide environmental services as well as generate energy. (This report excludes MSW from the biomass power generation statistics given, as comparable statistics for developing countries are not available and some contributors felt MSW belongs in a separate category and should not be mixed with "pure" biomass.)

Table N6. Added and Existing Wind Power, Top 10 Countries, 2004

Country	Added in 2004 (MW)	Existing in 2004 (MW)
Germany	2,050	16,600
Spain	2,070	8,300
United States	390	6,700
Denmark	10	3,100
India	880	3,000
Italy	360	1,300
Netherlands	200	1,100
Japan	230	990
United Kingdom	250	890
China	200	770

[N7] Grid-Connected Solar PV

Table N7 shows grid-connected solar PV from the largest programs worldwide, which make up most of the global grid-connected solar PV. Sources: Maycock 2004 and 2005a; Jones 2005; Dobelmann 2003; California Energy Commission 2004; Navigant Consulting 2005; submissions from report contributors.

EU-15 grid-connected capacity was 316 MWp in 2002, including 258 MWp in Germany (EREC 2004). Thus, about 60 MWp existed in the EU outside of Germany in 2002. Czech Republic has 120 kWp grid-connected, Poland 47 kWp, and Romania 10 kWp (EREC 2004).

Table N7. Grid-Connected Solar Rooftop Programs, 2004

Program and start year	Cumulative homes as of 2004	Cumulative installations as of 2004	Installations added in 2003	Installations added in 2004	Supporting policies
Japan (1994-2005)	200,000	800 MWp	190 MWp	260 MWp	"Sunshine program" capital subsidy started at 50% in 1994, declining to about 10% by 2003.
Germany (1999-2003)	150,000	680 MWp	140 MWp	300 MWp	"100,000 roofs program" provided low-interest loans for households and 50 eurocents per kWh feed-in tariff through 2003. Since 2004, market supported by feed-in tariffs of 45-62 eurocents/kWh.
California programs (1998-)	15,000	95 MWp	27 MWp	36 MWp	State program capital subsidy of $4.50/W(AC) declined to $3.50/W(AC). There are also municipal utility (SMUD, LADWP) and utility RPS programs.

Notes:

(a) California reports total number of installations, which includes both residential and commercial, but the number of residential installations is assumed to be much higher than the number of commercial installations. The number of homes reported is consistent with an average of 4 kW/home and residential being more than half of total installed capacity in 2004.

(b) Assumption of 4 kW/home for new 2004 installations in Japan and Germany. Cumulative homes for 2003 estimated at 170,000 in Japan and 65,000 in Germany based on prior reports of homes and capacity.

(c) On-grid solar PV capacity in Europe was 480 MWp in 2003, of which 375 MW was in Germany. The Netherlands was the major contributor, with 44 MW in 2003. So additional on-grid capacity in Europe in 2004, besides Germany, was probably about 110 MW.

(d) Korea in 2005 announced a 100,000 rooftop program targeting 0.3 GW of solar PV by 2011.

(e) Thailand has had a small rooftop solar PV program. As of July 2004, 67 kWp were installed, subsidized by EPPO.

(f) Japan's program was due to end in 2005. In 2004, Japan had 1,100 MWp of installed PV, 800 MWp for homes and 300 MWp for commercial and public buildings and other uses (not clear what fraction is grid-connected).

[N8] Solar Hot Water/Heating

Table N8a: Solar Hot Water Installed Per-Capita, Top 10 Countries, 2004

Country	Installations (m^2/1000 inhabitants)
Israel	740
Cyprus	620
Greece	260
Austria	260
Turkey	140
Japan	100
Australia	70
Germany	70
Denmark	60
China	50

Note: This table excludes Barbados and other small island nations with population less than 500,000. Barbados has 277,000 inhabitants and at least 35,000 SWH systems. The indicator would be around 250 m^2/1,000 inhabitants and this means Barbados would rank 5 of the top 10.

Source: Weiss et al. 2005; Li 2002 and 2005; ESTIF 2004 and 2005; Martinot 2004a; Karekezi & Kithyoma 2005; submissions from report contributors.

Table N8b: Solar Hot Water Installed Capacity, Top 10 Countries/EU and World Total, 2004

Country/EU	Existing 2003 (million m^2)	Additions 2004 (million m^2)	Existing 2004 (million m^2)	Existing 2004 (GWth)
China	50.8	13.5	64.3	45.0
EU	13.1	1.6	14.0	9.8
Turkey	9.5	0.8	9.8	6.9
Japan	7.9	0.3	7.7	5.4
Israel	4.7	0.4	4.9	3.4
Brazil	2.2	0.2	2.4	1.6
United States	2.1	0.05	2.0	1.4
Australia	1.4	0.1	1.5	1.1
India	0.9	0.1	1.0	0.7
South Africa	0.5	--	0.5	0.4
(other countries)	< 2	--	< 2	< 1.5
World Total	95	17	110	77

Notes:

(a) Figures exclude passive (swimming pool) heating, which is considered a separate application from domestic hot water and space heating.

(b) Retirements are difficult to estimate for some countries, so all figures are approximate. The totals here reflect 2 million m^2 of retirements in 2004, not including China.
(c) The International Energy Agency's Solar Heating and Cooling Program (IEA-SHC) recommended in December 2004 that SHW be reported in GWth (gigawatt thermies), with a standard conversion factor of 0.7 GWth per million m^2.
(d) Additions for 2004 and existing 2004 for Turkey, Israel, United States, Australia, India, and Egypt are extrapolations based on actual 2003 installations. A 5% retirement rate of existing stock is assumed in the extrapolation. The resulting global total checks against estimates of 2004 by Weiss et al. 2005.
(e) Modeling retirements in Japan is a complicating factor in both Japanese and global totals, as retirements have been high relative to new installations for the past several years. Weiss et al. 2005 have a total about 4.5 million m^2 higher than the figure used here for Japan in 2003, but the lower number used here is based on another model of retirements by Japanese researchers consulted for this report (also see the reference: Solar System Development Association website, www.ssda.or.jp/index.php). The global total of 110 million m^2 (77 GWth) would be 115 million m^2 (80 GWth) using the higher number for Japan.
(f) About 1.5 million is estimated to be installed in Africa, primarily in South Africa, Egypt, and Niger (Karekezi & Kithyoma 2005).
(g) Solar hot water numbers in a given year must account for both additions and retirements. Retirements are modelled and estimated by various organizations in different ways, and so figures are not always compatible, particularly for countries with long-standing markets in which many systems are now reaching the end of their service life. In particular, there is a large discrepancy as to how to account for retirements in Japan, leading to a large divergence between figures published by the IEA (Weiss et al. 2005), which give 12.4 million m^2 in 2004, and those provided by other Japanese sources, which give 7.7 million m^2 in 2004. The lower figure is used in this report.
Sources: Weiss et al. 2005; Li 2002 and 2005; ESTIF 2004 and 2005; Martinot 2004a; EurObserv'ER 2005b; Karekezi & Kithyoma 2005; submissions from report contributors.

The solar thermal industry in Europe will install 1.2 GWth of capacity during 2005 according to the latest statistics from the European Solar Thermal Industry Federation. See story at ReFocus, at www.sparksdata.co.uk/refocus/fp_showdoc.asp?docid=83735293&accnum=1&topics=

[N9] Ethanol and Biodiesel

Table N9. Biofuels Production, Top 12 Countries, 2004 (billion liters)

Country	Ethanol (billion liters)	Biodiesel (billion liters)
Brazil	15	---
United States	13	0.1
China	2	---
Germany	0.02	1.1
France	0.1	0.4
Italy	---	0.35
Canada	0.2	---
Thailand	0.2	---
Spain	0.2	---
Denmark	---	0.08
Czech Republic	---	0.07
Australia	0.07	---
World Total	31	2.2

Notes:
(a) Ethanol figures do not include production of ETBE in Europe, which was about 0.7 billion liters in 2004.
(b) Finland plans to build a biodiesel production plant of 170,000 tons/year capacity by 2007, which would put it in fourth place in Europe behind Germany, France, and Italy.
(c) Fulton et al. 2004 gives Germany 2002 biodiesel capacity as 750,000 liters/year and sales as 550,000 liters/year. Production was 550,000 tons in 2002; 720,000 tons in 2003; and 1 million tons in 2004 from EurObserv'ER 2005a.
(e) Germany added 0.3 billion liters/year biodiesel production capacity in 2004, and 0.1 billion l/yr for ethanol.
(f) Ethanol in the United States, 2005 figures, from presentation by Brian Jennings, Executive Vice President, American Coalition for Ethanol (Jennings 2005). Jennings gives 3.4 billion gallons produced in 2004, or 13 billion liters. Also same from the Renewable Fuels Association (www.ethanolrfa.org/pr050223.html), an increase of 21 percent from 2.8 billion gallons (10.6 billion liters) in 2003.
Sources: Adapted from Fulton et al. 2004; Lichts 2005; EurObserv'ER 2005a; US Renewables Fuels Association (www.ethanolrfa.org); IEA 2004d; and submissions by report contributors.

Australia Ethanol Limited gives 70 million liters/year produced in Australia (presumed current), and Fulton et al. (2004) gives 40 million in 2002.

In Spain, there are currently two ethanol production facilities, one in Cartagena, with capacity of 100 million liters, and the other in Teixeiro, with capacity of 126 million liters (IEA 2005c)

Other countries in Europe have also decided to go into biodiesel production. Spain started up its biggest biodiesel production unit (250,000 tons) last May in the region of Cartagena. The company, called Biodiesel Production, is part of the German group Sauter and has invested 50 million euros in this project. A first 100-ton biodiesel production unit will also be put into service in Portugal next August. The Ibersol company, a subsidiary of the German food group Nutas, is responsible for this 25 million euro investment. Other units are also under construction or in project stage in the United Kingdom and Finland.

In Canada, there are currently more than 1,000 retail locations selling ethanol-blended gasoline in six provinces. Approximately 7 percent of gasoline sold in Canada is currently blended with ethanol. Ethanol production is expected to grow to 1.4 billion liters to meet the Government of Canada's target of 35 percent of Canadian gasoline containing 10 percent ethanol by 2010. This target means that ethanol production will have to increase from production of 200 million liters per year (2004) to 1.4 billion liters per year. To reach that target the federal government, through Natural Resources Canada, has implemented an Ethanol Expansion Program (EEP) that provides funding for construction of new ethanol plants or plant expansions. Under the first round of EEP CDN, $72 million in contributions has been allocated to six projects across Canada, and in the second round an additional CDN$46 million have recently been allocated. In addition to EEP the federal government provides an exemption on its gasoline excise tax of $0.10 per liter of ethanol. At the provincial level, Manitoba provides the greatest exemption of the provinces at $0.25 per liter of ethanol produced and consumed in the province, British Columbia $0.11 /liter (when a plant is built in BC), Alberta $0.09 /liter (no restriction on ethanol source), Saskatchewan $0.15 /liter (ethanol must be produced/consumed in SK), Manitoba $0.25 /liter (ethanol must be produced/consumed in MB), Ontario $0.147 /liter (no restriction on ethanol source), Quebec $0.198 /liter (when plant is built in QC). (www.nrcan-rncan.gc.ca/media/newsreleases/2005/200550a_e.htm and other sources).

This report generally compares ethanol and gasoline based on equivalent energy content rather than volumetric equivalents. It may be that some of the comparisons mistakenly are based on volumetric equivalents, since source material sometimes isn't clear. The energy content of ethanol is only 70% or so of gasoline on a volumetric basis.

Liquid fuels from biomass have major impacts on land use, farm policy (which in turn bears indirectly on the poor agricultural countries in the developing world), and food pricing. Corn farmers in the U.S. appreciate the fact that in 2003 the substitution of 1.5% of gasoline on an energy basis consumed 14% of the corn crop. In 2005, due to demand for ethanol there was a savage spike in sugar prices. In Brazil, ethanol production fluctuates with sugar prices; when sugar prices are low more ethanol is produced, and when high less ethanol is produced. Fulton et al. (2004) covers the food and land issues.

[N10] Ethanol in Brazil

Total ethanol consumption by cars in Brazil was 12.5 billion liters in 2004, 5.22 as hydrated, used in neat ethanol and flex-fuel cars, and 7.22 as anhydrous, blended to gasoline. Total gasoline for road use (essentially cars, since almost no truck uses gasoline) in 2004 was 15.8 billion liters. Thus, on a volume basis, gasoline represents 15.8 billion liters in a total volume of 28.3 billions liters of liquid fuels for cars. Ethanol share is 44.2%. Production of ethanol in 2004 was 16.0 billion liters , which surpasses gasoline production of 15.8 billion liters. From the 16.0 billion, 2.52 billion was exported and 1.02 billion used for other purpose than fuel. For the year 2005 it is expected there will be an increase in ethanol consumption and a decline in gasoline, but even so gasoline will be responsible for more than 50%.

[N11] Renewable Energy Cost Comparisons

Three sources of recent information are the IEA reports *Renewables for Power Generation* (IEA 2003a), *Renewable Energy Market and Policy Trends in IEA Countries* (IEA 2004b), and *Biofuels for Transport* (IEA 2004d).

Sources for Table 2 include: IEA 2003a; IEA 2004b; OECD and IEA 2005; ICCEPT 2002; Fulton et al. 2004; Johansson & Turkenburg 2004; and submissions from report contributors.

Ethanol from cellulose shows great promise for future cost-competitiveness. Canada and Sweden are leading research and demonstration. Canada has helped to fund construction of the first commercial-scale cellulosic ethanol production plant, which converts wheat straw into ethanol using an advanced enzymatic hydrolysis process. Such plants may eventually become common, and will allow ethanol to be produced from almost any type of biomass, including agricultural and forestry wastes and high-yielding dedicated energy crops such as poplar trees and switchgrass. The province of Ontario plans to provide additional recognition for ethanol produced from cellulosic feedstocks (e.g., wood, straw) in its proposed ethanol regulation.

Technology cost estimates and projections for renewable power generation technologies, made by the International Energy Agency and Imperial College of London, are shown in Tables N11a and N11b. Compared to the costs of historical coal and natural gas generation costs (typically 2-4 cents/kWh, although recent natural gas price rises are increasing costs in some countries), hydro, geothermal, and some forms of biomass power generation are already competitive with good resources and sites. Wind power costs are approaching competitive levels, and are expected to achieve those levels sometime by 2010. Solar PV costs are still substantially higher, although compared to retail residential electricity rates in some countries with substantially above-average rates (i.e., 20-30 cents/kWh), the costs of solar PV should likewise become competitive before 2010, particularly in sunny (high insolation) climates.

Geothermal costs for Table 2 are those for new plants at new sites. Costs will vary higher and lower depending on whether they are for currently operating plants, expansion plants on existing fields, or new plants at new sites.

Table 2 states that wind-generated electricity fell from about 46 cents/kWh in 1980 (in the U.S.; 2003$) to 4-5 cents/kWh at good sites today. DOE document DOE/GO-102005-2115, April 2005, p. 4 says "…dramatic reductions in cost – from $.0.80 (current dollars) per kWh to about $0.04/kWh for utility-scale turbines…."

Also, the statement in Table 2, "how to make the machines bigger is still the number one technological issue in the turbine industry," oversimplifies the technical challenges facing the wind industry.

Table N11a. Power Generation Costs, 2002 and Projections for 2010

	Capital costs ($/kW)	Low-side generation costs (cents/kWh)	High-side generation costs (cents/kWh)	Low-side generation costs by 2010
Small hydro power	1,000-5,000	2-3	9-15	2
Solar PV power	4,500-7,000	18-20	25-80	10-15
Concentrating solar power	3,000-6,000	10-15	20-25	6-8
Biopower	500-4,000	2-3	10-15	2
Geothermal power	1,200-5,000	2-5	6-12	2-3
Wind power	850-1,700	3-5	10-12	2-4

Source: IEA 2003a

[N12] Global Investment in Renewable Energy

Investment figure of $30 billion/year developed from database of installed capacity by technology for the period 1995-2004, as used for Martinot 2004a, along with submissions from report contributors, using global average capacity costs (installed costs, including balance of plant for solar PV). Further details of cost estimates taken from the literature and explanations of cost assumptions used for those papers are available at www.martinot.info/markets.htm.

Typical investment costs for 2004 were estimated as follows:

- SHW in China: $150/m^2$
- SHW elsewhere: $800/m^2$
- Wind: $1,200/kW
- Solar PV (installed): $7,000/kW
- Geothermal heat: $500/kWth
- Geothermal power: $1,600/kW
- Biomass heat: $200/kWth
- Biomass power: $2,000/kW
- Small hydro in China: $900/kW
- Small hydro elsewhere: $1,300/kW
- Large hydro in China: $1,400/kW
- Large hydro elsewhere: $2,000/kW

Table N11b. Costs of Renewable Energy Compared with Fossil Fuels and Nuclear Power

Technology	Current cost (U.S. cents/kWh)	Projected future costs beyond 2020 as the technology matures (U.S. cents/kWh)
Biomass Energy:		
• Electricity	5-15	4-10
• Heat	1-5	1-5
Wind Electricity:		
• Onshore	3 - 5	2-3
• Offshore	6 - 10	2-5
Solar Thermal Electricity (insolation of 2500kWh/m^2 per year)	12-18	4-10
Hydro-electricity:		
• Large scale	2-8	2-8
• Small scale	4-10	3-10
Geothermal Energy:		
• Electricity	2-10	1-8
• Heat	0.5-5.0	0.5-5.0
Marine Energy:		
• Tidal Barrage (e.g. the proposed Severn Barrage)	12	12
• Tidal Stream	8-15	8-15
• Wave	8-20	5-7
Grid connected photovoltaics, according to incident solar energy (insolation):		
• 1000 kWh/m^2 per year (e.g. UK)	50-80	~8
• 1500kWh/m^2 per year (e.g. southern Europe)	30-50	~5
• 2500 kWh/m^2 per year (most developing countries)	20-40	~4
Stand alone systems (incl. batteries), 2,500 kWh/m^2 per year.	40-60	~10
Nuclear Power	4-6	3-5
Electricity grid supplies from fossil fuels (incl. T&D)		Capital costs will come down with technical progress, but many technologies largely mature and may be offset by rising fuel costs
• Off-peak	2-3	
• Peak	15-25	
• Average	8-10	
Rural electrification	25-80	
Costs of central grid supplies, excl. transmission and distribution:		Capital costs will come down with technical progress, but many technologies already mature and may be offset by rising fuel costs
• Natural Gas	2-4	
• Coal	3-5	

Source: ICCEPT 2002

Wind power costs from previous years might justify a figure than $1,200/kW, but in 2004 wind power costs rose, some said to more typically $1,300/kW, due to higher steel prices from high global demand for steel. Canada reported $1,500/kW in 2004 (according to a private communication with the Canadian Wind Energy Association). Solar PV prices also increased in 2004. Solar PV prices in 2004 in California were reported at $9,000/kWp installed. Canada solar PV prices in 2004 were reported at $8,000/kWp. However, the assumption of $7,000/kWp was left unchanged from 2003.

Solar hot water costs in China for 2002 were reported by Li (2005). Over 70% of solar hot water heaters were sold in 2002 at prices less than 1,500 RMB ($180) and the lowest-cost heaters typically comprise 2 m^2 of collector area. This would imply a cost of $90/$m^2$. A further 26% of products are sold between RMB 2,200-3,000 ($270-360), probably implying costs of $100-120/$m^2$. High-end systems, still a small market share, sell for $300/$m^2$. The China SHW industry in 2000 had 6 million m^2 production and $750 million revenue, or an average of $125/$m^2$ in revenue. This has probably increased since 2000 as larger and more expensive systems capture more of the market. Another expert source gives 1,000-1,500 RMB/m^2 as typical costs, or $120-180/$m^2$. An average cost of $150/$m^2$ is assumed for solar hot water collectors in China, for purposes of calculating global investment figures. This is still much lower than estimated costs in Europe and other developed countries.

Small hydropower costs in China are reported from one Chinese source as 3,000-6,000 RMB/kW, or $370-740/kW. This is significantly lower than small hydro costs elsewhere. But others have questioned such low figures, so $900/kW is used.

Cost data from a variety of sources, including Johansson & Turkenburg 2004, Turkenburg et al. 2000, EC 2002a, IEA 2004b, IEA 2003a, and ICCEPT 2002. EC CORDIS cost data from Section 1.9 on geothermal energy (12/20/02), Section 1.10 on photovoltaics (12/23/02), Section 1.11 on small hydropower (12/20/02), Section 1.12 on solar heating and cooling (12/20/02), Section 1.15 on wind energy (12/23/02) and Section 1.3 on CHP microturbines (12/18/02).

Investment of $4-5 billion for capital expenditures in 2004 by the solar PV industry is estimated by Michael Rogol, MIT, and CLSA Asia-Pacific (personal communication). See also CLSA Asia-Pacific Markets (2004). Some of this investment will not immediately translate into increased production in 2005 due to time required to get some capacity up-and-running (e.g. silicon production capacity takes 18-24 months or longer to reach full production) and due to constraints on silicon availability (e.g. significant portion of Chinese ingot growth capacity is idle). Rogol also estimates the figure will be $5-7 billion for 2005.

Comparisons with global investment in power generation are rough estimates based on 2.5-3% average growth in power generation worldwide and personal communications with experts. Some experts believe the total may be much higher than $150 billion, perhaps closer to $400 billion for the entire power sector, including transmission and distribution and fossil fuel supply chains. Comparisons of renewables power generation investment with global power generation investment exclude transmission and distribution investment and fossil fuel supply chains, which might mean the comparison is too favorable to renewable energy.

[N13] Private Financing and Venture Capital

Venture capital investment from Makower et al. (2005) and Liebreich & Aydinoglu (2005). CLSA Asia-Pacific Markets projections from CLSA Asia-Pacific Markets (2004). An updated version was available in mid-2005.

New Energy Finance, Ltd. (2005) analyzed 201 venture capital investment rounds from 2001 to 2004, covering total estimated investment of $2.2 billion, including about $1.2 billion in efficiency, fuel cells, and hydrogen. Investment increased from $414 million in 2003 to $958 million in 2004, although it is not clear how much of the increase was for renewable energy.

[N14] Public Financing

EIB total financing for renewables was reported by EIB as € 91 million in 2000, € 180 million in 2001, €682 million in 2002, € 414 million in 2003, and €469 million in 2004. The average for 2002-2004 is € 520 million. Converting to USD at an average exchange rate of $1.20 yields $630 million. EIB is a public sector institution in the sense that it is owned by the EU Member States. However, it raises its resources on capital markets. It only has access to "public money"—funds that come from government budgets—in the case of its financing operations under the Cotonou Agreement's Investment Facility in the African, Carribbean and Pacific (ACP) Countries. The Investment Facility resources in fact come from the European Development Fund financed by the EU Member States. Source: personal communication with EIB, 2005.

For information on EIB renewable energy lending between 1999 and 2003, see: http://www.eib.org/Attachments/thematic/renewable_energy_en.pdf

All exchange rate conversions done using € 1 = $1.20, the rate as of July 2005, and are thus conversions into current 2005 dollars rather than 2002, 2003, or 2004 dollars.

[N15] Multilateral and Bilateral Financing for Developing Countries

From 1990-2004, the World Bank Group committed $1.8 billion to new renewables, which along with co-financing of $450 million from the Global Environment Facility, resulted in $2.3 billion World Bank/GEF combined financing for new renewables. The World Bank also committed $3.9 billion to large hydro (>10 MW) during this period (World Bank 2005, Table 1). Thus, average World Bank Group financing for new renewables has historically been about $120 million per year (excluding GEF financing). This average has remained in recent years. During the three-year period 2002-2004, the World Bank Group committed an average of $113 million per year to new renewables ($338 million committed to new renewables by IBRD, MIGA, IFC, IDA, and carbon finance in 2002-2004 per Table 3, Annex 2). Associated with those commitments was GEF co-financing averaging $43 million per year during the three-year period 2002-2004. The World Bank Group also committed an average of $166 million per year to large hydro during the three-year period 2002-2004 (no

GEF co-financing involved). Thus total World Bank/GEF financing for all renewables during the three-year period 2002-2004 averaged $320 million per year. (Note: “World Bank Group commitment” as used in World Bank 2005 includes allocations by the GEF. This report separates the two agencies and reports on their commitments separately.)

World Bank and GEF projects often include non-renewables components, or are blended with energy efficiency components, making it difficult to analytically separate out the renewable energy finance from other finance. Reported figures by these agencies are subject to such analytical uncertainties, and it is possible that non-renewables finance from a few projects is included in reported renewables totals.

GEF-reported financing figures for renewable energy include fees paid to the GEF implementing agencies. If such fees are excluded, GEF financing would average closer to $90 million per year for the three-year period 2002-2004 rather than $100 million per year. Some discrepancies may exist with other reported figures because this report totals by calendar year, while the GEF totals by fiscal year.

From 1999 to 2002, OECD DAC overseas development assistance averaged about $130 million/year for non-hydro renewables and about $400 million/year for hydro (OECD DAC, cited in Saghir 2005; OECD DAC 2005). Total official development assistance (ODA) for hydro averaged more than $420 million per year during the five-year period 1999-2003. Donor statistics are from OECD DAC (2005) and include all forms of reported donor assistance to developing countries.

Table N15. Overseas Development Assistance for Renewable Energy, 1999-2003

	1999	**2000**	**2001**	**2002**	**2003**
	(million dollars)				
Hydro	244	368	584	694	239
Geothermal	33	0.3	0	1.7	0.2
Solar	8	13	197	32	50
Wind	33	3	31	53	151
Ocean	0	0.003	0	0	0
Biomass	0.9	8.4	3.8	10.4	1.5
Total non-hydro	75	25	232	97	203

Note: Average for period for non-hydro new renewables is $130 million/year, for hydro $420 million/year.
Source: OECD DAC 2005.

Financing amounts based on e-mail queries and interviews with agency officials and a variety of unpublished sources. The $500 million public financing for developing countries only includes public funds from projects—grants, loans, and other financing from governments, international agencies, or other public sources. These are often called “budgetary funds.” Figures do not include private financing tied to projects, often called “private financing” or “market funds.”

Source for OECD Agreement on Officially Support Export Credits: OECD 2005. Sources for future multilateral commitments: email inquires and interviews with development agency officials; OECD 2005; submissions by report contributors.

In 2004, KfW approved about € 151 million for renewable energy, of which € 81.6 million were "budget funds" and € 69.3 million were "market funds." The budget funds are considered public-source investment and the market funds are considered private-source investment. Source: KfW, personal communication. Use mid-2005 exchange rate of € 1 = $1.20 for conversions into dollar equivalent.

[N15b] Bonn Action Programme in International Context

Source for the content analysis of the Action Programme is Fritsche & Kristensen 2005.

There are no global estimates for CO_2 emissions reductions from renewables in the literature, so a rough estimation was made for power generation. Analysis of global CO_2 emissions is approximate and does not include rural energy technologies like solar home systems and biogas digesters (which are orders of magnitude lower than the other numbers here).

Power generation avoided CO_2 emissions calculated at 0.6 billion tons CO_2/year for new renewables, excluding biofuels and heating, and 3.6 billion tons/year for large hydro (based on 720 GW). Assumptions for power generation: (a) Large hydro replaces baseload power, i.e. coal. (b) Small shares of gas-CC are offset by similar shares of lignite. (c) Small hydro is same as large hydro. (d) Wind replaces intermediate load, i.e. 50% from coal and 50% from gas-CC in OECD, and 50% from coal and 50% oil-fired GT in developing countries. (e) Biomass replaces 50% baseload and 50% intermediate load. Same assumptions on mix for all countries. (f) Geothermal replaces 100% baseload. (g) Solar PV replaces 100% peak load from 50% gas-CC and 50% oil-fired GT. (h) Solar-thermal replaces 50% intermediate load and 50% peak load. (i) Ocean tidal replaces 100% baseload. Emissions factors (CO_2 eq in g/kWhel): 1,040 for coal in developing countries; 1,050 for coal in OECD; 451 for gas-CC; and 1,141 for oil-GT. Capacity factors: large hydro 68%, small hydro 57%, wind 23%, biomass 51%, geothermal 74%, solar-PV 11%, solar-thermal 23%, and ocean tidal 68%.

Solar hot water was probably around 25-30 million tons avoided CO_2/year in 2004. Weiss et al. (2004) give 15 million tons CO_2/year from all SHW, excluding unglazed, in 2001, with 70 million m^2 installed. Installed increased by 60% by 2004, to 110 million m^2. China reported 13 million tons CO_2 from solar hot water in 2003, with 52 million m^2 installed.

Geothermal heat supply is about two-thirds of solar hot water on a thermal output basis, and thus might be 20 million tons/year. Biomass heating is about 70% more than biomass power generation on an equivalent energy basis, and since much biomass is combined heat and power, the same fossil fuels would be displaced for both. Addition analysis for hot water/heating and gives about 0.2 billion tons CO_2/year total.

Biofuels probably add another 100-120 million tons/year. Rossillo-Calle & Cortez (1998) estimated 46 million tons CO_2/year avoided from Brazil biomass in 1998-1999, when production was 15 billion liters, about the same as today. The global biofuels market is now more than twice as large as Brazil.

[N16] R&D Spending and Subsidies

The IEA RD&D database for all IEA countries (IEA 2005d) gives $352 million, $364 million, and $356 million for solar RD&D for the years 1999-2001 (using data based on exchange rates rather than PPP). Total of all solar, wind, ocean, biomass, small hydro, and geothermal for these three years is $2,165 million, for an average of $720 million per year. Of this number, about $250 million was accounted for by the United States, and another $130 million by Japan, with the remaining $340 million by European countries. RD&D on large hydro for all IEA countries averaged $10 million per year. All numbers are slightly lower if PPP is used rather than exchange rates. There is a large discrepancy in reported RD&D for the U.S. in 1999 by the IEA, which gives $280 million, and the U.S. Energy Information Administration (1999), which gives $327 million.

Estimates of global subsidies for fossil fuels and nuclear power taken from UNEP & IEA (2002). Also, Johansson and Turkenburg2004 say “at present, subsidies to conventional energy are on the order of $250 billion per year” (p.29). Earthtrack (earthtrack.net) has a comprehensive set of references on subsidy policies and estimates.

Goldberg (2000) gives U.S. federal subsidy estimates for the period 1943-1999 (cumulative) of $5.7 billion (1999 dollars) for wind, solar, and solar thermal power. Another $1.6 billion is estimated for subsidies to hydropower during the same period. One source cited (EIA 1999) gives $1.1 billion subsidies for renewables in 1999 alone, including hydropower. This represents federal on-budget, for direct payments, tax expenditures, and research and development. It includes $725 million for ethanol excise tax exemption, $327 million for R&D, $15 million on income tax exemptions, and $4 million on direct expenditures. Ritschel & Smestad (2003) cite $135 million per year in California public benefit fund support for renewables in the late 1990s. They also quote $9 billion for global subsidies to renewable energy and energy efficiency, compared to $150 billion for fossil fuels and $16 billion for nuclear power, citing van Beers & de Moore (2001). In the United States, public benefit funds in more than a dozen states are spending $300 million per year on renewables (Martinot et al. 2005).

The OECD defines subsidies as: “any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers and producers.” EEA (2004) notes that energy subsidy definitions that refer only to a direct cash payment to an energy producer or consumer ignore a range of other indirect support mechanisms, including tax measures, and the effects of trade restrictions and other government interventions (such as purchase obligations and price controls) on prices received by producers and paid by consumers.

EEA (2004): Off-budget subsidies are typically transfers to energy producers and consumers that do not appear on national accounts as government expenditure. They may include tax exemptions, credits, deferrals, rebates and other forms of preferential tax treatment. They also may include market access restrictions, regulatory support mechanisms, border measures, external costs, preferential planning consent and access to natural resources. Quantifying off-budget subsidies is complex, in some cases impossible. It often requires that the benefit be calculated on the basis of differential treatment between competing fuels, or between the energy sector and other areas of the economy.

EEA (2004): Taxation policy is a key mechanism for off-budget support in energy markets. A fuel may be exempted from certain taxes, or enjoy lower rates of value added tax (VAT) and excise duty in relation to other fuels or to the wider economy. Tax exemptions, rebates and incentives for investments in the energy sector and for the installation of energy related materials and equipment may allow industry and consumers to offset their costs. Accelerated tax depreciation may also be permitted, allowing energy-related equipment to be amortised (have the costs written off) more quickly, thereby lowering effective tax rates in the early years of an investment.

EEA (2004): Regulatory support mechanisms make up the other most significant area of off-budget support for the energy sector. These mechanisms most commonly take the form of price guarantees and demand quotas for specific energy sources. They are introduced to support environmental, economic, employment or energy security policy objectives. Some of these mechanisms, such as feed-in tariffs or competitive tenders can be described as ‘supply push’ mechanisms, in that they stimulate production. Others, such as purchase obligations are ‘demand pull’ mechanisms in that they create an artificial demand to which the market responds.

EC (2004) estimated energy subsidies in the EU. It noted that “Various attempts have been made to quantify the type and amount of aid provided to energy industries. There is no comprehensive official record of historical and ongoing energy subsidies in the EU.” With various caveats and analytical notes, that report provides indicative estimates of € 0.6 billion in on-budget subsidies and more than € 4.7 billion in off-budget subsidies for renewable energy in 2001.

A Greenpeace-commissioned report in the late 1990s, titled “Energy Subsidies in Europe,” cited $1.5 billion in direct subsidies for renewable energy (Greenpeace 1997). Jennings (2005) gives $1.7 billion in ethanol fuel subsidies (excise tax exemptions) in 2004 (roughly 3.4 billion gallons times 51 cents/gallon).

One report contributor well versed with energy subsidies thought the subsidy numbers used for this report were too low. Some factors that might cause the numbers to be too low: (1) State and provincial subsidies are quite important with renewables. Sub-national subsidies are most relevant with oil, gas, and certain renewables (through the portfolio standards, but also many direct subsidies to ethanol). (2) As ethanol absorbs a higher percentage of total corn production, it's pro-rated share of corn subsidies rise as well. The ethanol share was 9.7% of corn production in 2003. Between 1995 and 2002, the Environmental Working Group tallied subsidies to corn at $34.6 billion, or $4.33 billion per year. The ethanol share of this in 2003 would have been $420 million, making it the second largest subsidy to the fuel. Pass-through of irrigation subsidies to corn would be additional, but I've not seen it estimated. It's important not to forget about these ancillary subsidies to key feedstocks, be they corn or uranium. (3) Tax-exempt debt used for energy purposes are often ignored in many public accountings of subsidization. Sometimes they pick up tax-exempt private activity bonds, but if the facility is municipally-owned the subsidies are often lumped in with all tax-exempt debt issued by states. Tax-exempt debt is used for WTE plants and landfills (affecting the cost of landfill-gas-to-energy), and perhaps for other projects classed as renewable energy as well. (4) Large scale hydro continues to receive large and varied subsidies associated with the government ownership that they often entail. Low market interest rates tend to reduce the value of some of these subsidies, since historically they had very long term bonds at fixed low interest rates. Such contracts deviate less from market conditions during low interest rate periods. For this reason, dam financing subsidies to hydro may be lower than in the past, though other forms of support still exist. It is not clear if some of the subsidy numbers include large hydro or not.

Global subsidy estimates are highly uncertain. If they are done by aggregating the various existing studies, they generally suffer from large inaccuracies associated with double-counting and non-systematic valuation methods. Often, very large but more complicated value transfers are missing entirely from at least a portion of the studies. This may include incomplete evaluation of tax breaks and loan guarantees; and exclusion of programs of are of large benefit to particular fuels, but not solely targeted to them. Shifting of accident or cleanup liability to the public sector is also commonly missing. If they are generated using price-gap methods for multiple countries (the gap between the domestic price and the world price for a fuel), they will pick up only the portion of subsidies that affect domestic prices, totally missing the support that leaks to other factors of production.

It is possible that many of these problems underlie what seems a low global value for nuclear subsidies of $16 billion per year. That is roughly what some estimated in the U.S. alone during the early 1990s, and accident liability caps outside of the U.S. are even more generous to producers than Price-Anderson is inside. Thus, the real value of nuclear subsidies is most likely much higher. Investment incentives, sovereign guarantees or guaranteed purchase contracts, accident liability caps, public responsibility for waste management, losses on uranium enrichment, and support for uranium mining are all common subsidies to the sector. Most likely many of these are missing from the $16 billion figure. It's also useful to be clear about separating fusion and fission subsidies, as the former is pretty much basic research while the latter is a market-distorting subsidy—even if supporting new reactor designs.

For the fossil fuels, a check to see if estimates include any allowance regarding research on externalities (such as climate change) or energy security (such as securing key infrastructure or shipping; or oil stockpiling) would be warranted. These are big-ticket items generally ignored in most subsidy studies.

[N17] Market Capitalization and Top 60 Publicly-Traded Companies

The following companies represent a preliminary list of companies that meet the following criteria: (1) publicly traded stock, and (2) more then US$40 million in market capitalization attributable to renewable energy. This list is provisional and may inadvertently exclude stocks that meet these criteria. Market capitalization attributable to renewable energy is a rough estimate. For "pure play" renewable energy stocks (stocks that have bulk of earnings from renewables), market capitalization is assumed to be 100% attributable to renewable energy. For companies engaged in renewable energy as a minority of earnings, we have made rough estimate of earnings from renewable energy, divided this by total earnings and multiplied this percentage by total market capitalization to derive a rough estimate of renewable energy market capitalization. In cases where this was not possible due to information being either confidential or not available, we made an outside-in estimate of renewable energy capacity, revenue and operating profit. We then took the ratio of renewable energy operating profit by the company's total operating profit, then multiplied this ratio by the total market capitalization. Categories of renewable energy included in this list include bio fuels/biomass, geothermal, hydro, solar, wave and wind energy. Sources include: Bloomberg, MarketWatch.com, CLSA Asia-Pacific Markets, InvestGreen.com, Investext, Reuters, and company data. List compiled by John Michael Buethe (Georgetown University) and CLSA Asia-Pacific Markets.

Acciona (Spain), Alliant Energy (USA), Automation Tooling Systems (Canada), Bharat Heavy Electricals (India), Boralex (Canada), BP (UK), Brascan (Canada), British Energy (UK), Calpine (USA), Carmanah Technologies (Canada), Conergy (Germany), Corning (USA), Cypress Semiconductor (USA), Daystar (USA), E.On Energie (Germany), Endesa (Spain), ENEL (Italy), Energy Developments (Australia), Enersis (Chile), Eni (Italy), Evergreen Solar (USA), Florida Power & Light Energy (USA), Gamesa Energia (Spain), General Electric/GE Wind (USA), Geodynamics (Australia), Greentech Energy Systems (USA), Ishikawajima-Harima Heavy Industries (Japan), Japan Wind Development (Japan), Kaneka SolarTech (Japan), Kyocera (Japan), Marubeni (Japan), Mitsubishi Electric (Japan), Mitsubishi Heavy Industries (Japan), Nordex Energy (Germany), Novera Energy (Australia), Omron (Japan), Ormat Technologies (USA), Pacific Hydro (Australia), Pfleiderer (Germany), Repower Systems (Germany), RWE (Germany), SAG Solarstrom (Germany), Sanyo (Japan), Scottish Power (UK), Sekisui Chemical (Japan), Sharp (Japan), Shell (UK), Solar Integrated Technologies (UK), Solar-Fabrik (Germany), Solarparc (Germany), SolarWorld (Germany), Solon (Germany), Spire (USA), Sunways AG Photovoltaic Technology (Germany), Talisman Energy (Canada), Tokuyama (Japan), TransCanada (Canada), TXU (USA), Vestas (Denmark), XCEL Energy (USA).

In addition to these companies with publicly-traded stock, there are many other companies involved in renewable energy, such as private unlisted companies and public utilities, that are not traded on stock exchanges. There were no clear criteria or data available to include these companies in an expanded list for this version of the report. Prominent examples of such companies include Iberdrola of Spain, Nuon and Essent of the Netherlands, Electricité de France, Hydro Quebec of Canada, Hydro Tasmania of Australia, Norsk Hydro and SN Power of Norway, and Enercon of Germany. It also excludes project developers that may not have large capital bases but still are major players in the renewables industry. Examples include Zilkha Renewables of the United States (owned by Goldman Sachs), Clipper Windpower and AES of the United States (which just bought Seawest), Eurus of Japan, and many others. There is also the issue of renewable energy value chains and what part of the value chain constitutes a renewable energy business—such as PV silicon wafer manufacturers, manufacturing equipment suppliers, and wind turbine blade manufacturers like LM Glasfibre of Denmark. Future versions of the status report could attempt to create a more comprehensive list.

[N18] Wind Power Industry and Costs

Wind technologies fall into two distinct types: large turbines, designed to supply electricity to the grid, typically 1-3 MW rated capacity with blade diameters of 60-100 meters, and small turbines rated from around 3 kW up to around 100 kW. As wind technology has matured, large wind turbines have become increasingly standardized. All are now broadly similar three bladed designs. However, the potential for innovation has not been exhausted. There is scope for cost reductions through site optimization and innovations in blade and generator design and in grid connection using power electronics. Offshore wind power is still in its infancy and large potential cost reductions exist.

Typical wind turbines produced today are in the 1-3 MW scale, although the 600 kW scale is still common in India and China. European manufacturers have introduced new wind-turbines in the 5 MW range, and achieved an evolution of cost per kW of installed capacity from 1,650 Euro/kW in 1986 to about 850 Euro/kW in 2004. At present little offshore wind capacity is installed anywhere in the world. As with onshore developments during the 1990s, Europe is the lead, with all the world's operating offshore capacity and ambitious plans for future development in the 2006-2007 timeframe. The first large-scale offshore wind farm (160 MW) was completed in 2002 in Denmark.

Wind technology costs have declined 12-18% for each doubling of global capacity, with costs of wind-generated electricity falling from about 46 cents/kWh in 1980 (in the US; 2003$) to 4-5 cents/kWh at good sites today. Technology development and cost reduction have been driven primarily by feed-in policies in just a few countries: Germany, Denmark, and Spain. The German Wind Energy Association (BWE) estimated that the costs of wind power in Germany fell in real terms by 55% between 1991 and 2004.

How to make the machines bigger is still the number-one technological issue in the turbine industry, with the current philosophy being that the larger the turbine, the greater its cost effectiveness. The average size of turbines installed increased by only around 3% to 1.25 MW in 2004, with the three-blade, three-stage gear box design remaining the most popular. Some progress is being made in producing a single-geared generator, with German company Enercon being the only one to commercially produce them at present. 5 MW turbines remained the largest available but so far only three prototype units have been installed worldwide. (Cameron 2005).

During 2003-2004, there were six competitively-bid wind projects in China and Canada , totaling almost 2,000 MW, that show winning-bid prices from 4.1-4.8 eurocents/kWh, considerably lower than most present feed-in tariffs (see Table N31). However, competitive bidding in new markets may not reflect commercially viable prices if aspiring market entrants underbid to gain market entry or mis-bid due to insufficient experience.

Wind power markets remain fragmented by country. That is, the wind market is not yet a global market but really a collection of national markets, each growing fairly independently. Wind power has become a mainstream commercial investment in about 8-10 primary countries (including Denmark, Germany, India, Italy, Netherlands, Spain, the United Kingdom, and the United States) (Figure 6). Several countries are now taking their first steps to develop large-scale commercial markets, including Russia and other transition countries of Europe, China, South Africa, Brazil, and Mexico. In the case of China, most wind power investments historically have been donor or government driven, but a shift to private investors has been underway in recent years. Several other countries are at the stage of demonstrating wind farm installations, looking to develop commercial markets in the future.

The global market for small-scale wind turbines has been growing rapidly in recent years. Small-scale wind turbines (typically 100-1,000 W) provide power for homes and remote locations. The largest installed base of small-scale turbines is an estimated 230,000 in Inner Mongolia in China, for household use. Sales of small wind turbines were estimated to be 13,000 in 2005, totaling 14 MW (an average of 1 kW per turbine), bringing total small wind capacity to 30 MW. Manufacturers are aiming to reduce hardware costs by 20 percent to $1,700 per installed kW by 2010; and the average size of small wind turbines has doubled from 500 W in 1990 to 1 kW in 2004.

[N19] Solar PV Costs, Industry, and Production Capacity Expansion

The three main types of solar PV in commercial production are single-crystal, polycrystalline, and thin film. Japanese single-crystal solar cell technology has seen its module conversion efficiency improve from 6% in 1963 to over 17% today. The average efficiency of polycrystalline silicon cells is approaching 15%, and of thin film 10-12%. Still under development are the super-thin flexible cell, which has attained 38% efficiency, and the condensed type, which has attained 28.5%.

Since 1976, costs have dropped about 20% for each doubling of installed PV capacity, or about 5%/year. (Module prices have fallen from $30/W in 1975 to close to $3/W today. Costs rose slightly in 2004 due to high demand (which outpaced supply) and the rising cost of silicon. Rooftop PV systems currently cost around $6,000-$9,000 per kW installed.

The potential for further cost reductions as markets expand is appreciable. The technologies are small-scale and modular, and the scale economies of batch production and new manufacturing techniques have been barely exploited. In addition, conversion efficiencies of PV modules have seen continuous improvement through the use of new materials and cell designs. One of the issues for the future of PV is whether and how fast crystalline silicon can be replaced by high-volume, low-cost thin-film production.

Global solar PV module prices reached a low of $2.60/Wp in 2002/2003 (Sharp), but have since rebounded to average of about $3.25/Wp in 2004. But grid-connected installed prices remained flat (about $5.50/AC-watt in Japan and $6.50-8.00/AC-watt in the U.S.). One reason for module price increases is the rising cost of silicon due to high demand (coupled with the industry's traditional reliance on computer-industry scrap silicon). Another reason is simply high demand relative to existing production. In China, solar PV module prices declined from an average of $5/Wp in 2000 to $3.50/Wp in 2003, but rose again to $4/Wp in 2004 due to raw material shortages and increased demand relative to supply. The high prices in 2004 were spurring many new manufacturers to get into the solar PV business, as profits were also high.

The PV industry celebrated its first gigawatt of global installed capacity in 1999. Five years later, by the end of 2004, this capacity had quadrupled to more than 4 GW. Solar PV market growth has very much been influenced by the grid-connected rooftop programs in Japan, Germany, and the U.S. state of California since the mid-1990s. Indeed, without these programs, the solar PV industry would likely be several years behind where it is today.

Investment in solar PV production capacity is growing in both capacity and plant scale. World solar PV production grew from 740 MW in 2003 to 1,150 MW in 2004. In 2004, U.S. solar PV production increased 39% even as its share of global production fell to 11%. Japanese production topped 600 MW. German production was up 66%, representing 60% of total European production. Production expansion continued aggressively around the world in 2004 (Table N19).

China and other developing countries have emerged as major solar PV manufacturers. As of 2004, China had 70 MW of cell production capacity and 100 MW of module production capacity, compared to the world total module production capacity of 1,150 MW. Chinese module production capacity doubled during 2004, from 50 MW in 2003. (China’s domestic PV market was 20 MW in 2004, so most production is exported.) Production capacity could double again in 2005, as the Nanjing PV-Tech Co. launched construction of China’s largest PV cell production facility, with 100 MW capacity, in early 2005. The Nanjing plant is scheduled to be finished by the end of 2005. Also, Chinese Electrical Equipment Group Ltd. plans to invest in new solar cell production capacity of 600 MW by 2008.

Other developing countries are also emerging as solar PV manufacturers. India’s primary solar PV producer is Tata BP solar, which expanded production capacity from 8 MW in 2001 to 38 MW in 2004. Central Electronics, Bharat Heavy Electrical, and WEBEL Solar are other leading solar cell/module manufacturers in India. In the Philippines, Sun Power doubled its production capacity to 50 MW in 2004. In Thailand in 2004, Solartron PLC, a solar-cell module assembler, announced plans to develop the country's first commercial solar cell manufacturing facility, with annual capacity of 20 MW, to start production in 2007.

Future plans for production expansion by the major solar PV manufacturers, as well as major new entrants, are also impressive. Announced plans by major manufacturers for 2005 included at least 400 MW increase in production capacity and several hundred megawatts further capacity in the 2006-08 period (Table N19).

Table N19. Solar PV Production Capacity Expansion

Company (in order of *PV News* 2004 rank)	**Expansion in 2004/early 2005**	**Future Plans**
1. Sharp (Japan)	Increased capacity at Katsuragi Plant, bringing annual capacity from	

	315 MW to 400 MW. New line represents investment of 5 billion Yen (US$50 million).	
2. Kyocera (Japan)	Capacity increased to 120 MW, from 72 MW in 2003. Opened new assembly plant in Mexico; increased production at facilities in Japan and Czech Republic to 24 MW.	Plans to double PV module manufacturing capacity to 240 MW/year during 2005. Mexico plant expected to reach annual production of 36 MW in 2005.
3. BP Solar (United States, Spain, Australia, Malaysia, Hong Kong, India)	15 MW increase in 2004. BP total global manufacturing capacity has increased from 34 MW in 1999 to 90 MW in 2004.	Plans to increase global production capacity from 90 MW to 200 MW by end-2006. Global expansion will include increase from 40 to 50 MW in Sydney, Australia; investment of Aus$8 million (about US$6.33 million). And more than $25 million to expand Frederick, MD, USA facility from 20 MW to 40MW.
4. Mitsubishi (Japan)	Total annual production capacity grew from 35 MW in Jan. 2003, to 50 MW in Sept. 2003, and to 90 MW in June 2004.	Will expand annual production capacity of PV cells and modules at Nakatsugawa and Kyoto Works from 90 MW to 135 MW by mid-2005 and planning to reach 230 MW by 2006. Will invest 3.3 billion Yen ($30 million) in new equipment.
5. Q Cell (Germany)	European production increased from 28 to 75 MW, making Q Cell the number-one producer in Europe.	
6. Shell Solar (U.S., Germany, Netherlands)	72 MW produced.	
7. Sanyo (Japan)	Expanded to 150 MW in Osaka, with 7.5 billion Yen (US$70 million) investment in 2004.	New plant in Hungary will be 50 MW by mid-2005 and 100 MW by 2006.
8. Isofoton (Spain)	Number two in Europe; increased production from 35 MW in 2003 to 53 MW in 2004.	
9. RWE Schott Solar (Germany)	Produced more than 50 MW in 2004.	Committed to 40 MW increase at facility in Bavaria, bringing total production to 100 MW.
10. Deutsche Shell (Germany)	Production up from 17 MW in 2003 to 24 MW in 2004.	
SolarWorld AG (Germany)		Increasing production capacity by 40 MW for total of 120 MW. Plan to double solar silicon PV manufacturing from 120 MW to 220 MW by end of 2006; have secured financing package of

		some € 80 million (US$100 million). Expect to reach at least 150 MW in 2005.
Photovoltech	13 MW produced.	Will increase cell production at Belgium facility from 13 MW to almost 80 MW in 2006.
Sun Power (Philippines, China)	Doubled Philippine cell production to 50 MW.	
Suntech (China)	Increased production, with 50 MW planned by 2004.	
Nanjing PV-Tech Co., Ltd (China) (also Chinese Electrical Equipment Group Co.)	(not yet operating)	In March 2005, launched construction of China's largest and most advanced solar production facility, in Nanjing. Expect 100 MW of production capacity in place by end of 2005. Plans to produce 600 MW solar cells by 2008.
Motech (Taiwan)	Production up by 106% to 35 MW in 2004.	
Evergreen Solar (United States)	Increased solar string production capacity in Massachusetts to 15 MW.	Announced 30-MW plant in Germany with Q-Cells as partner
First Solar - AZ (USA)	6 MW produced.	Plans to triple the output of its Ohio facility, to bring thin-film solar PV production to 40 MW/year by 2006, and 75 MW by 2007.

[N20] Biomass

Cost reductions have been achieved in the area of small- to medium-scale steam turbines for biomass-based co-generation (mainly from woody residues) in Germany and Finland, and for "new" smaller-scale co-generation technologies like ORC and stirling engines (mainly Austria and Germany). Currently, plants of this type are estimated to deliver energy at a cost between $0.07/kWh (a CHP scheme) and $0.12/kWh (electricity only). Engineering assessment suggests that capital costs could be reduced by half through replication and economies of scale once the plants enter early commercial application. Much lower costs could be achieved in co-firing applications, where suitable quantities of biomass can be supplied to existing coal plants for example.

The largest potential for cost reduction lies with gasification technologies. Costs of advanced biomass gasifiers are dropping to 10-12 cents/kWh for megawatt-scale gasifiers. Small-scale gasification of biomass still lacks development, but from RT&D in the area of biofuels (BtL schemes), positive impacts are expected to medium- to large-sized gasification and, hence, for efficient biomass-based electricity generation using gas turbines and combined cycles. China and Europe are both leaders in small-scale gasification technology.

Rural biomass pelleting for heat and power. The most prominent development in Europe is the rapid introduction of pellet heating systems, mainly in Finland and Sweden, and to a smaller extent in Austria, Germany, and the UK. Cost reductions per unit of installed kWth could be achieved by some 10%, and logistics to deliver pelletized fuels to customers improved significantly. In developing countries, rural use of biomass for power generation and heating could be on the verge of wide-scale commercial use because of deployment of pelleting and briqueting technologies. These technologies improve portability, reliability, and range of feedstocks. (E.g. Project in Bangalore to palletize agricultural waste and gasify it and a mobile pelletizing process technologies being developed in China.)

[N21] Geothermal

Geothermal energy has been used for electricity generation and heat for about 100 years. Electricity generation from geothermal sources can take place at various temperatures, starting from below 100 °C ("Binary" power plants, ORC or Kalina-cycle) to high-temperature steam plants with more than 300 °C steam temperature. The distribution of power plant types in terms of installed power is the following: Natural steam 29%, single flash 37%, double flash 25%, binary 8%, and back-pressure 1%. For heat production, hydro-thermal resources are commonly used for district heating, and CHP plants.

Natural steam or hydrothermal resources are easiest to exploit, typically located at depths of 1-4 km and containing steam or liquid hot water. Molten rocks (magma systems) may also be accessed in the future at greater depths (up to 7 km) as can hot dry/wet rocks at 4-8 km, depending on the temperature gradient. The hot dry/wet rocks concept, more generally called "enhanced geothermal systems," has been proven successfully in a European test facility. Hot dry/wet rock resources are much more abundant, and are in principle available everywhere just by drilling sufficiently deep to produce rock temperature useful for heat extraction.

Geothermal heat pumps, also called ground source heat pumps (GSHP), are increasingly being used for building heating and cooling. Ground couplings include borehole heat exchangers (vertical loops), groundwater wells, horizontal loops in the soil, and similar techniques.

The main technical challenges being addressed for reducing costs and opening up new resources include cheaper driller techniques (drilling typically accounts for half of the capital costs), remote detection of producing zones during exploration, well-stimulation measures or 'heat mining' to extract the heat more extensively and efficiently, and better power conversion technology.

[N22] Biofuels

Ethanol is the most common biofuel, accounting for more than 90% of the total usage. Ethanol is most frequently used in low-concentration blends with petroleum gasoline. In North America and parts of Europe, blends of 5-10% (E5 and E10) are common, and selected filling stations in a few major metropolitan areas sell

E85 for "flexible fuel" vehicles that can run on either gasoline or ethanol. The warm climate of Brazil also makes feasible the use of E95, and an increasing number of vehicles capable of using that fuel are being sold. ETBE, a mixture of ethanol and isobutylene (petrochemical), is used in low-concentration gasoline blends up to about 8-10% in fuels in parts of Europe, particularly France and Spain. (ETBE is "25% renewable" on a carbon atom basis and some question whether it should be considered a renewable fuel.)

In the U.S., construction of 12 new ethanol plants was completed in 2004, bringing the total to more than 80 plants. Also in 2004, construction of 16 new plants was started. More and more states are requiring that use of MTBE as a gasoline oxygenator be discontinued, due to its toxicity and contamination of drinking water, and ethanol is being used as a substitute. Consequently, by 2004, over 30% of all gasoline sold in the U.S. was being blended with ethanol as a substitute oxygenator (Renewable Fuels Association 2005).

There were more than 300 sugar mills/distilleries producing ethanol, served by a plantation area of 5.4 million hectares. In early 2005, 39 new distillers were licensed. As production increases, some even expect that ethanol exports could reach 6 billion liters/year by 2010. Several larger bioethanol plants will begin production in 2005 in Germany and the United States. Projections for the global market are for 60-75 billion liters/year by 2010.

Ethanol prices in Brazil have steadily fallen. Prices (in 2002 US$) fell from $11/GJ in 1980 to $5/GJ in 2002, and since 1999 have been equal to or below the equivalent Rotterdam gasoline price (Goldemberg et al. 2004).

Ethanol is now very competitive with gasoline. Cost reductions have been driven by Brazil and U.S. policies and also improvements in production efficiencies with additional investments and technology advances.

Ethanol from cellulose shows great promise for the future. Canada has led research in this field, and has helped to fund construction of the first commercial-scale cellulosic ethanol production plant, which converts wheat straw into ethanol using an advanced enzymatic hydrolysis process. Such plants may eventually become common, and will allow ethanol to be produced from almost any type of biomass, including agricultural and forestry wastes and high-yielding dedicated energy crops such as poplar trees and switchgrass.

International biofuels trade has expanded rapidly during the past few years. World ethanol trade volume hit a record level in 2004, reaching nearly 4.9 billion liters, compared with 3.7 billion liters in 2003. Brazil is by far the biggest exporter, accounting for about half of international shipments of ethanol during 2004. Japan and the U.S. were the largest importers, with India close behind. However, Brazilian ethanol prices during 2004 were near historic lows, fuelling trade, and higher ethanol prices likely during 2005 could slow or even reverse this trend, at least in the short term. There was also considerable biofuels trade (of both ethanol and biodiesel) within the EU (between various member countries), and growth in intra-EU trade appears likely to continue with the 10 new members beginning to play an active role.

Biodiesel was not produced in significant quantities anywhere in the world prior to 1996. By 2004, biodiesel markets had developed in seven primary countries (Austria, Belgium, France, Germany, Italy, Indonesia, and Malaysia). Germany has been the biggest biodiesel producer, with about 2 billion liters capacity on line or under construction. France, Italy, and the UK are the next largest producers.

A biodiesel market is emerging in the U.S., with currently between 20 and 25 biodiesel production sites, with an estimated production capacity over 150 million gallons per year. An additional 100 million gallons of annual capacity is under construction or has been announced. Sales of biodiesel exceeded 30 million gallons in 2004, and are expected to more than double in 2005 due to tax incentives. A recent example of expansion is a 15-million-gallon-per-year biodiesel production plant planned for Missouri by Mid-America Biofuels. The plant will use the soybean oil from nearly 10 million bushels of soybeans grown in the state, representing approximately 7 percent of Missouri's average annual harvest.

India has been examining for quite some time the supply of ethanol-blended petrol in the country. In order to ascertain financial and operational aspects of blending 5% ethanol with petrol, the government had launched three pilot projects in different states during 2001 and these pilot projects were supplying 5% ethanol-doped-petrol only to the retail outlets under their respective supply areas. The Society for Indian Automobile Manufacturers (SIAM) has confirmed the acceptance for use of 5% ethanol-blended petrol in vehicles. State governments of major sugar producing states and representatives of sugar/distillery industries have confirmed availability/capacity to produce ethanol. An expert group established by the government recommended blending of ethanol with petrol at supply locations (terminals/depots) of oil companies. In 2003, the government resolved that 5% ethanol-blended petrol would be supplied in the nine states and four union territories. For biodiesel, a national program aims to produce enough oil seeds for the production of biodiesel in sufficient quantities to enable its blending with diesel to the extent of 20%. Pilot projects and analyses of feed-stock collection and plantations were ongoing.

[N23] Concentrating Solar Thermal Power

In Europe, research and development for concentrating SEGS was significantly increased in 2003 and 2004. New designs using Fresnel reflectors are being proposed, promising 20% cost reductions as compared to the standard parabolic trough and tower concepts. Performance of trough receiver tubes continues to increase, thermal storage continues to be developed for trough systems, and advanced stirling dishes are under test at some laboratories.

[N24] Jobs from Renewable Energy

We conducted a literature review of analytical factors for jobs-per-existing-capacity and jobs-per-unit of produced capacity (Table N24c). We then totalled the jobs based on existing installed capacity in 2004 and new manufactured/installed capacity in 2004 (Table N24a). In general, employment impacts of renewable energy development are difficult to measure in a precise way, especially if total employment figures—including both direct and indirect jobs—are to be estimated. A proper approach would be to build input-output analysis models, an analytic tool that macroeconomists use to derive employment multipliers with which to predict the number of jobs (direct and indirect) created by sales increases from a given sector or industry. The simplified alternative adopted here is to use analytical approaches to define employment coefficients, generally based on (a) information on labor time needed for a unit of power (i.e. person-years per MW), or (b) data on expenditure necessary to support a full-time job annually (person-years/USD invested).

Table N24a. Estimation of Jobs from Renewable Energy, 2004

Technology	**Global capacity (MW as of 2004)**	**Additional capacity in 2004 (MW)**	**Current employment in manufacturing (person-years in 2004)**	**Current employment in O&M (jobs)**
Small hydropower	62,000	5,000	56,500	13,640
Wind power	48,000	8,200	31,160 – 60,680	4,800 – 9,600
Biomass power	38,000	800	1,600 – 6,800	12,160 – 79,040
Geothermal power	9,000	200	800 – 3,500	15,300
Solar PV	4,000	900	22,590* - 29,097	4,000 – 10,000
Solar thermal (hot water)**	116 million m^2	18 million m^2	13,6056	381,150
Solar thermal electric power	400	--	--	280
Ocean (tidal) power	300	--	--	30
Total			**249,000 – 293,000**	**431,000 – 509,000**
Ethanol production	--	32 billion liters	**902,000 direct jobs***	
Biodiesel production		2.2 billion liters	**31,000 direct jobs******	

(*) = This low estimate is obtained with the parameter from Pembina Institute (2004), as the lower figure from Greenpeace does not account for installation labor.

(**) = These estimates are obtained by using coefficients derived from 2000 Chinese industry data (see Table N24c) for Chinese production and de-rated (30% lower) coefficients for the production capacity of the other countries assuming higher labor productivity.

(***) = Estimated global direct jobs obtained by applying the Brazilian employment coefficient of Table N24c to production in Brazil (14 billion liters), China (2 bill. ltrs.) and others (1 bill. ltrs.), and a 30% discounted coefficient to take into account the less labor-intensive U.S. production (14 bill. ltrs.).

(****) = Estimated assuming jobs in biodiesel production are half of the jobs in ethanol production, per liter produced.

Table N24b. Some Additional Parameters, Country Data, and Relevant Employment Impact Estimates

Technology	Manufacturing & Installation	O&M	Source & Notes
Wind	2.6 Jobs/MW	0.3 Jobs/MW	EPRI, 2001
Geothermal	4.0 Jobs/MW	1.7 Jobs/MW	
Solar PV	7.1 Jobs/MW	0.1 Jobs/MW	
Biomass	3.7 Jobs/MW	2.3 Jobs/MW	
Wind	7.75 person-years/MW		Heavner & Del Chiaro 2003–2005 estimates Using EPRI factors (time adjusted), authors calculate total employment impacts for 2004-2017 (in person-years) in California, with an assumption that only 30% of manufacturing is locally provided. Here, the person-year/MW parameters are derived from their 2005 estimated scenario of added capacity.
Geothermal	41.57 person-years/MW		
Solar PV	5.2 person-years/MW		
Biomass	56 person-years/MW		
Wind	17 person-years/MW	5 person-years/MW	EWEA 2003. Figures derived from an Input-Output model.
Solar PV	20 Jobs/MW	30 Jobs/MW	EPIA 2004. Information on existing direct employment in Europe (the 30 jobs/MW figure includes installation, consulting, retail, and other services)
Small hydro	2,200 (1,200 manufacturing + 1,000 consulting and research) people employed in Europe in 2002		ESHA, www.esha.be/
Solar thermal power	356 person-years employed in U.S. in 2002		Data from US DOE, EIA
Solar thermal power	16.33 person-years/MWe	1.58 person-years/MWe	Schwer & Riddel 2004. Estimated employment impacts of 3 x 100 MWe concentrating solar plants in Nevada.

Additional Explanatory Notes:

Methodological premise. Employment impacts of renewable energy development are difficult to measure in a precise way, especially if total employment figures—including both direct and indirect jobs—are to be estimated. A proper approach would be to build *Input-Output analysis* models (see note-f below), an analytic tool that macroeconomists use to derive employment multipliers with which to predict the number of jobs (direct and indirect) created by sales increases from a given sector or industry. A simplified alternative is to use *analytical approaches* to define employment coefficients, generally based on (a) information on labor time needed for a unit of power (i.e. person-years per MW), or (b) data on expenditure necessary to support a full-time job annually (person-years/USD invested).

Table N24c summarizes some of the most relevant employment coefficients developed by analysts. The following points summarize additional explanatory elements on the employment impact parameters and estimates presented:

(a) Most of the studies in the literature focus on *direct jobs* that is, employment generated within the renewable energy industry chain, usually disaggregated in the following categories: manufacturing, construction and installation, operation and maintenance, and fuel collection. They therefore do not count the *indirect jobs*, that is, those jobs created in the economy by multiplier effects in the renewable energy sectors.

(b) There are different ways to build employment impact indicators. Many studies report on employment in the manufacturing and installation segment in terms of *person-years per MW*, that is the amount of labor time required to manufacture equipment (or build a power plant) equivalent to MW of power. In Tables N24b and N24c, this indicator has been selected to offer the picture of how many full-time employees were working in renewable energy manufacturing and installation in 2004. For this reason, whenever possible, other employment coefficients from the literature were adapted to person-years values. The indicator *Jobs per MW* is used in Table N24c with regards to the O&M and fuel collection segments of labor, it refers to permanent employment, that is the number of laborers needed continuously to support the ongoing operation of a power plant with a maximum output of one MW.

(c) Generally the employment created is measured against the power capacity installed (MWp), as it is in this report, but an alternative may be to consider as common denominator the average power capacity (MWa), the power capacity de-rated for taking into account the capacity factor of each energy technology. This way an indicator that standardizes the actual energy outputs is obtained and values referring to employment impacts of different RE technologies can be compared.

(d) Table N24a reports the range of values of estimated employment obtained by using the lowest and the highest employment coefficients of Table N24c for each technology. While for solar hot water heaters there are not many employment studies and parameters available, it should be noted that the Chinese industry is representative of the largest production (72% of global production in 2004). Therefore the choice was to use Chinese industry data to derive employment coefficients and adjust them to account for lower labor intensity for the non Chinese production figures. As for biofuels, the employment parameter (Table N24c) and the estimate figure (Table N24a) refer to total direct employment in the relevant agriculture and industrial sectors, thus it is presented separately from the other employment estimates.

(e) All figures estimating the labor requirement of renewable energy presented in Table N24c have been developed in the OECD countries, except for solar heating and biofuels. It can be recognized that in a developing country context the same processes and markets can be more labor intensive per MW, thus leading in a probable underestimation of global employment when applied to global renewable energy capacity figures in Table N24a.

(f) For further reference, see MITRE Project (EC 2002b**)** for a good example of this method applied to the growth scenarios of renewables across technologies and within EU 15 member states: starting from SAFIRE model of market penetration for the different RE technologies, an input-output model named RIOT (Renewables Enhanced Input Output Tables) was used to calculate production functions representing the value of inputs (including employment) needed from the different sectors of the economy to obtain a unit of energy from different energy sources (both conventional and renewables). These parameters were then used to model net employment impacts (including the substitution of conventional energy sector jobs) in the scenarios at 2010 and 2020.

Table N24c. Summary of Relevant Employment Coefficients

Technology	Estimates of Employment Coefficients: Manufacturing & Installation (person-yrs/MWp)	Estimates of Employment Coefficients: O&M and Service (Jobs/MWp)	Source	Type of study, type of impact, and basic assumptions
Small hydro	11.30	0.22	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Wind	3.80	0.10	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a 37.5 MW wind farm with 30% capacity factor; direct employment impacts.
	7.40	0.20	Heavner & Churchill 2002	Direct employment impacts projected from planned projects by California Energy Commission.
	6.0	(100-450 per TWh)	ECOTEC 2002	Based on information from EWEA, citing 20,000 direct jobs in wind industry in Europe in 2001.
	3.92	0.10	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Biomass	8.5	0.32 – 2.08*	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a set of co-firing plants (100 MW-750 MW) and several biofuels; direct employment impacts.
	2.0	0.95*	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Geothermal	4.0	1.70	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
	17.50	1.70	Heavner & Churchill 2002	Direct employment impacts projected from planned projects by California Energy Commission.
Solar PV	32.33	2.25	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a 2 kWp

				solar roof market; direct employment impacts.
	25.10	2.5	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
	17.0**	1.0 (O&M) + 30.0 (installation, retailing, other)	Greenpeace & EPIA 2005	These parameters have been developed with EPIA for a scenario analysis of direct employment in Europe.
Solar thermal power	6.25	0.70	US DOE 1997	Derived from information on the 9 plants (350 MW) of solar thermal electricity generation in California.
	20.0 per GWh	1.0 per GWh	GAC 2005	Gross direct and indirect employment estimates from I-O model developed in Germany.
Solar hot water (***)	8,330 per mill. m^2	3,850 per mill. m^2	Author estimates	Derived from 2000 Chinese industry figures, assuming 1/3 of employment absorbed by manufacturing and 2/3 by O&M.
Ocean (tidal) power	4.22	0.10	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Biofuel (ethanol)	33 direct jobs per million liters of production		Goldemberg 2004	Estimated starting from data and parameters developed by UNICA, Brazilian sugar cane producers association.

Notes:
(*) = Includes fuel collection and processing activities.
(**) = Does not include installation of PV systems, accounted for together with the O&M figure.
(***) = Parameters estimated by the authors based on data collected from the Chinese solar water heaters industry (6 mill. m^2 of annual production and 26 mill. m^2 of installed systems in 2000), which by 2004 had grown to account for about 70% of world annual production (13 mill. m^2 annual production and 65 mill. m^2 of installed systems).
Sources: Adapted from all sources indicated in 3rd column and from Kammen et al. 2004.

Individual jobs estimates:

The China solar hot water industry employed 200,000 people in 2002, with a market size of 40 million installed and 12 million produced annually (Li 2005). The top eight manufacturers are Himin, Tsinghua Yang AGuang, Linuo Paradigma, Tianpu, Hua Yang, Mei Da, Sunpu, and Five Star. Considering growth in the market and installed base, by 2004 there may have been at least 250,000 employed.

Europe wind power jobs from Global Wind Energy Council. Nepal biogas industry from Nepal Biogas Support Programme. Other jobs estimates from report contributors. Europe small hydro and solar PV jobs from EREC 2004.

Sources for job estimation parameters and methods: EC 2002b; ECOTEC 2002; GAC 2005; Goldemberg 2004; Heavner & Churchill 2002; Kammen et al. 2004; Pembina Institute 2004; Schwer & Riddel 2004; and US DOE 1997.

[N25] Policy Targets

Sources for Table 3 and Figure 11 are: IEA, OECD, and JREC policy databases (IEA 2005a and 2005b); DSIRE database (DSIRE 2005); Li 2002 and 2005; Sawin and Flavin 2004; Thailand DEDE 2004; South Africa Department of Minerals and Energy 2003; and many other submissions from report contributors.

Some of these targets are not legally binding within the countries concerned, but are rather indicative or planning targets. Some targets may include capacity or energy from large hydropower.

China's targets are from the draft renewable energy development plan being prepared by NDRC. The plan has not yet been approved by the government. The Chinese renewable energy law from February 2005 requires NDRC to publish the renewable energy development plan, including targets, by January 2006. Targets also include 140 million m^2 of solar hot water by 2010, 270 million m^2 of solar hot water by 2020, 20 GW of wind by 2020, and 20 GW of biomass by 2020, and 12.5% of total electric power capacity by 2020 (which would be an anticipated 125 GW out of 1,000 GW). China's target of 10% of total installed electricity from renewable energy, excluding large hydro, would mean 60 GW of renewables out of 600 GW total power capacity. In relation to the target of 5% total primary energy by 2010, China today stands at approximately 3.3-3.5% of total primary energy from renewables (excluding large hydropower).

In 2004, Korea established a goal of 1.3 GW of grid-connected solar PV by 2011. This follows a previously announced target of 100,000 solar PV homes by 2011, an expected 300 MW.

Korea's target of 7% electricity by 2011 includes large hydropower. Excluding large hydropower, the target becomes 5.6%.

Japan also has targets of 4.8 GW from solar PV and 3 GW from wind. Although these targets remain "on the books," they have been eclipsed by the RPS policy of 1.35% and are no longer regarded as primary.

EU data also from EC 2004a and 2004b, which provide the best overview of EU policy targets..

Note: The percentage contributions of RES-E are based on the national production of RES-E divided by the gross national electricity consumption. For the EU15, the reference year is 1997. For the EU10 (Czech

Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia), the reference year is based on 1999-2000 data.

Philippines: The Renewable Energy Policy Framework (REPF) aims to double the capacity of renewable energy resources by instituting favorable policies and incentive packages for industry participants with the following objectives in mind: (1) Increase renewable energy-based capacity by 100 percent by 2013, with 425 MW expected to be supplied by wind power. The Philippines has over 70,000 MW of potential wind energy, with estimates of realizable wind power ranging from 20-30,000 MW. (2) Become the top geothermal energy producer in the world. Currently, the Philippines is the second largest geothermal power in terms of generating capacity, having generated 9,822 GWh from geothermal energy in 2003, displacing around 16.9 MMBFOE. It is projected that geothermal installed capacity will increase from the current 2,146 MW to 2,206 MW by 2014, equal to 14,403 GWh generation and 23.41 MMBFOE. The country is estimated to have 4,790 MW of potential geothermal reserves. (3) Become the largest wind-power producer in Southeast Asia with a wind energy investment kit focusing on the development of 16 wind power areas, beginning with a 25 MW wind farm—which went online this year—and another 40 MW wind farm in Ilocos Norte. (4) Become the solar-manufacturing hub of Southeast Asia through the establishment of a local industry in the manufacture of affordable solar energy systems. A US$300 million solar wafer fabrication plant was inaugurated in April 2004 to manufacture high-efficiency PV cells with an anticipated initial production equivalent of 25 MW, increasing to 150 MW within the next five years. At full capacity, the plant can supply 6% of the world's total market for the PV industry. The manufacturing plant aims to distribute 30% of its production to the local market, thereby significantly decreasing the cost of local solar panels. (5) Push for the development of all viable mini- and micro-hydropower plants through various cost-efficient foreign loans. (6) Install 130-250 MW of biomass, solar, and ocean capacity; and (7) Partner with Congress for the passage of the Renewable Energy Bill that seeks to institutionalize the guidelines, procedures, and incentives for renewable energy development.

Table N25. EU Renewable Energy Targets

Country	**Target(s)**	**Actual 1997 level**
EU-25	21% of electricity and 12% of total energy by 2010	12.9%
Austria	78% of electricity by 2010	70%
Sweden	60% of electricity by 2010	49.1%
Latvia	49.3% of electricity by 2010; 6% of energy (excluding large hydro) by 2010	42.4%
Portugal	45.6% of electricity by 2010	38.5%
Finland	35% of electricity by 2010	24.7%
Slovenia	33.6% of electricity by 2010	29.9%
Slovak Republic	31% of electricity by 2010	17.9%
Spain	29.4% of electricity by 2010	19.9%
Denmark	29% of electricity by 2010	8.7%
Italy	25% of electricity by 2010	16%
France	21% of electricity by 2010	15%

Greece	20.1% of electricity by 2010	8.6%
Ireland	13.2% of electricity by 2010	3.6%
Germany	12.5% of electricity and 4% of energy by 2010; 20% of electricity by 2020	4.5%
Netherlands	12% of electricity by 2010	3.5%
United Kingdom	10% of electricity by 2010	1.7%
Czech Republic	8% of electricity by 2010; 5-6 % of energy by 2010; 8-10% of energy by 2020	3.8%
Poland	7.5% of electricity by 2010; 7.5% of energy by 2010; 14 % of energy by 2020	1.6%
Lithuania	7% of electricity by 2010; 12% of energy by 2010	3.3%
Belgium	6% of electricity by 2010	1.1%
Cyprus	6% of electricity by 2010	0.05%
Luxembourg	5.7% of electricity by 2010	2.1%
Estonia	5.1% of electricity by 2010	0.2%
Malta	5% of electricity by 2010	0%
Hungary	3.6% of electricity by 2010	0.7%

Note: Portugal's 35.6% target, Finland's 35% target, and the Netherlands' 12% target from IEA JREC database. Portugal's original target was 39%, Finland's was 31.5% and the Netherlands' was 9%.

[N26] Power Generation Promotion Policies

Sources for Table 4: IEA, OECD, and JREC databases (IEA 2005a and 2005b); IEA 2004b; Sawin & Flavin 2004; Wahnschafft & Soltau 2004; Johansson & Turkenburg 2004; Martinot et al. 2005; Beck & Martinot 2004; Osafo & Martinot 2003; Thailand DEDE 2004; Tumiwa 2005; Rousseff 2005; Austrian Energy Agency 2005; Stenzil et al. 2003; EWEA 2005c; EAEF 2005; EEA 2004; ECN Renewable Energy Policy Info website (and Vries et al. 2003) (www.renewable-energy-policy.info); country references noted in country data section; submissions from report contributors. IEA 2004b in particular contains a wealth of historical and current information on IEA country policies. EU data also from EC 2004a and 2004b.

Notes for Table 4:

(a) Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national-level policy. See separate table for RPS policies by state/province. In the case of Inida, however, the Electricity Act of 2003 mandates state-level policies, and states are developing different combinations of policies, including feed-in tariffs and RPS. Even though this could not be considered a "national feed-in law," the mandate is having a similar effect.

(b) Japan's net metering is voluntary by utilities and features separate buy/sell transactions, although the selling price is typically the same as the purchase price. Japan's feed-in tariffs are also voluntary by utilities, and some utilities have switching to annual caps with bidding.

(c) Spain's feed-in tariff system incorporates both fixed total prices and price premiums added to variable-cost components of electricity tariffs.

(d) Some policies listed may not be active or may not have associated implementing regulations developed. It is very difficult to separate active, inactive, and "not yet implemented" policies without extremely detailed data

gathering. So the table reflects enacted policies, and the information it portrays should be considered as "notional" rather than "definitive."
(e) Mexico has an atypical form of net metering that allows intermittent self-generators access to the grid for surplus self-generation, to be used at other times of the day, subject to certain limits based on local utility marginal costs. Mexico also allows wheeling costs to be based on average plant capacity factor.
(f) Norway had a type of feed-in policy (added premium) for wind power, but this was discontinued in 2003.

[N27] Feed-in Laws

Sources for Table 7: IEA OECD Policies database (IEA 2005a); IEA 2004b; Sawin & Flavin 2004; other sources from Table 10; REAccess 5/10/05 for United States, Washington State; REAccess 5/16/05 for Turkey; Austrian Energy Agency 2005; ECN Renewable Energy Policy Info website (www.renewable-energy-policy.info); country references noted in country data section; submissions from report contributors.

Italy adopted CIP6/92 from 1992 to 1995. Denmark, Spain, and Portugal all had forms of feed-in policies earlier than those shown in Figure 12, but the dates in Figure 12 reflect the modern versions of the laws that are credited with the major market impacts which have taken place. Other countries also had earlier pre-cursor feed-in policies that might be considered the original legislative enactment.

Notes for Table 7
(a) Tariffs can vary depending on size of plant, region of plant, whether onshore or offshore in the case of wind, year of commissioning of plant, season of operation in which the tariff is paid (summer vs. winter), and/or year of plant's operational life in which the tariff is paid. Some tariffs decline substantially or become invalid after a certain year of plant operation, and this varies widely by country. Ranges given reflect typical prices considering these factors, for Germany in 2004 and for other countries in 2002-2004.
(b) Germany's feed-in law has undergone continuous updating, reflecting changing conditions, objectives, and technology characteristics and costs, first in 1994, and then in 1998, 2000, and 2004.
(c) Denmark's price figures are from the old pricing system before feed-in tariff was suspended in 2003.
(d) "---" means law does not cover that technology.
(e) Some tariffs have upper limits to plant size. Czech Republic and Slovenia limit small hydro to 10 MW. Latvia limits small hydro to 2MW. Indonesia limits all plants to 1 MW.
(f) Spain's feed-in tariff system incorporates both fixed total prices and price premiums added to variable-cost components of electricity tariffs.
(g) In India, national feed-in tariffs (common guidelines to all states for a minimum buy-back rate of Rs. 2.25/kWh in order to bring uniformity) were declared by MNES in 1993. However, two states, Gujarat and Tamil Nadu, were offering attractive buy-back rates even earlier in order to attract private sector investment in wind (MNES annual reports for 1991-1994). Similarly, Maharastra and Tamil Nadu had promotional policies for bagasse-based cogeneration. Tamil Nadu had evolved a scheme in 1988 (TNEB-Tamil Nadu Electricity Board Notification dated 12 December 1988) called "Power feed scheme" permitting co-generators and

private-sector power producers of 2 MW capacity and greater to sell surplus power to the grid. It covered co-generation units, mini- and micro-hydro, wind farms, and diesel/gas turbines. The power purchase rate for this scheme in 1990-91 was Rs. 1.00 per unit subject to yearly review. MSEB (Maharashtra State Electricity Board), on the other hand, offered Rs. 1.20 per unit with periodic revisions. (Source for both the above is Winrock International & IDEA 1993.)

(h) India's Electricity Act of 2003 mandates national targets by 2012 and provides guidelines for fixing RPS and feed-in tariffs for each state.

(i) PURPA was first enacted in the U.S. in 1978 and actively implemented by many states during the 1980s. By the 1990s, fewer states still had active PURPA implementation, although currently several states still implement PURPA as a feed-in tariff for small projects; examples of this exist in Idaho, Minnesota, and Oregon.

(j) Some countries have feed-in tariffs that apply only to solar PV.

(k) Turkey Adopts National Feed-in Law for Renewables, news item at REAccess.com, 16 May 2005, at www.renewableenergyaccess.com/rea/news/story?id=29822

(l) Slovakia: Feed-in-Tariffs for Green Electricity 2006 issued. In June 2005, the Slovak Regulator has issued the
feed-in-tariffs for Electricity from Renewable Energy Sources and CHP for the year 2006. This latest decree brings about considerably higher tariffs, as compared to the current regulation. For example, the tariff for electricity from newly installed wind power plants put into operation after January 1st, 2005, is fixed with 2,800 Slovak Crowns per MWh (about 72 Euro). These tariffs are set by the Regulatory Office for one year. A complete table with the tariffs is now online on enerCEE:
www.energyagency.at/enercee/sk/supplybycarrier.htm#res

[N28] Renewables Portfolio Standards

RPS information comes from DSIRE database; Martinot et al. 2005; IEA 2004b; Pollution Probe 2004; Linden et al. 2005; ECN Renewable Energy Policy Info website (www.renewable-energy-policy.info); submissions from report contributors.

Some RPS targets include large hydro, for example in Wisconsin, Maine, New Jersey, Texas, Hawaii, Maryland, New York, Pennsylvania, District of Columbia, and British Columbia, while other targets restrict renewables to a certain maximum size, with the maximum usually falling between 1-30 MW.

A 2005 study by Global Energy Decisions estimated that state RPS laws currently existing in the United States would require an additional 52 GW of renewable energy by 2020, which would more than double existing U.S. renewables capacity.

Table N28a. States, Provinces, and Countries Adopting Renewables Portfolio Standards

Year Enacted	State/Province/Country	Final Target
1997	Massachusetts, USA	4% by 2009 then +1%/yr
1998	Connecticut, USA	10% by 2010
	Wisconsin, USA	2.2% by 2011
1999	Maine, USA	30% ongoing
	New Jersey, USA	6.5% by 2008
	Texas, USA	2,880 MW by 2009
	Italy	2% from 2002
2001	Arizona, USA	1.1% by 2007-2012
	Hawaii, USA	20% by 2020
	Nevada, USA	15% by 2013
	Australia	1.25% in 2004, increasing through 2010 to meet national target of 9,500 GWh/year
	Flanders, Belgium	6% by 2010
2002	California, USA	20% by 2017
	New Mexico, USA	10% by 2011
	United Kingdom	10% by 2010 and 15% by 2015
	Wallonia, Belgium	12% by 2010
2003	Minnesota, USA	10% by 2015
	Japan	1.35% by 2010
	Sweden	16.9% by 2010
	Maharashtra, India	compulsory but no percentage
2004	Colorado, USA	15% by 2015
	Maryland, USA	7.5% by 2019
	New York, USA	24% by 2013
	Pennsylvania, USA	8% by 2020
	Rhode Island, USA	16% by 2019
	Madhya Pradesh, India	0.5%
	Karnataka, India	5-10%
	Andhra Pradesh, India	to be set
	Orissa, India	2 million kWh by 2006-2007
	Poland	7.5% by 2010
	Nova Scotia (Canada)	5% by 2010
	Ontario (Canada)	10% by 2010
	Prince Edward Is. (Canada)	15% by 2010, 100% by 2015
	Thailand	5% of future new generation added
2005	District of Columbia, USA	11% by 2022
	Gujarat, India	5% by 2010

Canada: According to Pollution Probe (2004), there are 10 Canadian provinces with RPS or planning targets for renewable energy. Pollution Probe identifies the Nova Scotia and Ontario policies as RPS policies, while the others are planning targets. Other sources from early 2004 state that no RPS policies yet existed in Canada. News reports confirm Nova Scotia passed energy legislation in November 2004 with the RPS. Ontario enacted its RPS in its 2004 Electricity Restructuring Act. British Columbia has introduced a voluntary RPS targeting 10% of new generation from renewable sources (www.energyroundtable.org/energy_opp.php). Alberta's target is similarly voluntary. "Prince Edward Island introduced an RPS of 15% by 2010, 100% by 2015." PEI's Renewable Energy Act was enacted in December 2004. Hydro Quebec has issued an RFP to procure 1,000 MW of new wind power over 10 years.

Table N28b: RPS and Planning Targets in Canadian Provinces

Province	**Target**
Nova Scotia	5% by 2010 (legislated RPS)
Prince Edward Island	15% by 2010 (legislated RPS)
New Brunswick	1% by 2010 (target)
Quebec	3% by 2010 (target)
Ontario	10% by 2010 (voluntary RPS)
Manitoba	5% by 2010 (target)
Saskatchewan	all new generation through 2010 (target)
Alberta	3.5% by 2008 (target)
British Columbia	10% by 2010 (target)
Northwest Territories	10% of total energy by 2010 and 25% by 2025

Note: British Columbia's target applies to "clean energy," including co-generation.

[N29] Rooftop Solar PV Policies

Table N29. Grid-Connected Solar Rooftop Programs, Selected Countries, 2004

Location and Start Year(s)	Cumulative Homes as of 2004	Cumulative Installations as of 2004	Installations Added, 2003	Installations Added, 2004	Supporting Policies
Japan (1994-2004)	200,000	800 MWp	190 MWp	260 MWp	"Sunshine program" capital subsidy started at 50% in 1994, declining to 10% by 2003.
Germany (1999-2003)	150,000	680 MWp	140 MWp	300 MWp	"100,000 roofs program" provided low-interest loans for households and 50 eurocents per kWh feed-in tariff through 2003. Since 2004, market supported by feed-in tariffs of 45-62 eurocents/kWh.
California programs (1998-)	15,000	95 MWp	27 MWp	36 MWp	State program capital subsidy of $4.50/W(AC) declined to $3.50/W(AC). There are also municipal utility (SMUD, LADWP) and utility RPS programs.

Notes:

(a) California reports total number of installations, which includes both residential and commercial, but the number of residential installations is assumed to be much higher than the number of commercial installations. The number of homes reported is consistent with an average of 4kW/home and residential being more than half of total installed capacity in 2004.

(b) Assumption of 4kW/home for new 2004 installations in Japan and Germany. Cumulative homes for 2003 estimated at 170,000 in Japan and 65,000 in Germany based on prior reports of homes and capacity.

(c) On-grid solar PV capacity in Europe was 480 MWp in 2003, of which 375 MW was in Germany. The Netherlands was the major contributor, with 44 MW in 2003. So additional on-grid capacity in Europe in 2004, besides Germany, was probably about 110 MW.

(d) Korea has a 100,000-rooftop program, with an expected 0.3 GW by 2011. Korea provides 70% capital subsidy for systems less than 200 kW. The subsidy is expected to decline to 30-50% in the future.

(e) Thailand has had a small rooftop solar PV programme. As of July 2004, 67 kWp were installed, subsidized by EPPO.

Sources: Maycock 2004 and 2005a; Jones 2005; Dobelmann 2003; California Energy Commission 2004; Navigant Consulting 2005; submissions from report contributors.

[N30] Other Power Generation Promotion Policies

See Martinot et al. (2005) for further details and full references on U.S. public benefit funds (available at www.resource-solutions.org).

Net metering policies from Martinot et al. (2005), plus IEA and JREC policy databases (IEA 2005a and 2005b) and submissions from report contributors.

[N31] Public Competitive Bidding and Other Regulatory Measures

Many broad policies for power sector reform/restructuring also affect renewable energy in significant ways, beyond the administrative measures specifically targeting renewable energy. Such policies are beyond the scope of this report, but good discussion can be found in Beck & Martinot (2004).

Table N31. Recent Public Competitive Bidding of Wind Power, China and Canada

Country (Year)	Bidding	Award Prices (local currency)	Award Prices (U.S. cents)
Canada (2004)	1,000 MW in Quebec	CAN 6.5 cents/kWh	5.2 cents/kWh
China (2004)	100 MW in Inner Mongolia	CNY 0.382/kWh	4.6 cents/kWh
	100-200 MW in Jilin	CNY 0.509/kWh	6.1 cents/kWh
	100-200 MW in Jilin	CNY 0.509/kWh	6.1 cents/kWh
	100-150 MW in Jiangsu	CNY 0.519/kWh	6.2 cents/kWh
China (2003)	100 MW in Jiangsu	CNY 0.437/kWh	5.3 cents/kWh
	100 MW in Guangdong	CNY 0.501/kWh	6.1 cents/kWh

Notes:
(a) Project size ranges in China reflect optional additional capacity expansions that can take place after the initial development of 100 MW in each project.
(b) An additional three concessions for 450 MW of bidding in 2005 was mentioned in Ku et al. 2005.
(c) Details of Ontario's programs can be found on the Ontario Power Authority Web site, www.ontarioelectricityrfp.ca.
(d) Exchange rates used are 1.24 CAN and 8.28 CNY.
Sources: Ku et al. 2005; submissions from report contributors.

[N32] Solar Hot Water Policies

More information on China can be found in Li (2005).

For more information about solar hot water policies in Spain, see: Instituto para la Diversificación y Ahorro de la Energía (Institute for Energy Diversification and Saving), at www.idae.es and Comision Nacional de la Energia (National Energy Commission), www.cne.es and www.energias-renovables.com

For specialized news group on renewables in Spain, see:
www.energias-renovables.com/paginas/Contenidosecciones.asp?Id=5993 and
www.energias-renovables.com/paginas/Contenidosecciones.asp?ID=5202&Tipo=&Nombre=Solar%20t%C3%83%C2%A9rmica

Agència d'Energia de Barcelona (Barcelona Energy Agency), at www.barcelonaenergia.com

For Barcelona Solar Ordinance, see www.barcelonaenergia.com/cas/observatorio/ost/ost.htm

[N33] Biofuels Policies

Table N33. Ethanol and Biodiesel Blending Mandates, Selected Countries

Year Enacted	**Country/State/Province**	**Ethanol Blend (percentage)**	**Biodiesel Blend (percentage)**
1975	Brazil (national)	22-25%	2% by 2005
1997	United States (state of Minnesota)	10% 20% by 2013	2% (future)
---	Dominican Republic (national)	15% by 2015	5% by 2015
---	China (provinces of Heilongjiang, Jilin, Liaoning, and Henan)	10%	---
2003	India (9 states and 7 federal territories)	5%	---
2004	United States (state of Hawaii)	10% by 2006	---
	Columbia (national)	10%	
2005	Canada (province of Ontario)	5% by 2007	
	United States (state of Montana)	10%	

Note: As part of Thailand's national 8% of energy target by 2011, biomass transport fuels are targeted at 1570 ktoe/year, which could be achieved by 3 million liters/day of ethanol and 2.4 million liters/day of biodiesel. But it is still unclear what the actual blending mandates will be.
Sources: Submissions from report contributors. Some of the information is inadequately verified.

In Canada, the province of Ontario announced in 2004 that it intends to require that all gasoline sold there must contain an average of 5% ethanol by 2007. The province of Saskatchewan enacted an ethanol fuel act in 2002 that creates the legal framework to mandate ethanol blending with gasoline and is planning to move in that direction in 2005; the province of Manitoba is also considering enacting a policy to support ethanol blending.

[N34] Green Power Purchasing and Utility Green Pricing

Recent data on green power customers are not readily available. Most recent data show 600,000 green power customers in Germany (almost double from 2002) and almost 3 million in the Netherlands. According to some sources, Netherlands as of the end of 2003 was 2.2 million. UK and the Switzerland are almost the same number in 2004 as of the end of 2002, they were 45,000 and 46,000 for each.
http://www.greenprices.com gives roughly 4 million green power customers total in Europe. Individual county numbers for Europe totaled together give a slightly smaller number, perhaps 3.7 or 3.8 million.

Bird et al. (2002) gives these totals of green power consumers for 2002: Australia: 60,000; Canada: 6,000; Finland: 8,000 in 2001; Germany: 325,000 (including 250,000 large hydro); Japan: 38,000; Netherlands: 775,000; Sweden: 9,000 GWh; Switzerland: 46,000; and United Kingdom: 50,000. Australia government (2004) gives 70,000 green power consumers.

Sources for green power include: Bird et al. 2002, Bird & Swezey 2004, Martinot et al. 2005, and submissions from report contributors.

An important distinction to make in considering numbers of green power customers is what percentage of these purchases are for new renewables and thus are serving to expand the deployment of renewable power generation. Many of the European purchases are for existing large hydro at prices on par with conventional energy, while the U.S. EPA Green Power Partnership has strict eligibility criteria for new renewables content (minimum 50% new).

See FOE (2004), which says that only "retired" ROCs in the UK are really comparable to U.S. voluntary products; most Green Power buyers in the UK are merely subsidizing the utility's need to buy some renewables.

The Shanghai electricity comes from a 3.4 MW wind farm in Fengxian District, with another 20 MW of wind power capacity coming on line in mid-2005 in two other wind farms. The first round of green electricity purchases by these 12 enterprises is equal to 50% of the power output from these 3 wind farms. (News release from the Shanghai Energy Conservation Supervision Center, 12 June 2005.)
The consumer's cooperative union in Japan that initiated green power in 1999 was the Seikatsu Club Hokkaido (SCH). Together with a regional utility, SCH established a fund to support the development of new wind projects in the region. Under the program, SCH collects electricity bills instead of the utility, and the members who joined the program can make contributions by adding 5% to their electricity bills. SCH also established the Hokkaido Green Fund (HGF) for contributions from non-members. In turn, the Hokkaido Green Fund established Hokkaido Civic Wind Co. to allow members to purchase shares of wind projects in return for dividends from the sale of electricity from the wind turbines. Thus was built the first "citizen-owned" wind turbine in 2001. By early 2005, the Hokkaido Civic Wind Co. had invested in 7 MW of wind capacity. After this program, HGF and the Institute for Sustainable Energy Policies established the Japan Green Fund Co. to allow further citizen investments in renewable energy. By 2005, the Japan Green Fund had constructed five wind turbines. And by early 2005, there were 1,300 members of HGF's green pricing program.

[N35] Municipal Policies

Table N35a. Cities with Local/Municipal-Scale Renewable Energy Policies, 2004

City	RE Goals	CO_2 Goals	SHW	Solar PV	Planning	Demos	Other
Adelaide, Australia	X	X			X	X	
Barcelona, Spain	X	X	X	X	X	X	X
Cape Town, South Africa	X	X			X		
Chicago, United States	X						
Daegu, Korea	X	X			X	X	
Freiburg, Germany	X	X		X	X	X	
Gelsenkirchen, Germany					X	X	
Goteborg, Sweden					X	X	
Gwangju, Korea	X	X			X		
The Hague, Netherlands		X					
Honolulu, United States							X
Linz, Austria						X	
Madison (WI), United States				X			
Minneapolis, United States	X					X	
Oxford, United Kingdom	X	X	X	X	X		
Portland, United States	X	X	X	X	X	X	
Qingdao, China					X	X	
San Diego, United States							X
San Francisco, United States							X
Santa Monica, United States					X	X	
Sapporo, Japan		X			X	X	
Toronto, Canada		X					
Vancouver, Canada		X					

Notes:

(a) "X' indicates significant activity in the given category.

(b) Categories are defined as follows: "RE goals" means targets or goals set for the future share of energy from renewable energy; "CO_2 goals" means future CO_2 emissions targets set, usually on a city-wide or per-capita basis; "SHW" means policies and/or incentives for solar hot water enacted; "Solar PV" means policies and/or incentives for solar power enacted; "Planning" means overall urban planning approaches considering future energy consumption and sources; "Demos" means specific projects or one-time demonstrations subsidized by public funds; and "Other" means other policies or programs.

Sources: International Solar Cities Initiative, www.solarcities.or.kr, and www.martinot.info/solarcities.htm, December 2004, with updates from DSIRE database and submissions from report contributors. Barcelona energy improvement plan at www.barcelonaenergia.com.

Table N35b. Cities with Future Targets for Renewable Energy Shares, 2004

City	RE share of municipal electricity consumption	RE share of total city electricity consumption	Other targets
Adelaide, Australia		15% by 2014	
Aspen (CO), United States		50% currently	
Austin (TX), United States		20% by 2020	
Cape Town, South Africa		10% by 2020	10% of homes by 2010 have SHW
Chicago (IL), United States	20% by 2006 10% currently		
Daegu, Korea			5% of total energy by 2012
Ft. Collins (CO), United States		15% by 2017	
Freiburg, Germany		10% by 2010 4% currently	
Gwangju, Korea			2% of total energy by 2020
Los Angeles (CA), United States	20% currently		
Minneapolis (MN), United States	10% currently		
Oxford, United Kingdom			10% of homes by 2010 have SHW and/or solar PV
Portland (OR), United States	100% by 2010		
Sacramento (CA), United States		20% by 2011	
San Diego (CA), United States	23% currently		
San Francisco (CA), United States			1 MW/year added
Santa Monica (CA), United States	100% currently		

Note: Austin's target includes energy efficiency improvements.

Sources: International Solar Cities Initiative, www.solarcities.or.kr; www.martinot.info/solarcities.htm, December 2004; DSIRE database.

Table N35c. Cities with CO_2 Emissions Reductions Targets, 2004

City	Target
Adelaide, Australia	Zero net emissions by 2012 in buildings Zero net emissions by 2020 in transport
Calgary, Canada	6% reduction from 1990 levels for corporate and community emissions
Freiburg, Germany	25% below 1992 levels by 2010
Gwangju, Korea	20% below baseline levels by 2020
The Hague, Netherlands	City government "CO_2 neutral" by 2006; whole city "CO_2 neutral" in long term
Portland (OR), United States	10% below 1990 levels by 2010
Sapporo, Japan	10% below 1990 levels by 2012
Sudbury, Canada	>30% reduction below 1990 levels
Toronto, Canada	Municipal energy 20% below 1990 levels by 2005
Vancouver (BC), Canada	6% below 1990 levels by 2012 and municipal energy 20% below by 2010

Notes:

(a) Calgary: GHG reduction goal is 6% reduction from 1990 levels for corporate emissions, and 6% reduction from 1990 levels for community emissions.

(b) Sudbury: GHG reduction goal is 574,800 tons of GHGs per year (77% through energy, 10% through transportation, 13% through solid waste). This translates into a target of more than a 30% reduction below 1990 levels.

(c) Toronto: GHG reduction goal is 20% from 1990 levels for corporate emissions, 6% for community emissions.

Sources: International Solar Cities Initiative, www.solarcities.or.kr; www.martinot.info/solarcities.htm, December 2004; DSIRE database; submissions by report contributors. Vancouver CO_2 reduction goal from http://vancouver.ca/sustainability/coolvancouver/backgrounder.htm; Toronto CO_2 reduction goal from www.city.toronto.on.ca/taf

(San Francisco, CA, Refocus Weekly, 15 June 2005) Politicians from 50 of the largest cities in the world have signed a treaty to source 10% of their city's peak electric load from renewable energies. The non-binding 'Urban Environmental Accord' was signed at the United Nations World Environment Day conference in San Francisco. The accord lists 21 specific actions, topped by an action item to "adopt and implement a policy to increase the use of renewable energy to meet 10% of the city's peak electric load within seven years." The mayors agreed to adopt municipal plans to reduce GHG emissions by 25% by 2030, including a system for accounting and auditing greenhouse gas emissions. Signatories include Jakarta, Delhi, Istanbul, London, Seattle, Melbourne, Kampala, Zurich, Dhaka, Moscow, Rio de Janeiro, Copenhagen and Islamabad. Available at www.wed2005.org/pdfs/Accords_v5.25.pdf?PHPSESSID=d3f44c0bb102b22541fbf9f35b268650

"Green Cities Declaration" (see PDF file)

[N36] Rural Energy and Development Assistance

For basic references and sources on rural energy, see World Bank 1996, UNDP et al. 2000, and Goldemberg & Johansson 2004.

For information on the World Bank's renewable energy strategies, see:

- World Bank Renewable Energy Action Plan, described in World Bank's RE/EE Annual Report, at http://siteresources.worldbank.org/INTENERGY/Resources/335544-1111615897422/Annual_Report_Final.pdf;
- World Bank, "Fuel for Thought: Environmental Strategy for the Energy Sector." (2000 strategy paper), at http://www-wds.worldbank.org/servlet/WDSServlet?pcont=details&eid=000094946_0008040539585
- "The Strategy of the World Bank in Financing Renewable Energy Projects in South Asia," at www.worldenergy.org/wec-geis/publications/reports/renewable/annexes/annex_2.asp#strategy

For information about ASTAE, see www.worldbank.org/astae.

For Global Environment Facility-related information, see:

- GEF project briefs and documents, at www.gefweb.org.
- Other GEF monitoring and evaluation reports, at: http://thegef.org/MonitoringandEvaluation/METhemesTopics/METClimateChange/metclimatechange.html
- GEF, Office of Monitoring and Evaluation. 2004. Climate Change Program Study. Washington, DC, at http://thegef.org/MonitoringandEvaluation/METhemesTopics/METClimateChange/2004_ClimateChange.pdf

For information about UNEP, see:

- Rural Energy Enterprise Development Programme, at www.uneptie.org/energy/projects/REED/REED_index.htm, www.b-reed.org, and www.c-reed.org
- UNEP Sustainable Energy Finance Initiative, at www.sefi.unep.org
- UNEP Activities on Renewable Energy, at www.uneptie.org/energy/act/re

For information on UNIDO see: UNIDO initiative on rural energy for productive use, at www.unido.org/doc/24839 (lists UNIDO projects by technology type)

For information on African Development Bank, see "Renewable Energy Summary," at www.afdb.org/en/what_s_new/events/s_minaire_sur_l_nergie_olienne_octobre_2004/adb_intervention_in_renewable_energy

The Asian Development Bank (ADB) is currently developing a renewable energy operational and strategic action plan to promote renewable energy by building a pipeline of feasible renewable energy projects. The ADB established a Renewable Energy, Energy Efficiency and Climate Change (REACH) Program (www.adb.org/reach), which supports capacity building, institutional development, and project development activities in the area of energy efficiency and renewables, in 15 DMCs of Asia. It is expected that these technical assistance interventions will lead to increased lending in the area of renewable energy and energy efficiency.

[N37] Rural Biomass Use

Further references on rural biomass use include Kartha and Larson 2000; Kartha et al. 2004; Bailis et al. 2005; Karekezi & Kithyoma 2005; and Elauria et al. 2002.

All data on biomass consumption and rural household energy is from Bailis et al. 2005. Information on the health impact of traditional biomass use is from Ezzati & Kammen 2002.

Biomass energy is used extensively as fuel in the Philippines, particularly in the residential and industrial sectors. The types of fuel used in the country are: wood fuel, wood wastes, and other agricultural residues such as sugar cane bagasse, coconut husk and shell, rice-hull, and industrial and animal wastes. The residential sector accounted for about 70% of biomass use, with cooking as the major end-use. The shares of various biomass fuels consumed in the residential sector are 77 % wood fuel, about 19% agricultural residues, 4% charcoal, and 0.4 % animal manure in the form of biogas. Biomass consumption in the industrial sector is mainly for steam and power generation, which consumed about 84% of the total consumption of the sector while baking and commercial cooking used about 1%. The remaining 15% is used in commercial applications such as fish- and crop-drying, ceramic processing, food manufacturing, metal works, and brick-making. Applications of biomass energy systems are dominated by ovens/kilns/furnaces and biomass dryers, roughly 15,000 of each in 1997, along with about 5,000 cook stoves and on the order of hundreds of biomass-fired boilers and biogas systems, and a few dozen gasifiers (Elauria et al. 2002).

[N38] Traditional Biomass and Improved Cook Stoves

Cook stove data from Li & Shi 2005, AFRENPREN 2004, and Kammen 2005. Kammen (2005) notes that in Kenya, the Ceramic Jikko stove (KCJ) is found in over 50% of all urban homes, and roughly 16-20% of rural homes.

China's National Improved Stove Program operated during the 1980s and 1990s. For a description, see http://ehs.sph.berkeley.edu/hem/page.asp?id=29.

India's National Program on Improved Cookstoves lasted from 1985-2002, provided over 100 different models, and provided a 50-75% direct cash subsidy. The cost of each cook stove was $2-6. Reported lab efficiencies were 20-45% (compared with traditional stove efficiencies of 5-10%). Source: Maithel 2005.

Table N38a: Rural Household Cooking in Developing Countries

Country/Region	Households using traditional biomass for cooking/heating (million)	Improved (more efficient) biomass stoves in use (million)
Africa	130	5
China	190	180
Indonesia	35	n/a
Rest of Asia	30	1
India	130	34
Rest of S. Asia	30	n/a
Latin America	20	n/a
Total	570	220

Notes:

(a) Figures are approximate, based on assumption of 4.4 persons per household for all regions (Worldwatch Institute 2004). Most data are for 2000.

(b) The biggest improved cook stove (ICS) programs of the world are being undertaken in China where 177 million stoves have been installed so far, covering 76% of rural households and in India where about 30.9 million improved stoves were installed by 1999, covering 23% of rural households (Bhattacharya 2002).

(c) Biomass, mostly traditional use, accounts for a large share of total primary energy supply in many developing countries. In 2001, this share was 49% in Africa, 25% in Asia, and 18% in Latin America. "Traditional use" means burning wood, agricultural waste, and dung for home cooking and heating fuel plus for process heat. Often the biomass fuel itself is "free," insofar as there is no direct monetary cost, although large amounts of time, particularly for women, may be used to collect it. A share of biomass is converted to charcoal, which is then sold commercially for the same uses. (IEA 2003a; Karekezi et al. 2004)

(d) Developing countries at large depend on traditional biomass fuels (charcoal, fuel wood, agricultural residues, and animal dung) for just over 26% of their total fuel mix (Johansson & Goldemberg 2004; Figures 1.2 and 1.4, pp. 26-27). Sub-Saharan Africa relies on these same fuels for over 61% of total energy supply (UNDP et al. 2000**,** Fig. 7, p. 29; McDade 2004).

(e) In China, by the early 1990s, 130 million improved stoves had been installed under the National Improved Stoves Program (Sinton et al. 2004). This figure increased to 177 million by 2000 (Bhattacharya 2002).

(f) In India, an estimated 130 million rural households use biomass as the primary fuel for cooking. This compares with about 7 million rural households that use LPG for cooking and about 2 million that rely on kerosene. In India, 700 million people live in homes where biomass is the primary fuel for cooking. However, only about 33.6 million, or 17.5% of all Indian homes, use LPG as their primary cooking fuel, with 90% of rural homes still dependent on some form of biomass. (D'Sa & Murthy 2004).

(g) Roughly two-thirds of African households, more than 580 million people, depend on wood fuels for their daily cooking and heating needs (Utria 2004).

(h) Currently, about one-fourth of Mexican households (27.2 million people) cook with fuel wood, either

exclusively (18.7 million people) or in combination with LPG (8.5 million). Fuel wood use is concentrated within rural and peri-urban households. Fuel wood is still the main residential fuel in Mexico, accounting for approximately 50% of total energy use and 80% within rural households. Despite the rapid urbanization process that has taken place in Mexico in the last 30 years the use of fuel wood has remained virtually constant with an increasing share of mixed fuel wood-LPG users in total consumption (Masera et al. 2005).
Sources: Karekezi et al. 2004, IEA 2002a, Graham 2001, TERI 2001, and D'Sa & Murthy 2004.

Table N38b. Estimated Number of Improved Biomass Cook Stoves in Selected African Countries, 2001

Country	Number of Improved Stoves
Kenya	3,136,739
South Africa	1,250,000
Niger	200,000
Burkina Faso	200,000
Tanzania	54,000
Uganda	52,000
Eritrea	50,000
Ethiopia	45,000
Sudan	28,000
Zimbabwe	20,880
Malawi	3,700
Botswana	1,500

Sources: AFREPREN 2004; African Ministerial Meeting on Energy Proceedings 2004; Kammen 2005.

In Africa, regional organizations like the Southern African Development Community (SADC) have put in place a number of key interventions aimed at ensuring the sustainable use of energy resources. Since 1997, SADC started the Programme for Biomass Energy Conservation in Southern Africa (ProBEC) which is implemented by GTZ. In addition to the German Government, other donors committed to co-funding the program include the Dutch Ministry for Foreign Affairs (DGIS), UNDP-GEF, and the EU Energy Initiative. The purpose of the program is the adaptation and development of efficient technologies and management strategies for biomass energy consumption in households and small businesses in order to use the available resources sustainably. An expansion of ProBEC to the rest of the continent is requested by the NEPAD Action Plan (iii energy, para 110), endorsed by the African Union Summit in Mozambique in July 2003.

[N39] Biogas Digesters

Information on biogas digesters is from: the Biogas Support Programme Nepal 2005; Martinot et al. 2002; Bhattacharya 2002; Karekezi et al. 2004; Graham 2001; TERI 2001; D'Sa and Murthy 2004; China national biogas action plan; and submissions from report contributors.

[N40] Biomass Gasifiers

Information primarily from Bhattacharya 2002.

Note: This report does not cover the lessons and operational experience of different renewable energy technologies, although that is an important subject. For example, dual-fuel gasifiers in the Philippines suffered from low acceptability due to technical problems such as gas-cleaning, lack of consumer acceptance, and lower petroleum prices (Elauria et al. 2002).

[N41] Village-Scale Mini-Grids

Historical data from Martinot et al. 2002. Updates for China and India's installations and programs from submissions by report contributors and from Ma 2004 and Li & Shi 2005. See also NREL 2004 for China program information.

[N42] Water Pumping

Estimates are from the Indian Renewable Energy Development Agency (IREDA) (TERI, personal communication May 2005); Karekezi & Kithyoma 2005; and Martinot et al. 2002. Results reported are from GTZ projects. Original sources from Martinot et al. 2002.

Donor programs have demonstrated that PV-powered pumps can be economically competitive with conventional diesel pumps, in smaller villages up to 2,000 inhabitants. Pumping costs range from \$0.30-1.00/m^3 (0.03-0.1 cents/liter), according to GTZ.

Commercial project examples are being conducted by a subsidiary of Australia's SOLCO in the case of the Maldives and by U.S.-based Worldwater Corporation in the case of the Philippines.

[N43] Solar Home Systems

Table N43a. Solar Home Systems Worldwide, 2004

Country/Region	Added in 2004	Existing in 2004 (at least)	Sources
China	>130,000	450,000-500,000	CREDP 2004; task managers; Martinot et al. 2002
Sub-Saharan Africa		460,000	AFRENPREN 2004; Kammen 2005
India	20,000	310,000 SHS (+ 510,000 solar lanterns)	TERI, as of March 2004
Sri Lanka	15,000-20,000	75,000	World Bank/GEF project; www.energyservices.lk
Thailand	100,000	100,000	New program for 2004-2005
Bangladesh	15,000-20,000	40,000	World Bank/GEF project and Grameen Shakti
Mexico		>80,000	Huacuz 2000
Other Latin America		50,000	
Morocco		>80,000	Martinot et al. 2002; data are for 1995
Indonesia		40,000	Tumiwa 2005
Nepal	16,000	80,000	Rai 2004; World Bank **[which year?]]**
Vietnam		5,000	
Others		50,000	
Total	>320,000	~ 2 million	

Notes:

(a) China: The China REDP project had installed 234,000 systems as of December 2004, 130,000 of these in 2004 and most of the remaining 100,000 in 2003. China had 150,000 SHS as of 2000 (Martinot et al. 2002). Li et al. (2005) say there is 30 MW of PV in off-grid applications. The Township Electrification program added 20 MW of hybrid systems. 10 MW of SHS, assuming 25W systems, is 400,000. 2002 = 83,000 SHS installed, 2003 = 75,000 installed, 2004 = 130,000 systems installed (+ non-REDP). Assuming 50,000 in 2001, then 2004 existing = 478,000. By end-2003, 410,000 cumulative in six Western provinces, per REDP report. This comes to a total of 540,000 by end-2004.

(b) Sri Lanka and Bangladesh: As of March 2005, World Bank projects in Bangladesh had installed 30,000-40,000 systems, and Sri Lanka RERD had installed 42,000 systems (see www.energyservices.lk). Sri Lanka had 3,000 systems as of 2000, and the first RERD project added 30,000 systems.

(c) Thailand: A new government program to electrify the remaining rural households of the country installed at least 100,000 in 2004 and planned to complete a 300,000-system program in 2005. Prior to 2004, there were no SHS in Thailand.

(d) Large numbers of installed solar home systems, estimated at 10-20% by some and even higher percentages by others, may not actually be operational due to lack of service and spare parts, among other reasons (Martinot

et al. 2002).
(e) China installed about 40,000 systems from 2000-03 through pilot projects of the “Brightness” program. This was in addition to 230,000 systems installed through the World Bank/GEF Renewable Energy Development Project in 2002-04.
Sources: As given in table, plus submissions from report contributors. See also Martinot et al. 2002 and Niewenhaut et al. 2000.

In Kenya, government and donor projects remain a steady source of income for some PV businesses. There are more than 20 major PV import and manufacturing companies, and hundreds of rural vendors, many of which sell a range of brands. Rural vendors sell about half of the household-size modules; the other half are purchased directly from distributors in major cities. After an initial market fueled by donor aid and government programs in the early 1990s, by the mid-1990s commercial sales of solar PV for household use had surpassed other uses, and those sales continued to dominate the Kenyan PV market.

India commercial bank program: In 2003, UNEP initiated a credit facility in Southern India to help rural households finance the purchase of solar home systems. Two of India’s largest banks, Canara Bank and Syndicate Bank, along with their eight associate Regional Rural Banks (or Grameen Banks), established a Solar Loan Programme through their branch offices across Karnataka State and part of neighboring Kerala State. Previous to this program, only about 1,400 SHS had been financed in Karnataka. In addition to providing financial support in the form of interest rate subsidies for borrowers, the program provides assistance with technical issues, vendor qualification, and other activities to develop the institutional capacity for this type of finance. As of January 2005, the programme had financed nearly 12,000 loans (homes), through more than 2,000 participating bank branches. Sales volume had reached 1,000 systems per month. The fastest growth in loans is currently in rural areas, thanks in part to the increasing participation of the nine Grameen banks. The three-year program is on target to finance 20,000-25,000 solar home systems, making it one of the largest SHS loan programs globally. In response, other Indian banks have recently launched competing SHS loan programs.
(*) Program supported by the United Nations Foundation and the Shell Foundation.

Table N43b. Estimated Number of Solar Photovoltaic Systems Disseminated in Africa

Country	Number of Systems	Estimated Installed Capacity (kWp)
Kenya	150,000	3,600
Zimbabwe	84,500	1,689
Botswana	5,700	1,500
Ethiopia	5,000	1,200
Zambia	5,000	400
Eritrea	2,000	400
Tanzania	2,000	300
Uganda	3,000	152
Mozambique	(1000)	100

Swaziland	1,000	50
Malawi	900	40
Angola	(200)	10
South Africa	150,000	8
Total	**410,000**	

Source: AFREPREN 2004

[N44] Rural Access to Electricity

Table N44. Rural Access to Electricity, Selected Countries, 2004

Country	Share of rural households electrified (percent)	Number of rural households remaining unelectrified
China	98	7 million (30 million people, 29,000 villages)
Thailand	97	0.3 million
Costa Rica	90	
Mexico	84	1 million
Cuba	80	
Viet Nam	80	3.5 million
Brazil	70	2.5 million (12 million people)
Philippines	60	3 million
South Africa	50	2 million
India	44	78 million
Sri Lanka	30	2 million
Bangladesh	19	18 million
Zimbabwe	19	
Ghana	17	
Nepal	15	
Tanzania	2	> 3 million
Kenya	2	> 4 million
Ethiopia	1	< 7 million
Mali	1	
Uganda	1	>3.5 million
World Total		**350 million (1.6 billion people)**

Notes:

(a) By 2004, the most common number cited for number of people without access to electricity was 1.6 billion (see Goldemberg et al. 2004). This number used to be cited as 2 billion, but was revised downward in recent years due to analytical refinements. Assuming 4.4 people per household in developing countries (Worldwatch Institute 2004), this comes to 360 million households. It appears from the data above, in comparison with previously published statistics, that progress in several countries with rural electrification, including China and India, has reduced this number significantly. The 14 countries listed in this table represent a majority of the population in developing countries, yet show only 135 million households unelectrified.

(b) Only 1% of the rural households in Kenya and Uganda has access to electricity. This percentage has been relatively constant over the past decade (Karekezi & Kimani 2004).

(c) Rural household access to electricity in India was 33% in 2001-02 (Sihag et al. 2004).

(d) Annual rural connection rates vary, and a global estimate does not exist. In Kenya, roughly 3,000-4,000 rural households were receiving new electricity connections each year in the early 2000s.

(e) Rural access to electricity, rather than both rural and urban combined, is more appropriate to compare with renewable energy, since renewables will not be a competitive option for access in urban (peri-urban) areas close to existing electric grids. Rural-access percentages are harder to find in the literature than just the overall electrification rate for a country.

Sources: Karekezi & Kimani 2004 and 2005; D’Sa & Murthy 2004; AFREPREN 2004; Sihag et al. 2004; Goldemberg, et al. 2004; Krause & Nordstrom 2004; ESMAP 2002; World Bank 2004; India 2001 census; contributions and updates from report researchers and contributors.

[N45] Market Facilitation Organizations

Note: This listing is a work in progress and further updates are expected.

Industry Associations

American Biomass Association	www.biomass.org
American Council for Renewable Energy (ACORE)	www.american-renewables.org
American Wind Energy Association (AWEA)	www.awea.org
Australian Wind Energy Association	www.auswea.com.au
Brazilian Renewable Energy Companies Association	www.brsolar.com.br
British Association for Biofuels and Oils	www.biodiesel.co.uk
British Biogen	www.britishbiogen.co.uk
British Photovoltaic Association	www.pv-uk.org.uk
British Wind Energy Association (BWEA)	www.bwea.com
Business Council for Sustainable Energy (BCSE)	www.bcse.org
Canadian Solar Industries Association (CANSIA)	www.cansia.org
Canadian Wind Energy Association (CANWEA)	www.canwea.ca
China Renewable Energy Industries Association (CREIA)	www.creia.net
Danish Wind Industry Association	www.windpower.org
European Biomass Association	www.ecop.ucl.ac.be/aebiom
European Biomass Industry Association (EUBIA)	www.eubia.org
European Geothermal Energy Council (EGEC)	www.geothermie.de
European Photovoltaic Industry Association	www.epia.org
European Renewable Energy Council (EREC)	www.erec-renewables.org
European Renewable Energy Federation (EREF)	www.eref-europe.org
European Small Hydro Association (ESHA)	www.esha.be
European Solar Thermal Industry Federation (ESTIF)	www.estif.org
European Wind Energy Association (EWEA)	www.ewea.org
Finnish Wind Power Association (FWPA)	www.tuulivoimayhdistys.fi
German Energy Agency (DENA)	www.deutsche-energie-agentur.de
German Renewable Energy Association	www.bee-ev.de/
German Industry Assoc. for the Promotion of Rural Electrification.	www.cle-export.de/
German Solar Industry Association	www.bsi-solar.de
German Wind Energy Association	www.wind-energie.de
Global Wind Energy Council (GWEC)	www.gwec.net
Indian Wind Energy Association	www.inwea.org
Indian Wind Turbine Manufacturers Association	www.indianwindpower.com
(India) Wind Power Developers Association	[n/a]
International Geothermal Association (IGA)	http://iga.igg.cnr.it/index.php
Irish Wind Energy Association (IWEA)	www.iwea.org

Japanese Wind Power Association	www.jwpa.jp
Japanese Wind Energy Association	http://ppd.jsf.or.jp/jwea
Sustainable Energy Industries Association (Australia)	www.seia.com.au
Sustainable Energy Ireland (SEI)	www.irish-energy.ir
Solar Energy Industries Association (SEIA)	www.seia.org
Swiss Wind Energy Association	www.suisse-eole.ch
World Wind Energy Association (WWEA)	www.wwindea.org

NGOs

African Energy Policy Research Network (AFREPREN)	www.afrepren.org
ASEAN Centre for Energy	www.aseanenergy.org
Association for the Promotion of Renewable Energy	www.apere.org
Austrian Biofuels Institute	www.biodiesel.at
Australian and New Zealand Solar Energy Society (ANZSES)	www.anzses.org
Basel Agency for Sustainable Energy (BASE)	www.energy-base.org
Bioenergy Austria	www.bioenergy.at
Biomass Users Network Brazil (BUN)	www.cenbio.org.br
Biomass Users Network Central America	www.bun-ca.org
Canadian Association for Renewable Energy	www.renewables.ca
Center for Resource Solutions	www.resource-solutions.org
Cogen Europe	www.cogen.org
Energieverwertungsagentur-Eva	www.eva.wsr.ac.at
European Renewable Energy Exchange	www.eurorex.com
Eurosolar	www.eurosolar.org
Greenpeace International	www.greenpeace.org
India (Kerala) Renewable Energy Center	www.mithradham.org
Intermediate Technology Development Group	www.itdg.org
International Institute for Energy Conservation (IIEC)	www.iiec.org
International Solar Energy Society (ISES)	www.ises.org
Mali Folkecenter	www.malifolkecenter.org
MicroEnergy International	http://microenergy-international.com
Mosaico Network	www.mosaiconetwork.org
Organizations for the Promotion of Energy Technologies (OPET)	www.cordis.lu/opet
Photovoltaics Global Approval Program (PV GAP)	www.pvgap.org
Renewable Energy Policy Project (REPP)	www.crest.org
Solar Electric Light Fund (SELF)	www.self.org
Winrock International	www.winrock.org
World Alliance for Decentralized Energy (WADE)	www.localpower.org
World Business Council for Sustainable Development (WBCSD)	www.wbcsd.org
World Resources Institute (WRI)	www.wri.org

World Wildlife Fund (WWF)	www.wwf.org
Worldwatch Institute (WWI)	www.worldwatch.org
Brahmakumaris (India)	www.brahmakumaris.com.au
Ramakrishna Mission (India)	www.rkmcnarendrapur.org
Planters Energy Network (India)	[n/a]
Social Works and Research Centre (India)	www.barefootcollege.org
Ladhakh Ecological Development Group (India)	[n/a]
Solar Energy Society of India	[n/a]

International Partnerships and Networks

African Energy Policy Research Network (AFREPREN)	www.afrepren.org
European Green Cities Network	www.greencity.dk
European Renewable Energy Research Centers Agency (EUREC)	www.eurec.be
European Solar Cities Initiative	www.eu-solarcities.org
e7 Network of Expertise for the Global Environment	www.e7.org
Global Network on Energy for Sustainable Development (GNESD)	www.gnesd.org
Global Village Energy Partnership (GVEP)	www.gvep.org
International Network for Sustainable Energy (INFORSE)	www.inforse.org
International Solar Cities Initiative (ISCI)	www.solarcities.or.kr
Mosaico Sustainable Agriculture and Infrastructure Network	www.mosaiconetwork.org
Renewable Energy and Energy Efficiency Partnership (REEEP)	www.reeep.org
Renewable Energy Policy Network for the 21st Century (REN21)	www.ren21.net
UNEP Sustainable Energy Finance Initiative (SEFI)	www.sefi.unep.org
World Council for Renewable Energy (WCRE)	www.wcre.org
World Energy Council (WEC)	www.worldenergy.org
World Renewable Energy Network (WREN)	www.wren.org

International Agencies

Asian Development Bank	www.adb.org
African Development Bank	www.afdb.org
European Bank for Reconstruction and Development	www.ebrd.org
European Investment Bank	www.eib.org
Food and Agricultural Organization of the UN	www.fao.org
Global Environment Facility	www.gefweb.org
Inter-American Development Bank	www.iadb.org
International Energy Agency	www.iea.org
UN Asian and Pacific Centre for Transfer of Technology (APCTT)	www.apctt.org
UN Department of Economic and Social Affairs (UNDESA)	www.un.org/esa/desa.htm
UN Development Programme	www.undp.org

UN Economic and Social Commission for Asia-Pacific (ESCAP)	www.unescap.org
UN Environment Programme	www.unep.org
UN Industrial Development Organization	www.unido.org
World Bank Group	www.worldbank.org

Bilateral Aid Agencies

Australia AusAID	www.ausaid.gov.au
Canada International Development Agency (CIDA)	www.acdi-cida.gc.ca/home
Danish International Development Assistance (DANIDA)	www.um.dk
French Fund for the Global Environment (FFEM)	www.ffem.net
French Agency for Environment and Energy Management (Ademe)	www.ademe.fr
German Agency for Technical Cooperation (GTZ)	www.gtz.de
German Development Finance Group (KfW)	www.kfw.de
Netherlands Agency for Energy and the Environment (Novem)	www.novem.org
Swedish Energy Agency (STEM)	www.stem.se/english
UK Carbon Trust	www.thecarbontrust.co.uk
UK Department for International Development (DFID)	www.dfid.gov.uk
US Agency for International Development	www.usaid.gov
US Environmental Protection Agency	www.epa.gov

National Government Agencies

Brazil Ministry of Mines and Energy	www.mme.gov.br
Brazilian Electricity Regulatory Agency	www.aneel.gov.br
Canada Sustainable Development Technology Canada (SDTC)	www.sdtc.ca
China National Development and Reform Commission (NDRC)	www.ndrc.gov.cn
German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)	www.erneuerbare-energien.de
India Ministry for Non-Conventional Energy Sources (MNES)	www.mnes.gov.in
India Renewable Energy Development Agency (IREDA)	www.ireda.in
Japan New Energy and Industrial Tech. Develop. Org. (NEDO)	www.nedo.go.jp
Netherlands Senter Novem	www.senternovem.nl
New Zealand Energy Effic. and Conservation Authority (EECA)	www.eeca.govt.nz
Thailand Department of Alternative Energy and Efficiency	www.dede.go.th
US Department of Energy (USDOE)	www.eere.doe.gov

State/Provincial Government Agencies [for future development; one example below]

California Energy Commission	www.energy.ca.gov/renewables

REFERENCES

In addition to the sources listed below, the following online magazines and journals were used in collecting current information:

• Energy for Sustainable Development	www.ieiglobal.org/esd.html
• Energy Policy	www.elsevier.com/locate/enpol
• GVEP electronic newsletter	www.rsvp.nrel.gov/asp/newsletter_search.asp
• Photon magazine	www.photon-magazine.com
• Renewable Energy World	www.jxj.com/magsandj/rew
• RenewableEnergyAccess.com	www.renewableenergyaccess.com
• REFocus	www.re-focus.net
• Renewable Energy Portal	www.odysen.com
• Solar Buzz	www.solarbuzz.com

Acker, R. & Kammen, D.M. (1996). The Quiet (Energy) Revolution: The Diffusion of Photovoltaic Power Systems in Kenya. *Energy Policy* 24: 81-111.

AFREPREN (African Energy Policy Research Network). (2004). *Energy Data and Terminology Handbook*. Occasional Paper 23. Nairobi.

Allderdice, A. & Rogers, J.H. (2000). *Renewable Energy for Microenterprise*. Golden, CO: National Renewable Energy Laboratory. www.nrel.gov/villagepower/vpconference/vp2000/handbooks/microenterprise_handbook.pdf.

Altinbilek, D., Seelos, K., & Taylor, R. (2004). Hydropower's Role in Delivering Sustainability. Presentation at 19th World Energy Congress, Sydney, Australia 5-9 September 2004.

Austrian Energy Agency. (2005). News and background information on renewable energy in Central and Eastern Europe. *enerCEE.net*. www.eva.ac.at/enercee/index.htm.

AWEA (American Wind Energy Association). (2005). Global wind power continues expansion. News release. 4 March 2005.

Ayoub, J. & Dignard Bailey, L. (2003). *Photovoltaic Technology Status and Prospects: Canadian Annual Report 2003*. Ottawa: Natural Resources Canada. http://cetc-varennes.nrcan.gc.ca/en/er_re/pva_sapv/p_p.html.

Bacon, R.W. & Besant-Jones, J. (2001). Global electric power reform, privatization, and liberalization of the electric power industry in developing countries. *Annual Review of Energy and the Environment* 26: 331-59.

Bailis, R., Ezzati, M., & Kammen, D.M. (2005). Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa. *Science* 308: 98-103.

Balce, G..R., Tjaroko, T.S., & Zamora, C.G.. (2003). *Overview of Biomass for Power Generation in Southeast Asia*. Jakarta: ASEAN Center for Energy.

Bartle, A. (2003). Hydro and dams gain more universal support. *International Journal on Hydropower and Dams* 10(1): 3-9.

Beck, F. & Martinot, E. (2004). Renewable energy policies and barriers. *Encyclopedia of Energy*. San Diego: Academic Press/Elsevier Science.

Bhattacharya, S.C. (2002). Biomass energy in Asia: a review of status, technologies and policies in Asia. *Energy for Sustainable Development* 6(3): 5-10.

Biogas Support Programme Nepal. (2005). Biogas Nepal 2004. Kathmandu: Alternative Energy Promotion Centre.

Bird, L. & Swezey, B. (2004). Green Power Marketing in the United States: A Status Report (Seventh Edition). NREL/TP-620-36823. Golden, CO: National Renewable Energy Laboratory (NREL).

Bird, L., Wüstenhagen R., & Aabakken, J. (2002). Green Power Marketing Abroad: Recent Experience and Trends. NREL/TP-620-32155. Golden, CO: NREL.

Bolinger, M. et al. (2001). States emerge as clean energy investors: a review of state support for renewable energy. *The Electricity Journal*. November: 82-95.

Boo, K., Yoo J., & Kim, K. (2004). New & Renewable Energy Policy in Korea Since the WSSD. Paper prepared for Regional Conference for Asia and the Pacific on Renewable Energies 2004, Bangkok, Thailand, 25-26 March.

BP. (2005). *Statistical Review of World Energy 2005*. London. www.bp.com/genericsection.do?categoryId=92&contentId=7005893

BTM Consult. (2005). Global Wind Market Report. Ringkobing, Denmark.

Cabraal, R.A., Barnes, D.F., & Agarwal, S.G. (2005). A New Approach to the Productive Uses of Energy for Rural Development. Draft manuscript. Washington, DC: World Bank.

California Energy Commission. (2003). "Distributed energy resources." www.energy.ca.gov. Viewed 26 January 2003.

California Energy Commission. (2004). Grid-Connected PV Capacity (kW) Installed in California. Sacramento. www.energy.ca.gov/renewables/documents/2003-07-31_GRID_PV.PDF

Calle, R. (1999). Sweet future? Brazil's ethanol fuel programme. *Renewable Energy World* 2(5): 46-53.

Cameron, A. (2005). Steady as she goes. The BTM world market update. *Renewable Energy World* 8(4): 134-145.

CEC (Commission of the European Communities). (2004a). Communication of the Commission to the Council and the European Parliament: The Share of Renewable Energies in the EU, COM(2004) 366 final. Brussels.

CEC (2004b). The share of renewable energy in the EU: Country Profiles. Overview of Renewable Energy Sources in the Enlarged European Union. Brussels. http://europa.eu.int/comm/energy/res/documents/country_profiles/2004_0547_sec_country_profiles_en.pdf

CLSA Asia-Pacific Markets. (2004). Sunscreen: Investment Opportunities in Solar Power. Solar power sector outlook. www.clsa.com.

CREDP (China Rural Energy Development Programme). (2004.) PV Industry Report. Beijing: World Bank.

CREIA (China Renewable Industries Association). (2001). New and renewable sources of energy in China—technologies and products. Beijing.

CRESP (China World Bank/GEF Renewable Energy Scale-up Program). (2004). Chinese PV Industry Development Report. Washington, DC: World Bank and GEF.

CRESP. (2005). Wind Power Industry Development in China. Draft report. Beijing.

Cropper, M. & Jollie, D. (2002). Fuel Cell Systems: A Survey of Worldwide Activity. *Fuel Cell Today*. 14 November. www.fuelcelltoday.com/FuelCellToday/FCTFiles/FCTArticleFiles/Article_528_WorldwideSurvey1102.pdf

de Vries, E. (2005). Thinking bigger: Are there limits to turbine size? *Renewable Energy World* 8(3): 42-55.

Dickson, M.H. & Fanelli, M. (2004). What is Geothermal Energy? Pisa, Italy: Instituto di Geoscienze e Georisorse, CNR. http://iga.igg.cnr.it/geo/geoenergy.php

Diesel and Gas Turbine Worldwide. (2002). 2002 power generation order survey. www.dieselpub.com/ww/surveys.asp

Dobelmann, J.K. (2003). Germany's Solar Success—the 100,000 roofs programme reviewed. *Renewable Energy World* 6(6): 68-79.

D'Sa, A. & Murthy, N. (2004). LPG as a cooking fuel option for India. *Energy for Sustainable Development* 8(3): 91-106.

DSIRE (Database of State Incentives for Renewable Energy). (2005). New York: Interstate Renewable Energy Council. www.dsireusa.org

Duke, R.D., Jacobson, A., & Kammen, D.M. (2002). Product quality in the Kenyan solar home industry. *Energy Policy* 30(6): 477-99.

Duke, R.D. & Kammen, D.M. (2005). Energy for Development: Solar Home Systems in Africa and Global Carbon Emissions. In P.S. Low (Ed.), *Climate Change for Africa: Science, Technology, Policy and Capacity Building*. Dordrecht: Kluwer Academic Publishers, pp. 250-66.

Dunn, S. (2000). *Micropower: The Next Electrical Era.* Worldwatch Paper 151. Washington, DC: Worldwatch Institute.

EAEF (EC-ASEAN Energy Facility). (2005). Policy Review of Renewable Energy Sources and Energy Efficiency in the European Union and its Member States. Report from Project 62- 2003: Capacity Building in Formulating Harmonised Policy Instruments for the Promotion of Renewable Energy and Energy Efficiency in the ASEAN Member Countries. Publication EuropeAid/116832/D/G/Multi. www.aseanenergy.org/eaef

EBRD (European Bank for Reconstruction and Development). (2004). Consultation workshops for supporting the development of a new EBRD Energy Policy. Discussion Paper. London.

EC (European Commission), Community Research and Development Information Service (CORDIS). (2002a). Energy Technology Indicators. www.cordis.lu/eesd/src/indicators.htm

EC. (2002b). MITRE project Web site. www.mitre.energyprojects.net (obsolete link).

EC. (2004). The Share of Renewable Energy in the EU: Country Profiles.

ECOTEC Research & Consulting Ltd. (2002). Renewable Energy Sector in the EU: its Employment and Export Potential. A final report to the DG Environment of the European Commission. Birmingham, UK. http://europa.eu.int/comm/environment/enveco/industry_employment/ecotec_renewable_energy.pdf

Edjekumhene, I. (2000). Status of Renewable Energy and Energy Efficiency Systems in West Africa. Kumasi, Ghana: Kumasi Institute of Technology and Environment. www.reeep.org/media/downloadable_documents/WE%20background%20paper.pdf

Edjekumhene, I. & Dubash, N. (2002). Ghana: Achieving Public Benefits by Default. In N. Dubash (Ed.), *Power Politics: Equity and Environment in Electricity Reform*. Washington, DC: World Resources Institute.

EEA (European Environment Agency). (2004). Energy subsidies in the European Union: A brief overview. Copenhagen. http://reports.eea.eu.int/technical_report_2004_1/en

EIB (European Investment Bank). (2004). The Extractive Industries Review (EIR)—The Position of the European Investment Bank. Luxembourg. www.eib.eu.int/Attachments/thematic/extractive_industries_en.pdf

Elauria, J.C., Castro, M.L.Y., & Elauria, M.M. (2002). Biomass energy technologies in the Philippines: a barrier and policy analysis. *Energy for Sustainable Development* 6(3): 40-49.

EPIA (European Photovoltaic Industry Association). (2004). *Photovoltaic Energy Barometer 2004*. www.epia.org

EPRI (Electric Power Research Institute). (2001). California Renewable Technology Market and Benefits Assessment. Prepared for the California Energy Commission. Palo Alto, CA.

EREC (European Renewable Energy Council). (2004). Renewable Energy Target for Europe—20% by 2020. Briefing paper. Brussels. www.erec-renewables.org/documents/Berlin_2004/targets/EREC_Targets_2020_def.pdf

EREC. (2004). Renewable Energy in Europe: Building Markets and Capacity. Brussels. www.erec-renewables.org/documents/RES_in_EUandCC/ExecutiveSummary.pdf

Ergeneman, A. (2003). Dissemination of Improved Cookstoves in Rural Areas of Developing World: Recommendation for the Eritrea Dissemination of Improved Stoves Program. Asmara, Eritrea: Eritrea Energy Research and Training Center. www.punchdown.org/rvb/mogogo/EriStoveAPA_Report.pdf

ESHA (European Small Hydro Association). (2005). Data on small hydro. www.esha.be

ESMAP (Energy Sector Management Assistance Program). (2002). Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits. Washington, DC: World Bank. www.worldbank.org/html/fpd/esmap/pdfs/255-02.pdf

ESMAP. (2005). Brazil Background Study for a National Rural Electrification Strategy: Aiming for Universal Access. Washington, DC: World Bank. http://wbln0018.worldbank.org/esmap/site.nsf/files/066-05+Brazil+Final.pdf/$FILE/066-05+Brazil+Final.pdf

ESTIF (European Solar Thermal Industry Federation). (2004). Solar Thermal Markets in Europe: Trends and Market Statistics 2003. Brussels. www.estif.org/fileadmin/downloads/Solar_Thermal_Markets_in_Europe_2003.pdf

ESTIF. (2005). Solar Thermal Markets in Europe. Brussels. www.estif.org/fileadmin/downloads/Solar_Thermal_Markets_in_Europe_2004.pdf

EurObserv'ER. (2005a). Biofuels Barometer. *Systemes Solaires* 167: 39-50. www.energies-renouvelables.org/observ-er/stat_baro/comm/baro167b.pdf

EurObserv'ER. (2005b). Solar Thermal Barometer. *Systemes Solaires* 168: 39-56. http://www.energies-renouvelables.org/observ-er/stat_baro/eufores/baro168.pdf

EurObserv'ER & EdF. (2000). Worldwide electricity production from renewable energy sources. Paris: Systemes Solaires.

European PV industry meets on a high. (2001, November). *Renewable Energy Report*, p. 30.

European Wind Energy Association (EWEA) & Greenpeace International. (2002). Wind Force 12: A Blueprint to Achieve 12% of the World's Electricity from Wind Power by 2020. Brussels. www.ewea.org/documents/WF12-2004_eng.pdf

EWEA. (2003). Wind Energy—The Facts. Brussels. www.ewea.org/06projects_events/proj_WEfacts.htm

EWEA. (2005a). Wind Market Report. Brussels.

EWEA. (2005b). Data on Wind Energy in Europe. Brussels

EWEA (2005c). Support Schemes for Renewable Energy: A Comparative Analysis of Payment Mechanisms in the EU. Brussels.

Ezzati, M. & Kammen, D.M. (2002). Household energy, indoor air pollution, and health in developing countries: knowledge base for effective interventions. *Annual Review of Energy and Environment* 27: 233-70.

Ferrey, S. (2004). Small Power Purchase Agreement Application for Renewable Energy Development: Lessons from Five Asian Countries. Washington, DC: World Bank Asia Alternative Energy Program. http://siteresources.worldbank.org/INTEAPREGTOPENERGY/Resources/Power-Purchase.pdf

Fishbein, R. (2003). Survey of Productive Uses of Electricity in Rural Areas. Washington, DC: World Bank. www.martinot.info/Fishbein_WB.pdf

FOE (Friends of the Earth UK). (2004). Friends of the Earth Guide to Green Electricity Tariffs 2004. London. www.foe.co.uk/resource/factsheets/green_electricity_tariffs_2004.pdf

Food and Agriculture Organization of the United Nations (FAO). (2004). Overview of FAO's approach to Bioenergy. Presentation at Business Forum on Bioenergy Trade, Rome, Italy, October 2004.

Food and Agriculture Organization of the United Nations (FAO). (2005, March). Interdepartmental Bioenergy Programme. Rome: FAO Sustainable Development Department. www.fao.org/WAICENT/FAOINFO/SUSTDEV/dim_en2/en2_050302a1_en.htm

Forecasts paint rosy picture for global wind power. (2002, May). *Renewable Energy Report*, p.4.

Friedman, D. (2003). A new road: the technology and potential of hybrid vehicles. Boston, MA: Union of Concerned Scientists.

Fritsche, U. & Kristensen, S. (2005). Content analysis of the International Action Programme of the International Conference for Renewable Energies, Renewables 2004, Bonn, Germany, 1-4 June 2004. www.renewables2004.net

Fulton, L. (2004). Driving ahead—biofuels for transport around the world. *Renewable Energy World* 7(4): 180-189.

Fulton, L., Howes, T., & Hardy J. (2004). *Biofuels for Transport: An International Perspective*. Paris: International Energy Agency.

GAC (German Aerospace Center). (2005). Concentrating Solar Power for Mediterranean Region. Study commissioned by Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany. Stuttgart. www.dlr.de/tt/med-csp

Geller, H. (2003). *Energy Revolution: Policies for a Sustainable Future.* Washington, DC: Island Press.

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (2002). Environmental Policy: Renewable Energy—Current German and European Legislation and More. Publication 6108. Berlin.

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (2004). General Explanations on the Renewable Energy Sources Act (as of 21 July 2004). Berlin.

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (2004, May). Renewable Energies. Berlin.

Global Energy Decisions, with contributions from Palmer Bellevue and Bio Economic Research Associates. (2005, 15 March). Renewable Energy: The Bottom Line. Boulder, CO.

Goldberg, M. (2000). Federal Energy Subsidies: Not All Technologies Are Created Equal. Renewable Energy Policy Project (REPP) Research Report No. 11. Washington, DC: REPP. www.repp.org/repp_pubs/pdf/subsidies.pdf

Goldemberg J. (2004). The Case for Renewable Energies. Thematic background paper for Bonn International Conference for Renewable Energy, Bonn, February 2004. www.renewables2004.de

Goldemberg, J., Coelho, S.T., Nastari, P.M., & Lucon, O. (2004). ''Ethanol learning curve—the Brazilian experience. *Biomass and Bioenergy* 26: 301-04.

Goldemberg, J. & Johansson, T. (Eds.). (2004). *World Energy Assessment Overview (2004 Update).* New York: U.N. Development Programme (UNDP), U.N. Department of Economic and Social Affairs (UNDESA), and World Energy Council. www.undp.org/energy/docs/WEAOU_full.pdf

Goldemberg, J., Johansson, T., Reddy, A. & Williams, R. (2004). A global clean cooking fuel initiative. *Energy for Sustainable Development* 8(3): 5-12.

Goldemberg, J., La Rovere, E.L., & Coelho, S.T. (2004). Expanding access to electricity in Brazil. *Energy for Sustainable Development* 8(4): 86-95. www.ieiglobal.org/ESDVol8No4/brazil.pdf

Goldemberg, J., Martinot, E. & Miller, A. (2002). Energy Since Rio: Achievements and Promising Strategies. Washington, DC: Global Environment Facility (GEF).

Gouchoe, S., Everette, V. & Haynes, R. (2002). Case Studies on the Effectiveness of State Financial Incentives for Renewable Energy. NREL/SR-620-32819. Golden, CO: NREL.

Graham, J. (2001, April). Ripening RE markets: capacity building for the rapid commercialisation of RE in China. *REFOCUS*, pp. 18-23.

Greenpeace. (1997). The Subsidy Scandal. http://archive.greenpeace.org/comms/97/climate/eusub.html

Greenpeace & EPIA. (2005). Solar Generation – Solar Electricity for over 1 Billion People and 2 Million Jobs by 2020. Amsterdam and Brussels. www.greenpeace.org/raw/content/international/press/reports/solar-generation-ii.pdfr

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) GmbH. (2004, June). Energy-policy Framework Conditions for Electricity and Renewable Energies—21 Country Analyses. Eschborn. www2.gtz.de/wind/download/TERNA_Study_2004_06_04.pdf

GWEC (Global Wind Energy Council). (2005, 6 June). Global Wind Power Continues Expansion. News release. www.gwec.net

Heavner, B. & Churchill, S. (2002). Renewables Work: Job Growth from Renewable Energy Development in California. Sacramento: CALPIRG Charitable Trust. www.calpirg.org/reports/renewableswork.pdf

Heavner, B. & Del Chiaro, B. (2003). Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California. Los Angeles: Environment California Research & Policy Center. www.environmentcalifornia.org/reports/renewables_jobs_7_03.pdf

Hoffmann, W. (2005). A clear vision: EPIA sets its sights on PV technology to 2030 and beyond. *Renewable Energy World* 8(3): 56-69.

HRC (Hangzhou (China) Regional Center for Small Hydro Power). (2004). A survey of SHP development in China. *Small Hydro Power News* 20(75): 2-8.

Huacuz, J. (2000). Photovoltaic rural electrification in Mexico: summary of activities and lessons learned. Presented at "Making a Difference in Emerging PV Markets: Strategies to Promote Photovoltaic Energy Generation," Marrakech, Morocco. Washington, DC: GEF.

IAEA (International Atomic Energy Agency). (2004). Energy, Electricity, and Nuclear Power Estimates for the Period up to 2030. Reference Data Series No. 1. July 2005 Edition. www-pub.iaea.org/MTCD/publications/PDF/RDS1-25_web.pdf

ICCEPT (Imperial College Centre for Energy Policy and Technology). (2002). Assessment of Technological Options to Address Climate Change. A Report for the Prime Minister's Strategy Unit. London. www.iccept.ic.ac.uk/pdfs/Tech%20initiative%20ICCEPT%20FINAL.pdf

IEA (International Energy Agency). (1998-2002). *World Energy Outlook*. Paris.

IEA. (2000). *Experience Curves for Energy Technology Policy*. Paris.

IEA. (2002a). *Renewables Information 2002*. Paris.

IEA. (2002b). Trends in Photovoltaic Applications in Selected IEA Countries Between 1992 and 2001. IEA-PVPS T1-11. Paris: IEA Photovoltaic Power Systems Programme.

IEA. (2003a). *Renewables for Power Generation: Status and Prospects.* Paris.

IEA. (2003b). *Renewables Information 2003*. Paris.

IEA. (2003c). *World Energy Investment Outlook: 2003 Insights*. Paris.

IEA. (2003d). *Electricity Information 2003 (with 2002 data).* Paris.

IEA. (2003e). *Renewable Energy in Russia*. Paris.

IEA. (2004a). *Renewables Information 2004*. Paris.

IEA. (2004b). *Renewable Energy: Market and Policy Trends in IEA Countries*. Paris.

IEA. (2004c). *Electricity Information 2004.* Paris

IEA. (2004d). Biofuels for Transport. T39:2004:01. Paris: IEA Bioenergy Task 39. www.ieabioenergy.com/media/43_BiofuelsforTransport-Final.pdf

IEA. (2005a). Renewable Energy Policies & Measures Database for IEA Member Countries. Paris. www.iea.org/dbtw-wpd/textbase/pamsdb/search.aspx?mode=re

IEA. (2005b). JREC Renewable Energy Policies and Measures Database. Paris. Note: JREC is the Johannesburg Renewable Energy Coalition formed at the 2002 World Summit for Sustainable Development. www.iea.org/dbtw-wpd/textbase/pamsdb/jr.aspx

IEA. (2005c). Global Bioresources Project. Unpublished document. Paris: IEA Renewable Energy Unit.

IEA. (2005d). RD&D Database. Paris. http://www.iea.org/textbase/stats/rd.asp

IREDA (Indian Renewable Energy Development Agency Ltd.). (2004). Operating statistics. New Delhi.

Islam, M., Fartaj, A. & Ting, D. (2004). Current utilization and future prospects of emerging renewable energy applications in Canada. *Renewable and Sustainable Energy Reviews* 8(6): 493-519.

Jäger-Waldau, A. (Ed.). (2004). Status Report 2004—Energy End-use Efficiency and Electricity from Biomass, Wind and Photovoltaics in the European Union. Ispra, Italy. Institute for Environment and Sustainability—European Commission Joint Research Centre (IES-JRC). http://streference.jrc.cec.eu.int/pdf/RE%20Status%20Report%202004.pdf

Jennings, B. (2005). The U.S. Ethanol Industry: Exceeding Expectations. Presentation at South Dakota Public Utilities Commission Energy Conference, Pierre, South Dakota, 20 April 2005. www.state.sd.us/puc/pucevents/Energy%20Conf%20Presentations/Brian%20Jennings-%20US%20Ethanol%20Industry.pdf

Johansson, T. & Turkenburg, W. (2004). Policies for renewable energy in the European Union and its member states: an overview. *Energy for Sustainable Development* 8(1): 5-24.

Jones, J. (2004). Onward and Upward: Trends in BTM's World Market Update. *Renewable Energy World* 7(4): 58-73.

Jones, J. (2005). Japan's PV Market—growth without subsidies? *Renewable Energy World* 8(2): 36-41.

Kammen, D. (2005). Renewable Energy Technology and Policy Successes in Developing Nations: The Kenyan Solar Photovoltaics Story and Improved Stoves in Africa. Berkeley, CA: University of California Berkeley, Energy and Resources Group.

Kammen, D., Kapadia, K., & Fripp, M. (2004.) Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? Berkeley, CA: University of California at Berkeley, Energy and Resources Group. http://ist-socrates.berkeley.edu/~rael/renewables.jobs.pdf

Karekezi, S. & Kimani, J. (2004). Have power sector reforms increased access to electricity among the poor in East Africa? *Energy for Sustainable Development* 8(4): 10-25.

Karekezi, S. & Kimani, J. (2005). Do the Poor Benefit from Power Sector Reform? Nairobi: AFREPREN.

Karekezi, S. & Kithyoma, W. (2005). Introduction to Renewable Energy in Africa: Opportunities and Constraints. Nairobi: AFREPREN.

Karekezi, S., Lata, K. & Coelho, S.T. (2004). Traditional Biomass Energy: Improving Its Use and Moving to Modern Energy Use. Thematic Background Paper for Renewables 2004 conference, Bonn, Germany, June 1-4. www.renewables2004.de

Karekezi S., Mapako, M., & Teferra, M.(Eds). (2002). *Energy Policy Journal*. Special Issue. 30(11-12). Oxford: Elsevier Science Limited.

Karekezi, S. & Ranja, T. (1997). *Renewable Energy Technologies in Africa*. London: AFREPREN/SEI and Zed Books.

Kartha, S. & Larson, E.D. (2000). *Bioenergy Primer: Modernized Biomass Energy for Sustainable Development.* New York: UNDP.

Kartha, S., Leach, G., & Rajan, S.C. (2004). Advancing Bioenergy for Sustainable Development: Roles for Policymakers and Entrepreneurs. Report prepared for ESMAP, World Bank. Stockholm: Stockholm Environment Institute.

Kishore, V.V.N., Bandari, P.M., & Gupta P. (2004). Biomass energy technologies for rural infrastructure and village power—opportunities and challenges in the context of global climate change concerns. *Energy Policy* 32: 801-810.

Komar, P. (2004). *Renewable Energy Policy*. New York: Diebold Institute for Public Policy Studies.

Krause, M. & Nordstrom, S. (Eds.). (2004). Solar Photovoltaics in Africa: Experiences with Financing and Delivery Models. New York: UNDP & GEF. www.undp.org/gef/undp-gef_publications/publications/solarphotovoltaics_africa.pdf

Ku, J., Lew, D., Shi, P. & Wallace, W. (2005). Accelerating wind development: the future is now. *Renewable Energy World* 8(4): 212-223.

Ku, J., Lew, D., & Ma, S. (2003, Sept-Oct). Sending electricity to townships. *Renewable Energy World*, pp. 56-67. www.nrel.gov/environment/pdfs/pubs_sending_electricity.pdf

Kumar, A. (2003). SHP: Potential, technology, and environment. *Small Hydro Power News* 20(73): 14-16.

Lertsuridej, P. (2004a). Policy on New and Renewable Energy Technology Promotion in Thailand. Technical Digest of International PVSEC-14, Bangkok, Thailand, March 2004.

Lertsuridej, P. (2004b). Renewable Energy for Sustainable Development: A Global Challenge. Presented at the International Conference for Renewable Energy, Bonn, Germany, June 2004.

Lichts, F.O. (2005). *World Ethanol & Biofuels Report 2005*. www.fo-licht.com

Li, H. (2002). China's solar thermal industry. *Renewable Energy World* 5(4): 99-107.

Li, H. (2005). From quantity to quality: how China's solar thermal industry will need to face up to market challenges. *Renewable Energy World* 8(1).

Li, J., Jingli, S., & Wallace, W. (2002). Market potential of PV village power in China. In Proceedings of the PV in Europe: from PV to Energy Solutions conference and exhibition, Rome, Italy, 7-11 October 2002.

Li, J. & Shi L. (Eds.). (2005). Overview of Renewable Energy in China 2005. China Renewable Energy Industries Association, CREDP, and China UNDP/GEF Renewable Energy Capacity Building Project. Beijing.

Liebreich, M. & Aydinoglu, B. (2005, 11 May). New and renewable energy technology—trends in venture capital investment. www.energypulse.net

Linden, N.H. van der et al. (2005). Review of international experience with renewable energy obligation support mechanisms. ECN-C--05-025. Petten, The Netherlands: ECN Policy Studies.

Lund, J. (2000). World status of geothermal energy use: past and potential. *Renewable Energy World* 3(4): 122-31.

Lund, J. (2005a). *Worldwide Utilization of Geothermal Energy 2005*. Klamath Falls, OR: Oregon Institute of Technology.

Lund, J. (2005b). 100 years of renewable electricity—geothermal power production. *Renewable Energy World* 8(4): 252-259.

Luo Z. & Shi L. (2004). Solar Hot Water Industry in China 2001-2003. China UNDP/China Renewable Energy Capacity Building Project, Beijing. [In Chinese]

Ma, S. (2004.) The China Township Electrification Program. Presentation at Renewables 2004 conference, Bonn, Germany, June 2004.

Maithel, S. (2005). Experience & Learning from Indian National Cookstoves Programme. Presentation at Ministry of Agriculture, Beijing, China, 14-16 January 2005.

Makower, J., Pernick, R. & Wilder, C. (2005). *Clean Energy Trends 2005*. www.cleanedge.com/reports/trends2005.pdf.

Martinot, E. (2004a). Indicators of investment and capacity for renewable energy. *Renewable Energy World* 7(5): 35-37. www.jxj.com/magsandj/rew/2004_05/indicators_of_investment.html

Martinot, E. (2004b). Solar (and Sustainable) Cities. www.martinot.info/solarcities.htm.

Martinot, E. (2005). Organizations engaged in renewable energy. www.martinot.info/organizations.htm.

Martinot, E. et al. (2002). Renewable energy markets in developing countries. *Annual Review of Energy and the Environment* 27: 309-48. www.martinot.info/Martinot_et_al_AR27.pdf

Martinot, E. & Reiche, K. (2000). Regulatory Approaches to Rural Electrification and Renewable Energy: Case Studies from Six Developing Countries. Washington, DC: World Bank.

Martinot, E., Wiser, R. & Hamrin, J. (2005). Renewable Energy Markets and Policies in the United States. San Francisco: Center for Resource Solutions. www.martinot.info/Martinot_et_al_CRS.pdf

Masera, O., Díaz R. & Berrueta V. (2005). From cookstoves to cooking systems: the integrated program on sustainable household energy use in Mexico. *Energy for Sustainable Development* 9(1): 25-36. www.ieiglobal.org/ESDVol9No1%5Cmexicoprogram.pdf

Maycock, P. (2001). The PV boom—where Germany and Japan lead, will California follow? *Renewable Energy World* 4(4): 144-63.

Maycock, P. (2002). The world PV market. *Renewable Energy World* 5(4): 146-61.

Maycock, P. (2003). PV market update. *Renewable Energy World* 6(4): 84-101.

Maycock, P. (2004). PV market update. *Renewable Energy World* 7(4): 86-101.

Maycock, P. (2005a). PV market update—global PV production continues to increase. *Renewable Energy World* 8(4): 86-99.

Maycock, P. (2005b, March). Solar PV production statistics for 2004 *PV News* 24(3).

McDade, S. (2004). Fueling development: the role of LPG in poverty reduction and growth. *Energy for Sustainable Development* 8(3): 74-81.

Milton, S. & Kauffman, S. (2005). Solar water heating trades up: the role for carbon finance. *Renewable Energy World* 8(3): 92-99.

Morrison, G. & Wood, B. (2000). Packaged solar water heating technology: twenty years of progress. *Renewable Energy World* 3(4): 171-83.

Navigant Consulting. (2005). Personal communication from Lisa Franztis.

New Energy Finance, Ltd. (2005). New and renewable energy technology—trends in venture capital investment. *Venture Economics* [issue unknown]

Niewenhaut, F.D.J. et al. (2000). Monitoring and Evaluation of Solar Home Systems: Experiences with Applications of Solar PV for Households in Developing Countries. Petten, Netherlands: Netherlands Energy Research Institute (ECN).

NREL (National Renewable Energy Laboratory). (2004). The China Township Electrification Program. Golden, CO.

OECD (Organisation for Economic Co-operation and Development). (2005). Arrangement on Officially Supported Export Credits, Agreement on Special Financial Terms and Conditions for Renewable Energies and Water Projects. TD/PG(2005)19. Paris. http://webdomino1.oecd.org/olis/2005doc.nsf/0/33016f08c238254dc125700000410aa5/$FILE/JT00184128.PDF

OECD DAC (Development Co-operation Directorate). (2005). International Development Statistics (IDS) online. Electronic database. www.oecd.org/dac/stats/idsonline.

OECD Nuclear Energy Agency & IEA. (2005). *Projected Costs of Generating Electricity—2005 Update.* Paris.

Öko-Institut e.V.—Institut für angewandte Ökologie (ÖKO). (2004). Bioenergy—New Growth for Germany. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany. Freiburg—Darmstat—Berlin. www.bmu.de/files/pdfs/allgemein/application/pdf/bioenergie_uk.pdf

Osafo, Y. & Martinot, E. (2003). An inventory of renewable energy policies in developing countries. Working draft. Washington, DC: GEF.

Pandit, N. & Pantar, M. (2004). Scale-up strategies for solar-thermal boiler feed-water preheating systems. *The Bulletin on Energy Efficiency* 4(4):17-19.

Pembina Institute. (2004). Canadian Renewable Electricity Development: Employment Impacts. Prepared for Clean Air Renewable Energy Coalition. www.cleanairrenewableenergycoalition.com/documents/FINAL%20Employment%20Predictions%20-%20Oct%2028.pdf

Photon International. (2003). Solar cell production increases significantly in 2002. March 2003 issue and web site news posting for March 3.

Pollution Probe. (2004). Targets and activities for electricity generation using green power by province and territory. Toronto, Canada. www.pollutionprobe.org/whatwedo/greenpower/provtargetgrnpower.pdf

Rai, S. (2004). Sustainable dissemination of solar home systems for rural development: experiences in Nepal. *Energy for Sustainable Development* 8(2):47-50. www.ieiglobal.org/ESDVol8No2/solarnepal.pdf

Reiche, D. (Ed.). (2002). Handbook of Renewable Energies in the European Union: Case Studies of all Member States. Bern, Switzerland: Peter Lang Publishing.

Renewable energy law website (maintained by a law firm). http://renewableenergylaw.blogspot.com

Renewable energy organization database (author unknown). www.yesweb.org/gkr/gkrfiles/rdbase.pdf

Renewable Fuels Association. (2005). Homegrown for the Homeland—Ethanol Industry Outlook 2005. Washington, DC. www.ethanolrfa.org/outlook2005.html

Ritschel, A. & Smestad, G. P. (2003). Energy subsidies in California's electricity market deregulation. *Energy Policy* 31: 1379-91.

Rossillo-Calle F. & Cortez, L.A.B. (1998). Towards Pro-Alcool II: a review of the Brazilian bioethanol programme. *Biomass Bioenergy* 14(2): 115-124.

Rousseff, D. (2005). Renewable Energy and Energy Efficiency Financing and Policy Network Forum. Presentation at World Bank Energy Week, World Bank, Washington, DC, 11 March 2005.

Saghir, J. (2005). The global investment challenge—financing the growth of renewable energies in developing countries. *Renewable Energy World* 8(4): 196-211.

Sawin, J. (2001). The Role of Government in the Development and Diffusion of Renewable Energy Technologies: Wind Power in the United States, California, Denmark and Germany. Doctoral Dissertation. Fletcher School of Law and Diplomacy, Tufts University. Ann Arbor, MI: UMI/Proquest.

Sawin, J. (2004). *Mainstreaming Renewable Energy in the 21st Century.* Worldwatch Paper 169. Washington, DC: Worldwatch Institute.

Sawin, J. & Flavin, C. (2004). National Policy Instruments: Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World. Thematic Background Paper for Renewables 2004 conference, Bonn, Germany, June 2004. www.renewables2004.de/pdf/tbp/TBP03-policies.pdf

Schwer, R.K. & Riddel, M. (2004). Potential Economic Impact of Constructing and Operating Solar Power Generation Facilities in Nevada. Prepared by the University of Nevada Center for Business and Economic Research for NREL. Golden, CO. www.nrel.gov/docs/fy04osti/35037.pdf

Sellers, R. (2003). The potential of second generation renewable energy. SDI 13-03/03. www.sustdev.org

Sihag, A.R., Mishra, N. & Sharma, V. (2004). Impact of power sector reform on the poor: case-studies of South and South-East Asia. *Energy for Sustainable Development* 8(4): 54-73.

Singh, V., with BBC Research and Consulting & Fehrs, J. (2001). The work that goes into renewable energy. Washington, DC: Renewable Energy Policy Project (REPP).

Singh, V. (2001). Blending wind and solar into the diesel generator market. REPP Research Report No. 12. Washington, DC: REPP.

Sinton, J.E. et al. (2004). An assessment of programs to promote improved household stoves in China. *Energy for Sustainable Development* 8(3): 33-52.

Solar thermal sets new record. (2002, November). *Renewable Energy Report*, p.18.

South Africa Department of Minerals and Energy. (2003). White Paper on Renewable Energy. Pretoria.

Stenzil, T., Foxton, T. & Gross, R. (2003). Review of renewable energy development in Europe and the US. London: ICCEPT.

TERI (The Energy Resources Institute). (2001). Unpublished material on renewable energy in India used in preparing Martinot et al. 2002.

Thailand DEDE (Department of Alternative Energy Development and Efficiency). (2004). Renewable Energy in Thailand: Ethanol and Biodiesel. Prepared for Conference on Biofuels: Challenges for Asia Future, Bangkok, 30 August 2004.

Tumiwa, F. (2005). Renewable Energy in Indonesia: A review of 25 years experience and the way forward. Paper prepared for Asia-Pacific Green Network Conference, Kyoto, Japan, 11-13 February 2005. Working Group on Power Sector Restructuring, Jakarta.

Turkenburg, W. et al. (2000). Renewable energy technologies. In UNDP, United Nations Department of Economic and Social Affairs (UNDESA), and World Energy Council, *World Energy Assessment*. New York: UNDP.

UNDESA. (2002). *Energy Statistics Yearbook 2000*. New York.

UNDP/GEF Capacity Building for Renewable Energy in China Project (2004). Overview of Renewable Energy Development in China. Project Management Office, Beijing.

UNDP, UNDESA, and World Energy Council. (2000). *World Energy Assessment*. New York: UNDP.

UNDP, U.N. Environment Programme (UNEP), World Bank, and World Resources Institute. (2002). *World Resources 2002-2004.* Washington, DC. http://pubs.wri.org/pubs_pdf.cfm?PubID=3764

UNEP. (2000). Natural Selection: Evolving Choices for Renewable Energy Technology and Policy. Paris. www.unep.fr/energy/publications/pdfs/naturalselection.pdf

UNEP. (2004). Financial Risk Management Instruments for Renewable Energy Projects. Summary document. Paris. www.uneptie.org/energy/publications/pdfs/RE_Risk_Manag.pdf

UNEP. (2005). Indian Solar Loan Programme Overview and Performance Report. Paris. www.uneptie.org/energy/act/fin/india/docs/IndSolLoanReview.pdf

UNEP & E+Co. (2005, March). The REED Report. Rural Energy Enterprise Development. www.areed.org

UNEP & IEA. (2002). Reforming Energy Subsidies. Paris. www.uneptie.org/energy/publications/pdfs/En-SubsidiesReform.pdf

UNEP & United Nations Foundation. (2003). Open for Business: Entrepreneurs, Clean Energy, and Sustainable Development. Paris. www.unep.fr/energy/publications/pdfs/Open%20For%20Business.pdf

UNESCO (United Nations Educational, Scientific, and Cultural Organization). (2005). Regional Energy Database—Renewable Energy and Energy Efficiency. Klong Luang, Thailand: Asian Institute of Technology. www.serd.ait.ac.th/ep/red/REDHome.htm

United Kingdom DFID (Department for International Development). (2002). *Energy for the Poor*. London.

Winrock International & International Development and Energy Associates, Inc. (IDEA) (1993, May). Advancing Cogeneration in the Indian Sugar Industry. Report prepared for USAID/New Delhi and the Office of Energy and Infrastructure, Bureau for Research and Development, United States Agency for International Development. www.weea.org/USAID%20Reports/Documents/Indian%20Sugar%20Industry.pdf

U.S. Department of Transportation, Bureau of Transportation Statistics. (1999). G-7 Countries: Transportation Highlights. Washington, DC.

US DOE (U.S. Department of Energy). (1997). Dollars from Sense—The Economic Benefits of Renewable Energy. Produced by NREL. Washington, DC. www.nrel.gov/docs/legosti/fy97/20505.pdf

US DOE, Energy Information Administration (EIA). (1999). Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy. Washington, DC. www.eia.doe.gov/oiaf/servicerpt/subsidy/pdf/sroiaf(99)03.pdf

US DOE, EIA. (2003-2004). Country analysis briefs, Various developing countries. Washington, DC. www.eia.doe.gov/emeu/cabs/

US DOE, EIA. (2004a). *International Energy Annual 2002*. Washington, DC.

US DOE, EIA. (2004b). Energy Use and Carbon Dioxide Emissions, 1980-2001. Washington, DC.

US DOE, EIA. (2005a). *International Energy Annual 2004*. Washington, DC.

US DOE, EIA. (2005b). Assumptions to the Annual Energy Outlook 2005. www.eia.doe.gov.

US DOE, EIA. (2005c). Policies to Promote Non-hydro Renewable Energy in the United States and Selected Countries. Washington, DC.

U.S. Environmental Protection Agency. (2004, November). Green power partnership, market indicators briefing. With data from Lori Bird, NREL.

Utria, B. (2004). Ethanol and gelfuel: clean renewable cooking fuels for poverty alleviation in Africa. *Energy for Sustainable Development* 8(3): 107-114.

van Beers, C. & de Moore, A. (2001). *Public Subsidies and Policy Failures: How Subsidies Distort the Natural Environment, Equity, and Trade, and How to Reform Them.* Cheltenham, UK: Edward Elgar Publishing Ltd.

van Campen, B., Guidi, D. & Best, G.. (2000). Solar Photovoltaics for Sustainable Agriculture and Rural Development Rome: FAO. http://www.fao.org/sd/EGdirect/EGre0057.htm

Vries, H.J. de et al. (2003). Renewable electricity policies in Europe: Country fact sheets 2003. ECN BS: ECN-C--03-071. Petten, The Netherlands: ECN Policy Studies

WADE (World Alliance on Decentralized Energy). (2004). Bagasse Cogeneration—Global Review and Potential. Edinburgh, Scotland, UK. www.localpower.org/documents_pub/report_bagasse_cogeneration.pdf

WADE. (2005). World Survey of Decentralized Energy 2005. Edinburgh, Scotland, UK. www.localpower.org/documents_pub/report_worldsurvey05.pdf

Wahnschafft, R. & Soltau, F. (2004). Accelerating Market Growth for Electricity from Renewables: Legislative Tools and Regulatory Measures. In "Words into Action," published for Renewables 2004 conference, Bonn, Germany, June 2004. www.renewables2004.de

Walubengo, D. (1995). Commercialization of improved stoves: The case of the Kenya Ceramic Jiko (KCJ). In Westhoff, B. & Germann, D. (Eds.), *Stove Images: A Documentation of Improved and Traditional Stoves in Africa, Asia, and Latin America*. Brussels: Commission of the European Communities.

Weiss, W. (2002). Time to come in from the cold? The solar thermal market in Europe. *Renewable Energy World* 5(4): 90-97.

Weiss, W. (2004). Solar heating systems status and recent development. *Renewable Energy World* 7(4): 214-225.

Weiss, W., Bergmann, I. & Faninger, G..(2004). Solar Heating Worldwide: Markets and Contribution to Energy Supply 2001. Paris: IEA Solar Heating and Cooling Programme. www.iea-shc.org/outputs/activities/iea_shc_solar_heating_worldwide_2001.pdf

Weiss, W., Bergmann, I. & Faninger, G.. (2005). Solar Heating Worldwide: Markets and Contribution to Energy Supply 2003. Paris: IEA, Solar Heating and Cooling Programme. www.iea-shc.org/welcome/IEASHCSolarHeatingWorldwide2003.pdf

Wenzlawski, H. (2003). The Global CSP Market—Its Industry, Structure and Decision Mechanisms. Master's

Thesis. Hamburg, Germany: University of Hamburg. www.martinot.info/Wenzlawski_UH.pdf

Williams, R.H. et al. (2000). Advanced energy supply technologies. In UNDP, UNDESA, and World Energy Council, *World Energy Assessment*. New York: UNDP.

Wimmer, N. & Barua, D.C. (2004). Microfinance for Solar Energy in Rural Areas. In "Words into Action," published for the Renewables 2004 conference, Bonn, Germany, June 2004. www.renewables2004.de

Wind Market Status. (2004, March). *Windpower Monthly*, pp. 45-90.

Winrock International. (2001). Renewable Energy State of the Industry Report # 3. Arlington, VA. www.winrock.org/GENERAL/Publications/State_of_Industry_3.pdf

Wiser, R., Bolinger, M., Milford, L., Porter, K. & Clark, R. (2002). Innovation, Renewable Energy, and State Investment: Case Studies of Leading Clean Energy Funds. LBNL-51493. Berkeley, CA: Lawrence Berkeley National Laboratory.

Wiser, R., Murray, C., Hamrin, J. & Weston, R. (2003). International Experience with Public Benefits Funds: A Focus on Renewable Energy and Energy Efficiency. San Francisco: Energy Foundation.

Wongsapai, W. (2004a.) Electricity from Solar Energy in Thailand (1). *Matichon Weekly*, 24(1245): 29-30 (in Thai).

Wongsapai, W. (2004b). Electricity from Solar Energy in Thailand (2). *Matichon Weekly*, 24(1246): 36 (in Thai).

Wood, E. (2005). Jobs in the renewable energy economy: can the sector become a significant employer in the U.S.? *Renewable Energy World* 8(3): 32-41.

World Bank. (1996). *Rural Energy and Development: Improving Energy Supplies for Two Billion People.* Washington, DC.

World Bank. (2004). *World Development Indicators*. Washington, DC.

World Bank. (2005). World Bank Group Progress on Renewable Energy and Energy Efficiency: 1990–2004. Washington, DC: The World Bank Group, Energy and Mining Sector Board.

World Energy Council. (2001a). Performance of Generating Plant 2001. London.

World Energy Council. (2001b). Survey of Energy Resources. London.

World Energy Council. (2004). Survey of World Energy Resources. London.

World Geothermal Council. (2005). Data on global geothermal use, mostly for 2000. www.geothermal.org

Worldwatch Institute. (2002). *Vital Signs 2002*. New York: W.W. Norton & Company.

Worldwatch Institute. (2004). Housing. In *Good Stuff: A Behind-the-Scenes Guide to the Things We Buy*. Washington, DC. www.worldwatch.org/pubs/goodstuff/housing

World Wide Fund for Nature (WWF). (2004). Progress Report on the EU Renewable Electricity Directive in Accession Countries. Gland, Switzerland.