Globally, the total annual primary energy consumption in 2005 is estimated to be 500 quadrillion (10^{15}) Btu.
The U.S. consumes 105 quadrillion Btu, distributed in
segments shown in Figure 1.1. About 40% of the total primary energy consumed is used in generating electricity. Nearly 70% of the energy used in our homes and offices is in the form of electricity. The worldwide demand of 15 trillion kWh in 2005 is projected to reach 19 trillion kWh in 2015. This constitutes a worldwide average annual growth of 2.6%. The growth rate in developing countries is projected to be approximately 5%, almost twice the world average. Our world has been powered primarily by carbon fuels for more than two centuries, with some demand met by nuclear power plants over the last five decades.
The increasing environmental concerns in recent years about global warming and the harmful effects of carbon emissions have created a new demand for clean and sustainable energy sources, such as wind, sea, sun, biomass, and geothermal power.
Among these, wind and solar power have experienced remarkably rapid growth in the past 10 yr. Both are pollution-free sources of abundant power. Additionally, they generate power near load centers; hence, they eliminate the need of running high voltage
transmission lines through rural and urban landscapes. Deregulation, privatization, and consumer preferences for green power in many countries are expanding
the wind and photovoltaic (PV) energy markets at an increasing pace.
The total electricity demand in the U.S. approached 4 trillion kWh in 2005, with a market value of $300 billion. To meet this demand, over 800 GW of electrical generating capacity is now installed in the U.S. For most of this century, the countrywide
demand for electricity has increased with the gross national product (GNP).
At that rate, the U.S. will need to install an additional 200-GW capacity by the year 2015.
China is now the world's second-largest consumer of electricity after the U.S. China's demand grew 15% in 2003, as against the 5% expected by economic
planners. The country is managing the strained power grids with rolling blackouts. The total demand is now expected to exceed 460 GW by the end of 2005. India is another country whose energy demand is growing at more than 10% annually. This growth rate, in view of the large population base, makes these two countries rapidly growing electric power markets for all sources of electric energy, including the renewables.
The new capacity installation decisions today are becoming complicated in many parts of the world because of the difficulty in finding sites for new generation and transmission facilities of any kind. In the U.S., no nuclear power plants have been
ordered or built since 1978. Given the potential for cost overruns, safety-related design changes during the construction, and local opposition to new plants during the last three decades. If no new nuclear plants are built and the existing plants are not relicensed at the expiration of their 40-yr terms, the nuclear power
output is expected to decline sharply after 2010. This decline must be replaced by other means. With gas prices expected to rise in the long run, utilities are projected to turn increasingly to coal for base-load power generation. The U.S. has enormous reserves of coal, equivalent to more than 250 yr of use at the current level. However, this will need clean coal-burning technologies that are fully acceptable to the public.
Alternatives to nuclear and fossil fuel power are renewable energy technologies (hydroelectric, in addition to those previously mentioned). Large-scale hydroelectric projects have become increasingly difficult to carry through in recent years because of the competing use of land and water. Relicensing requirements of existing hydroelectric plants may even lead to removal of some dams to protect or restore wildlife habitats. Among the other renewable power sources, wind and solar have recently experienced rapid growth around the world. Having wide geographical spread, they can be generated near the load centers, thus simultaneously eliminating the need for high-voltage transmission lines running through rural and urban landscapes.
The electricity demand in the U.S. grew at 6 to 7% until the late 1970s, tapering to just 2% in the 1990s and beyond. The 7% growth rate of the 1970s meant doubling the electric energy demand and the installed capacity every 10 yr. The decline in the growth rate since then has come partly from the improved efficiency in electricity utilization through programs funded by the U.S. Department of Energy. The small growth rate of the last decade is expected to continue well into the coming decades. The most economical sizes of the conventional power plant had been 500-MW to 1000-MW capacities. These sizes could be justified until the 1970s, as they would be fully

loaded in just a few years. At the present 2% growth rate, however, it would take decades before a 500-MW plant would be fully loaded after it is commissioned in service. Utilities are unwilling to take such long-term risks in making investment decisions. This has created a strong need for modularity in today's power generation industry.