RENEWABLES
Looking Toward Inexhaustible Energy

Michael Eckhart

Courtesy Wade Newhouse/ Stirling Energy Systems, Inc.

An artist's rendering of a planned Stirling Energy Systems solar power plant in the Mojave Desert, California.

A major expansion of renewable energy worldwide will require innovative government policies, a stable and predictable investment environment, and technology transfers to the developing countries.

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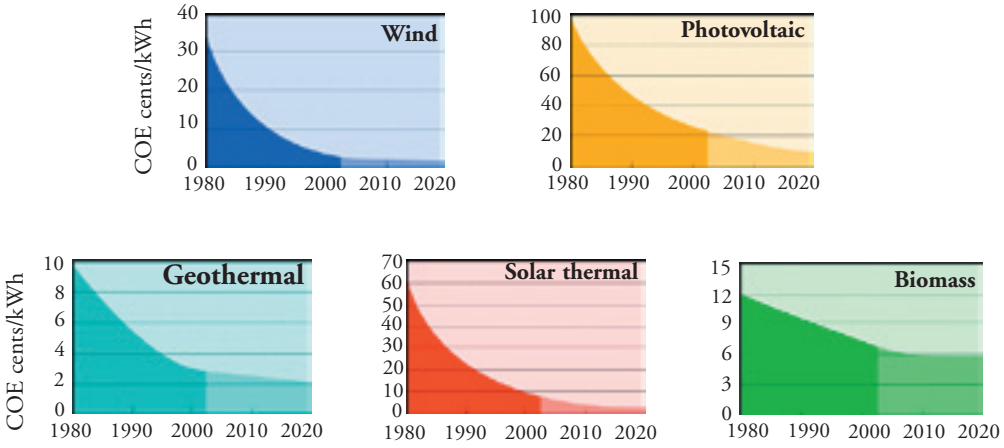
The renewable energy sector is about to turn a corner. Commercially available and economically competitive in many locations, renewables will further U.S. national interests by helping end our addiction to oil and begin to address the issue of global warming. The industry is poised for Phase II, putting America's 30-year, $15 billion investment in research, development, and demonstration of renewable energy technologies to use in the marketplace.

MARKET DRIVERS

There are three key drivers pulling markets toward renewables. The first is national energy security. Current projections show U.S. oil consumption increasing and outpacing flat domestic production curves, leaving the United States increasingly dependent on foreign oil

Decline in Renewable Energy Costs



These graphs are reflections of historical cost trends, NOT precise annual historical data.
COE = Cost of Energy.
Source: National Renewable Energy Laboratory (www.nrel.gov/analysis/docs/cost_curves_2002.ppt).

markets. This would make the U.S. economy vulnerable to disruption in oil imports.

Additionally, the rapid growth of developing countries such as China and India places an increasing strain on world oil markets, a problem that is likely to get worse over time. The effects of this can already be seen: The price of oil surpassed $70 per barrel in mid-June 2006, up from $30 only a few years ago. Renewable energy can help the United States rely on domestic sources of energy, which will reduce our need for oil or lessen the growth of our consumption.

A second driver toward renewable energy is concern about climate change. Renewable energy can help provide for our energy requirements while decreasing our greenhouse gas emissions. According to several news sources, more than 2,000 scientists have concurred that greenhouse gases such as carbon dioxide and methane are building up in the Earth's thin atmosphere and that this buildup of gases is increasing global temperatures. Many of these scientists believe that this increase of temperatures portends negative and potentially catastrophic consequences, that the time frame for addressing the issue is now, and that there are actions that can be taken. Use of carbon-free renewable energy is one of them.

A third market driver is the cost of renewable energy, which has been decreasing for decades and is projected to continue to decrease for some renewables, as shown in the figure above. The decreasing costs of renewable energies can be attributed to improvements in the technologies of the renewables. As the industry matures, costs will continue to decrease.

Putting Renewable Energy to Use

The uneven distribution of renewable energy resources across the United States makes it difficult to have a single, sweeping national policy. Solar energy is strongest in the Southwest; wind power is most used in the Great Plains, on mountain ridges, and offshore; and geothermal energy is available in the West. Biomass is available across the country, but regionally in different forms. Biofuels are being produced in the farming states but consumed in cities that have air quality restrictions.

There are multitude of local markets for renewable energy across America, each with unique resources, economics, culture, and politics. Individual states have taken the lead in the renewable sector. Nearly half of the states employ a renewable portfolio standard (RPS)—a system of goals for producing renewable energy. The employment of RPSs at the state level requires utilities to provide a particular amount of energy from renewable sources by a specific date, thus creating new demand for renewable energy immediately.

Elsewhere, the European Union has taken steps toward promoting renewable energy use and is a source of policy

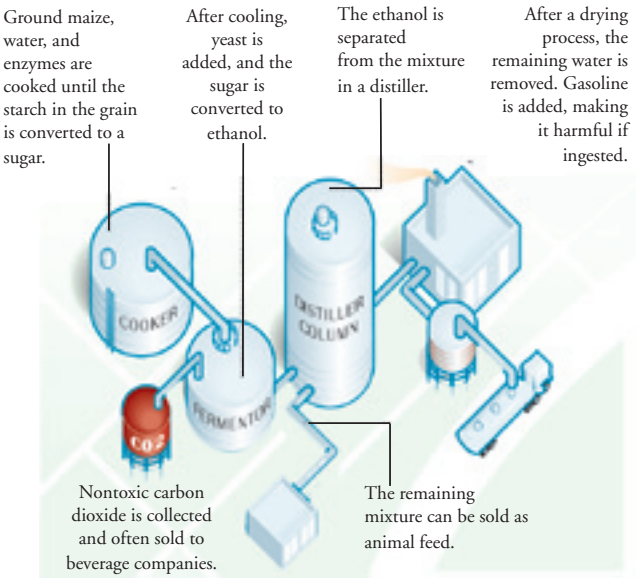
innovation. Germany, Spain, Italy, and others have implemented feed-in tariffs—the price per unit of electricity that a utility or supplier has to pay for renewable electricity from private generators. Meanwhile, Finland, Greece, and the United Kingdom have grants, tax incentives, and mandates for people to produce or use green power.

There have been widespread efforts to deploy renewable energy in the developing countries, with funding by the U.S. Agency for International Development and many donor agencies, and with financing support by the World Bank, European and other regional development banks, and the private sector. India was one of the first to commit to broad-based use of renewables and is active in wind, solar, hydro, and biomass energy. Brazil has been the early leader in sugar-based ethanol. Southern India, Sri Lanka, and Bangladesh have developed markets for the use of solar photovoltaics (PV), getting initial electricity to off-grid homes. China has developed a $3-billion-per-year solar water heating industry.

Maize-Based Ethanol Into Gasoline

The United States produced about 3.4 billion gallons of fuel ethanol in 2004. Almost 86 percent of that came from the Midwest, which produces more than two-thirds of the nation's maize.

Making of fuel ethanol



AP/Associated Press Graphics

Wind Power

Wind power is the leader in *wholesale* renewable electricity production in the United States. Total installed U.S. wind power capacity was 9,149 megawatts at the beginning of 2006, according to the American Wind Energy Association. A large part of this—2,420 megawatts—was installed in 2005, and an estimated 3,000 megawatts is planned for installation in 2006. With recent technological advances, the price competitiveness of wind generation versus natural gas has improved, supporting continued growth. In addition, the U.S. federal government offers companies a production tax credit for wind power equal to about 1.9 cents per watt-hour. This has been a powerful incentive to attract tax-oriented investors, such as utility companies, into wind farm ownership.

The original market for wind power was Denmark in the late 1990s, followed by Germany. Today, the hot markets are Spain, Italy, France, the United Kingdom, and India. But wind power is available almost everywhere.

Solar Energy

Solar PV, a $12-billion global industry, is the leading renewable power source for *distributed* power generation (consumers who generate heat or electricity for their own needs and send surplus electrical power back to utilities), with recent growth in Japan, Germany, and Spain.

In 2005, the U.S. Energy Policy Act established a 30 percent federal tax credit for solar systems purchased for both residential and business applications in the United States, on top of substantial subsidy programs in states such as California and New Jersey.

In the developing countries, PV has great opportunity but has proven difficult to implement because it requires a local infrastructure of companies to sell, install, and service the equipment, and needs financing, which often is not available. Yet, markets are growing in India, Sri Lanka, Bangladesh, Morocco, Kenya, South Africa, and elsewhere.

BIOFUELS

Biofuels, principally maize-based ethanol, present the biggest investment opportunity in renewable energy in the United States for the next several years. Recent evidence assembled by Lawrence Berkeley Laboratory rebuts outdated beliefs from the 1970s that, because of the energy-intensive production, environmental benefits from maize-based ethanol are nonexistent. It now appears that producing maize-based ethanol requires much less petroleum than producing gasoline and that greenhouse gas emissions from such an ethanol are about 15 percent to 20 percent lower than from gasoline. New cellulosic ethanol technology reduces both greenhouse gas emissions and petroleum inputs even more substantially. With ethanol replacing methyl tertiary-butyl ether (a chemical compound used as a fuel component in gasoline that has been banned in 22 states), demand has grown rapidly. In 2006, more than 4.7 billion gallons (17.9 billion liters) of ethanol will be produced, and there are 2 billion gallons (7.6 billion liters) per year of new processing capacity under construction in the United States.

The U.S. auto manufacturers have taken notice of the recent interest in biofuels. General Motors, for example, currently produces nine models that can run on E85, a mixture of 85 percent ethanol and 15 percent gasoline.

INVESTMENT

Large investments are being made in renewable energy companies and projects. Venture capitalists invested close to $181 million in alternative energy companies in 2005, an increase of $78 million from the previous year, according to PricewaterhouseCoopers, Thomson Venture Economics, and the National Venture Capital Association.

Major industry leaders have begun to take notice of this growing market opportunity and are showing their support. For example, General Electric recently invested $51 million in a 50-megawatt wind project in California, and Cascade Investment LLC placed $84 million into Pacific Ethanol, which produces and markets renewable fuels. The accelerated market growth has created a favorable environment for investors, with opportunities for substantial profits, as well as risks, in this now $50-billion-a-year industry.

Simon Fraser/Photo Researchers Inc.

Geothermally heated greenhouse in Hveragerdi, Iceland.

NATIONAL AND GLOBAL BENEFITS

Renewable energy is a broad category of sources that draws from the naturally available energy around us. While not a silver bullet, the more we use it, the better off we will be in terms of reducing oil imports, reducing pollution and greenhouse gas emissions, and increasing jobs.

Renewable energy can provide significant opportunities for developing countries and rural areas. For example, by providing new jobs and new sources of income for farmers and ranchers, the Colorado Green Wind Farm in Lamar, Colorado, boosted the local county tax base by 29 percent, increased the school general fund by $917,000 per year, and increased funding of the county medical center by $189,000.

The potential of renewable energy is vast. It contributes to America's needs for security of supply, a cleaner environment, good jobs, and investment opportunities. The rural sector of America stands to receive the most benefits from renewable energy development.

Such development also offers opportunity to the rural people of the world everywhere to gain access to modern forms of energy. Wind, solar, geothermal, biomass, and small hydro plants can generate electricity for rural

utilities and villages. Solar PV and solar water heating can bring modern energy to homes.

OUTLOOK

The outlook for renewable energy in the United States and around the world is positive and accelerating. This is a challenge for government policy planners who have to rely on computer modeling projections that can be out of date because oil prices have increased rapidly and demand for renewable energy has accelerated. For example, while the official U.S. forecast from the Energy Information Agency shows renewable energy contributing only about 10 percent of U.S. energy supply in 2030, various industry groups are more optimistic. The Energy Future Coalition is calling for 25 percent by 2025, and ACORE sees the potential for 20 percent, 30 percent, and 40 percent by 2020, 2030, and 2040, respectively.

To make this happen, conventional energy prices must continue to stay high, renewable energy costs must continue to come down, and government policies must be stable and predictable to encourage commitment of lenders and investors to the financing of renewable energy systems. There also must be international collaboration to transfer the technologies to the developing countries. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government.

AMORE
Renewable Energy for Development in Mindanao

A solar panel is not just a solar panel—a device generating "clean" electricity. In the developing world, it can open the door to development and light the road to it, too.

In the Philippine's Autonomous Region in Muslim Mindanao, ravaged by three decades of civil unrest, solar photovoltaic panels and micro-hydropower systems have helped improve public health and education, nourish entrepreneurship, empower women, and enhance a sense of community and peaceful coexistence. The panels were installed by the U.S. Agency for International Development's (USAID) Alliance for Mindanao Off-Grid Renewable Energy (AMORE). AMORE was established in 2002 to provide electricity from renewable sources to villages on the southern Philippines islands, which are far from the national energy grid.

Alliance for Mindanao Off-Grid Renewable Energy.

Villagers erect a solar photovoltaic panel in Mindanao, Philippines.

As of March 2006, AMORE had electrified more than 1,300 households, community centers, and streets in 227 *barangays* (villages). In the future it plans to equip with sustainable, renewable small-scale energy systems at least 170 more remote rural communities in the region.

Solar-powered lights cost 70 percent less per month to operate than kerosene lamps and save the carbon dioxide such lamps produce from entering the atmosphere. AMORE's efforts are helping to increase outdoor safety and significantly boost business and educational productivity by allowing work and study to extend into evening hours. Maintained by community development groups, the stand-alone energy systems also enable aspiring entrepreneurs to pursue new small-business projects such as mat-making and other local crafts.

But the development drive does not stop there. Electrification has given an impulse to related programs—installing solar-driven pumps to provide clean drinking water and irrigate vegetable farms, as well as delivering audio materials through radio to villagers wanting to study English. AMORE also has promoted using renewable energy for fish drying, for producing fish and seaweed by aquaculture, and for powering public telecommunications offices, a community computer center, and cable TV facilities. Some of these projects attracted partners that were not part of the original alliance.

AMORE energized the village of Chua in Bagumbayan, Sultan Kudarat, when it installed an 8-kilowatt micro-hydropower system and established a spring-fed potable water system, an integrated grain and bean mill, and a vegetable farm. Electrifying the local school enabled powering distant educational facilities.

In the village of Kahikukuk in Banguingi on the island province of Sulu, a potable water system is expected to reduce the incidence of diarrhea and other waterborne diseases. Before the system was installed, the village residents—mostly women and young girls—fetched water from unsafe makeshift wells 1.5 kilometers away from their residences.

AMORE applies in practice the idea of self-propelled development. Putting the operation and maintenance of energy and other systems into the hands of local development groups has ignited a sense of community and responsibility. Such a group in Barangay Lagasan not only used its own resources and funds to protect the systems from pilferage, but also raised funds to purchase a streetlamp. The U.S. embassy in Manila concluded in an article published on its Web site that Barangay Lagasan and similar groups have evolved into organizations that promote community progress. An island community leader was heard saying: "Among the best things that the AMORE program has done in our community was that they provided the light that brought us closer."

The AMORE Alliance includes the Autonomous Region in Muslim Mindanao, the government of the Netherlands, Mirant Philippines Corporation, the Philippines Department of Energy, Shell Solar, and SunPower Corporation. ■

CONVENTIONAL BIODIESEL CROPS

Typical crops for conventional biodiesel production include soy, sunflower, rapeseed, palm, and other oilseed bearing crops such as jatropha.

Soybeans are grown as a commercial crop in more than 35 countries. The major producers are the United States, China, the Democratic People's Republic of Korea, the Republic of Korea, Argentina, and Brazil. Soybean is grown primarily for the production of seed. It has a multitude of uses in the food and industrial sectors (including biodiesel production) and represents one of the major sources of edible vegetable oil and proteins for livestock feed use. Soybeans are often rotated with such crops as maize, winter wheat, spring cereals, and dry beans.

The many diverse species of sunflowers produce two types of seeds: oil-bearing and edible. Oil seeds have an oil content greater than 40 percent and are best suited for biodiesel production. The main producers of sunflower seeds are Russia, Ukraine, and Argentina, but sunflowers are also widely cultivated in China, India, the United States, and Europe. Yields vary widely according to the growing environment. Water availability is the main cause of the variations.

Rapeseed (colza) is a member of the mustard family. Two types of rape are commonly cultivated to produce either tuber-bearing or oil-bearing rapeseed. Rapeseed is used for the production of edible oil in Asia and elsewhere for the production of animal feed, vegetable oil, and biodiesel. China, India, Europe, and Canada are now the top producers, although rapeseed can be successfully grown in the United States, South America, and Australia. The spring-type oleiferous rapeseed performs well under a wide range of soil conditions but is not very drought tolerant. Oilseed rape cannot be grown on the same field more than once every three years to prevent the buildup of diseases, insects, and weeds.

Crops for biodiesel demand more than three times as much land as sugar cane used for ethanol to deliver the same amount of biofuel energy. Sunflower and rapeseed lead to much lower biofuel yields per hectare than those for ethanol. The typical yield of soybeans cultivated in Brazil is 600 to 700 liters of diesel equivalent per hectare, while European rapeseed yields are around 1,100 liters of diesel equivalent per hectare.

Palm oil offers an opportunity for expanding the energy supply in developing countries by using it as a biomass resource. Care should be paid to analyze which areas of land are used to supply the palm fruits, as palm oil plantations grown in tropical areas are a major cause of deforestation in countries like Malaysia and Indonesia. Malaysia is the world's largest producer and exporter of palm oil. As with other oily crops, current estimates of fuel yield from palm oil are low: about 900 liters of diesel equivalent per hectare.

Oil-importing countries are considering the production of biodiesel from physic nut or jatropha grown on degraded land. The idea is not to compete with land where profitable food production would be possible. The jatropha tree is indigenous to South America, but it is widely planted in Central America, Africa, and Asia. It is adapted to high temperatures, and it can tolerate drought. The tree is well adapted to marginal soils with low nutrient content. Its cultivation is technologically simple and requires comparatively low capital investment. The oil of the physic nut can be used after detoxification to make edible oil, or it can be converted into biodiesel. Nicaragua is a leading producer of biological diesel substitute based on the oil of the physic nut. ■

Source: *Energy Technology Perspectives: Scenarios and Strategies to 2050.* Paris: International Energy Agency, June 2006. *(Copyright OECD/IEA, 2006)*