BIO-ENERGY:
MOMENTUM IS BUILDING FOR LARGE SCALE DEVELOPMENT

DR. JIM BOWYER

DR. JEFF HOWE
PHIL GUILLERY
KATHRYN FERNHOLZ

MAY 20, 2005

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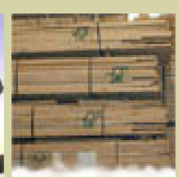
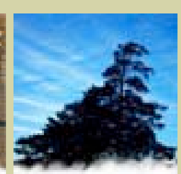
    

Bio-Energy

Momentum is Building for Large Scale Development

Introduction

Bio-energy is not a new idea. The first deliberate use of bio-energy occurred when prehistoric peoples discovered how to use fire to keep warm. The use of fire for heating and later for cooking, pottery making, and to provide light goes back at least 200,000 years. In the United States, wood was a principal fuel for heating and cooking as recently as 1900. Thereafter, coal, oil, and natural gas became dominant fuels. However, the oil embargo of the early 1970s resulted in marked growth of wood consumption for fuel, with volumes consumed for that purpose briefly rising to near the levels of 1900. Worldwide, the primary use of wood today is still as a fuel for heating and cooking. In other regions where wood is scarce, animal dung – another biomaterial – has long been used as a fuel.

After decades of debate about how long the age of petroleum abundance might last, it now appears that the year of peak petroleum production worldwide may be in sight. With the peak now likely to occur within one to three decades, complacency is beginning to be replaced by a sense of urgency. Alternative fuels and energy sources will soon be needed. So, too will alternative sources of chemicals and industrial feedstock now provided as by-products from liquid fuels production.

Biomaterials are one potential source of energy and chemicals. In a period in which a great deal of attention has been focused on development of cost-effective means of capturing and using solar energy, bio-materials as a source of energy have, until fairly recently, remained below the radar of policy-makers. However, biomass produced by plants through solar-energy-driven photosynthesis and subsequent growth processes has the potential to provide significant quantities of energy, as well as a wide array of chemical compounds useful to industry. It appears that a bio-revolution – as long predicted by Dr. David Morris of the Minneapolis-based Institute for Local Self Reliance (http://www.ilsr.org) – may soon be at hand as momentum builds for large-scale bio-energy development.

> The Carbohydrate Economy
>
> New technologies, new laws and an increasingly aware public are ushering in a new materials base for the 21st century – plant matter. Carbohydrates, the building blocks of plant matter, can be converted into chemicals, energy, textiles, building materials, paper, and many other industrial products. We call this new materials base a "carbohydrate economy." A carbohydrate economy reduces pollution, builds stronger rural communities, and supports a rooted farmer-owned manufacturing sector.
>
> *http://www.carbohydrateeconomy.org/*

Petroleum – Past, Present and Future

Past to Present

The Chinese are known to have used natural gas as a fuel as long ago as 1000 BC after accidentally discovering gas deposits while drilling for salt. In about 600 BC the Babylonians used asphalt in building walls and paving streets. Native Americans are also known to have used oil as a fuel and in making medicine at least as long ago as the early 1600s.

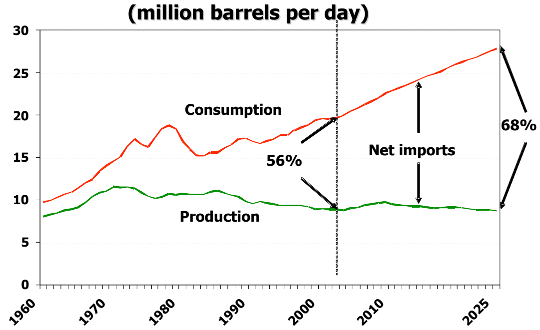
Large-scale use of petroleum did not occur until the mid-1800s. In that period, simultaneous development of oil resources is known to have begun in several locations around the world. Production and use of about 2,000 barrels of oil occurred in Romania in 1857, the nation credited with having the first oil industry. In that same year, the first oil well became operational within Canada. The first U.S. oil company was formed in 1857, and the first domestic oil well began production in 1859. The global oil industry developed rapidly thereafter.

The first common product made from oil was kerosene for use in lamps. This was by far the major petroleum product used in the U.S. through the latter half of the 19th century. By 1900 gasoline had become another established petroleum product, although only about 8,000 gasoline-powered vehicles were in use across the nation at that point. That number mushroomed to about 450,000 by 1910. The petroleum era was in full swing.

Rising consumption led to a worldwide search for what came to be known as "liquid gold." Oil was discovered in Iran in 1908, in Iraq in 1927, and in Saudi Arabia in 1938. By 1959, exactly 100 years after the first U.S. oil well came into operation, and less than 60 years after petroleum consumption became significant, U.S. petroleum reserves peaked. In 1970 domestic petroleum production peaked, beginning a steady decline that continues today.

Within three years of the U.S. peak in petroleum production, a reduction of petroleum production and an embargo on energy shipments to the U.S. and other nations by a number of Arab nations created energy supply problems and chaos in world economies. Marked price increases by principal oil-exporting nations again caused economic problems only several years later. Within the U.S. these developments helped to spur domestic energy conservation programs, development of nuclear energy, and the initiation of alternative energy research on a broad scale. Unfortunately, the obvious political maneuverings that led to the 1970s oil shortages also led to a widely held public view that shortages were not real, but only manufactured by governments and multinational corporations motivated by greed. After only a few years, interest in energy conservation and alternative energy research waned and robust growth of U.S. petroleum consumption resumed. The U.S. petroleum import reliance, which was 29 percent at the time of the oil embargo, has now grown to 58 percent, with this number expected to grow to 68 percent by 2025 (Figure 1).

Figure 1
U.S. Petroleum Supply, Consumption, and Imports, 1970-2025,
(million barrels per day)



Source: EIA Annual Energy Outlook, 2005.

What Lies Ahead

Numerous projections of petroleum reserves and depletion dates over the several decades following the 1970s oil shocks were mostly discounted by business and government leaders and by the general public. So too were rather sobering projections offered in the 1990s by several highly credible research organizations (Table 1). For example, the energy section of the Organization for Economic Cooperation and Development forecast that peak production would occur sometime between 2010 and 2020. Jonathan Edwards, who predicted within one year the U.S. peak, put the peak globally at 2020. However, what began to draw the attention of doubters was a year 2000 study by the U.S. Geological Survey, done at the request of the U.S. Department of Energy. This was the most comprehensive petroleum forecast undertaken, and involved assessments of known reserves, estimation of original and remaining stocks, and predictions of future expansion of reserves resulting from discovery of new oil fields and new technology development. Using 2% annual growth in global consumption as the most likely scenario, the USGS study concluded that peak production would likely occur in 2037. It was the first time that an entity of the U.S. government had predicted that peak production would be reached within the relatively near term. Subsequently, in early 2005, the 2% annual consumption growth figure was revised upward by DOE, to 3%. The effect was to lower the USGS peak production estimate to 2030.

Table 1
Consensus is Emerging that Peak Petroleum Production in in Sight

OECD International Energy Agency	2010-2020
World Resources Institute	2007-2014
J. Edwards, Colo. School of Mines	2020
U.S. Department of Energy	2037

Source: Kerr, R. 1998. The Next Oil Crisis Looms Large – and Perhaps Close. Science 281 (August 21), pp. 1128-1131.

Part of the reason for growing pessimism about longevity of petroleum supplies can be traced to the rapid emergence of China as an economic power. A net importer of fewer than 10,000 barrels of oil daily in 1970, China had net imports more than 200 times that by 2004. By 2025 China's daily net imports will approximate current U.S. net imports – more than 9 million barrels daily. Increasing oil consumption is not, of course, limited to China; other growing economies, including those of India and other Asian nations, are also exerting pressure on world oil supplies.

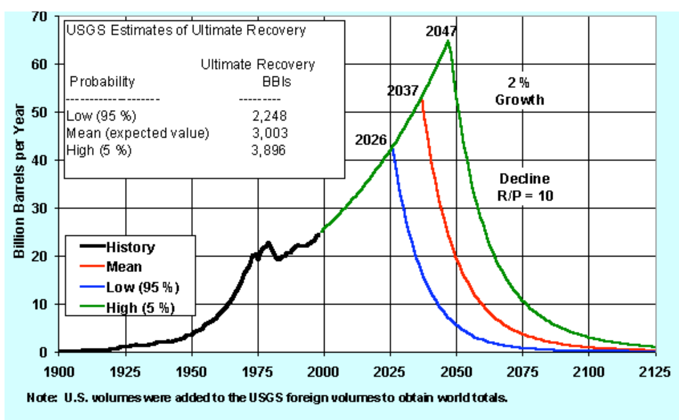
Table 2
China Petroleum Imports, 1970 -2030

Year	Barrels/Day Average Daily Imports
1970	< 10,000[a]
1997	800,000[a]
2004	2,100,000[b]
2025 (est.)	9,400,000[b]

Source: [a] Drennen, T. and Erickson, J. 1998. Science, vol. 279, p. 1483, and
[b] Energy Information Administration (www.eia.doe.gov/emeu/cabs/china.html)

As part of the USGS study, scenarios were developed regarding depletion of supply following peak production. That shown in Figure 2 is based on a rate of decline such that the reserve to annual production ratio remains constant at 10. All scenarios show a steep reduction as increasing consumption collides with a declining supply, suggesting chaotic conditions in world markets absent of the development of energy alternatives.

Figure 2
Annual Petroleum Production Scenarios With 2 Percent Growth Rates and Different Resource Levels



Source: U.S. Department of Energy, 2005.

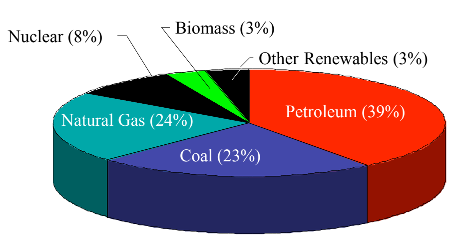
Within this environment it is interesting to note the U.S. response. To date, no clear answer to the petroleum supply dilemma has yet emerged. Large, fuel inefficient vehicles continue to dominate the U.S. passenger fleet. The average size of new homes continues to rise. No significant effort has been mounted to slow the growth in energy consumption. And, in the President's budget for 2006, large reductions in spending for alternative energy research and energy conservation are proposed. There are, however, proposed increases in the petroleum exploration budget as well as current proposals in both houses of Congress to markedly increase nuclear energy production. And, bio-fuels initiatives are being pursued by a number of states within the framework of a 1999 Executive Order issued by then President Clinton to accelerate the development and use of biomass fuels.

Bio-Energy Takes Center Stage

Potential Contributions Far Exceed Present Levels

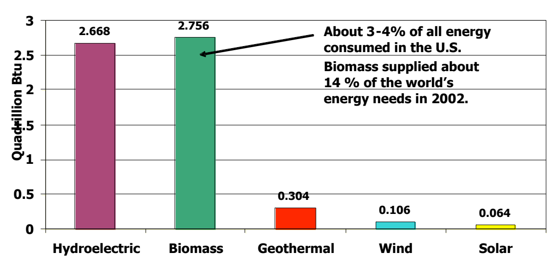
Biomass currently provides less than 3% of U.S. energy needs, but almost one-half of energy from renewable energy sources (Figures 3, 4). Today in the U.S., some 190 million tons of biomass is used annually for production of energy or bioproducts that directly displace petroleum-based feedstocks. Some 96 million tons, or slightly more than 50 percent of energy from biomass is produced by the forest products industry for use in powering manufacturing operations. As a result, this industry has a high degree of self-sufficiency, as over one-half of all energy used in the primary forest products industry is self-generated.

Figure 3
U.S. Energy Consumption by Fuel Type, 2003



Perlack, et al. 2005.

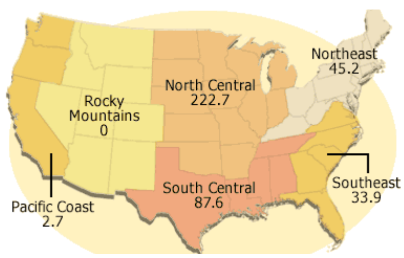
Figure 4
Consumption of Renewable Energy in the United States, 2002



Oregon Department of Energy. 2004. An Overview of Biomass Energy, (http:// www.energy.state.or.us /renew/)

The potential contribution of biomass to domestic energy production is far greater than the current level. For instance, there are about 392 million acres in the continental U.S. that are not being used for food production and that have the capacity of producing significant quantities of biomass without the need for irrigation (Figures 5, 6). Of these, some 55 million acres have been identified as available and having high potential for production of energy crops such as switchgrass, reed canary grass, poplar, eucalyptus, and other species. An estimated 377 million dry tons of biomass crops could be produced annually from these 55 million acres. In addition, an estimated 428 million dry tons of agricultural residues in excess of that needed for conservation tillage could be removed annually from U.S. farmland for production of bio-fuels. Another 368 million dry tons of woody biomass could be sustainably removed annually from the nation's forest lands and gleaned from current waste streams; a part of the woody biomass would come from non-commercial forest thinnings conducted for the purpose of reducing wildfire danger.

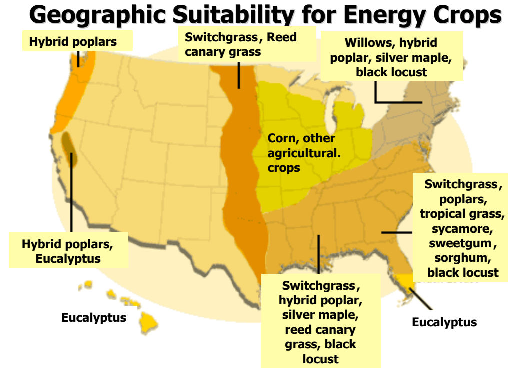
Figure 5
Available Acreage for Energy Crops



392 million acres of land in the U.S. is potentially available/suitable for energy crops.

Source: Tuskan, G., M. Downing, and L. Wright. 1994

Figure 6
Geographic Suitability for Energy Crops



Source: Tuskan, G., M. Downing, and L. Wright. 1994

Biomass is not the only potential source of bio-energy. Options include such things as methane gas from old landfill sites or from manure collected at feedlot or dairy operations, organic materials recovered from wastewater, and municipal solid waste. The volume of manure alone, considering only the volume in excess of that which can be applied for on-farm soil improvement, is estimated at 106 million dry tons annually.

As noted by Perlack et. al. (2005), if considering only agricultural and forest land, the two largest potential biomass sources, there is potential for annual production of over 1.3 billion dry tons of biomass in the U.S., a volume more than seven times the current volume of biomass consumed for production of bio-energy and bio-based products.

The potential for production of biomass-derived energy is outlined in a recent report issued jointly by the U.S. Department of Energy and the U.S. Department of Agriculture (Perlack et al. 2005). Goals as set forth in this report are based on use of 1.0 billion dry tons of biomass annually: by 2030 biomass will supply 5 percent of the nation's power, 20 percent of its transportation fuels, and 25 percent of its industrial chemicals and chemical feedstocks. This goal is equivalent to 30 percent of current petroleum consumption.

Not only is the energy production potential from such material substantial, but combustion of such material is carbon neutral. The growth of replacement crops following harvest sequesters atmospheric carbon in a quantity equivalent to that released when the harvested crop is burned. This represents a substantial advantage over the combustion of fossil fuels.

Bio-Energy Options

Options for use of biomass and other biomaterials in production of energy are many and include direct firing for electrical generation, production of ethanol, and use as a fuel in steam generation for either large-scale district heating or for powering manufacturing operations. Consideration of electric generation and ethanol production potentials illustrates the great potential for bio-energy production within the United States.

Wood May Be Tapped to Power Cars

April 12, 2005. Australia. A CSIRO analyst says wood could replace fossil fuels in powering vehicles and industry within 50 years.

Resource Futures senior analyst Barney Foran says wood alcohol, or methanol, will be used in the next generation of cars powered by fuel cells.

He says that forestry plantations will have to expand to provide enough wood but exhaust emissions from wood-based fuels would lower greenhouse gas levels.

“We just recycle the carbon through the trees, through our motors and then back into the atmosphere and back into the trees again,” he said.

“This is the essential game breaker we need to start doing something about Australia’s fossil fuel reliance, its oil dependency, and also the greenhouse emissions challenge this and other developed nations face.”

http://www.abc.net.au/news/newsitems/200504/s1343520.htm

Ethanol

In 2004, the production capacity of the U.S. corn ethanol industry reached about 3.3 billion gallons per year. The industry is concentrated in the Midwestern states, with Illinois, Iowa, and Minnesota the top producers. There is, however, considerable room for growth of this industry. It is estimated that production from biomass could eventually reach about 50 billion gallons annually, a sizeable quantity when compared to current annual gasoline consumption of about 138 billion gallons. Using current technology, production of this quantity of ethanol would require the consumption of the equivalent of approximately 30 billion gallons of gasoline, giving a net gain of some 20 billion gallons. Soon to be implemented technologies would raise the net gain to about 39 billion gallons. At current prices this would translate to a reduction in transfer payments to oil exporting nations of over $115 billion!

Electricity from Biomass

Sampson, citing a DOE database, reported a U.S. biomass electrical generating capacity of about 7,800 megawatts in 2000, with 350 plants spread across 39 of the 50 states. Another 650 biomass-powered generators in the nation’s industrial plants were in operation. Overall, the biomass electricity industry is estimated to have employed over 66,000 people in 1999, with an investment base of about $15 billion. A biomass electricity generating capacity of some 50,000 megawatts was said to be a possibility by as early as 2010; if all available biomass were converted to electricity, a capacity of over 70,000 average MW could be supported. This is again a large number when compared to U.S. electric consumption of 425,000 MW in 2004.

A Cautionary Note

Given the large potential contribution of bio-energy to the nation's energy supply rapid development is likely. However, it is worthwhile considering that the magnitude of bio-energy production as outlined can only be obtained by bringing vast areas of land into production. Moreover, the percentages of gasoline and electricity consumption cited herein are expressed in terms of *current* domestic consumption of both; even with maximum development of bio-energy resources, the percentages of national energy consumption of various energy products supplied in this way can be expected to drop steadily as consumption continues to grow.

As pointed out by several recent analyses of the emerging global energy picture, it is unlikely that world energy demand can be met in the decades ahead without success in reducing per capita consumption. As bio-energy development proceeds, parallel efforts to manage consumption and demand growth would appear to be imperative.

The Bottom Line

There is considerable potential for bio-energy development in the United States. Various forms of energy can be produced from biomass in the form of energy crops and crop residues and from forest thinnings. Significant energy potential also resides within such bio-resources as old landfill sites, manure collected at feedlot or dairy operations, organic materials recovered from wastewater, and municipal solid waste. Rapid development is currently underway.

As development proceeds, it is important to keep bio-energy potentials in perspective. Bio-energy is a carbon-neutral and renewable energy source. Nonetheless, the potential supply of bio-resources is not unlimited. In addition, production of biomass for energy production will bring non-trivial impacts to producing areas, and caution will be needed to ensure that depletion of one non-renewable resource – petroleum – isn't simply replaced by depletion of another critical resource – soil.

The future will likely require demand side management in addition to ongoing development of new energy supplies. Achievement of a sustainable energy future will require simultaneous pursuit of both strategies.

Dr. Jim Bowyer is a professor within the University of Minnesota's Department of Bio-based Products (part time) and an Elected Fellow of the International Academy of Wood Science. He is the current Chairman of the Tropical Forest Foundation, Chairman of the Minnesota Bio-fiber Council, Scientific Advisor to the Temperate Forest Foundation and Past President of the Forest Products Society (93-94), and of the Society of Wood Science and Technology (87-88).

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This Dovetail Report is made possible through the generous support of the Rockefeller Brothers Fund, Surdna Foundation, the Laird Norton Endowment Foundation and the McKnight Foundation.

DOVETAIL PARTNERS, INC.
4801 N. Highway 61, Suite 108
White Bear Lake, MN 55110
Phone: 651-762-4007
Fax: 651-762-9642
www.dovetailinc.org