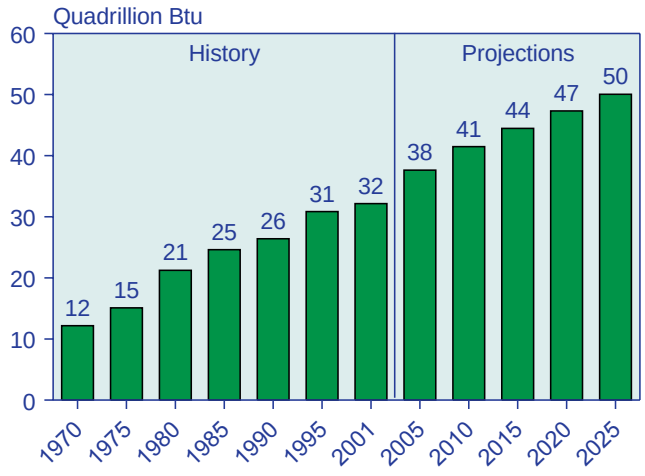
Hydroelectricity and Other Renewable Resources

The renewable energy share of total world energy consumption is expected to remain unchanged at 8 percent through 2025, despite a projected 56-percent increase in consumption of hydroelectricity and other renewable resources.

In the *International Energy Outlook 2003* (*IEO2003*) reference case, moderate growth in the world's consumption of hydroelectricity and other renewable energy resources is projected over the next 24 years. Renewable energy sources are not expected to compete economically with fossil fuels in the mid-term forecast. In the absence of significant government policies aimed at reducing the impacts of carbon-emitting energy sources on the environment, it will be difficult to extend the use of renewables on a large scale. *IEO2003* projects that consumption of renewable energy worldwide will grow by 56 percent, from 32 quadrillion Btu in 2001 to 50 quadrillion Btu in 2025 (Figure 69).

Much of the projected growth in renewable generation is expected to result from the completion of large hydroelectric facilities in developing countries, particularly in developing Asia, where the need to expand electricity production often outweighs concerns about environmental impacts and the relocation of populations to make way for large dams and reservoirs. China, India, Malaysia, and Vietnam, among others, are constructing or planning new, large-scale hydroelectric facilities. In September 2002, Malaysia awarded the main construction contract for the 2,400-megawatt Bakun hydroelectric project to Sime Engineering. At the end of 2002, India was poised to begin the final phase of reservoir filling for the 2,000-megawatt Tehri dam [***1***]. The first electricity generating units of China's 18,200-megawatt Three Gorges Dam hydropower project are scheduled to be installed in 2003 [***2***]. Of the 37 electric power projects planned for construction by the Vietnamese government by 2020, 22 are hydroelectric facilities, several with capacities of 600 megawatts or more [***3***].

Figure 69. World Consumption of Hydroelectricity and Other Renewable Energy Sources, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

Many nations of Central and South America also have plans to expand their already well-established hydroelectric resources. Brazil, Peru, and even oil-rich Venezuela have plans to increase hydroelectric capacity over the next decade. Brazil alone has plans to offer tenders for 34 new hydroelectric energy stations in 2003, with a combined 9,100 megawatts of capacity [***4***], despite a crippling drought in 2000-2001 that resulted in electricity rationing and threatened brownouts. Many of Brazil's new hydroelectric projects will be located in the northeastern part of the country, which was not as severely affected by the drought. In general, however, the nations of Central and South America are not expected to expand hydroelectric resources dramatically but instead are expected to invest in other sources of electricity—particularly, natural-gas-fired capacity—that will allow them to diversify electricity supplies away and reduce their reliance on hydropower.

Hydroelectric capacity outside the developing world is not expected to grow substantially. Among the industrialized nations, only Canada has plans to construct any sizable hydroelectric projects over the forecast period. Hydro-Québec alone is planning to add some 2,100 megawatts of additional hydroelectric capacity within the next decade [***5***]. In the countries of Eastern Europe and the former Soviet Union (EE/FSU), most additions to hydroelectric capacity are expected to come from repair or expansion of existing plants. In the industrialized and EE/FSU regions, most hydroelectric resources either have already been developed or lie far from population centers.

Among the other (nonhydroelectric) renewable energy sources, wind power has been the fastest growing in recent years. In Western Europe, Germany, Denmark, Spain, and other nations have installed significant

amount of new wind power capacity. Germany installed 2,659 megawatts of new wind capacity in 2001, a national and world record for wind installation in a single year [**6**]. In Spain and Denmark, wind power is doing so well that the governments are considering the elimination of subsidies aimed at promoting its installation.

Wind power also advanced strongly in the United States in 2001, largely because of the threatened end of the production tax credit for wind energy (which has subsequently been extended to December 31, 2003). Sixteen States installed 1,695 megawatts of new wind capacity in 2001, setting a national record and accounting for one-third of the total new wind capacity worldwide. Both houses of the U.S. Congress have included proposals to extend the production tax credit in their versions of the Bush Administration's proposed Energy Bill, which if enacted would extend the program through December 31, 2006 [**7**].

The *IEO2003* projections for hydroelectricity and other renewable energy resources include only on-grid renewables. Noncommercial fuels from plant and animal sources are an important source of energy, particularly in the developing world. The International Energy Agency has estimated that some 2.4 billion people in developing countries depend on traditional biomass for heating and cooking [**8**]. However, comprehensive data on the use of noncommercial fuels are not available and, as a result, cannot be included in the projections. Moreover, dispersed renewables (renewable energy consumed on the site of its production, such as solar panels used to heat water) are not included in the projections, because there are also few comprehensive sources of international data on their use.

Regional Activities

North America

As of January 1, 2001, the three countries of North America—the United States, Canada, and Mexico—had a combined 176 gigawatts of installed hydropower and other renewable capacity for electricity generation. Hydropower accounts for most of the renewable capacity in the region, with nonhydroelectric, on-grid renewable energy contributing just 17 gigawatts of the total. In the future, capacity fueled by alternative renewable energy sources—particularly wind but also geothermal and solar—is expected to expand more rapidly than hydroelectric capacity; however, hydroelectricity is projected to remain the dominant component of the renewable mix. Renewable energy consumption in the region is projected to increase from 9.4 quadrillion Btu in 2001 to 13.9 quadrillion Btu in 2025.

United States

Potential sites for hydroelectric dams have already been largely established in the United States, and regulatory requirements are projected to limit conventional hydroelectric generation in the future. EIA's *Annual Energy Outlook 2003* (*AEO2003*) projects that U.S. conventional hydroelectric generation will rise from 214 billion kilowatthours in 2001 to 302 billion kilowatthours in 2005 and remain at about that level through 2025.

Nonhydroelectric renewables are expected to account for 4.0 percent of all projected additions to U.S. generating capacity between 2000 and 2025. Generation from geothermal, biomass, landfill gas, solar, and wind energy is projected to increase from 81 billion kilowatthours in 2000 to 189 billion kilowatthours in 2025. Biomass (which includes cogeneration and co-firing in coal-fired power plants) is expected to grow from 38 billion kilowatthours in 2000 to 78 billion kilowatthours in 2025. Most of the increase is attributed to cogenerators, with a smaller amount from co-firing. Few new dedicated biomass plants are expected to be constructed over the forecast period.

The reference case projects substantial increments in U.S. geothermal and wind power. Geothermal capacity, all located in western States, is projected to increase to 5,600 megawatts, supplying 37 billion kilowatthours of electricity (0.6 percent of total generation) by 2025 [**9**]. Wind capacity in the United States is projected to grow by nearly 300 percent over the forecast period, from 4,290 megawatts in 2001 to 12,000 megawatts by 2025. Wind capacity was installed in 22 States by the end of 2001 (Figure 70), and State mandates for increasing the development of renewable energy sources are expected to provide the impetus for the large increment in wind power over the forecast. Where enacted, State renewable portfolio standards, which specify a minimum share of generation or sales from renewable sources, are considered in the U.S. forecast. Federal subsidies for renewables (in particular, wind) are also included in the projections.

Canada

Canada has extensively developed its hydroelectric capabilities. Hydroelectricity is the country's dominant source of electric power, accounting for 67,000 megawatts of the 111,000 megawatts of total installed generating capacity. Canada is one of the only industrialized countries that is expected to expand its mid- to large-scale hydroelectric capacity. Hydro-Québec alone has four sizable hydroelectric projects that are expected to be commissioned within the next decade, including the 480-megawatt Eastmain 1 (scheduled for completion in 2008), the 526-megawatt Toulnustouc (2005); the 882-megawatt Sainte Marguerite 3 (2003); and the replacement of the existing Grand Mère hydroelectric facility with a 220-megawatt facility (2004) [**10**].

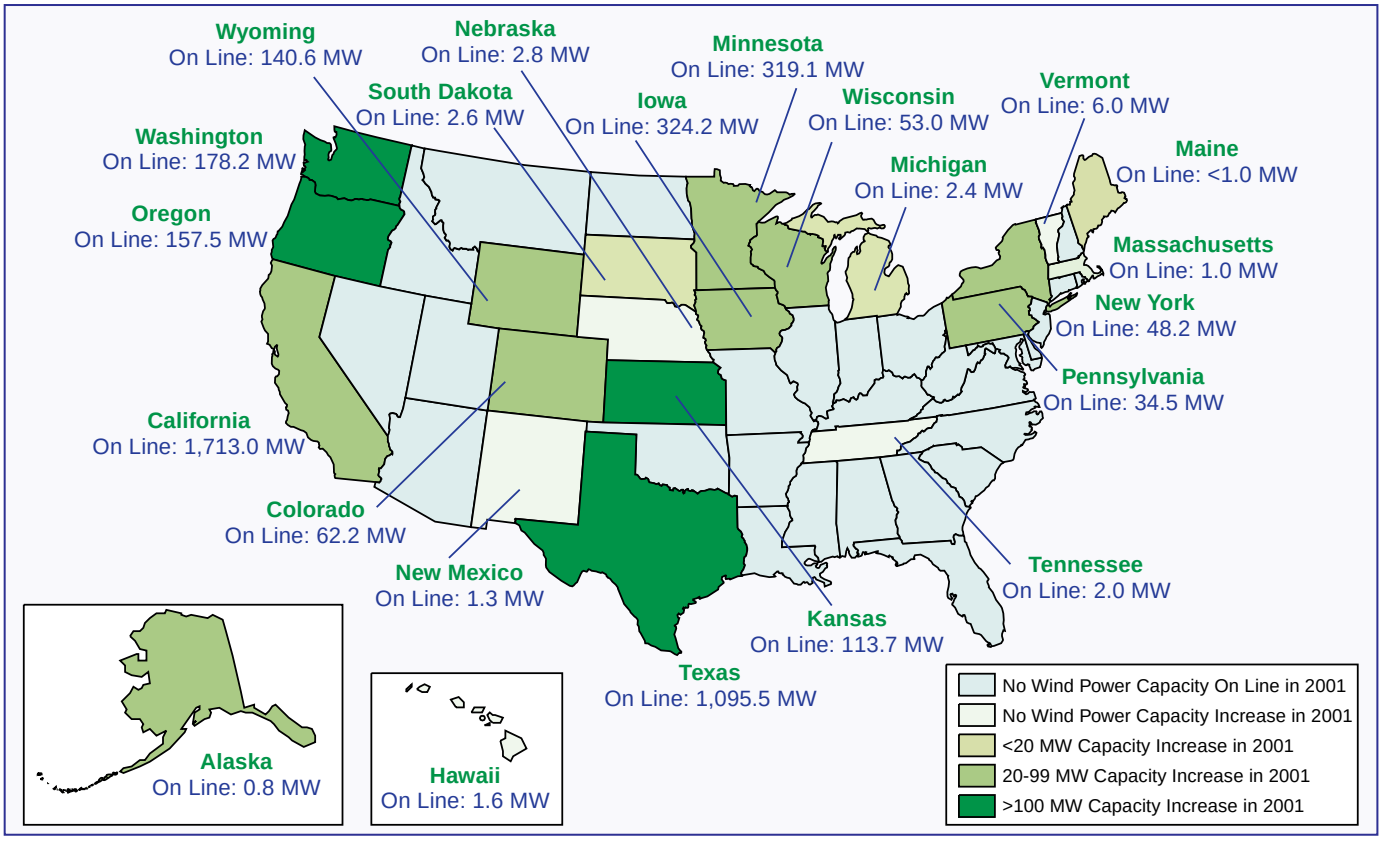
Other hydroelectric projects are also under consideration throughout Canada. Canada's Northwest Territories government is considering development of six hydroelectric projects that would add some 11,630

megawatts of new capacity [***11***]. On the Mackenzie River alone, there are proposals to install 10,500 megawatts of hydroelectric capacity. Other projects include a 200-megawatt run-of-river plant on the Talston River, a 600-megawatt project on the Bear River, and a 270-megawatt project on the Lockhart River. Two small hydroelectric facilities are also under consideration, the 33-megawatt Upper Snare River project and the 27-megawatt Lac La Marte River project. The territorial government has announced its intention to export the electricity from the six projects to Alberta Province as well as to U.S. markets.

Negotiations have continued between Newfoundland and Labrador and Québec provinces on the proposed development of a hydroelectric plant with two dams on the Lower Churchill River in Labrador. In 1998, the two provinces agreed to construct the 3,200-megawatt project, but financing difficulties caused the project to be shelved [***12***]. In 2001, however, U.S. aluminum company Alcoa, Inc., and the Newfoundland provincial government together funded a feasibility study for the revival of the Lower Churchill project. The new proposal reduced the size of the project to 2,000 megawatts of hydroelectric capacity, with an estimated cost of $1.6 billion [***13***]. It would still consist of two dams—one at Gull Island and one at Muskrat Falls [***14***]. Whereas the original project envisioned exporting the electricity produced to the U.S. market, Alcoa would like to use the output to power one or more new aluminum smelters in the province, and the Newfoundland government has also discussed exporting the electricity to neighboring Québec province [***15***]. The government still must secure consent to construct the Lower Churchill Falls project from the indigenous Innu Nation. If the project receives final approval, it is expected to begin operation by 2012.

In addition to hydropower, Canada has been developing new wind capacity. A reported 198 megawatts of wind capacity was operating in Canada at the end of 2001. Several new wind facilities were commissioned in 2001, including North America's largest commercial wind turbine, a 1.8-megawatt unit at the Pickering Nuclear Generating Station [***16***]. In February 2002, the first wind project in the province of Saskatchewan began operation, an 11-megawatt project at Gull Lake [***17***]. The Gull Lake project, located on the Trans-Canada Highway about 200 miles west of Regina, consists of 17 wind turbines. It cost some $15 million to construct and was financed, in part, by an $8 million subsidy from the Canadian government for promoting "green" energy development in Saskatchewan. Provincial utility

Figure 70. Capacity of Grid-Connected Wind Power Plants in the United States as of December 31, 2001, and Growth in Capacity During 2001



Source: International Energy Agency and PWT Communications, *IEA Wind Energy Annual Report* (Boulder, CO, May 2002), p. 218.

Hydro-Québec has also committed to calling for bids to construct wind power capacity and has stated its intention to finance 1,000 megawatts of new capacity between 2003 and 2013 [**18**]. The utility also has plans to support the development of 200 megawatts of forest biomass capacity over the same period.

Mexico

Hydroelectric generation currently provides 20 percent of Mexico's total electricity supply and is its predominant source of renewable energy. Most hydropower sites are in the southern part of the country. A drought in 2002 reduced output from hydroelectric plants substantially, with the Mexican Energy Ministry reporting that hydroelectric reservoir levels were at 10-year lows [**19**].

Although Mexico's hydroelectric capacity is not expected to grow substantially in the *IEO2003* reference case, there are plans to construct new capacity over the next decade. The most ambitious plan is for the construction of the 750-megawatt El Cajón hydroelectric project, the first large-scale hydropower project to be considered for construction in Mexico in more than a decade [**20**]. The state-owned Comisión Federal de Electricidad (CFE) has called for bids to construct what is being called the largest publicly funded infrastructure to be financed by Mexico's Fox Administration. El Cajón is to be located in the municipalities of Yesca and Santa Maria del Oro in Nayarit state on Mexico's west coast. The project is expected to cost an estimated $650 million to complete, with a 610-foot high dam, the highest of its kind in the world. Construction on El Cajón is slated to begin in the first quarter of 2003 and scheduled for completion in the summer of 2007. Construction was expected to begin on January 31, 2003, and to be completed by the end of August 2007.

Of the other, nonhydroelectric renewable sources of energy, geothermal energy is most widely established in Mexico. In 2002, Mexico reported 855 megawatts of installed geothermal capacity, making the country the third largest producer of geothermal electricity in the world, behind the United States and Philippines [**21**]. CFE has estimated that another 1,000 megawatts of geothermal capacity could be developed in Mexico. Currently, however, there are only two geothermal electricity plants under construction, the 100-megawatt Los Azufres plant in Michocán state and the 10-megawatt Las Tres Vígenes plant in Baja California [**22**].

Wind power has had a difficult time advancing in Mexico, although there are rich wind resources in the southern La Ventosa region. By some estimates, La Ventosa could support up to 2,000 megawatts of installed wind capacity [**23**]. Thus far, however, there are only two significant wind projects operating in Mexico, the 1.5-megawatt La Venta project located in La Ventosa and the 0.6-megawatt Guerrero Negro project in Baja California. There are other small wind turbines operating in remote parts of the country.

Nonhydroelectric renewables received some much-needed support in 2001 from the Mexican government, which announced that it would invest $14 million on renewable energy projects in 2002. The government has announced goals to increase wind capacity to 2,000 megawatts by 2006 and solar energy to 13 megawatts by 2009.

Partly as a result of government incentives, wind power capacity is expected to increase substantially in Mexico over the next several years. The Mexican company Fuerza Eólica del Istmo has obtained government permission to construct a 30-megawatt wind farm in the south central Mexican state of Oaxaca [**24**]. Upon completion, the plant will provide electricity for a cement factory owned by Cementos de la Cruz Azul. Fuerza Eólica del Istmo has proposed four additional projects to Mexico's Energy Regulatory Commission, which would add another 215 megawatts of wind capacity. There also some efforts to add solar energy to Mexico's renewable energy mix, with BP attempting to deliver solar generated electricity to some 300 rural communities in 15 municipalities.

Western Europe

With most of its hydroelectric resources already extensively developed, wind remains the fastest growing renewable energy source in Western Europe. According to the European Wind Energy Association, wind energy capacity reached 20,447 megawatts in the fourth quarter of 2002, so that Western Europe now accounts for 74 percent of the world's total wind capacity [**25**]. Germany, Denmark, and Spain continued to see the fastest regional growth in new wind power installations, but several other countries—notably, the United Kingdom and Ireland—also have made advances in wind power development.

The German market for wind generation remains especially strong. In August 2002, Germany passed the 10,000-megawatt milestone for installed wind capacity mark and estimated that it would reach 11,750 megawatts by the end of the year [**26**]. There are more than 12,000 wind turbines currently operating in Germany, and the government has set a goal of 20,000 megawatts by 2010 [**27**]. In the *IEO2003* reference case, Western Europe's consumption of hydroelectricity and other renewable energy is projected to grow by 1.5 percent per year on average, from 6.1 quadrillion Btu in 2001 to 8.8 quadrillion Btu in 2025 (Figure 71).

One indicator of the success of wind power development in Western Europe is the fact that, after many years of subsidizing wind generation, several countries are now considering eliminating or scaling back the subsidies. Denmark is among the world's most successful

wind markets, with approximately 2,500 megawatts of installed wind capacity in 2001, sufficient to meet 12.6 percent of the country's total electricity needs [***28***]. Wind installations in Denmark have already exceeded the goals set by the government's Energy 21 program in 1996, which called for the installation of 1,500 megawatts by 2005. The program has a target of 5,500 megawatts of wind capacity by 2030, of which 4,000 megawatts will be offshore. In part because of the success of the country's wind program, the Danish government has announced that it will not renew the subsidies for new wind turbines, beginning in 2004 [***29***].

Spain is also considering removal of its renewable energy subsidies. With 3,337 megawatts of installed wind capacity at the end of 2001, Spain has the second largest amount of installed wind capacity in Western Europe, after Germany [***30***]. In October 2002, Spanish Energy Minister Jose Folgado stated that renewable energy use in Spain was on schedule to provide up to 25 percent of the country's electricity generation within 10 years [***31***]. He further noted that wind, biomass, and hydroelectric facilities were strengthened enough so that they could now compete in an open market. The Spanish Minister instead supports the implementation of a "green certificate" program under a Renewable Energy Certificate System. Under the proposed scheme, national authorities would issue certificates verifying the amount of electricity produced, and the certificates could be sold to those who wished to purchase electricity from a certain source, such as wind.

The wind market in the United Kingdom (UK) has developed more slowly than those in other countries. Difficulties in obtaining siting licenses and public aversion to wind farms have made it difficult to install wind turbines [***32***]. At the end of 2001, 468 megawatts of wind capacity had been installed in the UK, far less than the 2,676 megawatts of wind capacity with power purchase contracts under the Non Fossil Fuel Obligation, which had been used before 2001 to secure funding for renewable energy sources.

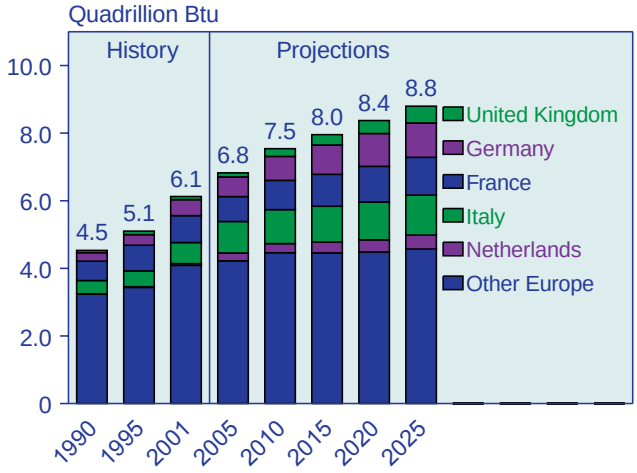
In April 2002, the UK enacted its newest Renewable Obligation (RO) under the New Electricity Trading Arrangements program [***33***], which replaced the Non-Fossil Fuel Obligation program used to collect taxes to support the country's nuclear power plants and renewable energy projects. Under the terms of the new RO, electricity suppliers are required to provide 3 percent of their electricity sales from approved renewable energy sources until March 2003, and the requirement rises to 10.4 percent of sales in March 2011. If the supplier cannot meet its requirements, it must purchase renewable certificates. The cost of the certificates has been set at about $47 (30 British pounds) per megawatthour, which may be adjusted after April 1, 2003, in accordance with the retail price index for electricity [***34***]. The RO also includes provisions for financing energy crops and offshore wind programs and establishes a $158 million renewable energy fund.

Several renewable energy projects advanced in the UK in 2002. In July, the 30-megawatt Bein an Tuirc wind project began operating at Carradale on the Kintyre peninsula in Scotland [***35***]. The project consists of 46 660-kilowatt turbines, which are expected to provide enough electricity to supply 25,000 homes. It is hoped to be the first of three wind farms developed by Scottish Power. The $32.3 million project is capable of producing power very efficiently, because it is situated on the Kintyre peninsula where wind resources are among the best in Western Europe, according to the UK Department of Trade and Industry. Scottish Power hopes to install at least another 785 megawatts of wind capacity by 2010, which would meet more than one-half of Scotland's renewables target.

In June 2002, Canadian oil producer Talisman Energy announced that it would install a 500-megawatt offshore wind project near one of the UK's oil fields off the northern coast of Scotland [***36***]. The UK initiated a feasibility study of the proposed project, which will consist of up to 120 turbines, and in July 2002 consent was granted for its construction. When it is completed it will be the largest offshore wind project in the UK. The 90-megawatt North Hoyle wind project, to be constructed about 5 miles from the North Wales Coast in Denbighshire, is scheduled for completion by the end of 2003. It will supply electricity for more than 50,000 homes.

Ireland has only recently begun introducing wind-powered electricity to its energy mix. To encourage the

Figure 71. Renewable Energy Consumption in Western Europe, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

development of renewable energy capacity in the country, the Irish government approved $404 million for renewable energy projects, with the hope that the investment would double the amount of electricity generated from wind, biomass, and hydroelectric resources [***37***]. In July 2002 the Irish energy company Airtricity announced that it had begun construction on Ireland's first wind farm. The 25-megawatt facility is being constructed on the Irish west coast, near Sligo. The project was expected to cost approximately $34 million and to be operational by spring 2003.

Eastern Europe and the Former Soviet Union

There are only a few plans to expand the use of renewable resources in the countries of Eastern Europe and the former Soviet Union (EE/FSU). Much of the increment in hydroelectricity from 2001 to 2025 is expected to be in the form of repairing and expanding existing facilities that suffered from a lack of maintenance during the Soviet era. In general, renewables are not competitive in the FSU, where fossil fuel resources are abundant and demand for clean forms of electricity can be met with cheaper natural-gas-fired capacity. There has begun to be some modest activity, however, toward exploiting wind resources and other nonhydroelectric renewable energy resources among the former Soviet Republics. Renewable energy demand in the FSU is projected to increase by 0.8 percent per year over the forecast period. In Eastern Europe, the growth rates projected for hydroelectricity and other renewables are substantially higher than those for the FSU at 2.2 percent per year, reflecting the relatively small amount of renewable capacity currently installed in the region. By 2025, the reference case projects that use of hydropower and other renewable energy sources in Eastern Europe will be 43 percent of the current level in the FSU (Figure 72).

Former Soviet Union

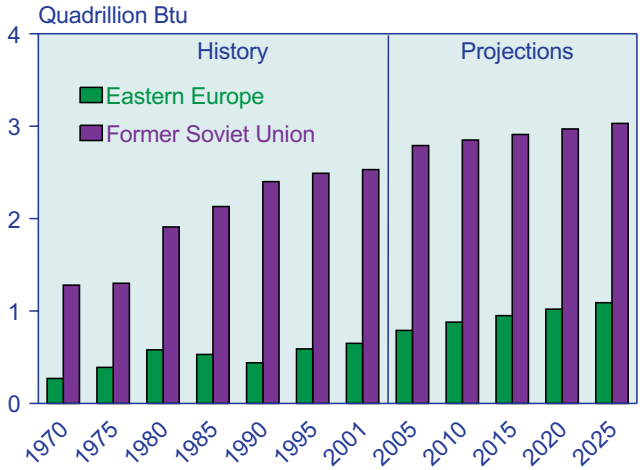
Although most of the development of hydroelectric resources in the FSU today consists of updates and repairs to old infrastructure, Armenia has announced plans to construct several new hydroelectric projects over the next several years. Armenia has developed plans to construct 38 small and 3 large hydroelectric power plants, with a combined installed capacity of 296 megawatts [***38***]. Two of the three large hydropower projects, the 60-megawatt Lori Berd and the 75-megawatt Shnokh, are to be located in the northeastern part of the country. The third, the 79-megawatt Megri, is to be sited on the Araks River on the Armenian-Iranian border. The estimated cost of the Megri project, which would take 5 years to complete, is between $60 million and $80 million. The World Bank and the European Bank for Reconstruction and Development have committed to part of the funding for the $300 million program. No construction schedule has yet been submitted, and the Azerbaijan government is protesting the plan, arguing that its Nakhichevan region would be adversely affected.

In Azerbaijan, the 4,000-megawatt Yenikand hydroelectric project was completed in 2000 [***39***]. Construction on Yenikand began in 1985, but work was suspended in 1987 as a result of financing difficulties. Construction resumed in 1996 with the help of a $53 million loan from the World Bank. In 2001, the restoration of the $41 million Mingechaur hydropower project was completed. The 360-megawatt project is located on the Kura River.

Georgia has announced plans to construct two new hydroelectric projects on the Rioni River, the 250-megawatt Namakhvani and the 100-megawatt Zhoneti. The country is attempting to attract foreign investment to fund the additions. In September 2001, the Georgian-Chinese Energokorporatsia Vostoka company opened the first phase of the 24-megawatt Khador hydroelectric project near the Georgian-Russian border in the eastern Kakheti region. The project is scheduled to be completed before the end of 2003. In January 2002, Georgia announced that China's Sichuan Machinery, which is constructing Khador, would invest $10 million in a second hydroelectric station in Georgia. The 9.3-megawatt plant will be built on the Chelta River in the Kakheti region.

There are also plans to expand hydroelectric capacity in Russia. The largest project currently under construction in Russia is the Bureyskaya hydroelectric project. Construction on this 2,320-megawatt project in the Russian Far East region of Amur was started in 1976, but work was suspended because of difficulties in securing

Figure 72. Renewable Energy Consumption in Eastern Europe and the Former Soviet Union, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

financing for its completion [***40***]. Unified Energy System of Russia (UES) resumed construction on Bureyskaya in 2000, and it is now scheduled to begin operating by the end of 2003. UES has also announced a scheme for constructing a 20,000-megawatt hydroelectric station, the Turukhan project, on the Nizhnaya Tunguska River [***41***]. According to UES, Turukhan would be used to supply electricity to western parts of Russia, as well as for exports to Europe. On a smaller scale, in 2002 construction began on the 15-megawatt Gunibskaya power station on the Karakoysu River in the Russian Republic of Dagestan [***42***].

The FSU is seeing increasing interest from the international community for participation in the development of nonhydroelectric renewable energy resources. Russia's first commercial wind project began operating in the Kaliningrad region in July 2002 [***43***]. The 45-megawatt Kulikovo project was constructed by UES and the Danish company SEAS, and there are already plans to construct a second wind facility offshore in the same region.

Estonia is another FSU country that has made moves to develop wind-powered electricity generation. In October 2002, the country's first commercial wind project, the Virtsu Wind Park, began operation [***44***]. The 1.8-megawatt project was constructed as a joint venture between state-owned utility Eesti Energia, ÖU Roheline Ring, and German wind turbine manufacturer Enercon GmbH at an estimated cost of $2.4 million, funded by the German Federal Ministry of Economics and the Estonian Regional Development fund. The utility has also granted a licence to Estwind Energy (which has subsequently been acquired by Canadian Secureview Systems, Inc.) to install a total of 3 megawatts of wind capacity, divided between Saamemaa and Tostamaa [***45***]. Estonia is particularly interested in renewable energy projects to meet its renewable requirements for European Union membership. The country hopes to increase the renewable share of its total energy use to 10 percent (from 1 percent at present), but no timetable has been set. Eesti Energia established a subsidy for renewable energy generation as an incentive for increasing renewable energy projects.

Eastern Europe

Among the countries of Eastern Europe, Romania has perhaps the greatest potential to expand its use of hydroelectricity. To date, only about 6 megawatts of hydroelectric capacity has been installed in Romania. In September 2001, state-owned Hidroelectrica and the Romanian Ministry of Industry and Resources tendered 21 hydroelectric projects, involving the completion of 36 hydroelectric plants by 2004 at an estimated cost of $1.3 billion [***46***]. Hidroelectrica is attempting to finalize deals for the first 9 of the 21 projects that have received bids from potential investors, which include Italy's Enel and France's Electricité de France. Enel signed an initial agreement to undertake a feasibility study on eight hydroelectric facilities on five rivers, including the 75-megawatt Comesti-Movileni project on the Siret River, the 116-megawatt Cornetu-Avrig project on the Olt River, and the 22-megawatt Valea Sadului on the Jiu River, as well as a water supply tunnel at the Raul Mare Retezat facility [***47***]. The company has estimated the cost of work on the entire set of projects at $400 million to $500 million. Hidroelectrica has announced that it will make a decision about development plans for the remaining 12 projects in the first quarter of 2003.

Several other East European countries have made plans to renovate or add hydroelectric capacity. In Hungary, there are plans to modernize the 28-megawatt Kiskorei Vizeromu hydroelectric facility [***48***]. A consortium led by Hungarian-based Siemens RT estimates that the $10.4 million upgrade will be completed by 2006. U.S. Triangle General Contractors has begun a feasibility study for the upgrade of the Koshnjentin hydroelectric project in Kosovo, near the Albanian border [***49***]. Local authorities are also investigating the possibility of constructing a new hydroelectric project at Zhur. Macedonia is beginning to add several small hydroelectric facilities. In July 2002, construction on the fifth of six hydroelectric plants in the Stezevo cascade began [***50***]. The 8.8-megawatt Lera hydroelectric project is scheduled for completion in early 2004. The project is being financed through a $7.5 million credit from the Spanish government. The Stezevo hydroelectric system will be completed with a 2.5-megawatt power plant near Kazani.

Plans to expand Bulgaria's hydroelectric capacity have been hampered somewhat both by financing difficulties and by protracted efforts to privatize the country's electric power sector. Privatization of the electric utility sector is expected to be completed by June 2003, with the sale of seven Bulgarian electricity companies [***51***]. State-owned Natsionalna Elektricheska Kompania (NEK) has been unbundled into three generating companies, in addition to distributors. Twenty-two hydroelectric power plants are to be sold to private companies.

NEK has announced plans to renovate or complete a number of hydroelectric projects, most notably the $300 million Gorna Arda project. Plans to renovate the 170-megawatt Gorna Arda ran into difficulties in 2000 when Turkey's Ceylan Holding faced financial problems. Italy's Enel expressed an interest in taking on the project in late 2001 and by mid-2002 had been chosen by an international tender to complete the project, but shareholders of the Gorna Arda project were unable to oust Ceylan Holding, which owns 31 percent of the joint venture. The project remains stalled, and deadlines for the completion of Enel's feasibility study for Gorna Arda have been repeatedly delayed [***52***]. NEK financed the construction of the first plant in the complex, the Madan

hydroelectric project, which is scheduled for completion in early 2003. Enel has also launched a feasibility study for a hydroelectric project to be sited in central Bulgaria on the Cherni Osum reservoir [***53***]. If the outcome of the study is positive, construction on the estimated $82 million project could start as early as fall 2003.

One Eastern European country that has made some substantial moves to increase its wind-generated electricity capacity is Poland. Poland is expected to join the European Union in 2004 and, as a result, must increase its renewable energy use to meet EU obligations of 12 percent of total electricity generation by 2010 [***54***]. Poland has stated it will spend $3.2 billion over the next decade for the development of wind, water, and biomass (i.e., straw) generators, as well as solar panels. In April 2002, the German company P&T Technology announced that it would install 1,500 megawatts of wind capacity before 2012. The first 220 megawatts of capacity—wind turbines located near the city of Poznan and in northeastern Poland—are expected to begin operating by June 2003.

Central and South America

The hydroelectric resources of Central and South America have been widely developed. Many countries in the region rely on hydropower for more than 70 percent of their total electricity generation. Such heavy dependence on hydroelectric resources can be problematic when a nation is faced with drought conditions. In the 2000-2001 period, for instance, Brazil experienced severe droughts that threatened blackouts and electricity shortages. The government responded with mandatory conservation rules, which finally were lifted in the early part of 2002, but the government also saw the urgency of diversifying the electricity supply mix. Many South American countries are working to develop natural-gas-fired electricity generation to lessen dependence on hydroelectricity and the impact of future droughts on their economies, but plans are also under way in the region to expand hydroelectric power, as well as other renewable energy sources. The *IEO2003* reference case projects 1.2-percent average annual growth in the region's renewable energy use from 2001 through 2025 (Figure 73).

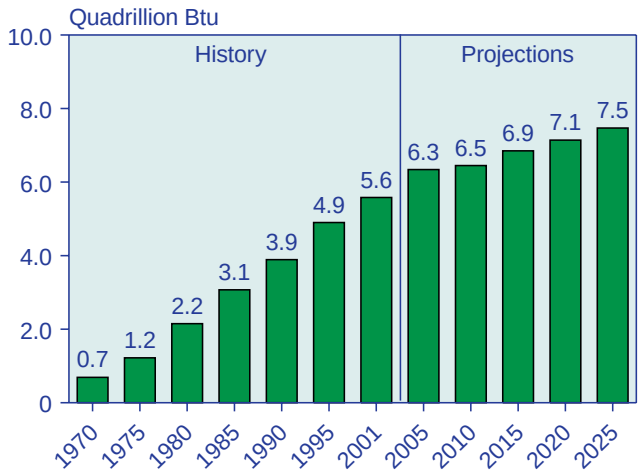
Brazil

Despite the fact that many parts of Brazil experienced severe drought over the past 2 years, there are still plans to add to the country's hydroelectric capacity both in the northwest, where the drought was less extreme than in other parts of the country, and in the southeast, where electricity demand is growing fastest. In July 2002, Brazil's power regulator Agência Nacional de Energia Eléctrica (Aneel) awarded concessions to several foreign and Brazilian consortia to construct and operate an additional eight new hydroelectric power plants in the northeast and central regions. The projects, adding 1,600 megawatts of capacity in five states, are expected to cost approximately $1.2 billion [***55***]. Canadian aluminum producer Alcan, Inc., won two concessions to build three small plants [***56***]. Alcan is also constructing five other small plants in Brazil, which should satisfy the company's 300-megawatt needs. Three of the new plants should begin operating in 2006, another four in 2007, and the last one in 2008.

A consortium led by Belgian energy company Tractebel (and including Brazil's Camargo Correa Energia, Companhia Vale do Rio Doce, BHP Billito, and U.S. Alcoa) was successful in attaining the contract to build, own, and operate the largest of the eight projects, the 1,087-megawatt Estreito hydroelectric project in northern Brazil [***57***]. Estreito is to be constructed on the Tocantins River, on the border between the states of Tocantins and Maranhão. The first unit of the facility is scheduled to begin operating in 2007. The consortium has a number of other hydroelectric projects currently under construction, including the 300-megawatt Aimorés, the 140-megawatt Candonga, and the 180-megawatt Funil, all located in the southern state of Minas Gerais [***58***].

The expansion of Brazil's hydroelectric power is expected to continue in 2003, when Aneel is expected to auction concessions for an additional 34 hydroelectric energy stations [***59***]. The new power plants will add 9,100 megawatts of electricity capacity and require investment of around $4 billion. Aneel has stated that Brazil's installed electric capacity increased by 6,244 megawatts in 2002 and will expand by another 15,709 megawatts in 2003 and 2004 and 4,675 megawatts in 2005, based on new hydroelectric plants that either are

Figure 73. Renewable Energy Consumption in Central and South America, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

under construction or have been approved. In contrast, 20 new thermal power plants are expected to add 7,000 megawatts to the country's electricity system by 2005.

Brazil is currently the world's largest consumer and producer of ethanol from sugar cane, which is widely used in the country's automotive sector. Alcohol fuel use is a legacy from the Proácool program, which was created by the government in response to the 1973-74 oil embargo to lessen Brazil's dependence on oil imports and allow it to develop its own oil production and reserves [***60***]. About 3 million older cars still in circulation in Brazil run on 100 percent ethanol (hydrous ethanol vehicles), and the all the country's motor fuels contain 25 percent ethanol. Only about 1 percent of all the new cars sold in Brazil today are hydrous ethanol vehicles; however, there is renewed government interest in reviving the Proácool program both for domestic consumption and to serve growing export markets. There is a 10-year ethanol accord between Brazil and Germany, under which Germany will receive carbon credits under the terms of the Kyoto Protocol by paying for the production of 100,000 new hydrous ethanol cars.

The Brazilian government has also made substantial efforts to encourage the development of wind-generated electricity. In October 2002, only eight wind stations were operating in Brazil, with a total capacity of 21.4 megawatts [***61***]; however, more than 5,100 megawatts of new wind capacity has been approved for construction by federal regulator Aneel. In 2001, Aneel approved 38 wind projects with a total of 3,337 megawatts of capacity, and by October 2002 another 29 projects had been approved, with a combined capacity of 1,793 megawatts. The projects are sited in the Brazilian states of Bahia, Ceará, Pernambuco, Piauí, Rio de Janeiro, and Rio Grande do Norte. All the projects are scheduled to become operational between 2002 and 2007; however, their construction will depend on the ability of developers to obtain financing and purchase power agreements.

Over the past 2 years Brazil has taken a number of steps to increase the use of alternative renewable energy sources. In July 2001, in the midst of the electricity crisis brought on by persistent drought, the Power Crisis Management Chamber established an emergency wind energy program, Proeólica, with the goal of adding 1,050 megawatts of wind capacity to the national grid by December 2003. Under Proeólica, the federal government guarantees a "beneficial" purchase of wind-generated electricity by state utility Eletrobras for at least 15 years. Further, Brazil's legislature passed Law 10.438 (or Proinfa) in April 2002, establishing incentives for alternative electricity sources. In addition, the state government of Rio de Janeiro passed a law in January 2002 that authorizes tax benefits for wind, solar, and biomass electricity generation projects [***62***]. The law also encourages regional incentives for generation projects that use nonhydroelectric renewable energy sources.

Other Central and South America

Despite economic and political problems in many countries of Central and South America, some renewable energy projects have advanced in the region. Hydroelectric power still dominates the renewable energy picture in the region. In Peru, new hydroelectric projects were banned under the former Fujimori administration in an effort to attract investment in the country's Camisea natural gas fields. The ban was lifted by the Toledo administration, and a spate of new hydroelectric projects are now under development in Peru. The country has 11 new hydroelectric dams currently planned or under construction, at an estimated total cost of $1.5 billion. All the projects are expected to be operational within the next 6 years, adding some 1,500 megawatts of capacity to the Peruvian electricity grid [***63***]. They include the $304 million, 130-megawatt Yuncan—the only state-owned project among the eleven—which is already one-third complete and is scheduled to begin generating electricity by July 2004. The project has been funded by the Japanese government.

Other Peruvian hydroelectric projects include a 100-megawatt project in the La Libertad region to be constructed by the Taruncani Generating Company; the 27-megawatt Poechos project to be constructed by Sinersa near the Ecuadorian border; and the 270-megawatt El Platanal project to be built in Lima by Cementos Lima. El Platanal is scheduled for completion in July 2006. Work on the 96-megawatt Marañon and 525-megawatt Cheves hydropower projects is to be completed by February 2005 and November 2009, respectively. The Peruvian privatization agency, ProInvestment, is planning to auction the concession to build and operate the 143-megawatt Olmos hydroelectric project on the Huancabamba River in Northern Peru [***64***]. The project is expected to cost $245 million, with the Peruvian government contributing $77 million to the costs over the 3-year construction period.

There is increasing interest among several Central and South American countries in developing their nonhydroelectric renewable energy resources. In September 2002, Colombian utility Empresas Públicas de Medellin (EPM) offered two tenders for the construction of the 20-megawatt Jepirachi wind project in the Guajira province on the Atlantic coast [***65***]. Jepirachi is scheduled for completion by October 2003 [***66***]. The $21.5 million project will be the first developed by Colombia under the provisions of the Kyoto Protocol's Clean Development Mechanism, with the backing of the World Bank's Prototype Carbon Fund. Launched in 2000, the Prototype Carbon Fund is a mutual fund that invests in clean technologies in developing countries and in the EE/FSU.

Resulting reductions in greenhouse gas emissions are to be verified and then transferred to the fund's contributors in the form of emissions reduction certificates that may be used by the contributors to meet their emissions targets under the Kyoto Protocol.

Geothermal energy is also being increasingly exploited in the Central and South America region. Countries in the region added some 242 megawatts of geothermal generating capacity between 1990 and 2000, more than doubling the use of geothermal energy from its 1990 level of 165 megawatts [***67***]. There are plans to expand Nicaragua's geothermal capacity beyond the current level of 70 megawatts. In 2002 construction began on a $140 million geothermal project near Leon, about 56 miles northwest of Managua [***68***]. The San Jacinto-Tizate steam field will be the country's first fully private geothermal power facility. The first phase of the project consists of a 10-megawatt pilot plant, which will eventually be expanded to 66 megawatts.

El Salvador is also expanding its geothermal capacity, adding 38 megawatts of capacity. Italy's Enel GreenPower has entered into a joint venture with El Salvador's state-owned geothermal generator, Gesal, to develop the project at an estimated cost of $91 million. Gesal currently operates two geothermal plants in El Salvador, the 95-megawatt Ahuachapán and the 66-megawatt Berlín.

Developing Asia

In developing Asia, much of the development of renewable resources is expected to center on increasing the amount of mid- to large-scale hydroelectric capacity. The region has some of the world's largest hydroelectric facilities either planned or under construction. China has particularly ambitious plans to increase hydroelectric capacity, including the 18,200-megawatt Three Gorges Dam project and the 5,400-megawatt Longtan project, both of which are under construction [***69***]. Other countries in the region, including Vietnam, Malaysia, and India, also have plans to expand their use of large-scale hydroelectricity over the next decade in an effort to diversify electricity sources and meet the rapidly growing demand for new electricity to fuel their expanding economies. Consumption of hydroelectricity and other renewables is expected to more than double among the nations of developing Asia, from 5.1 quadrillion Btu in 2001 to 11.0 quadrillion Btu in 2025 (Figure 74).

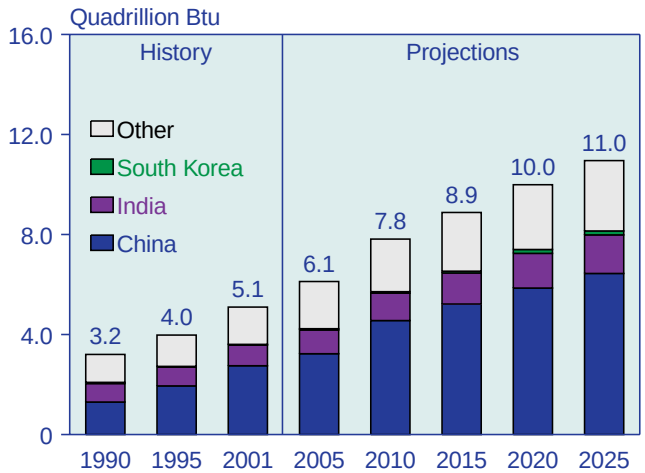
China

Over the next decade, China has extensive plans to expand its hydroelectric capacity above the current 79,000 megawatts of installed capacity. The Three Gorges Dam project remains the largest and most ambitious hydropower project currently under construction. With the displacement of more than a million people living around the construction site and destruction of significant architectural sites, it is also among the most controversial projects in the world today. Despite criticism from the international community, the Chinese government has been adamant in its pursuit of the 18,200-megawatt project, which will cost $25 billion or more to complete [***70***]. The government argues that the dam is needed both to provide electricity to meet rapidly growing demand in the country's urban areas and to control devastating flooding along the Yangtze River.

In November 2002, work on the Three Gorges Dam project reached a significant milestone with the successful blocking of the Yangtze River [***71***]. The river's waters are now being channeled through diversion holes in the partially completed dam. The dam's reservoir is scheduled to begin to be filled in early 2003. By the end of 2003, the project is expected to begin generating electricity with the installation of the first four 700-megawatt generators [***72***]. Three Gorges Dam is expected to become fully operational in 2009.

Several additional hydroelectric projects are now being developed in China. The Yellow River Hydro Electric Corporation is developing 25 hydropower projects on the Yellow River with a combined 15,800 megawatts of installed electricity capacity [***73***]. In addition to Three Gorges, the Chinese government has several other large-scale hydroelectric projects either under construction or in the planning stages. In July 2001, construction began on the 5,400-megawatt Longtan project on the Hongshui River, which is expected to begin operating in 2007. Other large-scale projects under construction

Figure 74. Renewable Energy Consumption in Developing Asia, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

include the 1,350-megawatt Dachaoshan hydroelectric project, scheduled to be completed by the end of 2003, and the 4,200-megawatt Xiaowan project, scheduled to be completed in 2012. Both are located on the Mekong River. Proposals have been submitted for the 14,000-megawatt Xiluodo project (on the upper portion of the Yangtze River, known locally as the Jinsha River); 6,000-megawatt Xiangjiaba project (Jinsha River); 5,000-megawatt Nuozhadu project (Mekong River); and 1,500-megawatt Jinghong project (Mekong River) [***74***].

In addition to the hydroelectric expansion taking place in China, there has also been some progress in installing alternative, nonhydroelectric renewable energy sources. The government has instituted a number of programs to increase the use of nonhydroelectric renewables. The Brightness Program was launched in 1996 to encourage the use of solar panels and wind turbines for electricity generation with low-cost loans. Pilot projects under the program have been set up in the regions of Inner Mongolia, Gansu, and Tibet. The ultimate goal of the program is to provide electricity from these sources to 8 million people by 2005 and to 23 million people by 2010.

In an effort to boost interest in wind-powered electricity generation, the Chinese government has announced that it will cut the value-added tax on wind-generated electricity by half, reducing the average cost of wind generation by between $6 and $7 per megawatthour. Wind projects have also found funding from international sources that are interested in reducing China's dependence on coal use. The Asia Development Bank is providing loans worth some $58 million to erect wind projects in Xinjiang, Liaong and Heilongjiang provinces. One of the projects is a 200-megawatt wind farm in Xinjiang that will be China's largest wind installation upon completion in 2003 [***75***]. Another project to be funded with foreign investment is the 100-megawatt Hulai Shipaishan wind project in Guangdong province [***76***]. Tenders for the $120 million project were offered by local government authorities in Hulai county.

India

At present, India has 25,140 megawatts of installed hydroelectric capacity[***77***]. With an overall development potential of 84,000 megawatts, there are ample resources still to be exploited [***78***]. Numerous government-funded hydropower projects are under construction throughout the country, including the 1,500-megawatt Nathpa Jhakri project in Himachal Pradesh state and the 1,000-megawatt Tehri project in Uttar Pradesh. At the end of 2001 India announced that it would revive construction of the $1.2 billion Tehri hydroelectric dam project [***79***]. The final two tunnels associated with the first phase of the project were scheduled for completion in December 2002, and Tehri should begin supplying electricity in August 2003 [***80***]. There are additional plans to expand Tehri's capacity to 2,000 megawatts in subsequent phases, but no work beyond the initial phase has been approved.

A number of smaller hydroelectric facilities have also been approved for construction in India. In Himachal Pradesh the government awarded private power developers permission to construct eight hydroelectric projects in 2002 [***81***]. The projects range in size from the 10.5-megawatt Baragaon project to the 100-megawatt Malana II and Sainji projects. The government of Himachal Pradesh has announced its intention to develop 20,000 megawatts of its hydroelectric potential. As of 2002, 3,900 megawatts of hydroelectric capacity had been installed in the state, with another 6,800 megawatts under construction.

Other Developing Asia

Vietnam has recognized the need to increase its electricity generation in order to power its growth in industrial production and gross domestic product, which have been expanding by 6 to 7 percent annually in recent years. Hydroelectricity is expected to make a large contribution toward meeting the increased demand for electricity. The state-owned Electricité de Vietnam (EVN) has announced plans to add 37 new electric power plants by 2020, to the existing 18 power plants [***82***]. Twenty-two of the planned power projects are hydroelectric plants, and the rest are to be fueled by oil, natural gas, and coal. EVN has announced its intention to fund approximately one-third of the investment needed to construct the new projects, with the rest to come from private and foreign investment.

In 2002, Vietnam's second largest hydroelectric project (after the Hoa Binh project), the 720-megawatt Yaly Falls became fully operational [***83***]. The $546 million project, located on the Se San River in the central part of the country, is expected to supply about 10 percent of Vietnam's total electricity generation. The 475-megawatt Ham Thuan / Da Mi hydroelectric project in the southern part of the country is also nearly completed [***84***]. In 2002, construction began on the 300-megawatt Dai Ninh in the central province of Lam Dong and the 300-megawatt Se San in the central province of Gia Lai. Construction is expected to begin by March 2003 on the 324-megawatt Na Hang hydroelectric project [***85***]. The $500 million project is scheduled to begin generating electricity in 2006 and to be fully operational by 2007. Finally, in October 2002, the Vietnamese government gave final approval for construction of the 2,400-megawatt Son La hydroelectric project, which will become the country's largest hydroelectric facility [***86***]. Construction on the $1.7 billion project is expected to begin in 2004 and to be completed in 2012.

In 2002, Laos made some progress in reviving construction on the controversial Nam Theun 2 hydroelectric

project. Construction of the 920-megawatt, $1.2 billion project has been delayed since 1997, pending a trade agreement between Laos and Thailand on the output from the project [***87***]. Electricity produced by Nam Theun was originally to be sold exclusively to Thailand, which has offered to sign an initial 13-year power purchasing agreement with Laos after indicating that it cannot support the original 25-year agreement for the electricity from the project. In 2002, a consortium led by Electricité de France was awarded a build-operate-transfer contract for Nam Theun 2. If the Laotian and Thai governments are able to finalize a power purchase agreement, Nam Theun 2 could be in operation by 2008 [***88***].

The Malaysian government in 2002 reiterated its commitment to develop its hydroelectric resources, citing the country's need to diversify the electricity fuel mix away from an overreliance on natural-gas-fired generation. State-owned utility Tenaga Nasional Bhd completed construction of the 600-megawatt Sultan Ismail Petra dam in the northern state of Kelantan in 2002 and is considering a 1,000-megawatt project in Pahang state. The controversial 2,400-megawatt Bakun hydroelectric project also progressed slightly in 2002. The main construction contract for the project was awarded to the Malaysian company, Sime Engineering in September, and in October a consortium was formed to supply materials and services to support construction of the $3.6 billion project [***89***].

The Bakun project has been the subject of much controversy since it was conceived in the 1980s, both because of its cost and because of its potential impact on the environment. The project was scaled back in 1998, during the Asian economic crisis, which made the project too expensive to pursue given the drop in electricity demand associated with the recession. In 2001, however, the government announced that it had reconsidered, and the project was returned to its originally planned capacity [***90***]. Environmentalists argue that the reservoir required to supply water to Bakun will mean that an area the size of Singapore will have to be flooded, displacing as many as 15 villages of the indigenous Iban people in Sarawak state and destroying the habitat of up to 100 endangered species [***91***].

Among the countries of developing Asia there has also been some recent interest in developing renewable energy sources other than hydropower. South Korea and Taiwan, for instance, have expressed increasing interest in developing their wind resources. In 2002 the South Korean government announced that it had approved plans to construct a 99-megawatt wind project on the country's east cost at Daekwanryung in Kangwon province [***92***]. The $110 million project is to be constructed in two phases, the first consisting of 28.5 megawatts of capacity scheduled to be completed by July 2004 and the second phase consisting of 70.5 megawatts of capacity to be completed by November 2005. A second 6-megawatt project is planned for construction by state-owned Korea Southern Power. It will be sited at Yongsuri on the island of Cheju. Construction was scheduled to begin in March 2003 and to be completed by April 2003 at an estimated cost of $12.3 million. Another 150-megawatt, $230 million multi-phase wind project funded by local and national government organizations is also under construction on Cheju, with final completion scheduled for 2006.

The government of Taiwan has established a goal of installing up to 1,500 megawatts of wind capacity by 2020 [***93***]. State-owned Taiwan Power Company announced in 2002 that it would invest $144 million in wind power projects between 2002 and 2007. At the end of 2001, the company completed a $4.3 million, 2.4-megawatt wind power project on Penghu Island. It has also announced plans to install up to 80 megawatts of wind capacity in Taichung county.

Industrialized Asia

The extent to which available renewable resources are currently exploited in the industrialized nations of Asia (Australia, Japan, and New Zealand) varies substantially. In New Zealand, for example, more than two-thirds of the country's electricity needs are met by renewable energy sources—mostly hydroelectricity and geothermal. In contrast, Australia meets most of its electricity demand with thermal generation, predominantly from coal; and in Japan almost all of the country's electricity is supplied from thermal sources and nuclear power. Hydroelectricity and other renewable energy consumption in the region is projected to grow by 1.7 percent per year between 2001 and 2025 (Figure 75), to 12 percent of the region's total energy use in the electric power sector by 2025.

Japan

With an electricity market dominated by thermal and nuclear generation, the growth in Japan's renewable energy resources has been fairly slow. Fossil fuels (oil, natural gas, and coal) account for 70 percent of Japan's total installed generating capacity and nuclear another 20 percent.

There have been some efforts by the Japanese government to increase the penetration of nonhydroelectric renewables in the country. The Law on Special Measures for Promotion of Utilization of New Energy (the New Energy Law), which entered into force in mid-1997, included provisions to encourage the development of wind-powered electricity generation in the country [***94***]. Japan ratified the Kyoto Protocol in 2002. If the Protocol enters into force, Japan will be required to reduce its output of greenhouse gases by 6 percent relative to its 1990 emissions level between 2008 and 2012. These

developments may provide an opportunity for increased development of the country's renewable energy sources. Indeed, although Japan's wind capacity increased by only 31 megawatts between 1989 and 1998, its installed wind capacity grew by nearly 40 megawatts in 1999, by 50 megawatts in 2000, and by another 40 megawatts in 2001.

Australia

The Australian government introduced the Mandated Renewable Energy Target in 2001, decreeing that electricity retailers and large power purchases must increase the renewable share of their electricity mix by an additional 2 percent before 2010 [***95***]. The Renewable Energy (Electricity) Act of 2000 specifies a number of interim yearly targets over the 2001-2020 time period. As a result of the new legislation, wind energy projects are receiving new interest, and a number of wind projects were either planned or under construction in 2002. In August, the Victoria state government approved the Australian company Pacific Hydro's plans for developing a 180-megawatt wind farm at Portland [***96***]. In November, Pacific Hydro also confirmed its plans to construct a 100-megawatt wind project in northwest Tasmania [***97***]. Another Pacific Hydro wind project is currently under construction at Challicum Hills, near Ararat [***98***]. The 53-megawatt wind facility is expected to cost an estimated $76 million and is scheduled for completion by mid-2003.

Several other companies are entering the Australian wind market. The New Zealand electricity generator and retailer Trustpower has announced plans to construct a 60-megawatt wind project near Myponga on the Fleurieu peninsula of South Australia [***99***], which will be the company's first venture in Australia. The startup of construction on the $55 million project is pending approval from the state Development Assessment Commission. A second 35-megawatt wind project is already being built by Australia's Tarong Energy on the Fleurieu peninsula at Starfish Hill. Tarong received government approval for the project in April 2002. The $36 million project is scheduled to begin operating in April 2003.

The Indian-based company Ausker Energies is developing the Tungketta wind project, which is to be constructed on the Eyre peninsula of South Australia [***100***]. The first phase of the project will consist of 49.5 megawatts of wind capacity, with subsequent phases that could increase capacity to between 115 and 200 megawatts.

There are also several projects under consideration for New South Wales. Australian energy developer Michelago is planning to construct a 30-megawatt wind project near Goulburn in the Southern Highlands region of New South Wales. In addition, Wind Corporation of Australia has proposed building a $14 million, 20-megawatt wind project at Black Springs near Oberon [***101***].

New Zealand

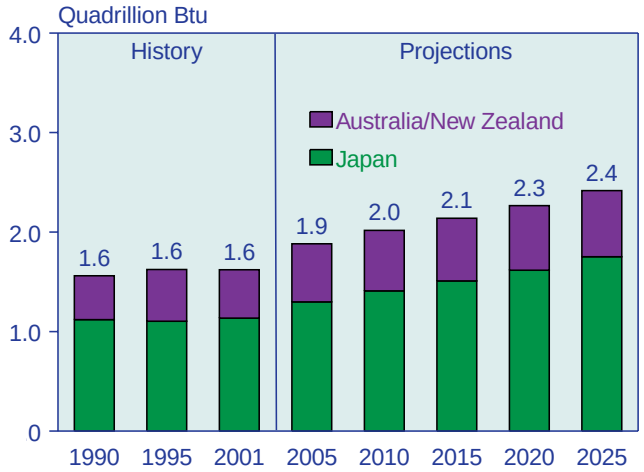
New Zealand has already extensively exploited its renewable energy resources. The country relies on renewable energy sources, particularly hydroelectricity, for nearly 70 percent of its total electricity supply [***102***]. Geothermal energy sources in New Zealand are also widely established, and installed geothermal capacity has grown by 54 percent over the past decade, reaching 437 megawatts in 2000, according to the Geothermal Energy Association [***103***].

Development of New Zealand's wind power resources has been lackluster by comparison. At the end of 2001, slightly more than 35 megawatts of wind capacity had been installed at three sites, the latest of which became operational in 1999 [***104***]. There is some hope that the release of the government's National Energy Efficiency and Conservation Strategy, which calls for increasing the renewable share of total energy supply by an additional 19 percent (to 42 percent) by 2012, will help spur an increase in wind-generated electricity.

Africa/Middle East

For the most part, hydroelectricity and other renewable energy resources have not been widely exploited in Africa or the Middle East. Most of the hydroelectric power projects in the Middle East are located in Turkey and Iran. In Africa, the largest installed hydroelectric capacities are in Egypt and Congo (Kinshasa). Several African countries—including Ivory Coast, Kenya, and Zimbabwe—rely almost exclusively on hydropower for commercial electricity generation; however, it is because

Figure 75. Renewable Energy Consumption in Industrialized Asia, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

of the absence of an electricity infrastructure in these and many other African countries rather than the presence of an extensive hydroelectric system. Other, nonhydroelectric renewable energy resources are also used in Africa and the Middle East, primarily to serve small, rural communities that are not served by national electric power grids. Renewable energy consumption in Africa and the Middle East is expected to increase from 1.2 quadrillion Btu in 2001 to 2.3 quadrillion Btu in 2025 (Figure 76).

For many nations in Africa, future hydroelectric projects may depend on the ability to attract investment dollars. Because large-scale hydroelectric projects are often controversial, many traditional funding sources for hydropower development—particularly, the World Bank but also many import-export banks that are needed by developers to guarantee loans in areas that have a high risk of defaulting on agreements—have increasingly decided against providing financial aid to governments that wish to pursue them.

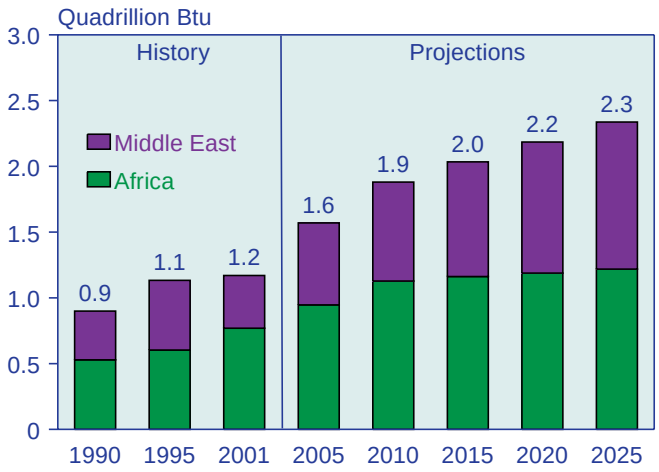
One example of the hesitancy of international financing sources to fund hydroelectric power projects is the 200-megawatt Bujagali Dam at the Bujagali Falls on the Nile River in Uganda. U.S.-based AES Corporation announced plans to construct the $550 million project in 1994 [***105***] and by December 2001 had secured funding commitments from the World Bank, International Finance Corporation, African Development Bank, Wesdeutsche Landesbank Girozentrale, and Australia and New Zealand Banking Group Limited, with export credit guarantees obtained from several European Banks. The argument for lending financial support to the construction of the Bujagali Dam was that the electricity was desperately needed in a country where less than 5 percent of the populace has access to electricity. However, international environmental groups have countered that the project would submerge a number of local cultural sites and displace more than 90 households [***106***]. In June 2002, with allegations of corruption surrounding the bidding process for Bujagali, the World Bank postponed its decision to approve $250 million in loan guarantees. The Ugandan government has vowed to continue with the project, but no schedule has yet been announced for the 4-year effort.

Similar problems have beset the Sondu Miriu hydroelectric project in Kenya. Originally conceived in 1985 as a multiple-purpose system of dams, the project was substantially scaled back, and in 1989 the Kenya Power Company, Ltd. (now the Kenya Electricity Generating Company, Ltd., or KenGen) obtained funding from the Japanese government [***107***]. Funding for the first phase of the $150 million project was provided in 1997, and construction on the 60-megawatt dam began with an original completion date of March 2003 [***108***]. Concerns over human rights violations and the impact of the project on the environment led the Japanese Bank for International Cooperation to delay releasing funds for the second phase of the project, however, and now completion is not expected before 2005 [***109***].

It took some 13 years to complete the 200-megawatt Manantali hydroelectric project in southwestern Mali, adding transmission lines to the hydropower project that had been completed in 1987. Funding problems and disputes among the three countries—Mali, Senegal, and Mauritania—that share the Senegal River, where the project is located, delayed completion of the project. By some estimates the project cost almost $1 billion—far more than the original budget. Funding to complete the project was finally provided by the World Bank and other international donors in 2002, and it was scheduled to begin supplying electricity to the three countries involved by the end of 2002. Electricity from the project is to go to Mali (52 percent), Mauritania (15 percent), and Senegal (33 percent), with plans to expand electricity exports to other West African countries, including Togo, Benin, and Ghana.

Several other hydropower projects are either planned or under construction in Africa. Construction of the 300-megawatt Tekeze hydroelectric project in Ethiopia began in 2002 [***110***]. The $224 million project is the largest African joint venture with China; the China National Water Resources and Hydropower Engineering Corporation is building the 607-foot dam, which will be higher than China's own Three Gorges Dam. The project, expected to be completed by 2007, will supply both electricity and water for irrigation to large parts of northern Ethiopia.

Figure 76. Renewable Energy Consumption in Africa and the Middle East, 1990-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2001*, DOE/EIA-0219(2001) (Washington, DC, February 2003), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2003).

Construction continued on the Lesotho Highlands Water Project in the southern African kingdom of Lesotho. The project has received $106 million from the World Bank for completion, including a 72-megawatt hydroelectric station as one part of the system [***111***]. The project has faced delays, mostly because of corruption allegations and issues surrounding the resettlement agreement with the population to be affected by the construction of a reservoir, but in October 2002 the impoundment of the Mohale Reservoir started, marking the final step of construction in the first phase of the water project [***112***].

Mozambique plans to construct the Mepanda Uncua hydroelectric project, which will be located about 45 miles downstream from the existing 3,750-megawatt Cahora Bassa dam on the Zambezi River [***113***]. Much of the output from Cahora Bassa is exported to South Africa and Zimbabwe, and with growing demand for electricity Mozambique believes that the new Mepanda Uncua project will be essential for the country to meet its needs. The cost of the project has been estimated at $1.8 billion. The construction is two be completed in two phases, adding 1,300 megawatts in the first phase and another 1,100 megawatts in the second phase. The government is currently pursuing potential investors for the project and plans to begin construction in 2005.

Sudan is also pressing forward with plans to construct the Hamdab hydroelectric dam in Merowe, about 250 miles north of Khartoum [***114***]. The 1,250-megawatt project, which would triple electricity generation in Sudan, would take 6 years to complete. In 2002 the Sudanese government began the process of accepting bids for construction of Hamdab; however, it is unclear when construction might actually begin, given the economic disrepair of the country, which has suffered from a 19-year civil war.

Some nonhydroelectric renewable energy projects are also advancing in Africa. Egypt, for instance, has become the largest wind-generating country in the region and predicted that its installed wind power capacity could increase to 150 megawatts in 2002 [***115***]. The country's New and Renewable Energy Authority has undertaken the construction of a 60-megawatt wind farm at Za'farana in northern Egypt. The Egyptian government has stated its intention to change all oil-fired power plants to natural gas and is also looking at the potential for solar and wind generation to supplement electricity supplies. Morocco is also considered one of the more important markets for wind generation in Africa. The country has installed multiple wind projects, ranging from a few kilowatts up to 50 megawatts in size [***116***].

There is growing interest in the potential for alternative renewable energy markets in Africa. For instance, in July 2002 the Chinese-based company Shenzhen Topway Solar announced its intention to transfer its manufacturing base to Africa [***117***], stating that the move was desirable because the region is currently considering locating its base either in Nairobi (Kenya) or Kampala (Uganda) before 2004. The company currently supplies solar products to 15 African countries.

In the Middle East, hydroelectric development is centered primarily in Turkey. There area already more than 100 hydroelectric plants operating in the country, contributing 11,000 megawatts of the total Turkish installed electric capacity of 26,000 megawatts. The country has plans to continue developing its hydroelectric resources. It is currently constructing the massive Southeast Anatolia Project (called "GAP"), which includes portions for hydroelectric generation and irrigation [***118***]. The $32 billion project includes 21 dams and 19 hydroelectric plants that will add around 7,500 megawatts of installed generating capacity upon completion.

The largest dams to be constructed as part of GAP include the 2,400-megawatt Ataturk, the 1,800-megawatt Karakaya, and the 1,200-megawatt Ilisu. When completed, Ilisu would be the largest hydroelectric project on the Tigris River. British civil engineering company Balfour Beatty withdrew from the Ilisu project in November 2001 when the UK Export Credit Guarantee Department indicated that it would withdraw its support for the dam under considerable pressure concerning the impact the dam would have both on the environment and on the people who would have to be relocated to construct Ilisu [***119***]. More than 60,000 people, mostly ethnic Kurds, would be displaced by the construction. In a similar development, the British engineering company AMEC decided in March 2002 to withdraw from the Yusefeli dam project in Turkey [***120***]. The company denied that it had withdrawn because of the experience of Balfour Beatty, citing its conclusion that the project would not yield sufficient returns to justify AMEC's continued participation.

Several hydroelectric projects are moving forward in Turkey. In 1998, the United States and Turkey signed a joint statement on hydroelectric development that includes provisions for construction of nine dams [***121***], including the $337 million Alpasian II to be constructed on the Murat River in eastern Turkey. The U.S. company Earth Tech signed a contract with the State Hydraulic Works of Turkey for the design phase of the 200-megawatt project, which will include an irrigation component.

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