The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Climate Change and Electricity From Biomass

Posted by Dave Cohen on August 1, 2006 - 1:28pm
Topic: Alternative energy
Tags: biomass, carbon emissions, climate change, coal, degree-days, electric car, electric light rail, electricity, global warming, igcc, natural gas, power plants, streetcars [list all tags]

[editor's note, by Prof. Goose] Forget not the reddit and digg buttons!

The time has come to put the ongoing biomass debate in a larger context. My thanks to many TOD participants for their informative comments. I usually work the "problem" side of climate change, peak oil and natural gas supply in North America. Here I intend to address the "solutions" side of the debate. It is important to remember that no solution is without its attendant problems.

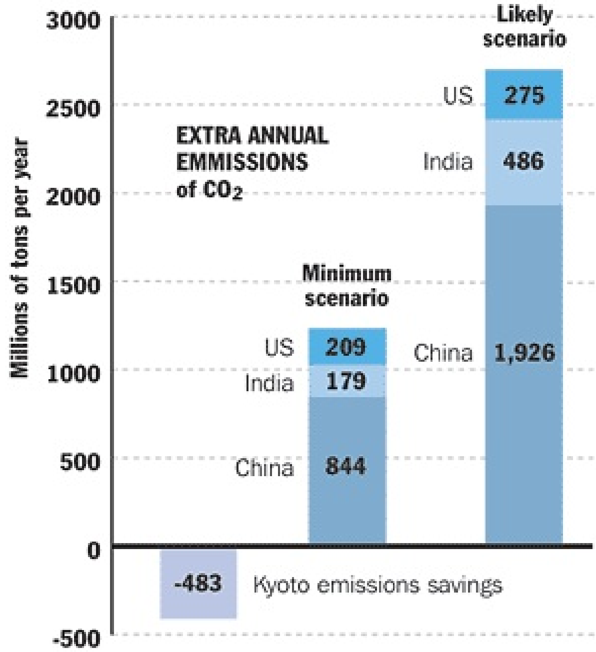
This post is lengthy and complex because the larger picture requires that I talk about a number of different subjects: electricity generation and usage trends, the weather & climate, coal trends, natural gas trends, CO_2 emissions as they relate to electricity demand and biomass for power generation. However, if you'll bear with me, a coherent picture emerges at the end. I will confine myself to the United States and not talk too much about oil.

Two recent deplorable developments and months of thought have inspired this post.

- The current liquid biofuels boom and bubble focusing mainly on corn ethanol as discussed by Robert Rapier here, here and now here. Is this the best way to use biomass? It is not and I agree with Jim Kunstler that we've got to make other arrangements for our future. The American cultural tendency is to maintain our happy motoring utopia at all costs. This tendency in turn underlies the misplaced enthusiasm for liquid biofuels.

- Two strong negative indicators appeared recently concerning the continuing fight to mitigate carbon dioxide (CO_2) emissions and achieve some modicum of stability regarding anthropogenic climate change. The first is this report of a memo from the Intermountain Rural Electric Association (IREA) resurrecting an absurd plan to discredit climate change science and prepare the way for a coal-fired future without carbon sequestration. The second indicator is the new enthusiasm for geoengineering (realclimate.org, Gavin Schmid of NASA GISS). In this case, Nobel Prize winning chemist Paul Crutzen, who invented the excellent term Anthropocene, has suggested that we put sulfur into the lower atmosphere to spur the creation of sulfate aerosols. This would have a "global dimming" effect (like after the Pinatubo volcanic eruption) and hence cool the Earth. This is also absurd (see Gavin's story) and is tantamount to giving up the battle to mitigate climate change by reducing greenhouse gas emissions.

As promised, I will confine myself to the US except for the following chart from the Christian Science Monitor New coal plants bury 'Kyoto'.



COAL'S KNOCKOUT BLOW TO KYOTO: By 2012, expected cuts in greenhouse-gas emissions under the Kyoto treaty will be swamped by emissions from a surge of new coal-fired plants built in China, India, and the United States

> "**Environmental optimists were assuming the world was going to switch to [natural] gas, but when you're short of gas you use your own coal**," says Philip Andrews-Speed, a China energy expert at the University of Dundee, in Scotland. "What you're seeing with China and the others is the cheapness and security of coal just overwhelming the desire to be clean."

As you can see, the problem is much bigger than American coal usage for generating electricity. Now that the context is established, I will talk about trends in the US while noting that we Americans have an obligation in this world to lead by example given that we use 25% of the liquid fuels and generate about the same percentage of CO2 emissions from fossil fuels. Also, I do not live in China and nor can I vote there.

Electricity Consumption and CO2 Emissions

I will be referencing a recent EIA report with the innocuous title US Carbon Dioxide Emissions from Energy Sources (requires Flash). See also the introduction to the report (June 28, 2006). Click on any of the figures below to enlarge them in a new window.

Figures 1 and 2

Figure 3

Figures 4 and 5

Guide to the Slides and Pertinent Data

- *Figure 1 -- US Consumption of Residential Natural Gas, Electricity and Motor Gasoline*. Electricity demand is outstripping gasoline and natural gas demand but prices remain stable. "Even though weather and population trends affect the demand ...". *Even though*?

- *Figure 2 -- Carbon Dioxide Emissions by Fuel Type*. While pretroleum fuel usage still generates the most emissions (2585 MMTons CO2) and is rising, natural gas is flat or slightly declining and coal (2136 MMTons CO2) also shows a steady rise.

- *Figure 3 -- Electric Power Emissions by Source*. Electric power emissions have risen an astonishing 30.9% since 1990 with coal responsible for 83 to 86% of total emissions. Natural gas, which powers about 19% of electricity generation (not in slide), creates only 12 to 13% of emissions over the last 5 years.

- *Figure 4 -- Carbon Dioxide Emissions by End-Use Sector*. In 1999, transportation emissions surpassed those generated by industry, which is flat since 1990. Emissions from the electric power sector show the most growth. Residential is rising 1.8%/year and commercial is rising 2.0%/year, greater than transportation at 1.4%/year.

- *Figure 5 -- Residential Sector*. Heating degree-days (winter) is flat but cooling degree-days (summer A/C) rose by over 13% from 2004 to 2005. While total emissions increased by 3.2%, electricity-related emissions rose by 4.9%. Population growth and greater electricity demand are the key factors affecting emissions growth.

Let's discuss this data. Most of it is self-explanatory, you can see the trends. Heating and cooling degree-days data is maintained by the National Climatic Data Center. "Degree day is a quantitative index demonstrated to reflect demand for energy to heat or cool houses and businesses". There don't seem to be easily obtainable national statistics for the period of interest here (1990 to 2005) but the problem is being worked on.

> "Call it what you will -- trends, global warming -- the bottom line is we're much warmer lately"...
>
> "We look at something called the number of National Cooling Degree Days," said [Jon] Davis [chief climatologist for Chesapeake Energy Corp]. "We're seeing a tremendous increase in cooling days. The weather variable in energy is going to get more and more (important) from this point on."

We know that electricity usage has risen substantially between 1990 and 2005. What is the cause? As to the relationship to climate warming, we can not establish what that is yet. Naturally, the one data point (2004 to 2005) allows us to conclude nothing. The question is whether this is a statistically significant trend. Do warmer winters offset hotter summers? Are there more degree-days year-on-year for the period? Fewer heating degree-days in the winter could offset more cooling degree-days in the summer. If no significant trend can be identified, then increased electricity demand is probably due to increased population, larger residential and commerical buildings using central A/C & heating -- or both of these factors. However, I conjecture that climate warming is playing a role here but its true significance is unknown over the time period we care about (from 1990 to the present). All this requires further data analysis.

Coal and Natural Gas Power Generation Trends

As electricity demand increases over time, so should coal and natural gas consumption. However, *Figure 1* indicates the natural gas consumption is only slightly higher over the 1990 to 2005 period, currently declining and does not reflect increased electricity demand over the period. In addition, the EIA's slide #3 (not shown) indicates that electricity prices are flat over the period indexed to constant dollars. What's going on? The answer must be *coal*.

From the natural gas section of EIA's Annual Energy Outlook 2006 with Projections to 2030.

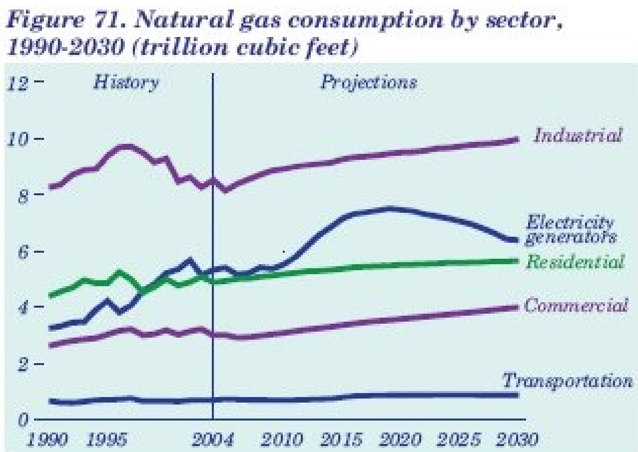


Figure 6

> Currently, high natural gas prices discourage the construction of new natural-gas-fired electricity generation plants. As a result, only 130 gigawatts of new natural-gas-fired capacity is added from year-end 2004 through 2030, as compared with 154 gigawatts of new coal-fired capacity. Natural gas consumption in the electric power sector peaks at 7.5 trillion cubic feet in 2019, then starts falling as new coal-fired electricity generation increasingly displaces natural-gas fired generation. Natural gas use for electricity generation declines to 6.4 trillion cubic feet in 2030.

Space restrictions prevent a thorough treatment of natural gas prices in this post. Suffice it to say that prices are high and have just spiked (NYMEX Henry Hub) to $8.21/Mcf (= MMbtu/Mcf, see below) as of this writing. A recent EIA gas update tells us why.

> As a result of the record-setting heat and correspondingly higher power usage in many areas, natural gas spot prices increased at all market locations since last Wednesday, July 19. The Edison Electric Institute (EEI) reported yesterday that U.S. electricity demand reached an all-time record last week. According to EEI, domestic utilities delivered 96,314 gigawatt hours (GWh) during the week ending July 22, surpassing the previous record, which was set last year during the week ending July 23, 2005, by more than 1 percent. Price increases on the week varied widely, ranging between 49 cents and $1.11 per MMBtu.

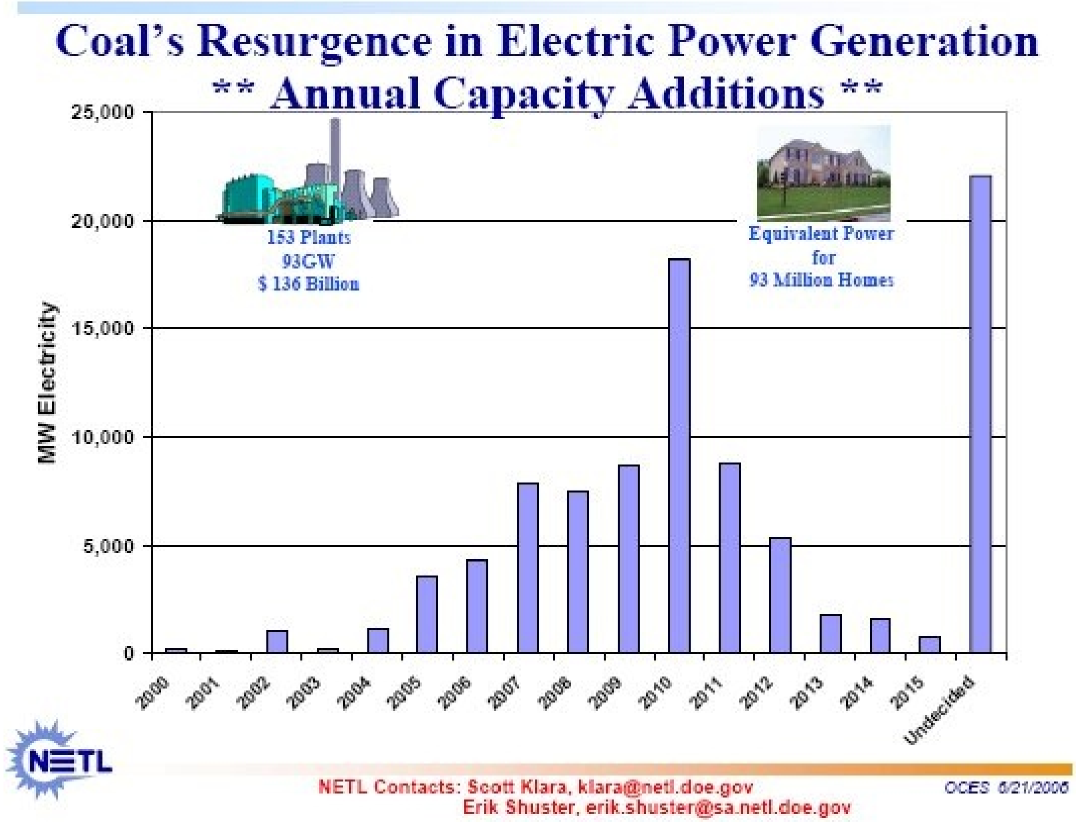
Consider the following table from EIA's annual natural gas prices report.

Price Type	2000	2001	2002	2003	2004	2005

Wellhead Price	3.68	4.00	2.95	4.88	5.46	7.51
Electric Power Price	4.38	4.61	3.68	5.57	6.11	8.45

Note: Prices are in MMBTU: One million Btu's is equal to approximately 1,000 cubic feet of natural gas (Mcf).
Electric Power Price: price of gas used by electricity generators (regulated utilities and non-regulated power producers) whose line of business is the generation of power.

Understanding *Figure 6* is the key to what's going on. HO and I have done numerous posts on natural gas but I will do a quick summary here. I suggest you read back through some of them. Remember, using natural gas has very low CO2 emissions relative to coal. What happened is as follows. Starting in about 1996 and culminating in 2004, most new power plants were built using natural gas. Wellhead gas prices have more than doubled since 2000 due to tight supply and had increased previous to that since the mid-90's. Matters have not been helped any by extreme weather events (like this summer's heat wave) and especially the shut-ins in 2005 due to the hurricanes in the Gulf of Mexico. We are still in the hurricane season although the weather has been quiet so far. As if that wasn't bad enough, natural gas wells deplete rapidly and the shallow-water Gulf of Mexico is being used up. As a result, due to simple extraction economics rigs are leaving the Gulf. Given the lead times for adding additional electrical power generation, plans for building coal-fired plants started to hold sway; plans for natural gas generation have flattened out. However, around 2009 LNG imports from Qatar will boost imports and presumably make natural gas electricity generation affordable again. Meanwhile, coal is the power generation fuel of the present -- see Tracking New Coal-Fired Power Plants -- Coal's Resurgence in Electric Power Generation (June 26, 2006, pdf). According to the EIA, the electricity fuel of the future will be natural gas again after LNG gets going. Meanwhile, our NETL source tells us that there are 153 proposed coal plants with an estimated 93 gigawatts of electricity generation. Here's the big picture from the link above:



>

Note how anticipated coal generating capacity starts growing in 2004 and reaches its peak in 2010. Note the large *undecided* category. This is probably due to uncertainty regarding future natural gas supply. And what about coal prices? Coal is still cheap. Relative to natural gas, they are *low*. In fact, the NYMEX Central Appalachian Coal Futures price is dropping! All this is a climate change disaster.

Biomass for Electrical Power Generation

Three detrimental things have happened as US electricity demand has risen year-on-year as it has since 1990 at a rate of 1.8%/year and 31% overall.

1. Natural gas prices have increased due to increasing scarcity of supply and growing demand.
2. Plans to build coal-fired power plants increased.
3. CO2 emissions have risen due primarily to the dependence on coal. This trend will get worse on our current path.

As Robert Rapier has told me (personal communication):

> I don't know what the EROI [for BTL] will be, but they are partially burning the biomass. That will generate a lot of energy in which to make the liquid products. In my opinion, Fischer-Tropsch diesel is the best route. But this is a much more expensive option [regarding capital costs] than using biomass to generate electricity.

Forget the corn ethanol. Forget the cellulosic ethanol too. In these cases, using BTL processes for liquid transportation fuels increases capital costs to levels that don't pay off much and substituting food stocks for transportation fuels does not replace a significant part of our gasoline usage in any case -- it makes no sense. What are the CO_2 emissions for various biofuels strategies? Brazil has had some success with biofuels from sugar cane but they started subsidizing their production 20 years ago. What makes the biomass worth using is the energy yield from simply burning it. So, let's use the biomass for electricity generation directly in a sustainable manner. Then use the generated power to build nationwide electric rail or trolley in cities or electric cars. Here are some details.

As detailed in the EIA's study Biomass for Electricity Generation, there are four ways to use biomass.

> Biomass for electricity generation is treated in four ways in NEMS: (1) new dedicated biomass or biomass gasification, (2) existing and new plants that co-fire biomass with coal, (3) existing plants that combust biomass directly in an open-loop process,18 and (4) biomass use in industrial cogeneration applications. Existing biomass plants are accounted for using information such as on-line years, efficiencies, heat rates, and retirement dates, obtained through EIA surveys of the electricity generation sector.

Here I will restrict myself to option #1 though the co-generation strategies (#2, #4) are viable as well. Specifically, the EIA is talking about a *closed-loop* process using *biomass integrated gasification combined cycle* (BIGCC) technology where

> A closed-loop process is defined as a process in which power is generated using feedstocks that are grown specifically for the purpose of energy production. Many varieties of energy crops are being considered, including hybrid willow, switchgrass, and hybrid poplar. If biomass is utilized in a closed-loop process, the entire process (planting, harvesting, transportation, and conversion to electricity) can be considered to be a small but positive net emitter of CO_2. It is not precisely a net zero emission process in a life-cycle sense, because there are CO_2 emissions associated with the harvesting, transportation, and feed preparation operations (such as moisture reduction, size reduction, and removal of impurities). However, those emissions are not the result of combustion of biomass but result instead from fuel consumption (mostly petroleum and natural gas) for harvesting, transportation, and feed preparation operations.

The most important benefit of such a process is environmental; specifically the drastically reduced CO_2 emissions. An obvious point bears repeating here: when referring to clean coal in IGCC electric power generation, the pollutants being considered are primarily sulfates (SO_2) and nitrogen oxides (NO, NO_2), not carbon dioxide. While it may be possible to sequester CO_2 at IGCC power plants, this is currently a research matter. Why not reduce CO_2 emissions at the source using biomass? I'm sure that the irony is not lost on readers here that just as the US has mounted a clean coal inititative, Crutzen suggests that we seed the lower atmosphere with sulfur to promote global dimming! As I tried to make clear above, natural gas (with sequestration) is not a supply-side option in the short term and perhaps further out given uncertainties about building recieving terminals in the US to support the LNG lifeline.

A long study A Biomass Blueprint to Meet 15% of OECD Electricity Demand By 2020 (large pdf) by the World Wildlife Fund (WWF) and the European Biomass Association (AEBIOM) goes into considerable detail about the proposal given by its title. Here's the introduction to the report. You can read all the report details. The logistical problems as viewed today in switching to electicity-based transportation are daunting. Here's what Wojciech Olejniczak, the Polish Minister of Agriculture and Rural Development, had to say about it:

> Increasing energy prices result in deteriorating conditions for the whole economy, including agriculture. A very important element of [the] “professional” power industry, based on renewable energy resources, is overcoming the organisational, technical and technological barriers, which today make biomass less competitive than fossil fuels. Such possibilities already exist on the local markets, where biomass is easily accessible and is not connected with high transportation costs. Increases in renewable energy production will not only result in an improvement in the areas of environment protection and energy safety, but will also provide a great chance for agriculture.

And from the report's authors:

> **Governments should also redirect their agricultural subsidies** to support the development of a stable biomass fuel supply by allowing perennial woody and grass energy crops to benefit from incentive schemes and at realistic scales. This needs to be accompanied by the development and enforcement of best practice guidelines for for biomass production to maximise positive social and environmental impacts and minimise any negative effects. Bioenergy is a key technology to fight climate change and deliver economic and social benefits. Governments must act now to promote its world-wide development.

Here I present a modest proposal for implementing the supply chain infrastructure for large BIGCC and localized electric power generation solutions. Where BIGCC plants are not an option, other Combined Cycle plants using biomass can be built. The US can pay for the transition by implementing both carbon and gasoline fuel taxes, as has been called for here at TOD. Carbon sequestration for existing coal-fired plants must be implemented as soon as possible and let us pray that it is feasible. Co-generation using biomass must be added into those plants to reduce the carbon burden. The carbon market can supply production of domestic stranded oil using CO_2 EOR in suitable regions like the Permian Basin of west Texas and New Mexico. This has been demonstrated at Weyburn. This is only a stopgap measure to ease the transition. Current tax subsidies for fossil fuels must be phased out. The necessary transition will be long and painful. Sorry, there is no gain without pain. We must begin the work now.

In Conclusion...

If Hirsch, Skrebowsky, Simmons, Stuart and the rest of us are right about the oil depletion picture, oil consumption will actually start showing declines in the near future. Assuming a 2010 date for the peak and a slow squeeze scenario as shown by Hubbert Linerarizations, we might further assume a 2% year-on-year usage decline after that date. Concomitantly, CO_2 from petroleum as shown in *Figure 2* will decline at some comparable rate. However the picture for electricity consumption is that it may continue to grow at its current 1.8% rate (from 1990 to 2005), or even at a higher rate. The population problem can not be ignored in this context, nor can larger centrally heated or cooled residential & commercial spaces. We also can not dismiss the *degree-days* problem that is likely stressing our power grid beyond capacity -- this is happening now and may be due to climate warming in the present and may be exacerbated by increased warming in the future. Declining petroleum usage combined with generating a significant fraction of our electricity using biomass could mean *reduced CO_2 emissions* in the United States in the future. As I alluded to above, increased electricity supply can support various transportation options like electric rail, cars and streetcars.

Welcome to the Future -- Click to Enlarge

However, US government policies (taxes and subsidies) must change if this scenario is to happen. Particularly, the two political parties and venture capitalists like Vinod Khosla must be made to understand that BTL processes are not the best way to use biomass in the future. This is a failed strategy to maintain "business as usual". That will not work. Climate change considerations as constructed by Jim Hansen must be taken into account. As we make the transition to biomass for electric power generation, the US can create jobs and wealth, export technology to Asia (China & India), mitigate climate change and take a large step toward avoiding a longer term calamitous future.