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# Todd's Perspective

Summer 2008

## The Future of Energy

<sup>1</sup>Summary of Special Report in the June 21<sup>st</sup> Issue of the Economist

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Two years ago ("Global Warming: Bad News, Good News," Summer 2006) we wrote that (1) global warming is for real, (2) fossil fuels is the culprit, and (3) the good news is help is on the way thanks to technology plus the surge in oil in prices. In our Fall 2007 newsletter ("A Warning About the Future of Energy")<sup>1</sup> we wrote that oil prices had tripled over the last four years to \$90 a barrel. We stressed the need to invest in new sources of energy and conservation. We suggested a switch to a car with much better gas mileage. That's more important today with oil at \$130 a barrel!

Today alternative energy provides only 1% of our requirements. This study says fundamental changes are coming sooner than we might think. Windmills are almost competitive with coal (\$0.08 per kwh vs. \$0.05 for coal) and would be the same with a \$30 per ton carbon tax.

Solar power is where windpower was a decade ago, contributing only 0.01% of the world's electricity. A California-based company believes their solar solar-thermal power systems will soon be competitive with wind power much sooner. The most radical thinking in the renewable energy field is going on in bio-fuels, including switchgrass, not corn. Tomorrow's cars may just plug-in. The attraction is the electrical equivalent to a gallon of gas is about \$1.00 (an interesting website is [google.org/recharge](http://google.org/recharge)). Nuclear power, which already provides 15% of the world's electricity, is making a dramatic comeback.

The cover story in the June 21, 2008 Economist has an excellent 14-page report, "The Future of Energy," which updates us on exciting trends in energy. The next technology boom may well be based on

alternative energy and this article discusses what type it might be.

Below are excerpts from The Economist special report.

Bos Todd

"With the exception of the 1970s oil has been reasonably priced. The one novelty, nuclear power, went off the rails. The pressure to innovate, therefore, has been minimal. That has now changed. Oil is no longer cheap. It has never been more expensive. There is growing concern that the supply of oil may soon peak as consumption continues to grow. New reserves are becoming harder to find and much of the world's oil is in the hands of governments who have little sympathy with the United States and Europe.

The price of natural gas has risen in sympathy with oil. That is putting up the cost of electricity. Wind and solar alternatives no longer look costly by comparison. It is true that coal remains cheap. In theory, there is a long waiting list for coal-fired plants in the U.S., but few have been completed in recent years for two reasons. First, Americans have become intolerant of polluting industrial plants. Second, our utilities are fearful they will soon have to pay for one particular pollutant, carbon dioxide, as is starting to happen in other parts of the world.

That has opened up a capacity gap and an opportunity for wind and solar. The price of these resources is zero. That certainly has

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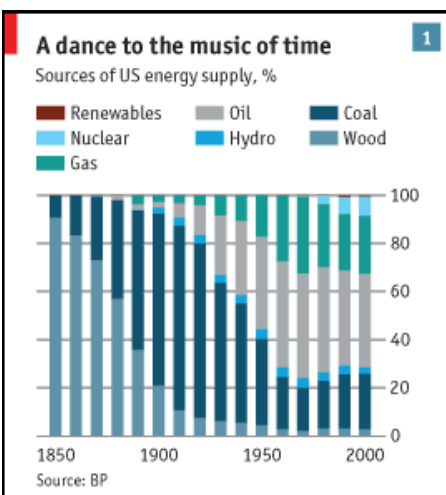
<sup>1</sup> Copies of earlier newsletters are available upon request. Please email [tbear@toddinvestment.com](mailto:tbear@toddinvestment.com)

economic value as a hedge, even as the capital cost of wind and solar is, at the moment, higher than for coal-fired electric power. There is plenty of oil from tar sands and liquefied coal so the stuff will not run out for a long time, but it is very expensive to produce. There is also political risk for oil which is often associated with unstable governments, such as Nigeria.

The market for energy is huge. The world consumes about 15 terawatts of power per year (a terawatt is 1,000 gigawatts, and a gigawatt is the capacity of the largest sort of a coal-fired utility plant).

That translates into business worth \$6 trillion a year, about 10% of the world's economic output. John Doerr, a venture capitalist, estimates that by 2050 power consumption is likely to double.

The transition from an economy based on fossil fuels to an economy based on renewable alternative energy will be slow. (See the chart below)



On the other hand, the scale of the market provides opportunities for alternatives to prove themselves at the margin, and then move into the mainstream, as is happening with wind power at the moment. Some energy technologies do have the potential to be disruptive. Plug-in cars, for example, could be fueled with electricity at a price equivalent to \$1.00 per gallon. That could shake-up the oil, auto, and electric utility industries.

The renewed interest in energy is bringing forth a raft of ideas. Larry Page and Sergey Brin, the founders of Google, have started an outfit called Google.org that is searching for a way to make renewable energy cheaper than coal. General Electric has a thriving wind turbine business and is gearing up its solar energy business. BP and Shell are sponsoring academic researchers. Exxon is conspicuously absent. It is true that renewables are only 1% of the world's electricity production. That includes biomass, wind, geothermal, and solar. Some complain that many forms of renewable energy rely on subsidies for their viability.

However, the whole energy sector is riddled with subsidies and costs that are not properly accounted for. American oil companies receive preferential treatment worth \$250 billion dollars a year.

A United Nations group of scientist estimates that fossil fuels should carry a tax of \$20 - \$50 for every ton of carbon dioxide they generate to pay for the environmental effects of burning them. Some subsidies amount to unwarranted market-rigging such as corn-based ethanol when Brazilian sugar-based ethanol is far cheaper.

If the world were rational, all these measures would be swept away and replaced by a proper tax on carbon – as is starting to happen in Europe. If that occurred, wind-based electricity would already be competitive with fossil fuels and others would be coming close.

China is building coal-fired utilities at a rapid pace, but it also has large wind-generation capacity which is expected to grow by 65% this year. China is also the world's second largest maker of solar panels - not to mention having the largest number of solar heated rooftop hot water systems in its buildings.

South Africa is leading the effort to develop a new class of safe and simple nuclear reactors.

### WIND POWER

Wind power has come of age. But, to make the most of it, electrical grids will have to be overhauled.

The world capacity for wind power is growing at 30% a year and will exceed 100 gigawatts this year. GE estimates that by 2012, half of the new generating capacity built in the U.S. will be wind powered.

Wind power currently provides only about 1% of the United States' electricity, but by 2020 that figure may rise to 15%.

In May, T. Boone Pickens announced a deal with GE to build a one gigawatt wind farm in West Texas, the world's largest, at a cost of \$2 billion dollars. GE alone expects to sell about \$6 billion dollars worth of turbines this year. Lester Brown, President of the Earth Policy Institute, estimates that a farmer in Iowa who gives up  $\frac{1}{4}$  of an acre of land to a turbine might earn \$10,000 a year from it (about 3% of the value of the electricity it produces). Planted with corn, the same land would yield only \$300 worth of ethanol.

Moreover, wind farms can be built piecemeal, unlike power stations. It produces revenue with the completion of the initial windmill. One consequence of this rapidly growing market is a virtuous circle of technological improvement that is pushing wind-generated electricity closer to competing effectively with coal. These improved turbines are producing energy at about \$.08 a kilowatt hour. That makes wind power competitive with the electricity generated by burning natural gas. Coal power is still cheaper, at about \$.05 a kwh. According to a study by MIT, that would rise to \$.08 if the CO<sub>2</sub> from coal-fired power stations had to be captured and stored underground, or for that matter, if a \$30 a ton carbon tax were imposed.

Since people do not necessarily live near where the wind blows, the task for engineers is to link them to places where the power is wanted. That means electricity grids are about to become bigger. Bigger means transcontinental. The proposed grids would use direct, rather than alternating current. AC was adopted as a standard over a century ago when the electrical world was different, but DC is better suited to transporting power over long distances. DC

cables have the unique distinction that they can be laid on the seabed. There is already a plan to use underwater cables to ship wind power from Maine to Boston in this way. Europe already enjoys the use of a DC grid. It links Scandinavia, Germany and the Netherlands and there is talk of extending it to the British Isles.

GE is collaborating with Hawaii, which is served by a series of small, isolated grids highly vulnerable to disruption. GE believes that clever grid management will allow up to 30% of local power to come from wind without any blackouts. If that improvement can be translated to grids on the mainland, wind's future looks assured.

### SOLAR POWER

Wind power works, and will work better in the future. But, wind is only an interim stop on the way to a world where electricity no longer relies on fossil fuels. The ultimate goal is to harvest the sun's energy directly by intercepting sunlight, rather than by waiting for that sunlight to stir-up the atmosphere and sticking turbines in the resulting airstreams.

The photovoltaic cell is currently the fastest growing type of alternative energy, increasing by 50% a year. The price of electricity it produces is falling as well. According to Daniel Yergin at Cambridge Energy Research, a kWh of photovoltaic electricity cost 50 cents in 1995. That had fallen to 20 cents in 2005 and is still dropping. These solar cells are like wind turbines in that even a single-solar panel can produce power immediately. Put a few on your roof and, if you live in a sunny place, you can cut your electricity bill. The problem is that at the moment it takes a substantial investment to pay for the panels, and you will not get your money back for a long time.

One engineer who is working on that problem is Emanuel Sachs of MIT. His latest venture, a firm called 1366 Technologies (after the number of watts of solar power that strike an average square meter of the earth's surface), aims to follow this up with new ideas that should bring about a 27% improvement in efficiency. He

claims these innovations will bring the capital cost of solar cells below \$2 a watt. That is closing in on the cost of a coal-fired power station: a gigawatt (one billion watts) costs about \$1 billion dollars to build.

Other researchers back a newer technology known as thin-film photovoltaic. Thin films can be made with silicon, but at the moment the commercial leader in this area is First Solar, which uses cadmium telluride as the film. But First Solar is about to be given a run for its money by a company called Miasole, a firm that uses a mixture of copper, indium, gallium, and selenium, known as CIGS. This mixture is more efficient than cadmium, though still not as good as traditional silicon.

Supporters of solar-thermal energy look askance at solar panels. Cadmium telluride and CIGS may be cheaper than silicon, but glass and steel, on which solar thermal relies, are cheaper still. Proponents want to fill the desert with steel and glass mirrors and use the reflected sunlight to boil water and generate electricity, then plug into long-distance DC networks to carry electricity to the cities. Algeria is now building an experimental solar-thermal power station about 250 miles south of Algiers which it hopes to open next year and deliver electricity across the Mediterranean to Europe. The process uses parabolic mirrors to focus the sun's rays on an elevated platform which either heats up water to make steam which drives a generator, or heats a salt with a low melting point that is used to make steam. Several pre-commercial trials are underway in the southwestern United States at the moment. Two years ago a task force put together by the governors of our western states identified 200 gigawatts worth of prime sites for solar-thermal power within their territory (meaning places that had enough reliable sunshine, were close to transmission lines and were not environmentally sensitive). That is equivalent to 20% of our existing electricity generating capacity.

Robert Fishman, head of Ausra, an Australia-American company based in California, estimates his firm's solar-thermal capability,

combined with a proprietary heat-storage system can produce electricity for 8 cents a kWh. That matches GE's wind turbines and mass production should bring it down further. It is still not as cheap as coal, which is about 5 cents.

The most intriguing technology belongs to SUNGRI, a firm based in Los Angeles. It uses mirrors to concentrate sunlight, but focuses it on a solar cell rather than a boiler. The system is said to turn 37% of the light into electricity. In April, the firm claimed it would be able to produce electricity for the magic figure of 5 cents a kWh. That claim has yet to be put to the test.

Solar power now seems to be roughly where wind was a decade ago. At the moment, it contributes a mere 0.01% to the world's output of electricity, but just over a decade of 50% of annual growth would bring that to 1% which is where wind is at the moment.

### BIOTECHNOLOGY

The biofuels the future will be tailor made. A few weeks ago there was an announcement by a small California-based biotech company called Amyris. This company announced it was going into partnership with Crystalsev, a Brazilian firm, to make motor fuel out of cane sugar. It is not ethanol, but a hydrocarbon that has the characteristics of diesel fuel. It is an example of how biotechnology will play a role in solving our energy crisis. The list of things that need to be done to create a proper biofuel industry is a long one. New crops, tailored to fuel rather than food, have to be created. One of the leading proponents of better grasses is Ceres, a California-based firm. The company is developing a variety of crops, such as switchgrass, which will grow fast in a variety of climates. It will make them cheaper as well as reducing the competition between food and biofuels, such as corn-based ethanol.

Numerous companies in all parts of the country are working in this field. The most radical thinking in the field of renewable energy is going on in biofuels. It is in this area that the most unexpected breakthroughs are likely to come,

says Steve Koonin, British Petroleum's chief scientist.

### **TOMORROW'S CARS MAY JUST PLUG-IN**

A few years ago there was agreement that if the internal combustion engine was replaced it would be by a fuel cell. No longer is this true. No one was very clear about where the hydrogen itself would come from. Why not plug your car directly into your electric circuits instead? That seems to be what is happening. You do not hear much about the hydrogen economy or fuel cells these days. The buzz phrase these days is "plug-in hybrid".

Plug-ins should not be confused with existing hybrids, such as the Toyota Prius. In a plug-in, the electricity comes from your electric socket. The goal is for the car to be powered by electric motors alone. If the battery is run down, a gasoline-powered generator would take over. But, most cars, most of the time, are used for short trips. Gerbrand Ceder, a battery scientist at MIT, reckons that, if the first 30 miles of an average car's daily range were provided by batteries rather than gasoline, annual consumption of gasoline would be halved. Given that the electrical equivalent of a gallon of gasoline costs about \$1.00, that is an attractive reduction.

The widespread adoption of plug-ins might also reduce carbon dioxide omission, depending upon what sort of utility made the electricity in the first place. Even energy from a coal-fired station is less polluting than the internal-combustion engine.

At the moment, the electric grid would be unable to cope if a large number of commuters arriving home plugged in their cars, more or less, simultaneously. Yet, if those same cars were recharged at three o'clock in the morning, when demand is low, it would benefit both the consumer (who would get cheap power) and the producer, who would be able to sell otherwise wasted electricity. That is the view of Peter Corsell of Gridpoint, a company based in Arlington, Virginia. His firm hopes to make its

living selling the load-management technology required for "smart grids".

Plug-ins might also provide another use for solar-cells. Google is already experimenting with photovoltaic parking lots. These have awnings covered in solar-cells which will shade its employee's cars and simultaneously recharge them.

Plug-ins are moving from idea to reality with amazing speed. General production of the Tesla, a new sports car, began in March. The Tesla is not even a hybrid. It draws all of its power from lithium-ion batteries (the sort that power laptop computers), and has a range of 180 miles.

Mass production of plug-ins is not far away and rising oil prices make them look more attractive by the day. GM intends to launch a plug-in hybrid called the Volt by 2010, and Toyota plans a plug-in version of the Prius. But what would really make a difference would be a breakthrough in battery technology.

At the moment, lithium-ion batteries are the favorite. But, the future probably lies with iron-phosphate, which has less of a tendency to overheat, a problem which has resulted in battery recalls in the past.

Iron-phosphate certainly will be the future if GM has anything to do with it. GM is collaborating with A123Systems, a firm started by one of Dr. Ceder's colleagues to develop batteries with iron-phosphate cathodes for the Volt.<sup>3</sup>

### **NUCLEAR POWER IS COMING BACK**

Nuclear power has only to overcome its image problem. It already provides 15% of the world's electricity and some believe it is the only possible way out of climate change. The Electric Power Research Institute estimates the cost of nuclear electricity at 6.5 cents a kWh. It is not cheaper than coal at 5 cents, but cheaper than coal with a carbon emissions tax.

Ernest Moniz, MIT's leading energy guru believes the key to a nuclear revival is to go from a craft-based approach, in which each reactor is unique, to a manufacturing approach, in which

modules of components are made in factories and simply bolted together on site.

Toshiba, which purchased Westinghouse's technology, is planning something known as nuclear batteries: factory-made sealed units with an output of 10 megawatts and a lifetime of 15-30 years. When they stop working, you simply send them back to the factory for disposal.

An example of a modular, factory-built, passively safe reactor design, however, is found in South Africa. People there have been experimenting with so-called pebble-bed reactors for decades. They hope to start building one for real in 2010. None of these projects deal with the question of nuclear waste. But that is largely a political problem, not a technical one. The best answer is to bury the stuff for the time being. That should be done in places where it can be easily be recovered for reprocessing one day when the technology has caught up.

### **BIG CHANGES LIE AHEAD IN THE ENERGY FIELD**

This report picks some technologies most likely to be important. A truly electric car would eliminate the need for biofuels, except, perhaps in aircraft. Truly cheap biofuels might price electric cars out of the market. A breakthrough in the capture and storage of carbon dioxide would bring coal back into play with a vengeance.

Solar may be better than wind.

Other technologies may make a contribution, but only on a small scale. The idea of floating platforms that capture wave energy is technically feasible, but it seems more trouble than building wind turbines. Fuel cells may become important, but only if a way can be found of storing the gas easily and at high density. This report ignored the question of efficiency, except in the context of smart grids. Car engines are more efficient than they used to be, and are likely to become still more so. The reason our cars are such gas guzzlers is that they have gotten heavier.

In some fields, such as information technology, change happened suddenly or not at all. In

others, such as energy, it can happen gradually to start with, but as the curve accelerates upward there comes a point where things move very fast. Ten years ago, wind turbines were marginal. Now, they are taken seriously, and in another decade, they may contribute as much as one-fifth of the world's electricity.

The same could happen to solar energy which is ten years behind wind. It is uncertain whether it would happen faster if carbon emissions were charged an honest price. Certainly, that is the only way to bring about the widespread adoption of carbon-dioxide capture and storage.

The lack of new coal-fired capacity creates a real opportunity for alternatives, among them renewables. But, the lack of an actual carbon price still keeps the cost of existing electricity down, and thus the necessary incentives in place to make alternative energy competitive with coal a reality.

It will be a long time before King Coal and Queen Oil are dethroned completely but their reigns as absolute monarchs of all they survey are slowly coming to an end."

Sources: "The Future of Energy," - *The Economist*, June 21<sup>st</sup> - 27<sup>th</sup>, 2008, printed with permission.

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