Meeting the Challenges of Contemporary Energy Crises*

Jan Anthony Chlapowski
USA

The "Carbon Footprint" Dilemma

There are interesting developments in the technologies applying new sources of energy to help advanced nations "kick the habit" of their addiction to carbon based fuels. Trends in engine and hybrid vehicle design move towards some version of a "car of the future." Crude oil supplies are slowly running towards "empty," yet the impact of such fuels as ethanol, biofuels, liquefied natural gas or hydrogen are hardly felt. "Clean" coal and nuclear power plants have the potential to alleviate climatic changes due to man-made emissions, however they are slow in gaining acceptance in the U.S.; as are wind farms and photovoltaic cells [solar panels].

Let's face it that an oil-based global civilization imposes a heavy toll on energy supplies and although the rate of increase in consumption in developed countries has slowed down in recent years, it is still high and will not reverse itself until significant changes in efficiency are interposed, reliance on crude oil is decreased and the use of renewable sources of energy is increased.

Today the spare production capacity of crude oil is about two percent of world consumption (2). While the supplies are decreasing, the hunger for oil is not decreasing. The 50% estimated increase in global demand for energy by year 2030, mostly from fossil fuels, would come from the developing nations. China and India alone claim 70% of that growth. For example, India is projected to spend 50 billion dollars on construction or updating of oil refineries in the next five years. In fact China, India, Japan and the rest of Asia/Oceania exceeds the U.S. as the world's largest emitter of CO_2 compared to the 25% of global CO_2 emissions that the U.S. already produces. Not really surprising when you consider that the factories and homes in China use one third of world coal production. Not only that, but they also plan to add about 100 coal fired electricity generating stations in the next few years (3).

With the declining crude oil supply is the issue that only about 30 countries (4) produce most of the crude and only about half of them export more than half a million barrels per day, often coming from state controlled sources open to political gamesmanship. Small wonder that the price of crude oil has gone up 109% since year 2003. So what is happening in this growing market for new sources of energy?

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Finally, serious encouragement is making headway to revive the technologies that turn coal into synthetic fuels. An aim first broached in the U.S. in 1975! China is already building two such plants. U.S. coal reserves alone contain 3.5 times the energy content of the oil in Saudi Arabia. The significance of that fact is apparent when coal is turned into syngas [CO and Hydrogen], which can be turned into gasoline or diesel fuel (5). We can also stop at the production of hydrogen and use it for hydrogen powered cars. So what is the problem? It is the carbon dioxide, which is the by-product in the synthesis of coal. One solution would be to liquefy CO_2 and sequester it underground in disused mines, or sell it to industries utilizing CO_2 gas.

Biomass Solution

Biofuels derived from degrading renewable organic matter attract increasing attention. Currently they provide about four percent of U.S. energy needs in the form of heat, electricity and as ethyl alcohol [ethanol] to fuel vehicles. Europe already widely uses biodiesel fuel and more will be heard about it in the U.S.. European Union overall has 23 bio-ethanol plants in operation and 40 more planned (6). The U.S. has 100 plants and 1000 filling stations for E85 fuel [85%ethanol/15% gasoline] (7). The biomass used can come from anything that is biodegradable [garbage, wood waste, sewage sludge, etc]. Vegetable oil discarded by the food industry can be used as diesel fuel, but if only filtered is characterized by a low cetane number [a measure of its volatility, akin to gasoline octane value]; also by high emissions associated with poor combustion. Furthermore, it gets downright waxy at temperatures below 40˚F [4˚ C]. Bio-diesel from vegetable oils undergoes a refining process [transesterification], which removes impurities and yields fuel with high cetane value. However it is still subject to gelling at low temperatures and its energy content is somewhat less than petroleum derived diesel, for best results it is blended and sold as B20 diesel fuel [20% bio-oil/ 80% diesel] at the pump. Biodiesel has a great potential as a diesel fuel extender (5).

Currently corn is the mainstay for production of ethanol in the U.S., about 2% of its transportation fuel mix. It can probably reach 5% due to its limitations [66% energy content of gasoline, a limit on its mix with gasoline without engine modifications.] This could change as we move to ethanol production not just from corn kernel starch but to the use of corn cob with stalk and leaves, straw, switchgrass and other organic waste which does not compete with food supplies and is more CO_2 neutral [CO_2 taken up by photosynthesis = CO_2 given off in ethanol production.] (5). A suitably modified engine can use E85 fuel [85%ethanol/15%gasoline], which can reduce greenhouse gases up to 80%. Currently only Sweden and Brazil have a fully developed infrastructure for E85 fuel.

There are other products derived from biomass in the offing such as biobutanol, a high performance fuel that can be mixed with gasoline without engine modifications. It may be available in U.K. as early as 2007. Some predict that by year 2020 as much as 30% of transportation fuels will come from renewable vegetable matter.

Car Culture

The biggest culprits in guzzling crude oil are motor vehicles. Their controls are getting smarter, they are running cleaner and in general they are becoming more efficient. So is that good enough? The problem is that in the U.S. at least the overall fleet fuel economy has been virtually static for the last 25 years. Why is that when cars, and to some extent trucks, have been getting more efficient? The problem is not a decrease in efficiency, it is an increase in consumption since more trucks, or truck based vehicles, are now bought. With their increased weight and power they easily average 10 miles per gallon [MPG] less than cars.

The gasoline/electric motor hybrid cars will make a difference, but they are not yet for everyone since they represented only about 1% of all vehicles sold in the U.S. In year 2006 (8). Their obvious advantage is that they give better MPG in city driving. Their disadvantage is in higher initial cost and limited option in styles.

There has been an interesting development in the construction of batteries suitable for "plug-in hybrids" that allows for more storage capacity. A plug-in hybrid is charged from a garage electric power outlet and only uses its gasoline engine when the battery is discharged. Since the average daily driving is for relatively short distances, it would make an electric car practical (9).

Us Energy Policy

So which way is the U.S. Democratic Congress going to swing? It has certainly declared its intention to tackle the energy issues. Support bio-fuels and other alternative energy sources? It has declared its intention to do that, yet so far it is lukewarm about coal gasification. Raise fleet gas mileage standards? This has been very slow in coming and with Michigan's Representative John Dingell in charge of the House Energy and Commerce Committee it will need a lot of compromises. Lately he has declared himself in general agreement with the need to move forward on this issue. He may have got the message when the Speaker of the House of Representatives, Nancy Pelosi, appointed a special committee on energy independence (9). That committee needs to be aggressive about extending tougher economy standards for vehicles, but so far all proposals for new legislation have been cautious. Both the U.S. Congress and Senate so far are only tackling the efficiency standards, ignoring the user penalties [carbon tax,] which would have a more immediate impact on curbing demand by in effect raising the cost of fuel. The incumbent Administration so far tackled "light" trucks, vans and SUVs raising their average fuel economy from 22 miles per gallon [MPG] to 23.8 MPG and the auto manufacturers can spread implementation over 4 years! Favor more nuclear power plants? Not the traditional Democratic position. Roll back tax breaks for oil companies? That is already happening, but mostly they targeted tax breaks for exploration and new or improved refining capacity, both of which are badly needed. Encourage cleaner emission standards? Most probably. It is already happening anyway to some extent at the state level. Raise taxes on hydrocarbon based fuels to fund "clean" sources of energy? It will take a brave politician to propose that, but they should. The former President Carter wanted to do it so maybe its time has come.

Car Engine Alternatives

Where are we on hydrogen powered cars? On a limited basis they do exist but the developers are still looking for a reasonable size of a fuel cell to generate the motive power and for a cheap source of hydrogen gas, which currently is mostly derived from natural gas. The patent for a hydrogen powered car dates back to 1916, a hydrogen powered car took part in former President Carter's inaugural parade in 1977 and the first hydrogen powered fuel cell vehicle was available in 1997. Not exactly a rapid rate of progress.

But in the next 10 years we should see results of the work going on now. Limited marketing of a fuel cell powered car has begun in Japan in 2007. Chevrolet is also planning to bring out a fuel cell vehicle that year and so is China. This is all on a preliminary basis as the manufacturers work out cold starting issues, hydrogen storage at a pressure of 5,000/10,000 pounds per square inch, plentiful hydrogen gas storage infrastructure [only 15 fueling stations are available in the U.S. Currently] (5) and limited car driving range [300 to 500 miles.] The cars hold equivalent of about 16 gallons of gasoline at a cost of about $40, or roughly even with gasoline at about $3 per U.S. gallon. An interesting initiative has been proposed in California to create a Hydrogen Highway from Baja California to Alaska, with hydrogen filling stations available at suitable intervals along its entire length. Iceland has started to totally convert from carbon based fuels to hydrogen and expects to accomplish that in a couple of decades.

Diesel engines are in a large proportion of new passenger vehicles sold in Europe, hardly any in those sold in the U.S.. Now that low sulphur fuel is available, the particulate and emission controls have been improved on the new models (10); there will be a revitalized interest in cars that provide up to 40% more fuel efficiency than their gasoline counterparts. And things will get even better when the ultra low sulphur diesel fuel becomes available. At the pump diesel fuel costs 10% more than gasoline, more than offset by the gain in better mileage.

Build More Windmills?

There is talk about the U.S. getting 20% of electricity from wind but there is no firm target date. Currently in the U.S. wind farms generate about 1% of total electricity production, or enough for about 2.5 million homes. The low level of utilization is a measure of the contentiousness of these projects, since the technology and places to put these wind farms are available. China's target date for significant production is 2020. Europe and Japan aim at about 12% of its power from wind by 2010 [Denmark is already at 20% and Germany at 16%]. (11) The good news is that generating capacity is being added and that the cost of wind generated power is very comparable with other means of power generation. The bad news is that in the U.S., at least, there is local opposition to every new proposed wind farm project and that they are very capital intensive. For example, an offshore wind farm on the Texas coast with 500 windmills, will cost between 1 and 2 billion dollars and will take up to five years to complete. Texas already has what is probably the largest wind farm in the world with 421 turbines, generating 735 megawatts.

Sun Power

Currently only small amounts of energy are derived from solar cells (12), but the technology originally initiated by the U.S. space program is being improved and its use is growing. Of the world's top five manufacturers of solar panels, China is now in third place, after Japan and Germany, the main drivers for growth. The U.S. is in fourth place, but 6 with new solar programs being initiated in the U.S. and in Europe, we can be cautiously optimistic for the future. Just to give you an idea of the cost, for an average household sufficient solar panels to cover its electricity needs would cost about 40,000 U.S. dollars.

The Nuclear Option

Nuclear power is on the move again with new plants projected or in construction. The cost of Uranium has increased 1,200% since year 2003. Currently about 20% of U.S. electricity come from nuclear power [versus 80% in France.] Nuclear power is the only large scale, cost effective source of energy that can reduce emissions adding to atmospheric warming. Canada is adding two nuclear rectors. China has ordered four new reactors to start operating in 2013 with reportedly 32 additional plants projected. South Africa has ordered the latest design of a Pebble-Bed Modular Reactor [the fuel will be in the form of pellets, cooled by chemically and radiologically inert Helium gas]. Japan is adding a new reactor. Finland is building a new reactor, with three more planned. Iran's Russian built reactor may be up and running by now and they plan to add six more, also to come from Russia. India is ready to move ahead on new plants. Russia is looking to add nuclear power plants. In the U.S. the Nuclear Regulatory Commission has began to review the first licensing applications for potential 30 new plants intended to satisfy the projected 40% increase in electricity demand by 2030. In 2009 a new plant will be operational to reprocess used reactor fuel into new fuel rods. The disposal of piling up nuclear waste in the U.S. has been solved by the use of an underground repository in Nevada. Utilization of this storage has been delayed by some environmentalists and by the Nevada Senator Harry Reid, the new Senate majority leader (13).

The Non-Renew Able Fuel Squeeze

Has the world oil supply peaked? It has been in steady decline since 1985, yet in 2006 a massive oil field [up to 15 billion barrels] was discovered in the Gulf of Mexico. It is 29,000 feet under sea and earth so it is not going to be cheap to extract, but such finds help to stabilize the price of crude oil. Just because of that we should not dismiss the "peakists", at some point they will be right! The drawback of such finds is that it makes it easier to lull opinion to delay the necessary steps to reduce our dependence on oil.

That leaves us with natural gas which has doubled in cost in the last five years. While price of crude is set globally, gas is a much more local commodity mostly conveyed by pipelines and requires special facilities for transport by ships. Natural gas is not only a fuel it is also used as feedstock for a variety of products. Currently in the

U.S. about 20% of electricity comes from natural gas or from methane extracted from garbage in old landfills (14). Gas-fired electricity generating station tends to produce cleaner emissions than coal. It is not that we have run out of sources of natural gas, it is that getting at them is difficult or controversial. Two bills currently before the U.S. Congress would open up more coastal waters or other federally controlled areas, to exploration of known reserves. There is considerable reluctance to sanction this, yet the alternative may be uncontrolled drilling in the Caribbean or off the coast of South America. Americans are already drilling for gas all over the backyards in Fort Worth, Texas since the discovery that the city is sitting on top of substantial natural gas deposits. Doubtless there will be other finds equally inconveniently located.

Energy not to Burn

There is one more huge source of energy that has not yet been discussed here - it is conservation. Using less energy does not only mean there are more fuels to go around, it also means there is less pollution. If most drivers kept to the legal speed limit, or in effect lowered their speed by 10 mph, it could save as much as three million gallons per day in the U.S. alone. Not only may the engine be running more efficiently, but since wind resistance [drag] increases as the square of velocity, it will work a lot less hard. Car's cruise control feature is very useful in maintaining a steady speed under electronic control. Consider using "440 air conditioning," having four windows open in speeds up to 40 mph. Using car air conditioning can increase fuel consumption by up to 20%, at higher speeds it is more efficient to reduce drag and close the windows.

Replacing one incandescent bulb with a compact fluorescent one can save 500 pounds of coal and corresponding CO_2 emissions over its lifetime. Recycled paper requires 60% less energy to reprocess than making paper from wood pulp, saves landfill spaces and preserves forest. Only 45% of paper is recycled in the U.S., in contrast to Holland where 80% of paper is recycled. In the last 15 years the rate of recycling in the U.S. has doubled; unfortunately in that period it also increased its solid waste by 20%. (15) When buying a new vehicle consider its merits in terms of fuel economy and not its horsepower: a hybrid diesel anyone?

Future Outlook

Car and power station emissions lately have been given a lot of attention, but in reality harmful emissions are almost evenly split between transportation [33%], industry [28%], businesses/homes [38%]. Also, the U.S. is not the only culprit in environmental CO_2 "dumping." In 2004 Asia overtook North America or Europe in CO_2 emissions from burning fossil fuels. All things considered this problem is a truly global issue that needs to be tackled by both the developed and developing nations. Furthermore, the continuing dependence on oil is an economic and security risk which we need to tackle without delay.

Since the dawn of the industrial revolution, we have looked at technology to solve the needs for more and more energy and once again technology will come to our res-

cue, but in the meantime we also need to consider altering our energy-use habits. In the U.S., we need to look at both ends of Pennsylvania Avenue in Washington D.C. to take action to pass a national energy policy that deals firmly, fairly and sensibly with the reality of running out of easy options to solve the issues of pollution and of energy. However unpopular the answers may be politically, we need to drastically revise energy policy equation from the traditional finger pointing to cleaner, more efficient technologies and mandated conservation measures.

So let us take out the crystal ball and see what the next decade will bring. Certainly the demand for energy will not abate, neither will energy costs decrease given that the world economies are growing at rapid rates. Coal, crude oil and natural gas will continue as mainstays of our sources of power. Production will keep pace with global needs as it has done so far, barring occasional adjustments due to natural disasters or interruptions introduced for political reasons.

For the time being crude oil flow will be maintained by tapping into new sources or expanding the use of existing under-utilized deposits [note for example, Chinese investments in oil infrastructure in Sudan]. The natural gas pipeline expansion will be slow, but shipments of liquefied natural gas [LNG] will increase [in the U.S. five LNG terminals exist, but 15 more are being considered]. The cost of crude oil and of natural gas will continue their upward creep, even if only to keep pace with inflation.

Environmental impact due to power generation will continue to impose its toll. Stack emissions from conventional power stations have reduced particulates, sulfur and nitrogen oxides as much as is economically feasible. Capturing CO_2, while possible, has not been tried on a large scale. Fossil fired power stations are necessary and will be with us for the foreseeable future. Similar problem with CO_2 emissions applies to synthesizing coal into fuels, but it has some attraction in the near term, especially as a source of hydrogen where access to hydroelectric power is not easily available. Some additional measures of "carbon" trading as a means of penalizing CO_2 emitters will come to pass in the U.S.. Hopefully such trading will be in a form more effective than the European model.

When it comes to automobile engines, in the short term biofuels are the best bet as fuel extenders, with contributions from battery power alone or in tandem with a gasoline engine, more efficient power plants and the effect of carbon tax on fuel economy standards. Hydrogen will be the substitute fuel of choice towards the end of the decade, as fuel cells and hydrogen storage technology merge into a vehicle compatible package. It is doubtful that the hydrogen-dispensing infrastructure will keep pace with the availability of hydrogen driven cars, except for fleet use or in smaller technologically committed countries such as Iceland, Sweden or Japan. Popularity of advanced diesel engines using the low sulfur fuel may well extend its reach beyond the European continent into North America.

Wind generated power has been growing steadily in the world and will continue its advance even in the U.S., which has been slow so far to take advantage of this renewable source of energy, that was once so ubiquitous in the American farmland. As pressure mounts to eliminate sources of greenhouse gas emissions, this technology has an added advantage of being a highly visible sign that something is being done to honor the spirit of Kyoto Protocol. Harnessing wind and solar power are the favorites

of pundits advocating reduction of CO_2. Yet solar power does not seem to be pursued with the same vigor as wind, so solar technologies lag behind wind turbine applications. These undertakings will remain mainly efforts related to specific sites and local initiatives, dedicated to providing electrical power where it does not exist yet or targeted at electric power cost reduction, with electricity from the transmission lines [grid] providing the base load backup.

One problem with wind power is the uneven availability of wind itself, but when available it blows day and night. Availability of solar power is even more fickle - steady sunlight is very site specific, limited to daylight and even then subject to interruptions due to inclement weather. Most of Sub-Saharan Africa with its chronic shortage of electrical power stopping its development, is a prime candidate for wind and solar power initiatives, while they wait for the planned hydroelectric plants to come to fruition.

The renewed interest in nuclear power does not mean an unconditional revival is on the way. The issue is so wrought with emotion and distrust by the average person that it is hard to expect action without a lot of questions and misgivings. It is however the most sensible option to keep the electric circuits energized without worsening CO_2 emissions. A lot fewer nuclear power plants are required to provide the same megawatt output than any other renewable technology, particularly if we target elimination of coal fired power plants [in 2006 nearly 50% of U.S. electricity came from coal]. Yet, in the U.S. if the licensing process for a nuclear power plant started today, it would take at least seven years to bring it on line [approximately 40 months for licensing plus 40 months for construction]. Aggravating the situation is the ageing population of existing nuclear and fossil power plants that will need to be replaced due to obsolescence.

All these problems are further magnified by the ongoing increases in energy demand, some estimates say that even with enhanced conservation by both the developed and the developing countries [a big if in itself], energy demand will double by year 2050. So far, all U.S. and European initiatives aiming at CO_2 reductions have a 2020 end date [with an intermediate node in 2012]. The U.S. has made a start but it is nothing major. Europe's reduction standards are in place but there has been limited success so far in meeting them. It is clear that renewable sources of energy and conservation alone will not be enough to both reduce CO_2 and satisfy global energy demand and any drastic actions that disregard cost containment measures would be an unacceptable disruption of global economy and stability.

Fast Forward

The U.S. cannot continue to import 11 million barrels of crude oil per day (16) ad infinitum. Even with more efficient vehicles, there will need to be specific action taken to stem the consumption and to ease the restrictions on tapping the unused domestic reserves of crude oil and natural gas. The Economist Commodities Index has risen 100% between 2003 and 2007, driven in part by the rapid increase in the price of oil.

It is easy to blame automobile manufacturers for high gasoline consumption, but they have a proven record of being able to produce gas "sippers", they continue to supply gas "guzzlers" in response to public demand. This will continue in the U.S. until vehicles are taxed on the basis of their carbon footprint. Switching transport of goods from trucks to rail may be hard to achieve, but initially one could start with reduction in cross-country trips and, like Canada, stopping the environmentally unacceptable practice of running diesel engines when parked. Solar power is likely to gather momentum as photovoltaic cells become cheaper and start being more widely used by large businesses to reduce energy costs at specific locations by roof top installations; trapping sunlight on large scale in solar farms that focus sun rays to raise the temperature of a heat transfer fluid to drive a turbine-generator, has become of interest again. Originally thought to be not cost competitive, it will become attractive once the carbon footprint taxation is taken into account.

With energy prices rising and mounting concerns about adequate electricity supplies, if the fossil fuels are deemed environmentally unacceptable, the nuclear option has certain attraction. 25 reactors are already under construction outside the United States. That may already be stretching the capacity of heavy steel industry needed to support construction of reactor components.

Correspondence

Jan Anthony Chlapowski
7088 Fairway Drive South
Fayetteville, Pennsylvania 17222
U.S.A.
Email: panjan2@comcast.net