

Building the Energy Infrastructure of the Future

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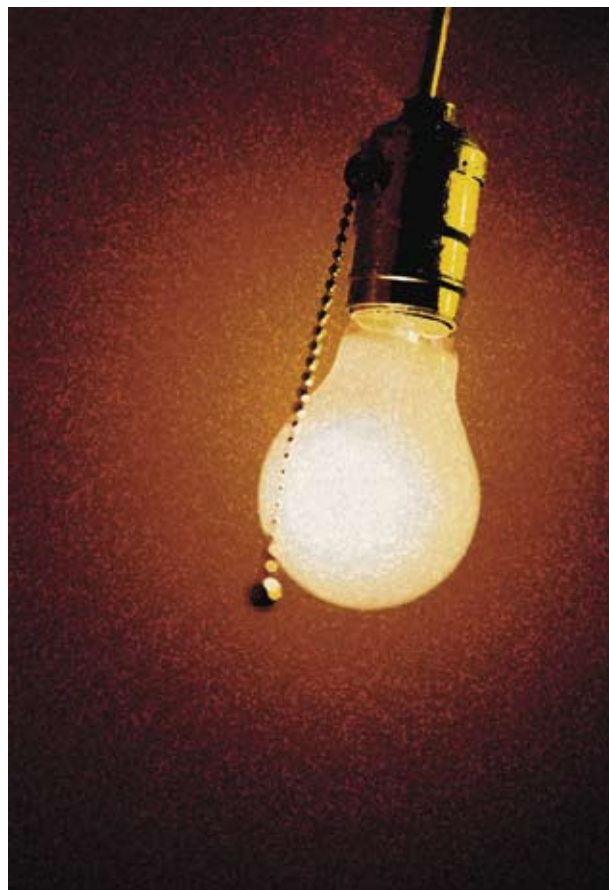
As the father of two young boys, I often think about what the future may hold for them and for their children. What will our world be like in 25 or 30 years? Will our energy sources still be primarily hydrocarbon based? Or will technology advance to the point where my sons will be driving vehicles fueled by hydrogen or solar power? Whatever the energy future may bring, there is one thing we can be sure of: Engineering and construction (E&C) companies will be needed to build the infrastructure that brings energy sources to consumers.

Hydrocarbons Will Still Be Around

Today, fossil fuels are the predominant energy source worldwide, and most forecasters believe this will still be the case 25 years from now. In its *World Energy Outlook 2005*, the International Energy Agency (IEA) predicts that fossil fuels will continue to dominate energy supplies between now and 2030. In fact, the IEA believes hydrocarbon-based fuels will meet more than 80 percent of the projected increase in primary energy demand, which is expected to double in the next 25 years.

The IEA believes the world's energy reserves are adequate to meet this level of demand, and it estimates that investment in the energy sector on the order of \$17 trillion will be needed during the period. While increased oil exploration and production will consume a major portion of the expenditures, the IEA also notes an urgent need for more distillation and upgrading capacity in the oil refining industry. Growth in demand for refined products, coupled with the trend toward production of heavier crude oils, is driving the need for additional capacity. Oilfield-services companies will help energy producers build the drill rigs to explore and produce from new fields and enhance production from existing fields, while E&C companies will help refiners expand their plants to process the crude and increase distribution channels.

But what if our oil resources run out? Adherents of the peak oil theory, initially proposed by geophysicist M. King Hubbert in 1956, suggest that world oil production



has already peaked or will peak in the next few years, followed by a gradual but inevitable decline in the amount of oil available worldwide and corresponding escalation of price. Some proponents of the peak oil theory predict near-doomsday consequences, including a sharp decline in world economic growth, lower living standards, higher food prices due to more expensive feedstock used to produce fertilizers, exploding transportation costs and political instability.

Opponents of the peak oil theory, while acknowledging that oil is a finite resource, argue that Hubbert's theory doesn't take into account the increasing amount of oil production from so-called nontraditional sources. Expanding the definition of oil to include a range of liquid hydrocarbons, nontraditional sources include oil recovered from ultra-deep waters, condensates and

natural gas liquids, and synthetic crudes derived from oil sands, gas-to-liquids and coal-to-liquids technologies. Analysts at Cambridge Energy Research Associates do not believe that peak oil is imminent and see no evidence to suggest a peak before 2020 at the earliest. An analysis by the U.S. Geological Survey in 2000 predicts that world crude oil production would be expected to peak in 2037.

Whatever side you may favor in the peak oil debate, we must face the reality that at some point in the future, oil will become scarcer and more costly to produce. At the same time, there is a growing consensus that alternatives to hydrocarbon-based fuels are needed to lower carbon dioxide emissions and improve environmental quality. These factors have prompted governmental bodies, like the U.S. Department of Energy, and major energy producers to engage in the research and development of potential future energy sources that are not hydrocarbon based.

Alternative Energy Sources Will Grow

A number of alternative energy sources are in various stages of development around the world. Some of these sources are considered renewable, in that they are derived from ongoing natural processes such as the sun, wind, tides and flowing water.

Nuclear power. This hydrocarbon alternative has been in use for many years with broadly commercialized technology. Nuclear power plants use the heat generated from fission reactions to produce steam that drives turbine generators to produce electricity. Consumption of electricity generated from nuclear power worldwide is projected to increase in the coming years. Prospects for nuclear power have improved in recent years, due in part to higher fossil fuel prices and the entry into force of the Kyoto Protocol, which requires participating countries to reduce energy-related carbon dioxide emissions. New nuclear generating capacity is expected to be built in emerging Asian economies and in the countries of the former Soviet Union.

Hydropower. Another proven alternative energy source, hydroelectric (hydropower) energy employs the force of falling water to drive turbine generators to produce electricity. Growth in electricity generation is expected to result from the completion of large hydroelectric facilities in emerging economies, particularly in Asia. China, India and Laos, among other Asian economies, already are constructing or planning new large-scale hydroelectric facilities.

Biomass is a renewable energy source that is produced from organic matter. Biomass fuels include wood, forest and mill residues, animal waste, grains, agricultural

crops and aquatic plants. These materials are used as fuel to generate steam, or they are processed into liquids and gases, which can be burned to do the same thing. One method of using biomass is to ferment and distill starch crops, such as corn, barley and wheat, to produce ethanol. Ethanol can also be produced from "cellulosic biomass" such as trees and grasses and is called bioethanol. Ethanol is blended with gasoline and is used to increase octane and improve the emissions quality of gasoline.

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Biodiesel is similar to biomass and can be manufactured from vegetable oils, animal fats or recycled restaurant greases. Biodiesel can be used in its pure form or can be blended with petroleum diesel in any percentage. Biodiesel recently received a commercial boost in the United States when country and western singer Willie Nelson began marketing "BioWillie" brand biodiesel in various locations across the country.

Geothermal energy uses heat from within the earth. Wells are drilled into geothermal reservoirs to bring hot water or steam to the surface, which is then used to drive a turbine to generate electricity. In some places this heat is used directly to heat homes and greenhouses, or to provide process heat for businesses or industries.

Solar energy is produced as special panels of photovoltaic cells capture light from the sun and convert it directly to electricity, which is stored in a battery. At present, the potential of the solar industry is underdeveloped, with less than 1 percent of global electricity produced from the sun.

Wind energy can also be used to generate electricity. The wind spins the blades on a wind turbine, which turns a generator to produce electricity. For a wind turbine to work efficiently, wind speeds generally must be above 12 to 14 miles per hour. Europe is the leader in wind-generating capacity, with about 75 percent of the global share. The European Union's Renewable Directive calls for 22 percent of its power to be produced from renewable sources by 2010, and wind energy will comprise a significant portion of this total.

Ocean-derived energy sources include tidal, wave and oceanic thermal energy conversion. Tidal energy works

from the power of changing tides, but it needs large tidal differences to function effectively. The tidal process uses the natural motion of the tides to fill reservoirs, which are then slowly discharged through electricity-producing turbines. Wave energy conversion extracts energy from surface waves, from pressure fluctuation below the water's surface or from the full wave. Oceanic thermal energy conversion converts solar radiation to electric power. This process uses the difference in temperature between warm surface waters heated by the sun and colder waters found at ocean depths to generate electricity.

Fuel cells are devices that directly convert hydrogen into electricity. The primary by-product of fuels cells is water, making it an extremely clean power source. Because hydrogen is rarely found in its pure form, it must be extracted from another substance such as water or natural gas before it can be used as a fuel.

Hydrogen can be produced from natural gas by a process called steam reforming, which converts methane into hydrogen and carbon monoxide by reaction with steam over a nickel catalyst. Hydrogen can also be produced by electrolysis, which uses electrical current to split water into hydrogen and oxygen. Today, about 95 percent of the hydrogen we use is produced by steam reforming.

Some experts think that hydrogen will form the basic energy infrastructure that will power future societies, replacing today's natural gas, oil, coal and electricity infrastructures. They envision a new "hydrogen economy" to replace our current fossil fuel-based economy.

However, significant questions regarding the economic and technical feasibility of this emerging industry must be answered before widespread use of hydrogen as a primary energy source is possible. For one thing, fuel cells are still many years from large-scale commercial development. Also, the hydrogen industry is only as sustainable as the sources and processes used to produce hydrogen. The current practice of producing hydrogen primarily from fossil fuels may be sustainable in the short term, but in the longer term, a way must be found to achieve large-scale production of hydrogen from renewable sources. In addition, for hydrogen to be used as a transportation fuel, better means of storing hydrogen on a vehicle must be found within the vehicular constraints of weight, volume, efficiency, safety and cost.

E&C Will Continue to Play an Important Role

Of the alternative energy sources outlined above, nuclear and hydropower have the most developed infrastructure, with wind and solar power also fairly well established. The other alternative and renewable sources cited are still in the research and development stage and/or in very

early stages of commercial development. Much work lies ahead before any of these sources will be able to provide a significant portion of the world's energy requirements for electricity and transportation.

Whatever the future may hold, there is no question that in the near term hydrocarbon-based fuel sources will continue to meet the bulk of the world's energy demand. And engineering and construction companies will work hand in hand with energy providers to expand production, processing, storage and distribution of these valuable natural resources. A critical task for E&C companies will be to ensure that we have sufficient human resources, especially engineers and skilled craftsmen, to design and build the facilities that will be required. Now, if I can only convince my sons to pursue careers in engineering. ■

Gerald M. Glenn is chairman, president and chief executive officer of CB&I, a global engineering, procurement and construction (EPC) company. He was appointed to his current position in February 1996.

Under Mr. Glenn's leadership, CB&I embarked on an ambitious cost-reduction and growth program, culminating in the acquisitions of Howe-Baker International, LLC, the Engineered Construction and Water Divisions of Pitt-Des Moines Inc., the U.S. EPC operations of Petrofac Limited and John Brown Hydrocarbons Limited. These acquisitions have vaulted CB&I's revenues to an annual rate of nearly \$2 billion and have positioned the company as one of the world's premier providers of turnkey low-temperature, cryogenic and above-ground storage systems, as well as hydrocarbon processing plants.

Mr. Glenn is active in the United Way and serves on the board of directors of Junior Achievement of Southeast Texas and the school board for the John Cooper School. He and his wife served as co-chairs of the 2005 Montgomery County Heart Ball. Mr. Glenn also sits on the board of the Gas Technology Institute, and he is a member of the Chicago Council on Foreign Relations, the Economic Club of Chicago, the Executives' Club of Chicago, the Mid-America Committee, the US-ASEAN Business Council, the 25 Year Club of the Petroleum Industry, the Greater Houston Partnership and numerous other organizations.

Mr. Glenn is a graduate of Clemson University, where he received a bachelor's degree in civil engineering. He and his wife, Candice, live in The Woodlands, Texas, with their two sons.