

# **The 21<sup>st</sup> Century Challenge**

**by Robert Jawitz**

As we begin the 21<sup>st</sup> century, the world faces two major problems: the demise of oil and the rise of global warming. Having to solve them together, is what can be called the 21<sup>st</sup> Century Challenge.

## **The Demise of Oil**

The demise of oil is sometimes called “Peak Oil”. This is the moment in time when maximum global oil production is reached after which the reserves are quickly depleted. It was proposed by geophysicist M. King Hubbert in 1956. His bell-shaped curve predicted that peak oil for the world would arrive in the beginning of the 21<sup>st</sup> century and production would precipitously decline 65% by 2050 and 90% by the 2100. He was proven correct with the US production of oil and many analysts feel he is correct with the world production of oil.

The second factor contributing to the demise of oil in the Western Hemisphere is the geopolitical nature of the sources of oil. In the following table showing the owners of the crude oil reserves of the world, we see that 90% of the world’s proven oil reserves are controlled by national oil companies (NOC’s), most of which have a great deal of enmity toward the US and the West. These NOC’s may not follow predictable behavior of the free market system and may very well use oil as a political weapon to cripple the economies of the West.

## CRUDE OIL RESERVE OWNERS

RESERVES OF CRUDE OIL; MILLIONS OF BARRELS

COMPANY	COUNTRY	STATE CONTROL	RANK	OIL RESERVES
Saudi Arabia	Saudi Arabia	100%	1	259,800
NIOC	Iran	100%	2	125,800
Iraq NOC	Iraq	100%	3	115,000
KPC	Kuwait	100%	4	99,000
ADNOC	Abu Dhabi	100%	5	92,200
PDVSA	Venezuela	100%	6	77,200
Libya NOC	Libya	100%	7	39,000
NNPC	Nigeria	100%	8	35,255
Lukoil	Russia	Majority	9	16,114
QP	Qatar	100%	10	15,207
Gaz Prom	Russia	Majority	11	13,797
Pemex	Mexico	100%	12	13,671
Yukos	Russia		13	12,581
PetroChina	China	90%	14	11,536
Petrobras	Brazil	100%	15	11,365
Sonotrach	Algeria	100%	16	10,986
Rosneft	Russia		17	9,300
TNK-BP	Russia/UK		18	9,230
Chevron	US		19	8,000
ExxonMobil	US		20	7,813
Petronas	Malaysia	100%	21	7,600
BP	UK		22	7,591
Total	France		23	6,592
Surgutneftgas	Russia		23	6,592
ConocoPhillips	US		24	6,168
Tatneft	Russia	100%	25	5,872
Shell	UK/Netherlands		26	4,636
ONGC	India		27	4,120
Pertamina	Indonesia	100%	28	3,995
Eni	Italy		29	3,773
PDO	Oman	Majority	30	3,360
Statoil	Norway		31	1,761

Note: 90% of the world's proven oil reserves are controlled by national oil companies

Source: Oil and Gas Journal, Evaluate Energy, Reuters

Between these two factors alone, there is sufficient impetus for the US and the West to get off oil.

## Global Warming

But there is another, even more powerful, impetus, global warming. According to the Intergovernmental Panel on Climate Change (IPCC), the combustion of fossil fuels, particularly oil, coal and natural gas is the major contributor to global warming. This is because the emissions of Carbon (Carbon Dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), and Nitrous Oxide (N<sub>2</sub>O)) in our industrialized world are greater than the capacity of the land to absorb it creating a greenhouse effect in the atmosphere. This greenhouse effect traps the heat from the sun and elevates the surface temperature(s). This elevation of temperature is having and will have disastrous effects on the climate and the levels of oceans.

According to the Energy Information Administration of the US DOE, in 2006, oil provided 39% of primary energy consumption (coal 23%, natural gas 24%, non-fossil 15%) and 42% of resulting CO<sub>2</sub> emissions (coal 37% and natural gas (21%).

Because of global warming, it is not so easy to simply substitute our other combustion resources- coal, natural gas and wood for oil. As indicated above, only 15% of the US primary energy consumption is from non-fossil fuels and 3.3% of that is from biomass (mainly wood). According to the IPCC (2006, Table 2.2), wood and wood waste products have 112,000 kg of Carbon Dioxide, 30 kg of Methane and 4 kg of Nitrous Oxide per TeraJoule of energy. Since Methane has 23 times the greenhouse gas effect of CO<sub>2</sub> and Nitrous Oxide has 296 times the effect (LEAD, table 3.1), the net CO<sub>2</sub> effect of wood burning is 113,874 kg of CO<sub>2</sub>e/ TJ. Comparing that to crude oil combustion with 73,547 kg of CO<sub>2</sub>e/TJ and coal of 95,067 kg of CO<sub>2</sub>e/TJ, we see that the greenhouse effect of burning wood is 55% greater than oil and 20% greater than coal.

Thus, because of global warming, we need to seriously reduce not only our combustion of oil but also coal, natural gas and wood. How to do that is the challenge of the 21<sup>st</sup> century.

## Responding to the 21<sup>st</sup> Century Challenge

We can see that if we must get off oil and we are limited in the substitution with coal, natural gas and wood, we have a very difficult task ahead. The following is a chart of energy consumption by source provided by the Energy Information Administration (EIA) of the DOE:

Energy Source	2002	2003	2004	2005	2006
<b>Total<sup>a</sup></b>	<b>97.684</b>	<b>97.971</b>	<b>100.051</b>	<b>100.161</b>	<b>99.398</b>
Fossil Fuels	83.994	84.386	86.191	86.451	85.307
Coal	21.904	22.321	22.466	22.795	22.452
Coal Coke Net Imports	0.061	0.051	0.138	0.044	0.061
Natural Gas <sup>b</sup>	23.558	22.897	22.931	22.583	22.190
Petroleum <sup>c</sup>	38.227	38.809	40.294	40.393	39.958
Electricity Net Imports	0.072	0.022	0.039	0.084	0.063
Nuclear Electric Power	8.143	7.959	8.222	8.160	8.214
Renewable Energy	5.893	6.150	6.261	6.444	6.922
Biomass <sup>d</sup>	2.706	2.817	3.023	3.154	3.374
Biofuels	0.309	0.414	0.513	0.595	0.795
Waste	0.402	0.401	0.389	0.403	0.407
Wood Derived Fuels	1.995	2.002	2.121	2.156	2.172
Geothermal Energy	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV Energy	0.064	0.064	0.065	0.066	0.072
Wind Energy	0.105	0.115	0.142	0.178	0.264

<sup>a</sup> Ethanol blended into motor gasoline is included in both "Petroleum" and "Biomass," but is counted only once in total consumption.

<sup>b</sup> Includes supplemental gaseous fuels.

<sup>c</sup> Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.

<sup>d</sup> Biomass includes: biofuels, waste (landfill gas, MSW biogenic, and other biomass), wood and wood derived fuels.  
MSW=Municipal Solid Waste.

**Note:** Data revisions are discussed in Highlights section. Totals may not equal sum of components due to independent rounding.

**Sources:** Non-renewable energy: Energy Information Administration (EIA), Monthly Energy Review (MER) December 2007, DOE/EIA-0035 (2007/12) (Washington, DC, Decemberr 2007,) Tables 1.3, 1.4a and 1.4b. Renewable Energy: Table 2 of this report.

We can see that the non CO2 generating sources of energy; nuclear, wind, solar, hydro and geothermal only represented 11.8% (11.762/99.398 Qbtu) of our energy needs in 2006. It appears highly unlikely (probably impossible) to substitute those non-CO2 generating sources, even with new technologies, for the others in the coming decades or in time to obviate the problems of global warming.

We have three approaches to respond to the challenge of the 21<sup>st</sup> century:

1. We decrease our consumption (conservation)
2. We increase our capacity of non-CO2e generating sources.
3. We increase the absorptive capacity of CO2e by the earth.

### **Conservation**

Reducing consumption through conservation is the first and, probably, most likely approach to respond to the challenge. It is most likely because, as prices of fuels go up and as incomes remain stable (or even go down because of recession or depression caused by the energy crises), people will naturally conserve.

How much can we expect for conservation to reduce our energy use and therefore emissions? According to table 2.1a of the EIA, Energy Consumption by Sector, 1949-2006, in 1949 the US used 31,981,503 Bbtu for all sectors while in 2006 it estimated a use of 99,872,921 Bbtu. In 1949, there were 149,188,130 persons in the US which represented an energy use of .21 Bbtu/person (31,981,503/149,188,130). In 2006, there were 298,754,819 persons in the US which represented an energy use of .33 Bbtu/person (99,892,921/298,754,819). Thus, between 1949 and 2006, each person increased his/her energy use by 57.1%.

A lot has changed since 1949. We've become dependent on electric appliances, one auto per person, long commutes, and purchases of products that come a long way to the market places. A lot of that is

unnecessary. Our appliances can be more efficient, our autos can be more efficient, we now have an information technology that doesn't require long commutes to the office and we can (and will) purchase local products that don't need to be transported great distances.

We have technology on our side. The incandescent light bulb is being replaced by fast start fluorescents. We have insulations that can double the efficiencies of houses. We have automobile technologies that can double or triple the gas mileage we experienced in 1949.

For a start, it is realistic to shoot for an energy use per person that is equal to what we used in 1949: .21 Bbtu/person. That would represent a total energy use (for all sectors) of  $.21 \times 298,754,819$  or 62,738,000 Bbtu. If we use the savings of conservation to reduce CO2 generating sources, our existing non CO2 generating sources will have increased from 11.8% to 18.7% of total (11,762,000/62,738,000).

The US Census estimates the population of the US will reach 350,000,000 by 2025. If we use the factor of .21 Bbtu/person as our target benchmark, we would need to plan for a total energy consumption of 73,500,000 Bbtu in 2025.

### **New Sources of Non-CO2 Generation**

We can see in table 1.1 above that of the 11,762,000 Bbtu of non-CO2 generated energy consumed in 2006, 11,083,000 Bbtu was from Nuclear and Conventional (large) Hydro. According to the International Nuclear Safety Center, there are 72 existing nuclear power reactors in the US. According to the US Nuclear Regulatory Commission there are 27 applications (in 2007 and 2008) for new reactors. Because the storage capacity of Yucca Flats (if finally finished) will be filled by 2018 with existing nuclear waste, it remains to be seen if any of these nuclear applications will be approved. Furthermore, it is unlikely that

new large hydro dams will be approved considering the problems of siltation, evaporation and fish and wildlife disruption they cause.

The new sources of non-CO2 generation will have to be Geothermal, Wind, Solar, Small Hydro and Wave energy.

Geothermal energy in the US represented only 2800 mw of electricity generation in 2006 (not counting geothermal heat pumps) according to the Geothermal Energy Association (GEA). In the US in 2006, the total electric energy capacity in all the grids amounted to 986,215 mw in the summer and 1,022,347 mw in the winter or an average of about 1,000,000 mw. That 1,000,000 mw represents 39,652,851 Bbtu of consumption. Thus Geothermal represents today only .28% of generation or 111,027 Bbtu. The Western Governor's Council identified sites that could yield an additional 13,000 mw. If half of that gets developed, Geothermal can deliver 9,300 mw, .93% of total or 368,771 Bbtu.

Wind energy has been the success story all over the world for non-CO2 generation. According to the Global Wind Energy Council (GWEC), the US doubled its capacity in 2007 (accounting for 30% of all new generation) to 16,800 mw. By the end of 2008, the GWEC estimates that wind energy will supply 21,800 mw. Assuming that is average delivered generation (not plate capacity), that would represent 2.2% of the total generation in the US or 872,362 Bbtu. The GWEC estimates that by the end of 2009, the US will be the largest generator of wind energy in the world. At the developing pace of 5,000 mw/year, wind can be expected to deliver 85,000 mw of new potential by 2025 or a total of 106,800 mw. This would represent 4,234,833 Bbtu.

Solar potential is very difficult to predict because of the estimated change of costs of the photovoltaics. The American Solar Energy Society, however, has made some projections where it claims by 2030 the total delivery of solar power can be 200,000 mw. However, this makes some grand assumptions of

change between 2025 and 2030 and their own graphs show an estimated 80,000 mw by 2025. If we use the 80,000 mw by 2025, this would represent 3,172,000 Bbtu.

Small hydro is the sleeper. Small hydro is defined as installations of 10mw or less. The technology for small hydro has been around for over 100 years. During the energy crises of the 1970's, Congress asked the US Army Core of Engineers (USACE) to evaluate the potential of small hydro in various districts. In New England, the USACE found potential of 1,000 mw in just existing flood control dams not currently generating hydroelectricity or breached dams. The current total of the New England ISO generates about 32,000 mw. Thus, those dams alone could generate an additional 3% of capacity. Of course, not all districts have the water resources of New England. However, many, including the Pacific West, the Rockies and much of Appalachia have more water resources. If we average the nation at 3%, that would represent 30,000 mw by 2025. 30,000 mw would represent 1,190,000 Bbtu.

If we total the anticipated yield of geothermal, wind, solar and small hydro, the total comes to 8,965,604 Bbtu. Adding that to the existing generation of 11,762,000 Bbtu, the total in 2025 can be estimated at 20,727,604 Bbtu. If our target, including conservation, came to 73,500,000 Bbtu for the 2025 US population, CO2 free generation can represent 28.2% of the total energy required. This is a start but is still far short of what would be required to halt global warming by emissions only.

A wild card is wave energy. Inventions for harnessing the power of waves are new but very promising. One company, Ocean Power Technologies (OPT) has operating buoys in Hawaii, New Jersey , Scotland and Spain and is developing projects in Oregon, California, Washington State, England and France. According to the founder, Dr. George Taylor, there is sufficient wave energy on the California Coast alone to power the entire State (60,000 mw). We hesitate to predict this, but if he did do 60,000 mw on the entire West Coast and Hawaii by 2025, that would add 2,380,000 Bbtu to the yield bringing the total non-CO2 generated power contribution to the total consumption to 31.4%.

Apparently then, by this analysis, the remainder of 68.6% of our energy needs will have to be supplied by CO<sub>2</sub> generating sources. The most promising of these are biodiesel, ethanol and methane generators. While these help with the problem of peak oil and petro-oil security, according to the IPCC, the emissions of these are approximately the same as their petro counterparts. Therefore, they alone cannot help solve our global warming problem.

### **Increasing the Capacity of the Earth to Absorb CO<sub>2</sub>e**

Increasing the capacity of the earth to absorb more CO<sub>2</sub>e is our third approach to address the challenge of the 21<sup>st</sup> century. To illustrate this approach, we discuss the issue of carbon flux.

#### **Carbon Flux**

Carbon Flux is the movement of carbon between the atmosphere and the land. Global warming is happening because the Flux is out of balance. There is more CO<sub>2</sub>e going into the atmosphere than the land (and sea) can absorb. As this continues (and increases) so does the global warming potential. If we let this continue, say to the end of the century, the IPCC says that sea levels could rise as much as 40' putting much of the coastal earth under water (see RJ's article on Global Warming-The World's Biggest Problem).

The following chart is the planet's current state of carbon flux (1 Tonne C= 3.7 Tonnes of CO2e):

### ATMOSPHERIC CARBON SOURCES AND SINKS

From The LEAD initiative - <http://www.virtualcentre.org>

	Carbon Flux	
	<u>Billion Tonnes C per year</u>	
	In	out
Fossil Fuel Burning	4-5	
Soil Organic Matter oxidation/erosion	61-62	
Respiration from animal organisms	50	
Deforestation	2	
Incorporation into the atmosphere from plantlife through photosynth.		110
Diffusion into oceans	_____	<u>2.5</u>
Total	117-119	112.5
Overall net increase	4.5-6.5	

Thus, we see that we need to reduce between 4.5 and 6.5 billion Tonnes of C to reach equilibrium in the carbon flux of the earth. We also can see that fossil fuel burning represents between 4 and 5 billion Tonnes, which is why the IPCC has been concentrating on reducing fossil fuel burning. The chart above, however, shows that other factors are at play causing this increase. One of them is Soil Organic Matter (oxidation/erosion) which is the largest contributor, Respiration from animal organisms, which is the next largest and Deforestation which is also significant.

### Reducing Livestock

This chart comes from Livestock's Long Shadow published by LEAD in 2006, The Livestock, Environment & Development Initiative, sponsored by The Food & Agricultural Organization of the UN,

The World Bank, and representative agencies of the EU, France, Germany, UK, US Denmark and Switzerland and the International Fund for Agricultural Development.

According to that report, “The livestock sector is by far the single largest anthropogenic user of land. The total area occupied by grazing is equivalent to 26 percent of the ice-free terrestrial surface of the planet. In addition, the total area dedicated to feedcrop production amounts to 33 percent of total arable land. In all, livestock production accounts for 70 percent of all agricultural land and 30 percent of the land surface of the planet.

Expansion of livestock production is a key factor in deforestation, especially in Latin America where the greatest amount of deforestation is occurring – 70 percent of previous forested land in the Amazon is occupied by pastures, and feedcrops cover a large part of the remainder.”

“The livestock sector is a major player, responsible for 18 percent of greenhouse gas emissions measured in CO<sub>2</sub> equivalent. This is a higher share than transport.

The livestock sector accounts for 9 percent of anthropogenic CO<sub>2</sub> emissions. The largest share of this derives from land-use changes – especially deforestation – caused by expansion of pastures and arable land for feedcrops. Livestock are responsible for much larger shares of some gases with far higher potential to warm the atmosphere. The sector emits 37 percent of anthropogenic methane (with 23 times the global warming potential (GWP) of CO<sub>2</sub>) most of that from enteric fermentation by ruminants. It emits 65 percent of anthropogenic nitrous oxide (with 296 times the GWP of CO<sub>2</sub>), the great majority from manure. Livestock are also responsible for almost two-thirds (64 percent) of anthropogenic ammonia emissions, which contribute significantly to acid rain and acidification of ecosystems.”

Reducing the impact of livestock, for both meat and dairy production, would have several benefits. If the world population significantly reduced its appetite for meat and dairy, it would halt the deforestation of

lands for pasture and would reduce the pollution caused by the animals themselves. It would open up the pasture lands for development of range fuels and could make a good part of that 30% of the planet's land surface more productive for CO<sub>2</sub>e absorption.

Reinstating the forests in the deforested lands alone would improve the imbalance between 30 and 44%. Apparently, for every acre of trees protected or restored we can reduce C by 1 Tonne (3.7 Tonnes of CO<sub>2</sub>e).

### **No-Till**

The greatest potential for improving the ratio of the flux would be in the oxidation and erosion of the soil organic matter. While more research will be required, it has been reported much of the emission of CO<sub>2</sub> from soil organic matter comes from the tilling of soil. There is a movement underway in farming circles to change to "no-till". No-till is a farming technique, similar to what the native Americans used, where seeds are planted with a dedicated amount of fertilizer without tilling the soil. A related technique called strip-till is used when soils are too dense for no-till. These techniques eliminate the exposure of most of the soil for CO<sub>2</sub> emissions and make the fertilizer more efficient. About 10% of farms in the US are now using no-till.

### **Conclusion**

In conclusion, an analysis of the 21<sup>st</sup> century challenge, (getting off fossil fuels and reducing CO<sub>2</sub>e emissions causing global warming) shows that by 2025 it may be possible to succeed. It is conceivable that non-CO<sub>2</sub> sources of energy could represent 31.4% of our energy needs by 2025 provided we reduce consumption to 1949 levels. It is conceivable that renewable but CO<sub>2</sub> emitting sources can do the remainder and that changes in our diet, ie. reducing meat and dairy consumption, and changes in our

agriculture, ie. utilizing no-till techniques, can allow our atmosphere to absorb the CO<sub>2</sub> of these other renewable energy sources.